Installation

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Aquamatic DPH, DPR
Volvo Penta IPS
Inboard

D4, D6

Installation
Marine Propulsion Diesel Engines
D4, D6
Aquamatic DPH, DPR
Volvo Penta IPS
Inboard

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Safety precautions

Introduction

This Installation Manual contains the information you will need to install your Volvo Penta product correctly. Check that you have the correct Installation Manual.

Read the Safety precautions and the General information in the installation manual carefully before servicing or operating the engine.

Important

The following special warning symbols are found in this manual and on the engine.

⚠ **WARNING**! Danger of personal injury, damage to property or mechanical malfunction if the instructions are not followed.

⚠ **IMPORTANT**! Possible damage or mechanical malfunction in products or property.

NOTE! Important information to facilitate work processes or operation.

Below is a list of the risks that you must always be aware of and the safety measures you must always carry out.

⚠ Plan in advance so that you have enough room for safe installation and (future) dismantling. Plan the engine compartment (and other compartments such as the battery compartment) so that all service points are accessible. Make sure it is not possible to come into contact with rotating components, hot surfaces or sharp edges when servicing and inspecting the engine. Ensure that all equipment (pump drives, compressors for example) has protective covers.

⚠ Make sure the engine is immobilized for as long as work continues, by not connecting the electrical system or by turning off the power supply to the engine at the main switch (breakers), and locking the switch (breakers) in the OFF position. Set up a warning notice at the engine control point or helm.

⚠ As a rule, no work should be done on a running engine. However, some work such as adjustments requires a running engine. Approaching an engine that is running is a safety risk. Loose clothing or long hair can fasten in rotating components and cause serious personal injury. If working in proximity of a running engine, careless movements or a dropped tool can result in personal injury. Take precautions to avoid hot surfaces (exhaust pipes, turbochargers, charge air manifolds, starting heaters etc.) and hot liquids in supply lines and hoses in engines that are running or have just been turned off. Reinstall all protective parts removed during service operations before starting work on the engine.

⚠ Ensure that the warning or information decals on the product are always visible. Replace decals which are damaged or painted over.

⚠ Turbocharged engines: Never start the engine without installing the air cleaner. The rotating compressor turbine in the turbocharger can cause serious personal injury. Foreign objects entering the intake ducts can also cause mechanical damage.

⚠ Never use start spray in the air intake. Use of such products could result in an explosion in the air intake pipe. There is a danger of personal injury.

⚠ Do not open the filler cap for the engine coolant (freshwater cooled engines) when the engine is hot. Steam or hot engine coolant can be ejected and any pressure in the system will be lost. Open the filler cap slowly and release coolant system pressure (freshwater cooled engines). If the filler cap or drain cock must be opened, or if a plug or engine coolant line must be removed on a hot engine, steam or hot coolant can be ejected.

⚠ Hot oil can cause burns. Avoid skin contact with hot oil. Make sure that the oil system is released before starting work on it. Never start or run the engine without the oil filler cap in place because of the risk of oil being ejected.

⚠ If the boat is in the water, stop the engine and close the sea cock before carrying out operations on the cooling system.

⚠ Only start the engine in an area that is well ventilated. Beware, the exhaust gas is poisonous to breathe. When the engine is run in an enclosed space, use exhaust extraction to lead the exhaust and crankcase gases away from the workplace.

⚠ Always wear protective goggles if there is a risk of splinters, grinding sparks and splashes from acid or other chemicals. Your eyes are extremely sensitive and an injury to them can result in blindness!

⚠ Avoid skin contact with oil! Long term or repeated skin contact with oil can lead to the loss of natural oils from the skin. This leads to irritation, dry skin, eczema and other skin problems. Old oil is more dangerous to your health than new. Use protective gloves and avoid oil-soaked clothes and rags. Wash regularly, especially before meals. Use special skin creams to help clean and to stop your skin drying out.

⚠ Most chemicals intended for the product (engine and reverse gear oils, glycol, gasoline (petrol) and diesel), or chemicals intended for the workshop (degreasing agent, paints and solvents) are harmful to your health. Read the instructions on the packaging carefully! Always follow protective measures (using a protective mask, goggles, gloves etc.). Make sure that other personnel are not unknowingly exposed to harmful substances, in the air that they breathe for example. Ensure good ventilation. Dispose of used and excess chemicals as directed.

⚠ Be extremely careful when tracing leaks in the fuel system and when testing injectors. Wear protective goggles. The jet from an injector is under very high pressure and fuel can penetrate deep into tissue, causing serious injury with a risk of blood poisoning (septicemia).

⚠ All fuels and many chemicals are flammable. Keep away from naked flames or sparks. Gasoline, some solvents and hydrogen from batteries in the correct proportions with air are very flammable and explosive. Do not smoke! Maintain good ventilation and take the necessary safety measures before welding or grinding in the vicinity. Always keep a fire extinguisher accessible in the workplace.

⚠ Store oil and fuel-soaked rags and old fuel and oil filters properly. Oil-soaked rags can ignite spontaneously in certain circumstances. Old fuel and oil filters are environmentally harmful and should be sent for destruction to a proper refuse station for environmentally harmful material for destruction.

⚠ Ensure that the battery compartment is designed according to current safety standards. Never allow an open flame or electric sparks near the battery area. Never smoke near to the batteries. The batteries give off hydrogen gas during charging which when mixed with air can form an explosive gas. This gas is easily ignited and highly volatile. Incorrect connection of the battery can cause sparks sufficient to cause an explosion with resulting damage. Do not shift the connections when attempting to start the engine (spark risk) and do not lean over any of the batteries.

⚠ Always ensure that the Positive and Negative battery leads are correctly installed on the corresponding terminal posts on the battery. Incorrect installation can result in serious damage to the electrical equipment. Refer to the wiring diagrams.

⚠ Always use protective goggles when charging and handling the batteries. The battery electrolyte contains extremely corrosive sulfuric acid. If this should come in contact with the skin, immediately wash with soap and plenty of water. If battery acid comes in contact with your eyes, flush immediately with water and obtain medical assistance.

⚠ Turn the engine off and turn off the power at the main switches (breakers) before carrying out work on the electrical system.

⚠ Clutch adjustments must be carried out with the engine turned off.

⚠ Use the lifting eyes fitted to the engine/reverse gear when lifting the drive unit. Always check that the lifting equipment used is in good condition and has the load capacity to lift the engine (engine weight including reverse gear and any extra equipment installed).

⚠ Use an adjustable lifting beam to ensure safe lifting and avoid damage to components installed on the top of the engine. All chains and cables must run parallel to each other and must be as perpendicular as possible to the upper side of the engine.

⚠ If extra equipment is installed on the engine which alters its center of gravity, a special lifting device is required to obtain the correct balance for safe handling.

⚠ Never carry out work on an engine suspended on a hoist.

⚠ Never work alone when installing heavy components, even when using secure lifting equipment such as a lockable block and tackle. Most lifting devices require two people, one to handle the lifting device and one to ensure that the components do not get caught and damaged.

⚠ The components in the electrical system, the ignition system (gasoline/petrol engines) and in the fuel system on Volvo Penta products are designed and manufactured to minimize risks of fire and explosion. Engines should not run in environments containing explosive media.

⚠ Always use fuels recommended by Volvo Penta. Refer to the Operator ’s Manual. Use of lower quality fuels can damage the engine. On a diesel engine, poor quality fuel can cause the fuel control rack to stick, causing the engine to overspeed with resulting risk of damage to the engine and personal injury. Poor fuel quality can also lead to higher maintenance costs.

General information

About the Installation Manual

This publication is intended as a guide for the installation of Volvo Penta marine diesel engines for inboard use. The publication is not comprehensive and does not cover every possible installation, but is to be regarded as recommendations and guidelines applying to Volvo Penta standards. Detailed Installation Instructions are included in most of the accessory kits.

These recommendations are the result of many years' practical experience of installations from all over the world. Departures from recommended procedures etc. can be necessary or desirable however, in which case the Volvo Penta organization will be glad to offer assistance in finding a solution for your particular installation.

It is the sole responsibility of the installer to ensure that the installation work is carried out in a satisfactory manner, it is operationally in good order, the approved materials and accessories are used and the installation meets all applicable rules and regulations.

This Installation Manual has been published for professionals and qualified personnel. It is therefore assumed that persons using this book have basic knowledge of marine drive systems and are able to carry out related mechanical and electrical work.

Volvo Penta continuously upgrades its products and reserves the right to make changes. All the information contained in this manual is based on product data available at the time of going to print. Notification of any important modifications to the product causing changes to installation methods after this date will be made in Service Bulletins.

Removal of the complete engine package

In the event the entire engine package needs to be removed from the vessel, it is the installers (boat builders) responsibility to make provisions for reasonable methods of removal and re-installation.

Reasonable means that the engine package can be removed and re-installed within reasonable time and with normal resources and methods available in the trade, thus limiting cost and downtime.For the sake of high demands at high season on yards etc. the vessel manufacturers instruction should be followed.

It is the policy of Volvo Penta to avoid unresonable installations driving additional cost for the boatowners during the vessels service life.

Plan installations with care

Great care must be taken in the installation of engines and their components if they are to operate satisfactorily. Always make absolutely sure that the correct specifications, drawings and any other data are available before starting work. This will allow for correct planning and installation right from the start.

Plan the engine room so that it is easy to carry out routine service operations involving the replacement of components. Compare the engine's Service Manual with the original drawings showing the dimensions.

It is very important that no dirt or other foreign matter gets into the fuel, cooling, intake or turbocharger systems when engines are installed, since this can lead to faults or engine seizure. For this reason, the systems must be sealed. Clean supply lines and hoses before connecting them to the engine. Only remove protective engine plugs when making a connection to an external system.

Certified engines

The manufacturer of engines certified for national and local environmental legislation (US/EPP, RCD94/25 imo, for example) pledges that this legislation is met by both new and currently operational engines. The product must compare with the example approved for certification purposes. The following must be observed during installation, so that Volvo Penta, as a manufacturer, can pledge that currently operational engines meet environmental regulations:

- Servicing of ignition, timing and fuel injection systems (gasoline) or injector pumps, pump settings and injectors (diesel) must always be carried out by an authorized Volvo Penta workshop.
- The engine must not be modified in any way except with accessories and service kits developed for it by Volvo Penta.
- Installation of exhaust pipes and air intake ducts for the engine compartment (ventilation ducts) must be carefully planned since their design may affect exhaust emissions.
- Seals may only be broken by authorized personnel.

⚠ **IMPORTANT**! Use only Volvo Penta Genuine Parts.
Using non-genuine parts will mean that AB Volvo Penta will no longer accept responsibility for the engine meeting the certified design.
No damage and costs caused by the use of non-genuine replacement parts will be compensated by Volvo Penta.

Seaworthiness

It is the boat builder's duty to check that the applicable security requirements are complied with, in the market in which the boat is sold. In the USA for example, these are the US Federal Regulations for pleasure boats described in Title 46. The requirements described below apply to EU regulations. Please contact the authority for the country concerned, for information and detailed descriptions of the safety requirements that apply to other markets.

As from 16 June 1998, pleasure boats and certain associated equipment marketed and used within the EU must carry CE labels to confirm that they comply with the safety requirements stipulated by the European Parliament and Council of Europe Pleasure Boats Directive. The normative requirements can be found in the standards drawn up to support the directive's objective of uniform safety requirements for pleasure boats in EU countries.

Life boats and boats for commercial activities are approved by classification societies or by the navigation authority for the country where the boat is registered.

Joint liability

Each engine consists of many components working together. One component deviating from its technical specification can cause a dramatic increase in the environmental impact of an engine. It is therefore vital that systems that can be adjusted are properly adjusted and that Volvo Penta Genuine Parts are used.

Certain systems (components in the fuel system for example) may require special expertise and special testing equipment. Some components are sealed at the factory for environmental reasons. No work should be carried out on sealed components except by authorized personnel.

Remember that most chemical products damage the environment if used incorrectly. Volvo Penta recommends the use of biodegradable degreasing agents for cleaning engine components, unless otherwise indicated in a Workshop Manual. Take special care when working on board boats to ensure that oil and waste are taken for destruction and not accidentally pumped into the environment together with bilge water.

Conversion factors

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	foot	3.2808	foot	m	0.3048
Area	mm^2	sq.in.	0.00155	sq. in.	mm^2	645.2
	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
	litre, dm^3	cu. ft.	0.03531	cu. ft.	litre, dm^3	28.320
	litre, dm^3	cu. in.	61.023	cu. in.	litre, dm^3	0.01639
	litre, dm^3	imp. gallon	0.220	imp. gallon	litre, dm^3	4.545
	litre, dm^3	U.S. gallon	0.2642	U.S. gallon	litre, dm^3	3.785
	m^3	cu. ft.	35.315	cu.ft.	m^3	0.0283
Force	N	lbf	0.2248	lbf	N	4.448
Weight	kg	lb.	2.205	lb.	kg	0.454
Power	kW	hp (metric) [1]	1.36	hp (metric) [1]	kW	0.735
	kW	bhp	1.341	bhp	kW	0.7457
	kW	BTU/min	56.87	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	in Wc	0.004	in Wc	Pa	249.098
	kPa	in Wc	4.0	in Wc	kPa	0.24908
	mWg	in Wc	39.37	in 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/kWh	g/hph lb/hph	0.736 0.00162	g/hph lb/hph	g/kWh g/kWh	1.36 616.78
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 mph	ft./s knots	3.281 0.869	ft./s knots	m/s mph	0.3048 1.1508
Temp.	°F=9/5 x °C+32			°C=5/9 x (°F–32)		

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

Engine application ratings

The engines covered by this manual are mainly used for two different operating conditions, Rating 4 and Rating 5, as described below.

Even at a very early stage, the output requirements and operating conditions for the installation concerned should be carefully specified so that a suitable engine with the right setting and convenient equipment can be ordered. This can save time in making modifications at a later stage.

NOTE! For complete information on ratings refer to Sales Guide

Rating 4

Special Light Duty Commercial

For light planing craft in commercial operation. Running hours less than 800 h per year.

Typical boats: High speed patrol, rescue, navy, and special high speed fishing boats. Recommended speed at cruising = 25 knots.

Full power can be utilized max 1 h per 12 h operation period. Between full load operation periods, engine speed should be reduced by at least 10% from the full load engine speed.

Rating 5

Pleasure Duty

For pleasure craft applications only, which presumes operation by the owner for his/ her recreation. Running hours less than 300 h per year.

Full power can be utilized maximum 1 h per 12 h operation period.

Between full load operation periods, engine speed should be reduced by at least 10% from the full load engine speed.

Marine engine environment

The marine engine and its environment

Marine engines, like engines for cars and trucks, are rated according to one or more power standards. The output is indicated in kW, usually at maximum engine speed.

Most engines will produce their rated power provided they have been tested under the conditions specified by the power standards and have been properly run in. Tolerances according to ISO standards are usually ± 5%, which is a reality that must be accepted for line produced engines.

Measuring output

Engine manufacturers normally assign an engine's output to the flywheel, but before the power reaches the propeller, losses occur in the transmission and in the propeller shaft bearings. These losses amount to 4-6%.

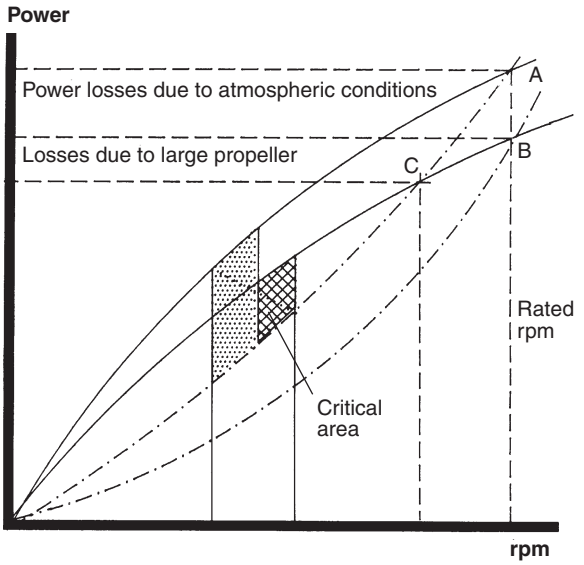
All major marine engine manufacturers indicate engine power according to ISO 8665 (supplement to ISO 3046 for leisure boats), based on ISO 3046, which means that the propeller shaft power is specified. If an exhaust system is optional, engine tests are conducted with a back pressure of 10 kPa. If all engine manufacturers followed the same test procedure it would be easier for a boat producer to compare products from various suppliers.

Engine performance

Engine output is affected by a number of different factors. Among the more essential are barometric pressure, ambient temperature, humidity, fuel thermal value and back pressure. Deviations from normal values affects diesel and petrol engines differently.

Diesel engines use a large amount of air for combustion. If the air mass flow of the air is reduced, the first sign is an increase in black smoke. The effect of this is especially noticeable at the planing threshold speed, where the engine must produce maximum torque.

If the deviation from normal mass flow is substantial, even a diesel engine will lose power. In the worst case, the reduction could be so large that the torque is not sufficient to overcome the planing threshold.



The figure above illustrates the consequences of climate variation.

Point A is where rated power from the engine is equal to the power absorbed by the propeller. It is correct to select a propeller where these values of point A are obtained in order to utilize maximum rated power at a certain weather and load condition.

If atmospheric conditions cause the power to drop to point B, the propeller curve will cross the output curve from the engine at point C. A secondary performance loss has occurred because the propeller is too large. The propeller reduces the rpm developed by the engine.

By replacing the propeller with a smaller one, the power curve of the engine will cross at point B, making it possible to regain previous rpm, but at reduced power.

For planing or semi-planing boats, the planing threshold ("hump" speed), which mostly occurs at 50 - 60% of max. speed, is the critical area. In this section it is important that the distance between the engine max. power curve and the propeller curve is large enough.

Other factors affecting performance

It is important to keep the exhaust back pressure at a low level. The power losses caused by back pressure are directly proportional to the increase of back pressure, which also increases the exhaust temperature.

The weight of the boat is another important factor affecting boat speed. Increased boat weight has a major effect on boat speed, especially on planing and semi-planing hulls. A new boat tested with half filled fuel and water tanks and without a payload easily drops 2-3 knots in speed when tested fully loaded with fuel, water and equipment for traveling comfort. This situation arises because the propeller is often selected to give maximum speed when the boat is tested at the factory. It is therefore advisable to reduce propeller pitch by one or more inches to accommodate user loading and hot climate. The top speed will be somewhat reduced but overall performance will improve and provide better acceleration, even with a heavily loaded boat.

With this in mind, it is important to remember that fiberglass boats absorb water when they rest in water, making the boat heavier over time. Marine growth, an often overlooked problem, also has a serious effect on boat performance.

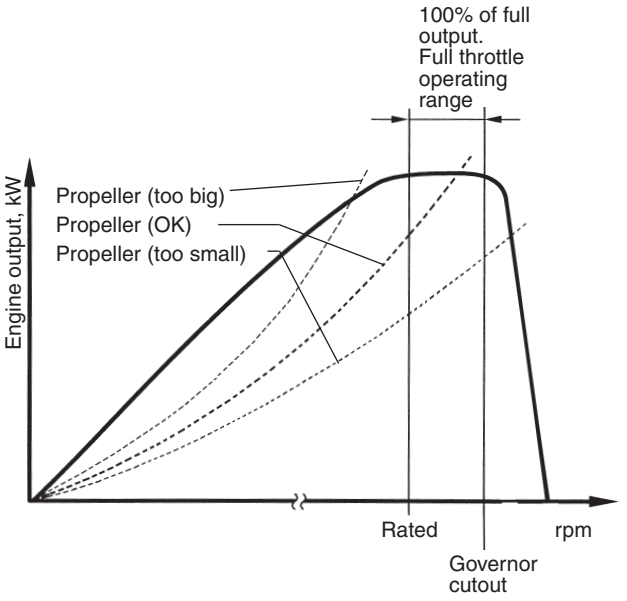
Propeller selection

Naval architects, marine engineers or other qualified people should choose the propeller. The required engine performance data to make the proper propeller selection is available in technical literature.

With regard to propeller selection, it is important to achieve correct engine rpm. For this purpose, we recommend the Full Throttle Operating Range.

In order to achieve good all-round performance, the propeller should be selected within this range.

When the prototype and first production boat is built, a Volvo Penta representative and a boat manufacturer should undertake a fully loaded trial of the vessel in conditions that are as near as possible to those which the boat will meet in customer service.



The most important conditions are:

- Full fuel and water on board.
- Ballast evenly distributed throughout the boat to represent the owner's equipment including such things as outboards, inflatable dinghies etc.
- Generator set/air conditioning equipment and all domestic appliances fitted.
- Appropriate number of people onboard.

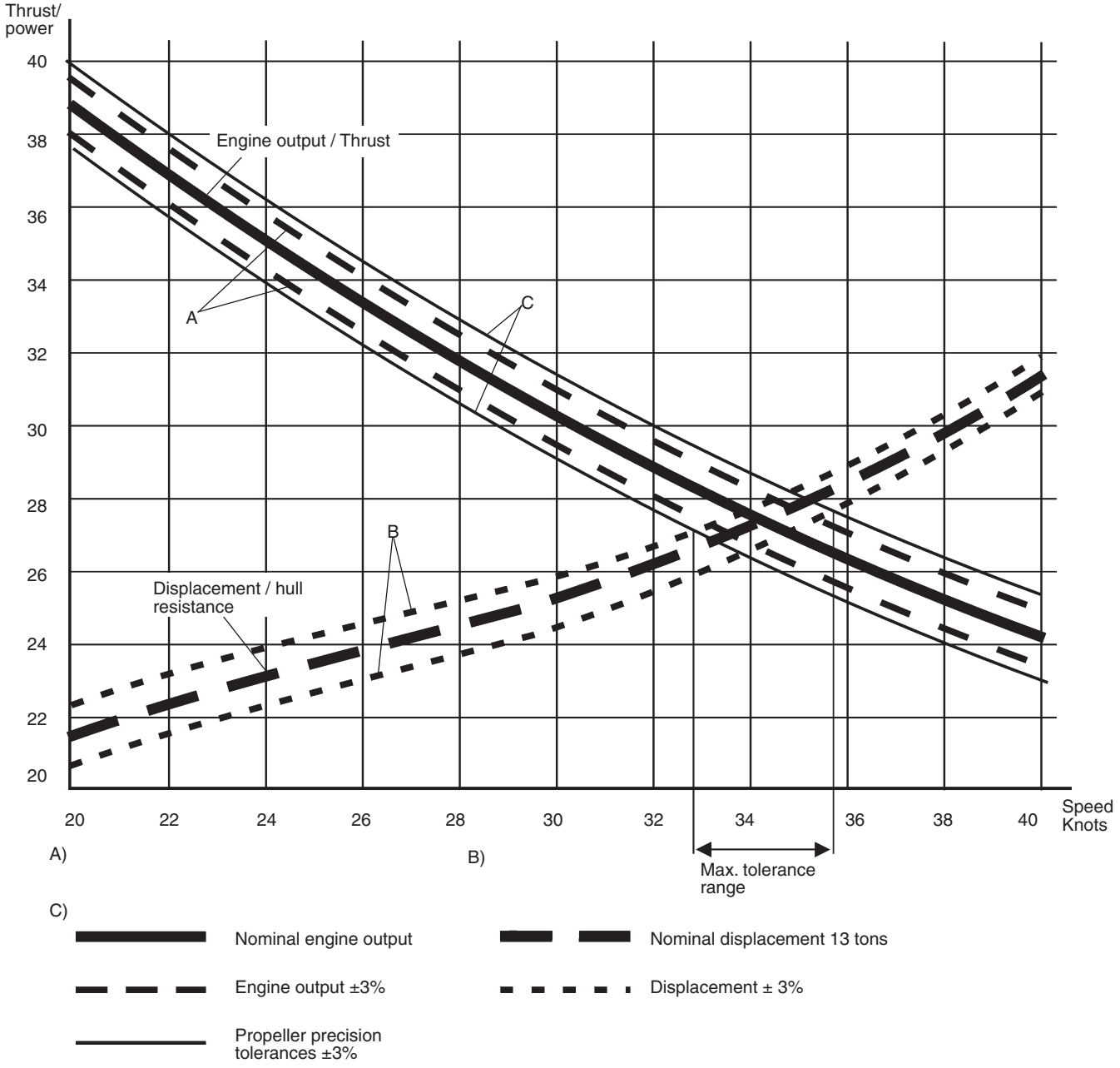
Once the vessel is set up under these conditions, a full engine/propeller trial should be undertaken where all engine parameters are checked, i.e. engine rpm, fuel consumption, rel. load, ref. rpm, boost pressure, exhaust temperatures, engine room temperatures, etc.

When the correct propeller has been established based on the tests, the engine rpm should be within the "Full Throttle Operating Range" at full load.

However, it is advisable to reduce pitch further, to allow for varying weather conditions and marine fouling. For this reason, boat manufacturers must monitor the relevant situation in each of their markets.

Inboard applications only

Typical sample of a planing hull and how displacement and engine output tolerances affect performance.



Production tolerances

Correct propeller size is essential in order to ensure optimum performance of the vessel and long engine life. Selecting the correct propeller will enable the engine to develop its full power and provide the performance that is expected.

There are a number of factors with tolerances that can greatly affect the performance of the vessel. These must be recognized for correct engine/propeller selection.

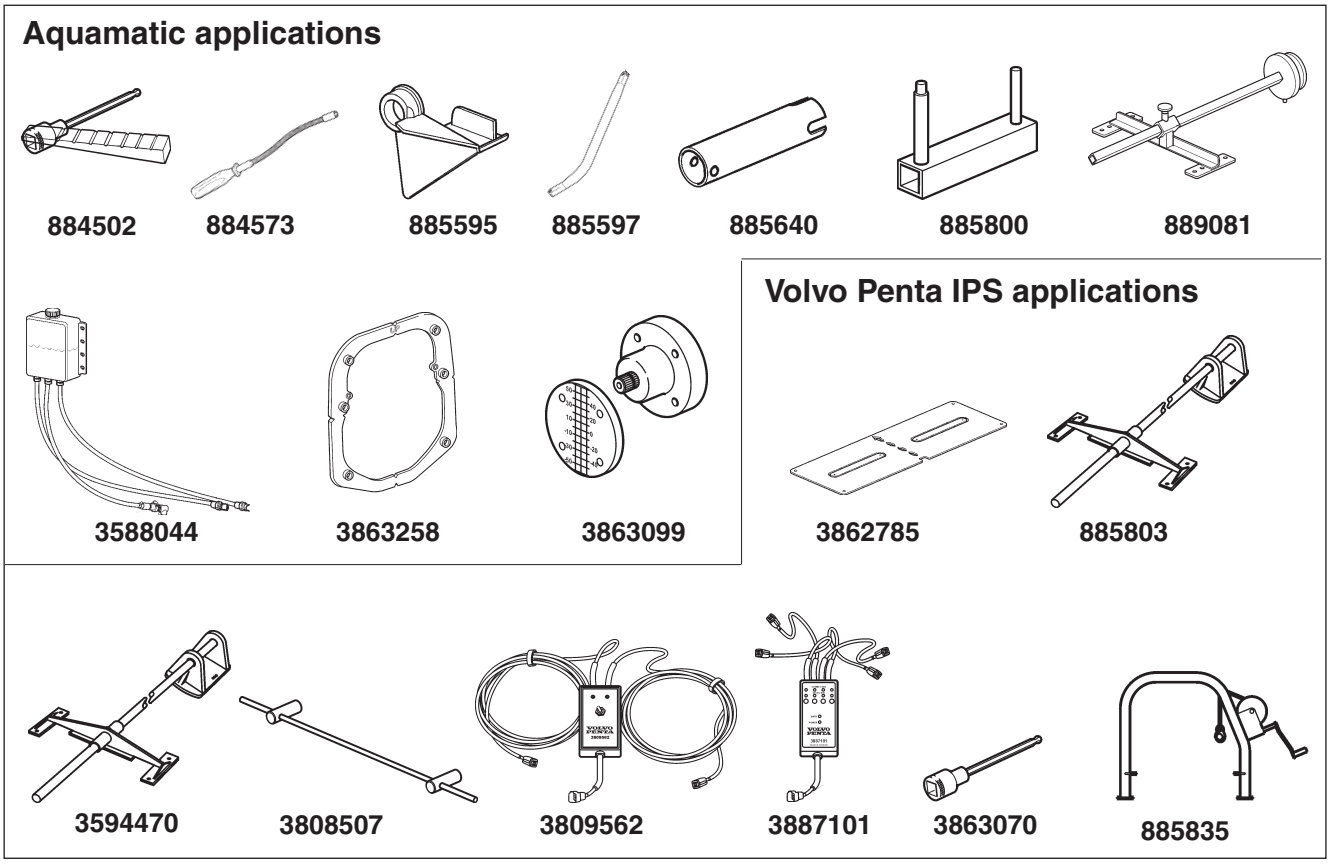
These factors are:

A) Engine power can vary within international power standard tolerances.

B) The calculated hull resistance/displacement may vary within certain limits.

C) The power absorbed by the propeller due to propeller manufacturing precision tolerances generally affects engine rpm.

Installation tools and literature



Aquamatic applications

884502 Alignment tool for the engine in relation to transom shield.

884573 Flexible screwdriver for tightening hose clamps.

885595 Sliding shelves (2 pcs). Facilitate the installation of the sterndrive to the transom shield.

885597 Handles (2 pcs, handles and clevis pins). Facilitate the installation of the sterndrive to the transom shield.

885640 Socket wrench. Tightening the front propeller nut.

885800 Yoke. Locking and securing the sterndrive in a tilted position.

889081 Alignment tool for positioning engine bed and front engine support.

3863258 Drilling fixture. Drilling holes in transom for shield installation.

3588044 Filling and purging kit. Filling and purging the power steering system.

3863099 Laser alignment tool kit for jackshaft installations.

Volvo Penta IPS applications

3862785 Template, hull insert installation.

885803 Alignment tool for engine bed and engine mounting positions (hull insert).

3594470 Alignment tool for engine bed and engine mounting positions (hull plug).

3808507 Parallel alignment tool for calibration of the Volvo Penta IPS units (propulsion units) position.

3809562 Switch used together with the VODIA tool when calibrating the Volvo Penta IPS units (drive legs) position.

3863070 Wrench for torque tightening propeller locking rings.

3887101 Switch used together with the VODIA tool when calibrating the Volvo Penta IPS units (drive legs) position.

885835 Lifting tool Volvo Penta IPS

Aquamatic, Volvo Penta IPS and Inboard applications

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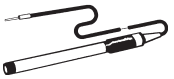

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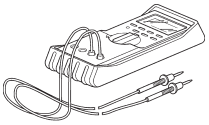

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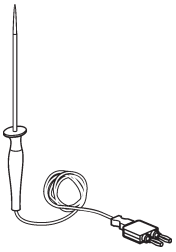

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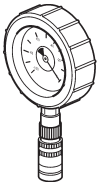

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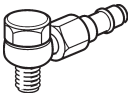

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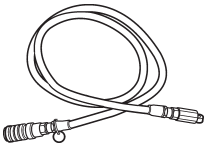

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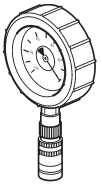

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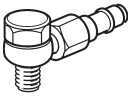

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Aquamatic, Volvo Penta IPS and Inboard applications

3838619 VODIA diagnostic scan tool, complete.

885151 Box with gauges, hoses and connections. For measuring pressures and exhaust temperature.

885156 Calomel electrode. For measuring galvanic and stray currents. Used in combination with multimeter 9812519.

885683 Flange. Measuring exhaust temperature and exhaust back pressure, D4 engines.

885164 Flange. Measuring exhaust temperature and exhaust back pressure, D6 engines.

9812519 Multimeter.

9812530 Temperature gauge. Measuring exhaust temperature. Used together with multimeter 9812519.

9990150 Pressure gauge. For measuring fuel feed pressure.

9996066 Nipple. Checking fuel supply pressure.

9998493 Hose used together with pressure gauge 9990150.

9996065 Pressure gauge. Measuring exhaust back pressure.

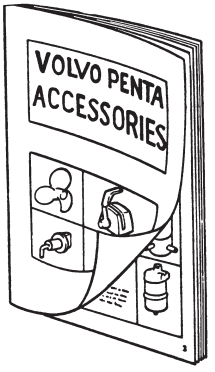
9996066 Nipple. Exhaust back pressure.

Dimension drawings

Drawings for current program, leisure and commercial applications are available at:
http://www.volvopenta.com

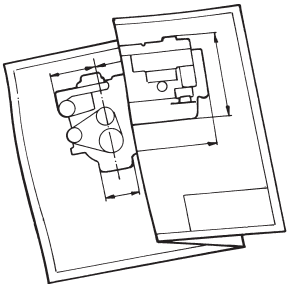
Publications

- ***Installation, Electronic Vessel Control EVC D4, D6***
- ***Installation, Electronic Vessel Control EVC Volvo Penta IPS***
- ***Installation, Water Jet***
- ***Volvo Penta Accessories & Maintenance Parts***
- **Workshop Manuals**
- **Operator's Manuals**
- **Sales Guide**



Posters

- ***Installation, Reference DPH/DPR, Transom Shield***
- ***Installation, Reference DPH/DPR, Drive Unit***
- ***Installation, Procedure Electronic Vessel Control EVC D4, D6***
- ***Installation, Reference Volvo Penta IPS, Hull insert and engine foundation***
- ***Installation, Reference Volvo Penta IPS, Volvo Penta IPS propulsion unit and engine***
- ***Installation, Reference Volvo Penta IPS, Jack shaft***
- ***Installation, Procedure Electronic Vessel Control EVC, Volvo Penta IPS***

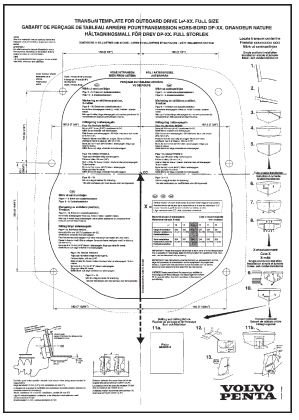


Templates

- ***Transom Template for Outboard Drive DPH/ DPR***

Installation instructions and template are included in the transom shield kit.

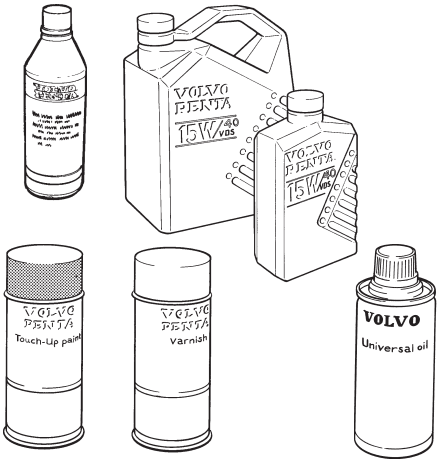
Regarding templates for controls, button panels, instruments etc., please refer to ***Installation Electronic Vessel Control EVC D4, D6***.



Chemicals

A wide range of chemical products are available from Volvo Penta. Some examples are:

- Oil and coolant
- Sealant and grease
- Touch-up paint
- Please refer to "Volvo Penta Accessories & Maintenance Parts"

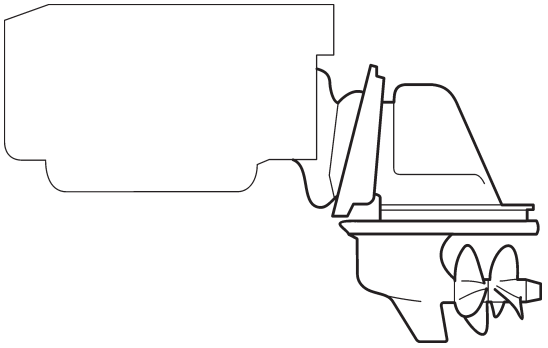


Design concepts of propulsion systems

There are different types of engines, reverse gears and drive systems, depending on the available space and other requirements during the installation.

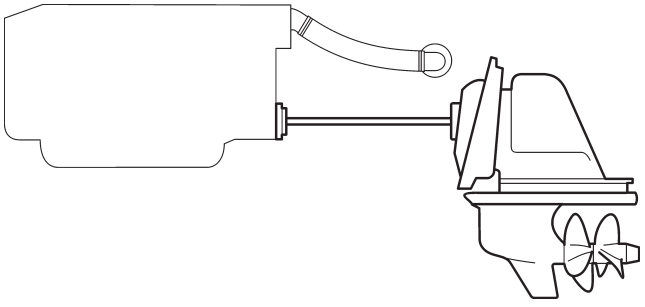
Follow the manufacturer's instructions when installing components and equipment not supplied by Volvo Penta.

Aquamatic Duo Prop (DP)® drive



The engine is close coupled to the drive by the universal joint and a shaft coupling with splines.

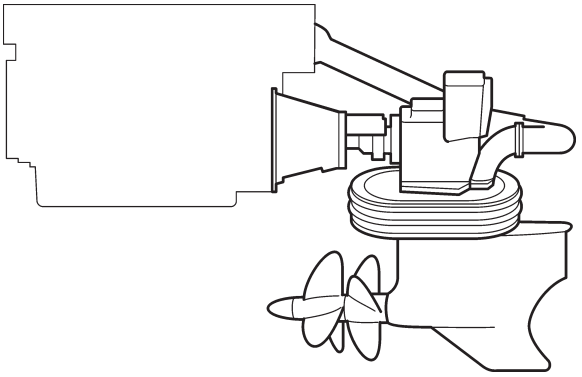
Aquamatic drive with jack shaft



The engine and the drive are separated from each other. The engine is mounted on an engine bed with four rubber mountings and coupled to the drive through a CV or universal drive shaft.

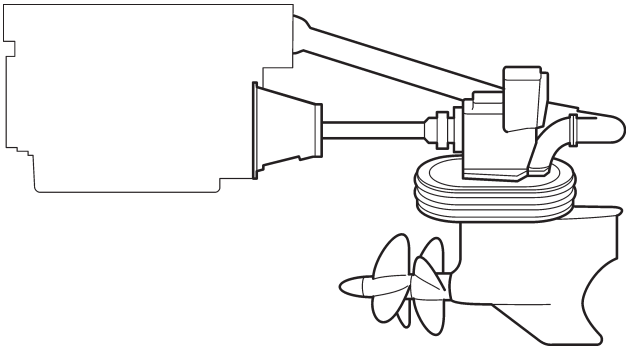
The standard set up is to position the engine in line with the drive connection flange, but installations with offset engine location are not uncommon.

Volvo Penta IPS, Inboard Performance System



Twin, triple or quadruple installations only. The engines and the propulsion units are separated from each other. The propulsion units have Duoprop technology with propellers at the front. The propulsion units are mounted in a special bed molded to the hull and the engines are mounted with rubber mountings on the engine bed and coupled to the propulsion unit by a shaft with a splined coupling and universal joints.

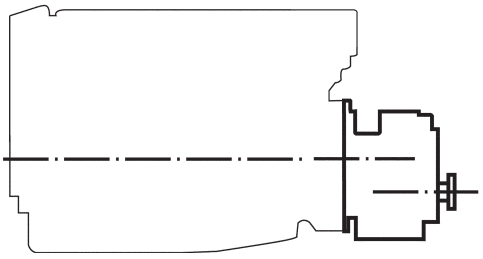
Volvo Penta IPS with jack shaft



The same type of installation as above but the drive shaft can be of various lengths.

Reverse gear, various types

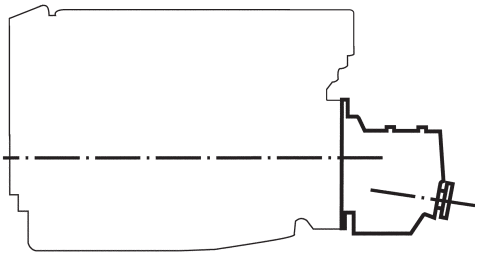
Drop center, parallel



The engine crankshaft and the reverse gear output shaft are parallel. The output shaft is at a lower level than the crankshaft.

The engine and reverse gear form one unit. The propeller thrust is absorbed by a thrust bearing in the reverse gear.

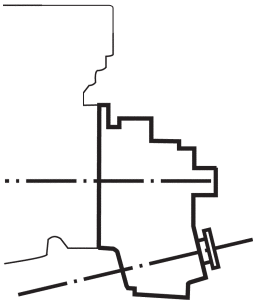
Drop center, down angle



The engine crankshaft and the reverse gear output shaft are at different levels. The angle of the propeller shaft deviates from the angle of the crankshaft.

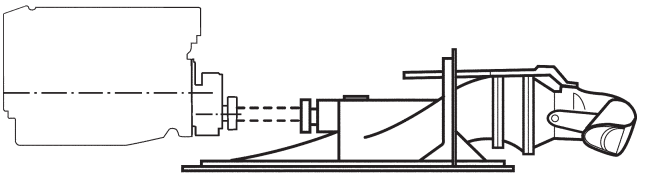
The engine and reverse gear form one unit. The propeller thrust is absorbed by a thrust bearing in the reverse gear.

Close coupled V-drive



The engine and reverse gear form one unit. The propeller thrust is absorbed by a thrust bearing in the reverse gear.

Water Jet

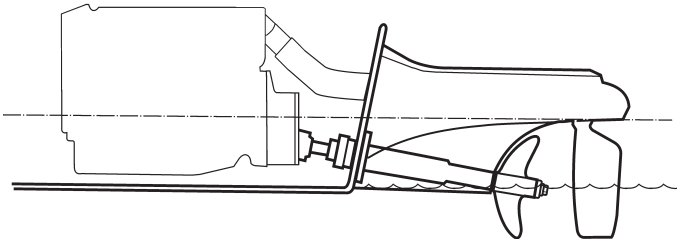


Water Jet drives work on the principle of jet propulsion. A jet of water is generated whose thrust sets the vessel in motion.

There are different types of water jets, there is a direct drive unit and one with a marine gearbox, which enables clutch engagement/disengagement and allows the system to be back flushed for cleaning.

Please refer to the ***Installation, Water Jet*** manual.

Surface drive



A number of surface piercing propeller systems are available in most markets. These systems are aimed at high speed applications where the systems are highly efficient. The systems are available with rudder arrangements or steerable drive units.

At planing speed, the propeller operates with half of its diameter submerged. At lower speed, the propeller is usually submerged and due to its high pitch torque, has greater power absorption compared with a conventional propeller.

Aquamatic applications - Accessibility

Accessibility for maintenance and repairs

When you design the engine installation, always pay attention to the access needed for correct engine service. Also ensure that the complete engine can be removed without damage to the boat structure.

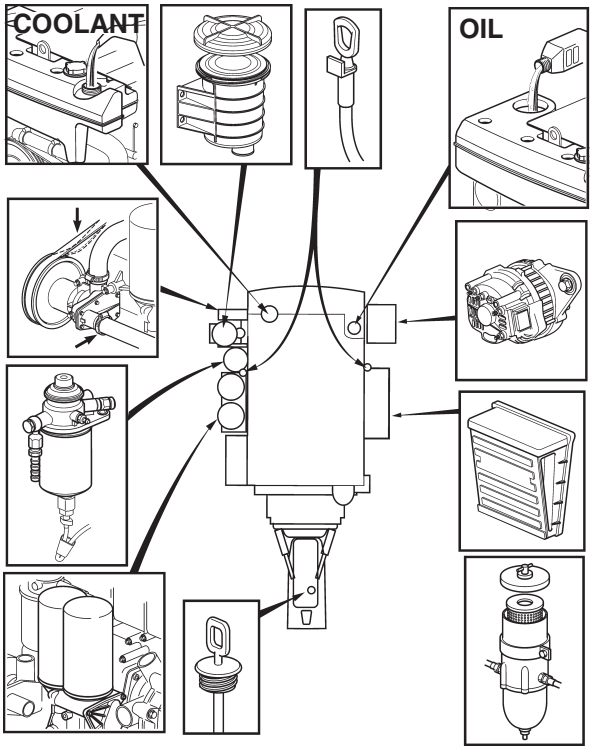
NOTE! There must also be sufficient space for the sound proofing material. The recommended minimum distance from sound proofing materials is 180 mm (7") and 200 mm (8") please refer to fig.

Study the installation drawing of the relevant engine carefully. Min. distance between engines in a twin installation is 950 mm (38").

Accessibility for maintenance

Areas that normally require access for maintenance:

- Oil change and refill (engine, power steering and power trim)
- Changing filters, (oil, fuel, air, & crankcase vent.)
- Change/Adjust drive belts and belt tension
- Removing the valve cover
- Changing the impeller, seawater pump
- Cleaning the water filter



Accessibility for repairs

Areas that may require access for repairs:

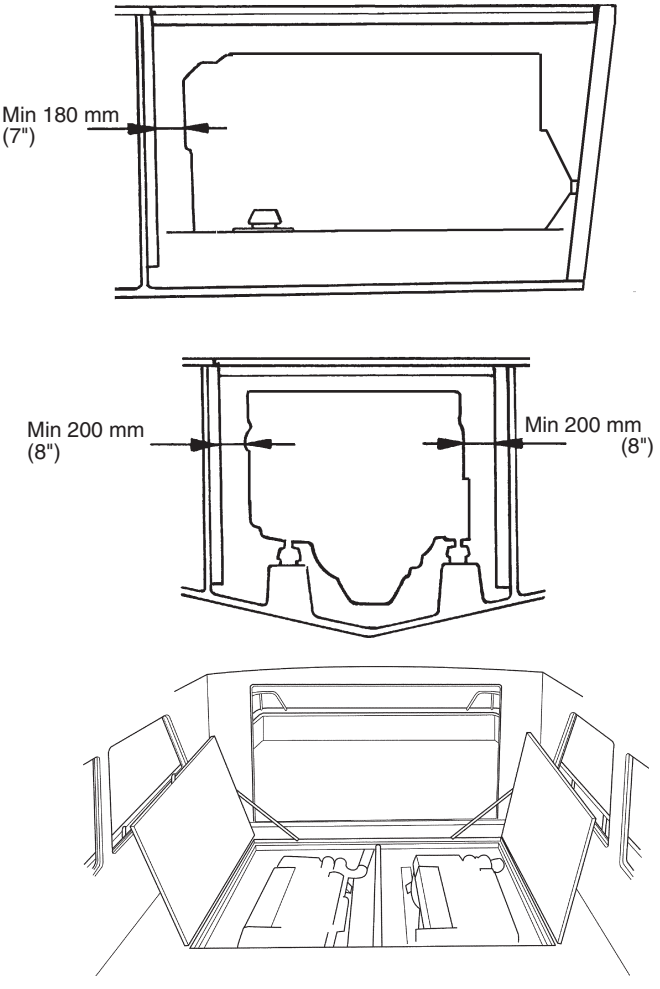
- Removal of injectors, cyl. head, coolers, etc.
- Removal or replacement of electrical components
- Removing the flywheel and vibration damper
- Removing or changing steering equipment

Removal of complete engine package

If the entire engine package needs to be removed, it is the installers (boat builders) responsibility to provide reasonable methods of removal and re-installation. This means, within reasonable time, with normal resources and methods available in the trade, to limit cost and downtime.

For the sake of high demands at high season on yards etc. the vessel manufacturers instruction should be followed.

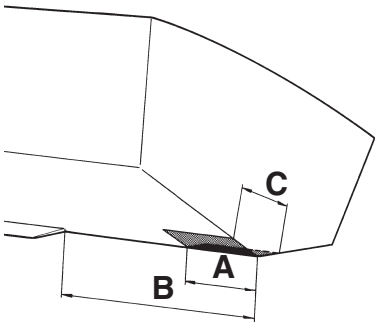
It is the policy of Volvo Penta to avoid unresonable installations driving additional cost for the boat owners during the vessels service life.



Aquamatic applications
Transom

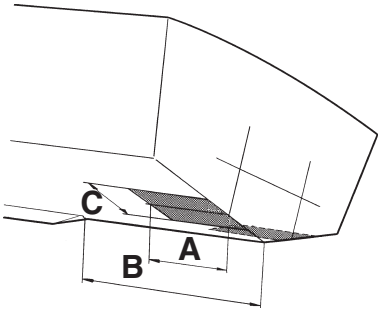
General

Single installation



Area	Minimum in mm (inch)
A	650 (26)
B	1500 (59)
C	800 (32)

Twin installation



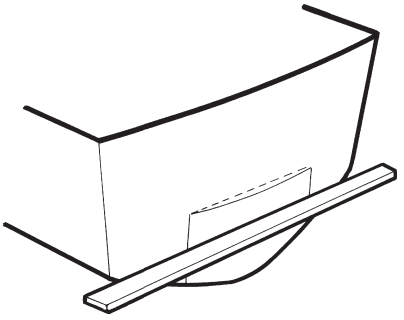
NOTE! Make sure there is nothing in front of the drives, to create turbulence in front of the propellers.

Senders for log, echo sounder etc., must not be located within the shaded area.

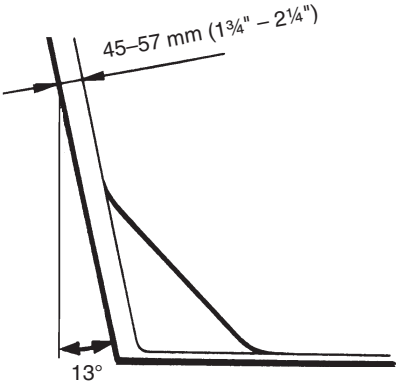
Keels, chines, steps etc. must not be located within distance B from the transom.

Twin installation

Please refer to item 1 for measurements A and B. Measurement C must be 800 mm (31.5") for each sterndrive. The critical areas might overlap each other, depending on the distance between the engines.

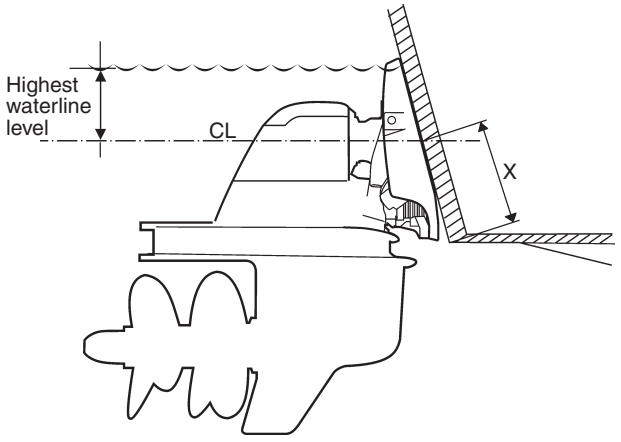


The transom must be flat within the area where the transom shield is to be installed.



The picture above reflects the required transom thickness, 45–57 mm (1¾" – 2¼"), and recommended transom angle, 13°.

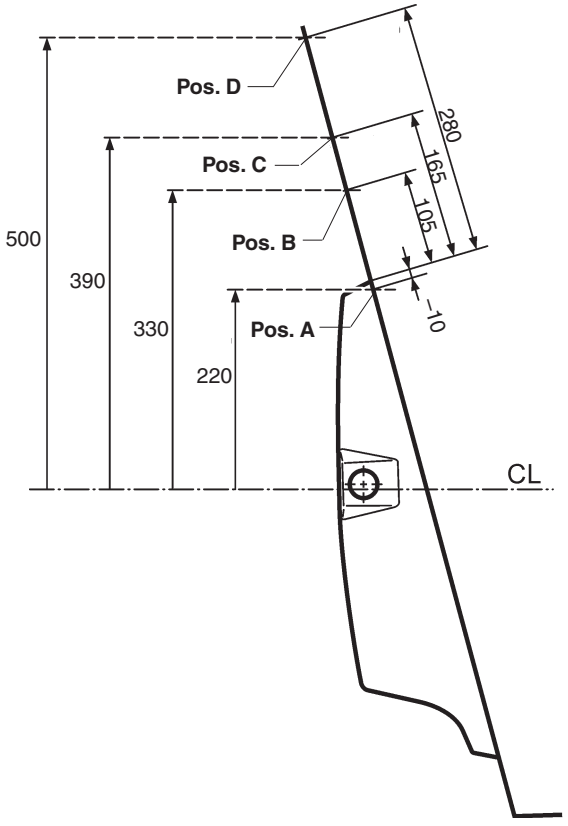
Water level at maximum load



⚠ **IMPORTANT**! The highest waterline level above the crankshaft centerline (CL) must be in accordance with the data below.

All D6 single installations shall have an exhaust riser installed. For all other AQ installations, it is of utmost importance that the maximum water level is checked.

NOTE! In positioning the waterline, the boat must float on its static plane.



Measure from top of the transom shield along the transom as shown in illustration.

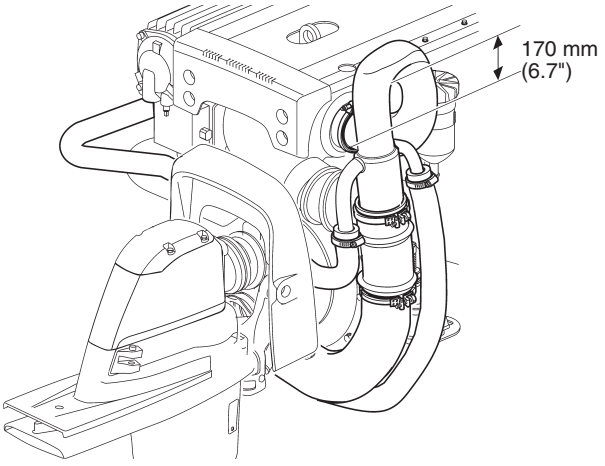
There are different measuring methods, depending on how the boat is loaded:

⚠ **IMPORTANT**! For each load case ensure that maximum water level is not exceeded regardless of weight distribution.

No riser installed

Pos A: Boat loaded with full fuel and full water. No extra load and no crew.
Water level above crankshaft: Max. **220 mm (8.7")**.

Pos B: 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. **330 mm (13.0")**.



Riser installed

If the waterline is higher, a riser must be installed after the turbocharger, replacing the exhaust elbow. This will increase the allowed water level measurement above the crankshaft centerline by max. **170 mm (6.7") (A)**.

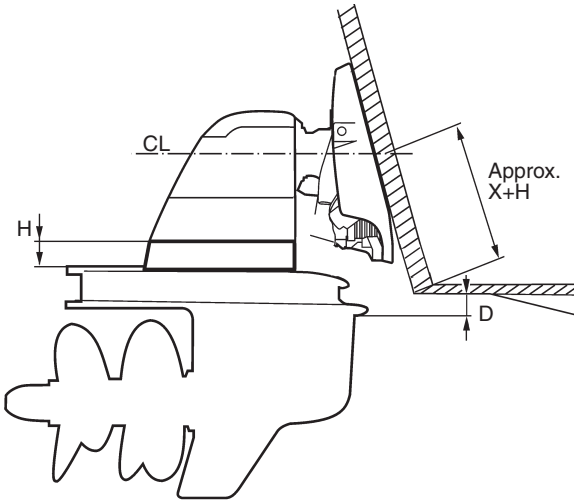
Pos C: Boat loaded with full fuel and full water. No extra load and no crew.

Water level above crankshaft: Max. **390 mm (15.4")**.

Pos D: 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. **500 mm (19.7")**.

Extension



If there is still a problem with the waterline level, an extension must be installed on the drive. This allows the engine and transom shield to be raised while maintaining the position of the cavitation plate, distance (D).

Extension height (H) = 1" (25.4 mm).

Follow the installation 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), 1" (25.4 mm).

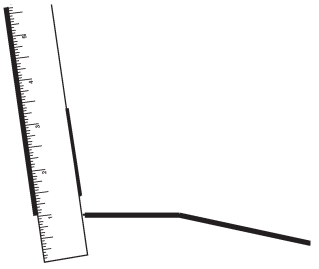
NOTE! Refer to tables Recommended X dimensions, single and twin installations.

Transom cutout

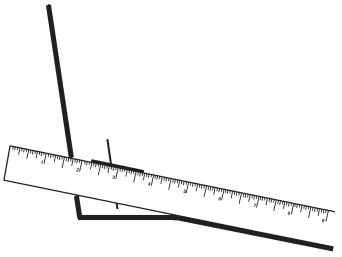
Determine the transom angle

The boat's transom angle can be measured with several different protractors or shop devices. Two commonly used protractors are the machinist's adjustable protractor (A) and the universal plumb and level protractor (B). Both of these protractors can be obtained locally and should be used to determine the transom angle of the boat.

Locate transom centerline

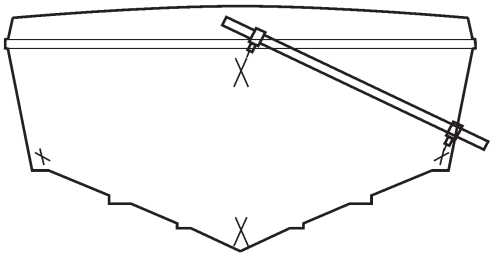


1. Draw a line parallel to the boat side by the port and starboard chines.

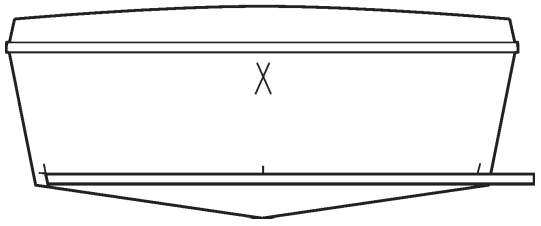


2. Draw an intersecting line parallel to the boat bottom at the port and starboard chines. Lightly mark the points of intersection. These points will be the centers of arcs drawn to find the transom centerline.

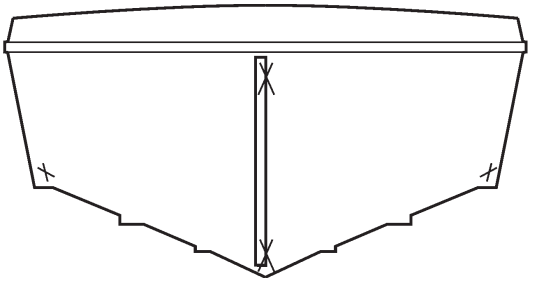
NOTE! The vertical centerline of the transom is most accurately found by using a beam compass. A workable beam compass may be made by clamping a pivot point and a pencil to a bar. A stiff wire with loops at each end for pivot point and pencil will also work, if used carefully.



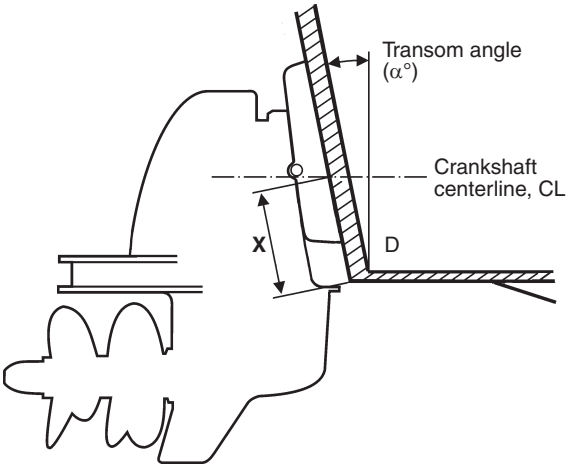
3. Strike an arc at the top of the transom from one chine point and an intersecting arc from the other chine point, without changing beam compass length. The exact same radius must be used to strike both arcs to locate the upper transom center point accurately. Repeat the procedure to locate the lower transom center point, using a different radius if necessary.



4. If the boat bottom is flat or a very shallow "V," a lower center point may be found by measuring across the transom from chine point to chine point and marking the midpoint on the transom.



5. Draw a straight vertical line through the upper and lower center points. This transom centerline will be used for the transom shield centerline on single engine installations and as a reference line on twin engine installations.



6. **The X-measurement** is the location of crankshaft centerline CL from lower edge of boat bottom measured along the transom, and determines at what height the sterndrive will be positioned.

A 13° transom angle (a) is recommended. However, other transom angles given in the tables can be used.

Note! Refer to the Recommended X dimensions, single and twin installation tables.

Each boat model combination with a sterndrive is unique, and water is not flowing identically under the hull on different boat models.

The X-measurement indicated in the following is considered a good choice for most boats, however the best installation height (X-measurement) for a particular boat model can only be determined by testing, and the Volvo Penta recommended X-measurement should be used as a starting point.

Volvo Penta recommends that the following procedure is used to find the best installation height for a particular boat model:

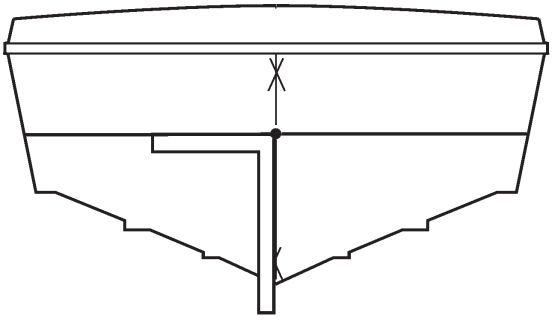
a) On the first hull, add 15 mm (0.59") to the Volvo Penta recommended X-measurement (drive will be “lifted” 15 mm).

b) Run the boat and make a thorough performance test and handling test with different trim angles and load conditions to evaluate the installation height.

c) Mount a 25 mm (1") extension on the sterndrive and redo the tests.

d) By comparing the results and the overall boat behaviour, it should be possible to choose the best X-measurement for the serial production.

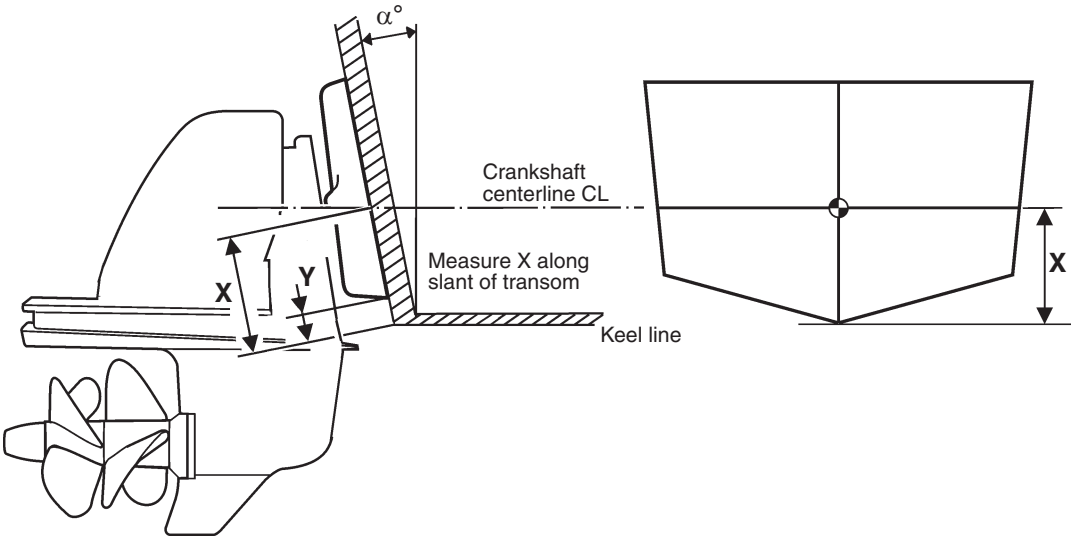
Single engine installation



7. Determine the X measurement from the table below and mark the height from the boat bottom to the crankshaft center (the X measurement).

8. Use a carpenter's square to mark a horizontal line perpendicular to the vertical centerline and marking of the crankshaft center.

9. Determine the X measurement from the table below and mark the heights from the boat bottom to the crankshaft center, the X measurement.



Recommended X-dimensions. Measurements in mm (inches)

Transom angle, α°	**15**	**14**	**13***	**12**	**11**	**10**
Single installation, drive DPH/DPR X	366 (14.41)	363 (14.29)	360 (14.17)	357 (14.06)	354 (13.94)	351 (13.82)

*) A 13° transom angle is recommended.

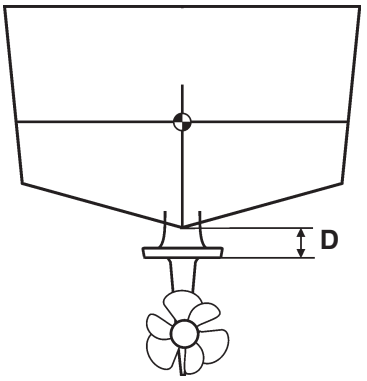
Reference measurement (Y) mm (inches). Lowest edge of shield–boat bottom

Transom angle, α°	**15**	**14**	**13**	**12**	**11**	**10**
Single installation, drive DPH/DPR Y	67 (2.64)	64 (2.52)	61 (2.40)	58 (2.28)	55 (2.17)	52 (2.05)

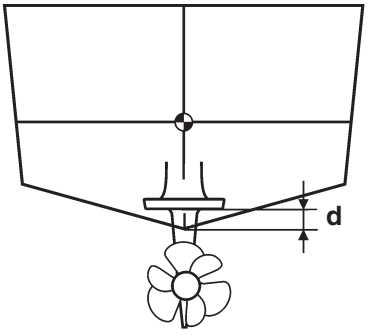
D/d-measurement, cavitation plate–boat bottom

When the recommended X dimension is used, the D/d measurement can be used as a reference measurement.

DPH



DPR



Single installation	**DPH (D)**	**12.0 mm (0.47")** below boat bottom
	DPR (d)	**36.5 mm (1.44")** above boat bottom

DPR only:

Single installations with a stepped hull or with a "ski" (flat bottom) over an 150 mm (6") wide area:

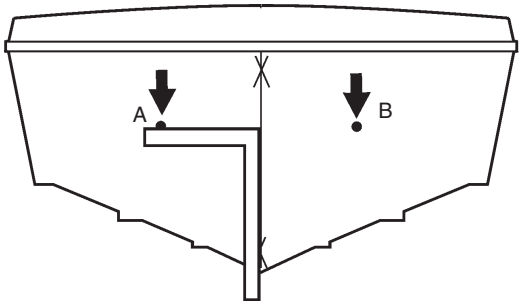
Standard X-dimension minus 20 mm (0.79").

d=16.5 mm (0.65") above boat bottom

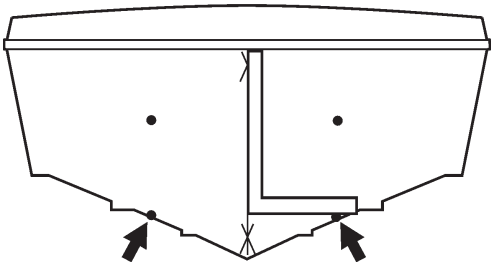
Twin engine installation

Centerline spacing

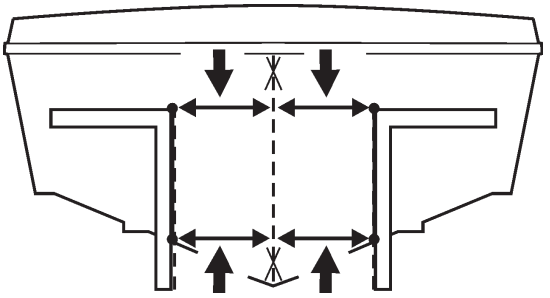
NOTE! The minimum engine centerline distance for twin engine installation determines the transom shield centerline and engine spacing. The centerline distances for D4 and D6 engines are min. 950 mm (38").



10. Use a carpenter's square to mark the transom. Place a mark at (A), the selected engine centerline distance to port of the transom centerline. Place a second mark (B) at the selected engine centerline distance to starboard of the transom centerline.



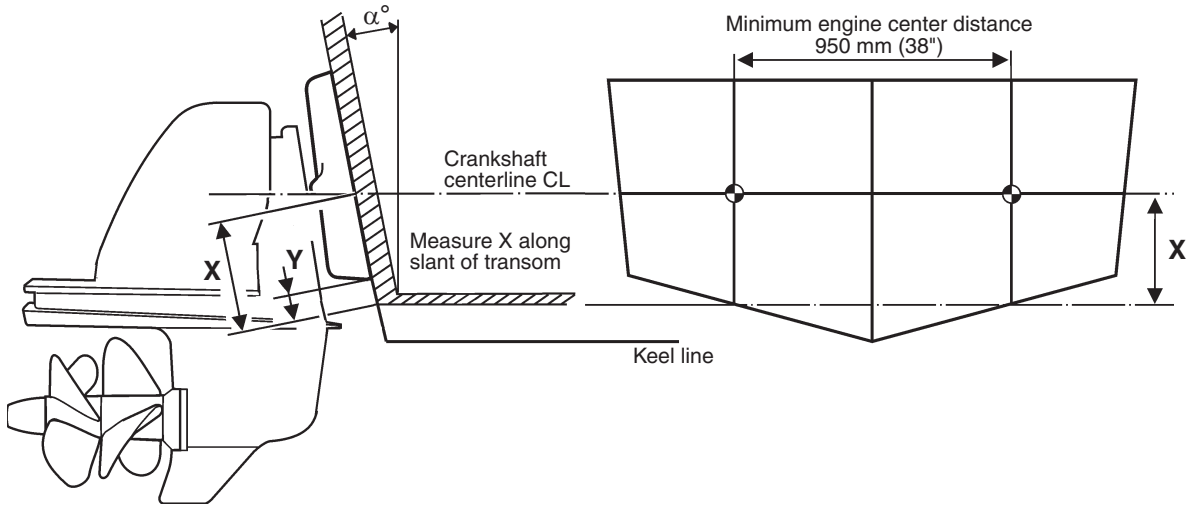
11. Make similar measurements from the transom centerline near the bottom of the boat to locate the bottom points.



12. Use a carpenter's square or straight edge to connect both port and starboard transom shield centerline marks. Check the distance at both top and bottom to ensure the transom shield centerlines are equidistant from the transom centerline used as a reference.

X-measurement

13. Determine the X measurement from the table on the following page and mark the heights from the boat bottom to the crankshafts center, the X measurement.



Recommended X-dimensions. Measurements in mm (inches)

Transom angle, α°	**15**	**14**	**13***	**12**	**11**	**10**
Twin installation, drive DPH/DPR X	354 (13.94)	351 (13.82)	348 (13.70)	345 (13.58)	342 (13.46)	339 (13.35)

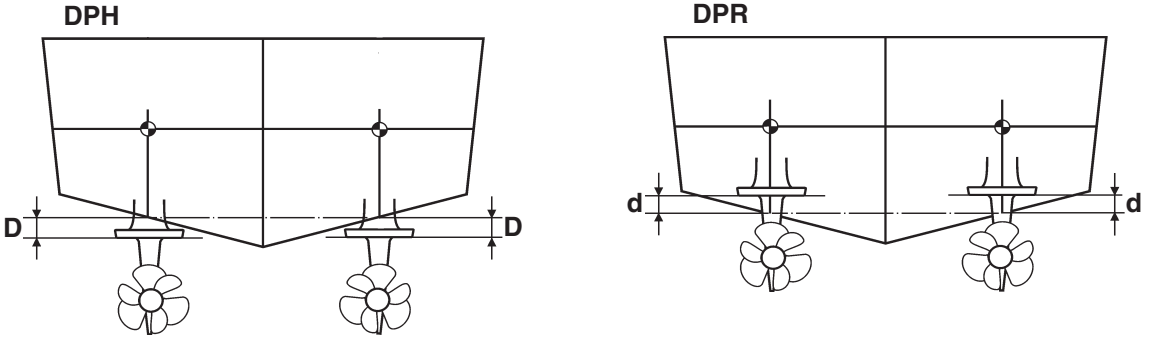
*) A 13° angle of the transom is recommended.

Reference measurement (Y) mm (inches). Lowest edge of shield–boat bottom

Transom angle, α°	**15**	**14**	**13**	**12**	**11**	**10**
Twin installation, drive DPH/DPR Y	55 (2.17)	52 (2.05)	49 (1.93)	46 (1.81)	43 (1.70)	40 (1.57)

D/d-measurement, cavitation plate–boat bottom

When using the recommended X-dimension the D/d-measurement can be used as a reference measurement.



Twin installation	**DPH (D)**	**24.0 mm (0.94")** below boat bottom
	DPR (d)	**24.5 mm (0.96")** above boat bottom

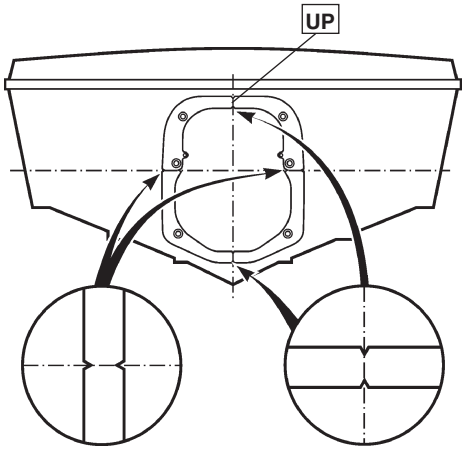
DPR only:

Twin installations with a stepped hull:

Start by reducing X-measurement with 10 mm (3/8"). Check and test position of drive.

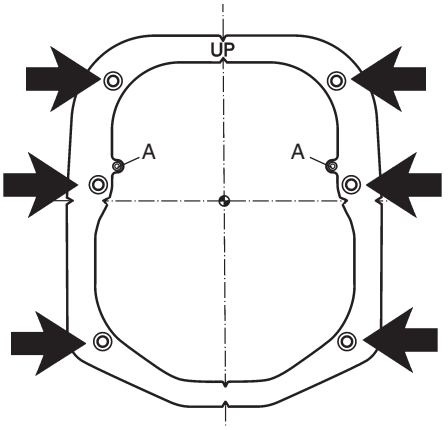
d=14.5 mm (0.57") above boat bottom

Using the drill fixture, special tool 3863258



1. Align fixture **3863258** against the transom. The "V" notches must coincide with the centerline and the horizontal line at four points.

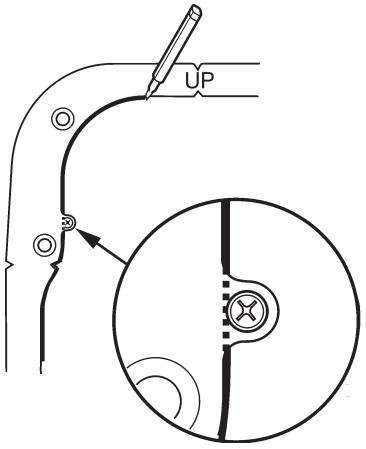
NOTE! The "**UP**" marking on the drill fixture.



2. Temporarily attach the drill fixture with two self tapping screws Ø 6 mm (1/4") (A).

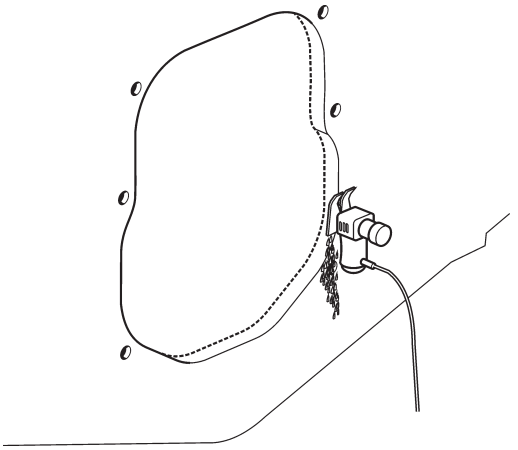
Drill all six holes Ø 14 mm (9/16").

NOTE! Drill perpendicularly to the transom.

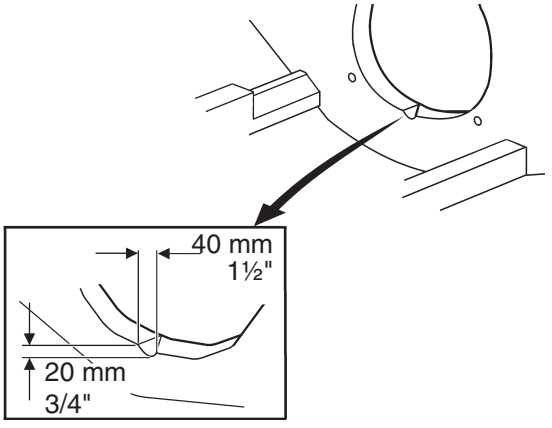


3. Mark off the transom shield hole on the transom with a pencil.

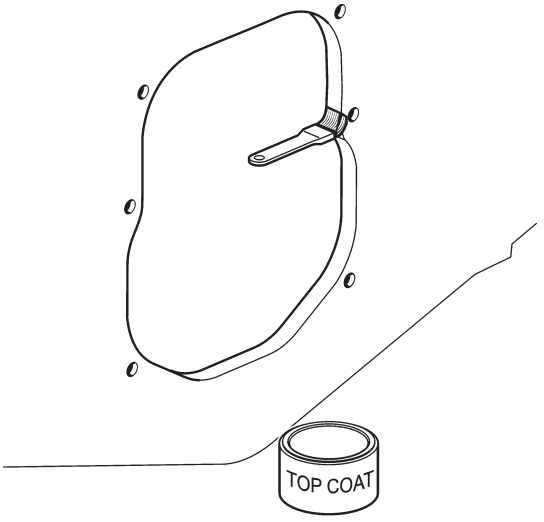
NOTE! No marking around the attaching screws.



4. Cut out the hole using a jig saw. Make sure you hold the saw at an angle of 90° against the transom.

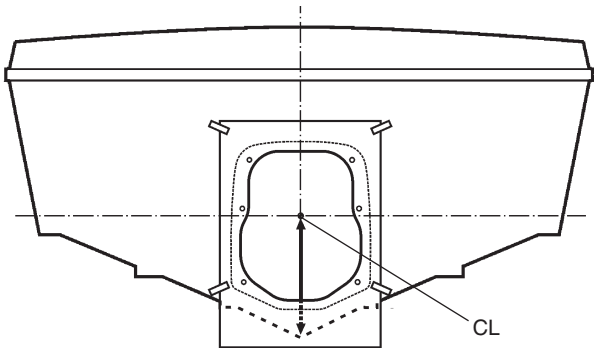


5. Chamfer the **inside** of the transom as in the figure, for water to drain out.

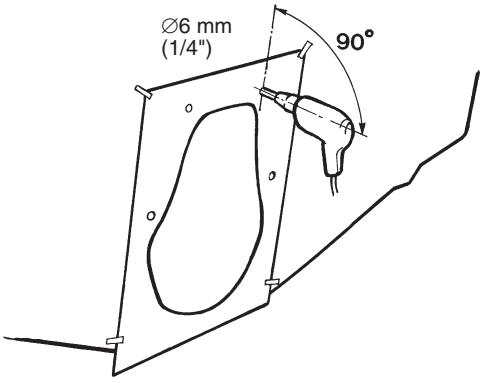


6. Paint or coat all cutout surfaces with topcoat or sealer.

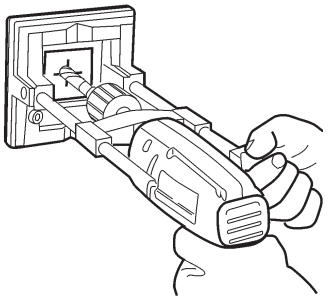
Using the paper template



1. Attach the template to the transom so that the vertical and horizontal lines through crankshaft center (CL) on the template and the transom coincide.

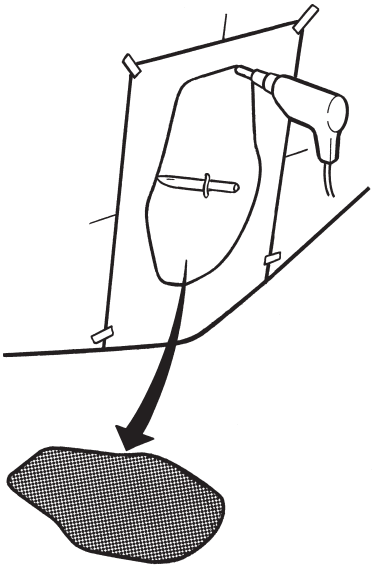


2. Use a 6 mm (1/4") drill and mark up the six holes by drilling to a depth of approx. 5 mm (0.2").



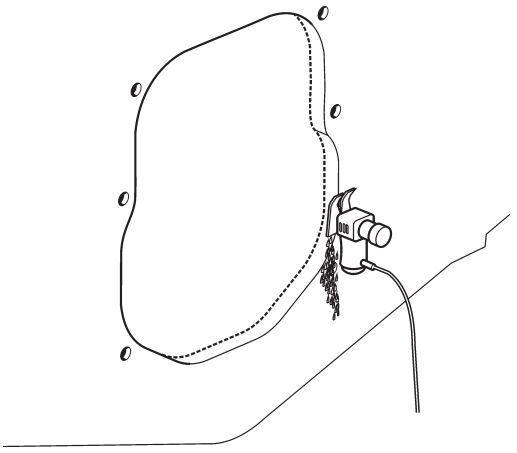
3. Drill the six holes 14 mm (9/16") for the transom shield bolts.

NOTE! Make sure you drill at absolutely right angles to the transom. Also make sure you locate the holes in their exact positions. Failure to do so will make it extremely difficult to fit the transom shield. Use of a portalign drill giude to ensure that the holes are drilled at right angels to the transom through the transom.

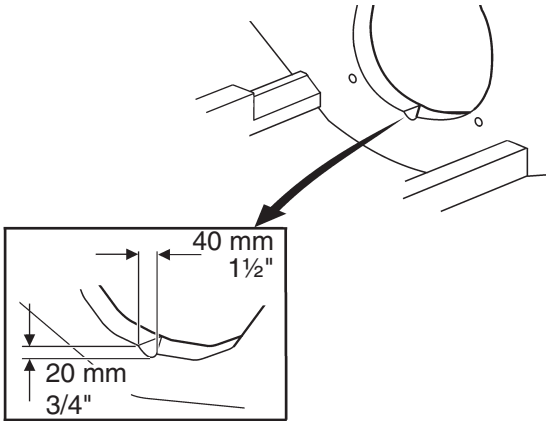


4. Cut out the transom shield hole in the paper template. Use a pencil and mark off the transom shield hole on the transom. Drill a hole in any of the corners, big enough to allow a jig saw to enter.

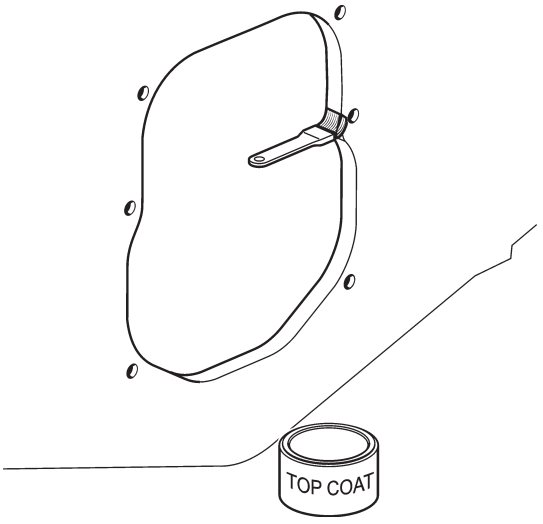
Remove the template.



5. Use a jig saw and cut out the hole. Make sure that you hold the saw at right angles to the transom.



6. Chamfer the inside of the transom as per figure, for water to drain out.

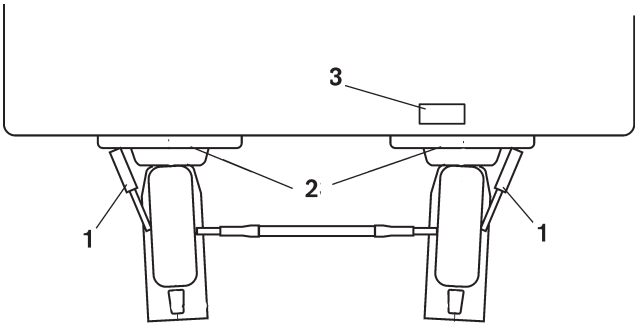


7. Paint or coat all cut surfaces with top coat paint.

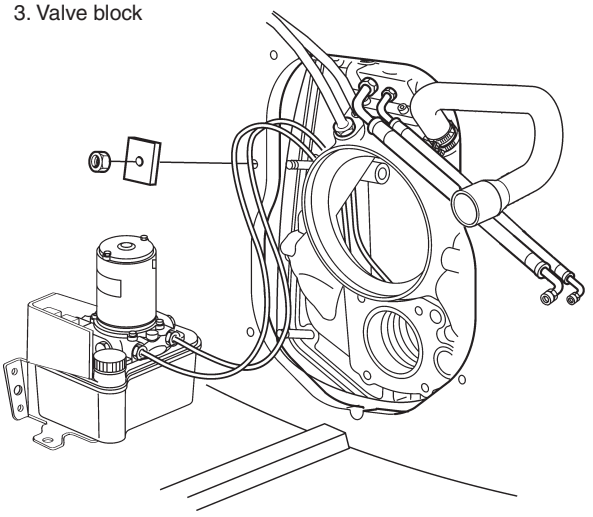
Installing the transom shield

Note! In a DPH twin installation, the starboard TSK have the steering cylinder on the starboard side and the port TSK have the steering cylinder on the port side, see figure below.

In a DPR twin installation, the starboard TSK and port TSK have steering cylinders on both sides.



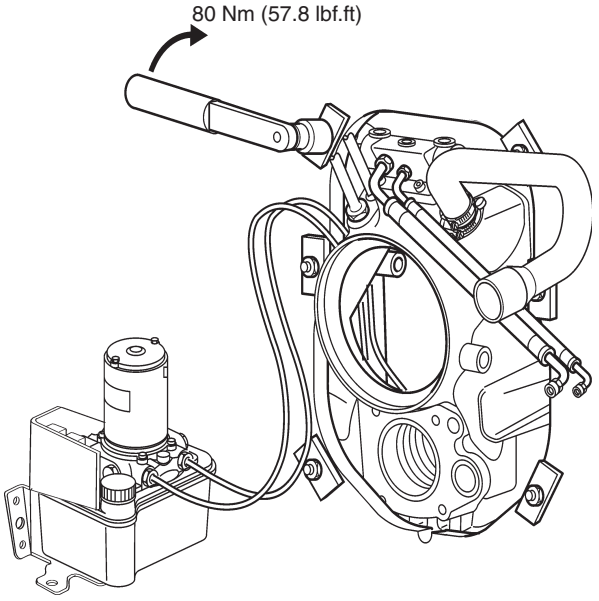
1. Steering cylinders
2. Shields
3. Valve block



1. Pass the trim pump, the hydraulic steering hoses, the shift cable protection hose and the water inlet hose through the transom cutout.

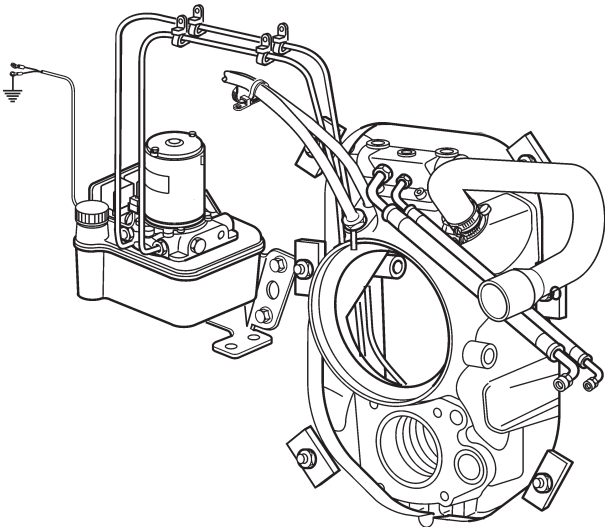
NOTE! The hoses shall always be placed on the starboard side.

2. Align the transom studs with the holes in the transom and press the transom shield flush against the transom.



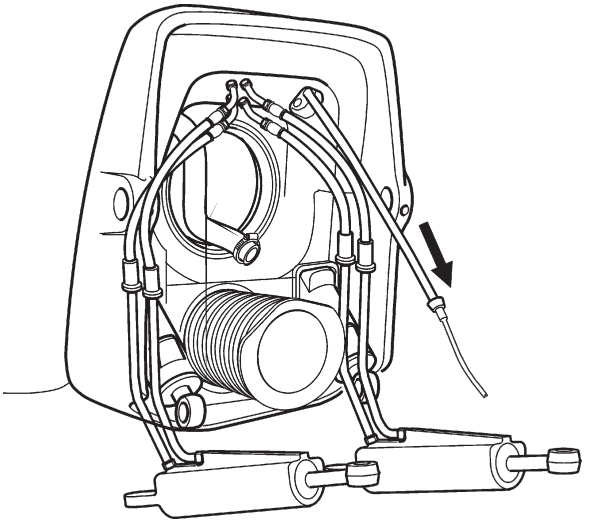
3. With the transom shield in place, install the six rectangular washers on the studs and then the nuts. Tighten the nuts evenly.

Tightening torque: **80 Nm (57.8 lbf.ft)**.

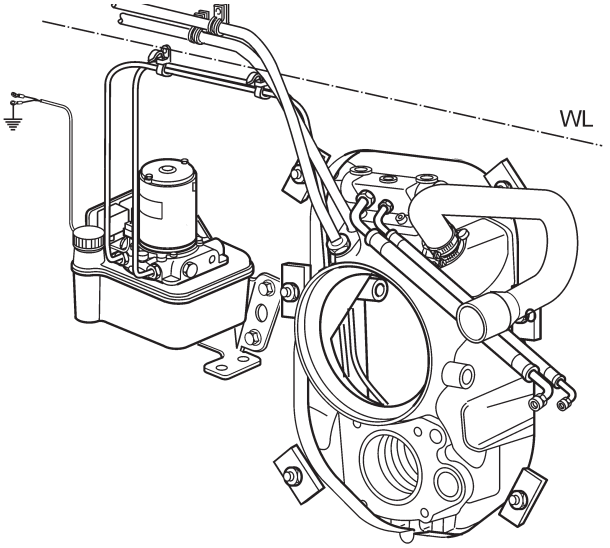


4. Install the trim pump on the transom or on a bulkhead. Make sure it is easily accessible for oil filling and service, and well clear of any possible bilge water.

⚠ **IMPORTANT!** The trim pump must be installed vertically. Please refer to the picture above.



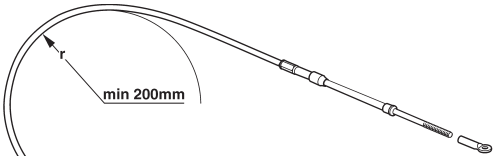
5. Insert the shift cable through the protective hose and out through the transom shield. Apply some oil on the cable for easier installation.



6. Clamp the hoses to the shifting cable and the accessory hose (autopilot/rudder indicator).

Clamp the hydraulic hoses to the trim pump.

⚠ **IMPORTANT!** The ends of the hoses must always be clamped and must be well above the maximum waterline, to prevent water from entering into the boat.



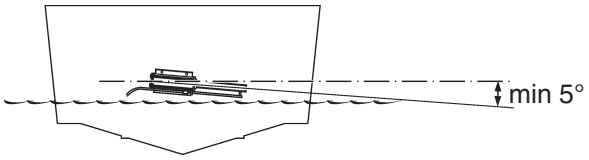
7. Bend up the shift cable and clamp it to the inside of the transom.

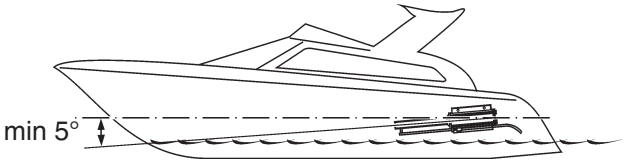
NOTE! Minimum bending radius for the cable: **200 mm (8").**

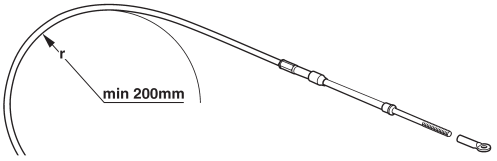
If the radius is smaller, the control will be stiff to operate and there is a risk that it will lock up.

Installing gear shift actuator and gear shift cable

⚠ **IMPORTANT!** The shift actuator must be positioned above the water level and at a minimum angle of 5°, refer to figures.

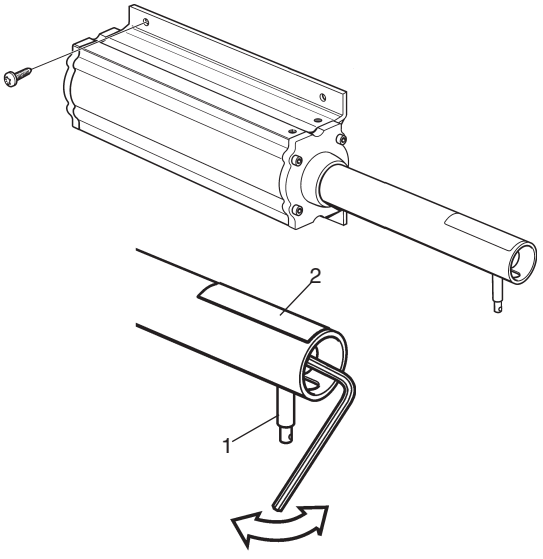






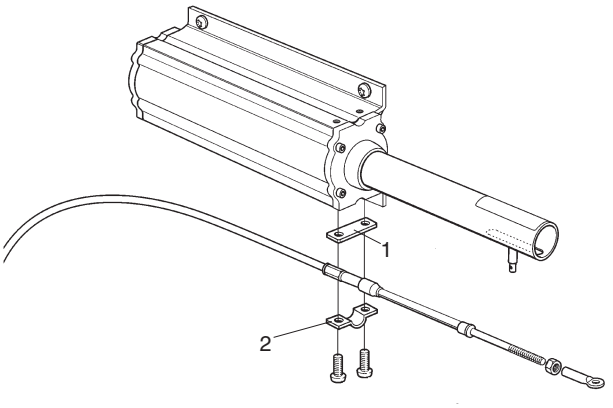
1. Install the actuator in a position such that the gear shift cable (push-pull cable) can be installed and clamped correctly.

NOTE! Minimum bending radius for the cable: **200 mm (8").**



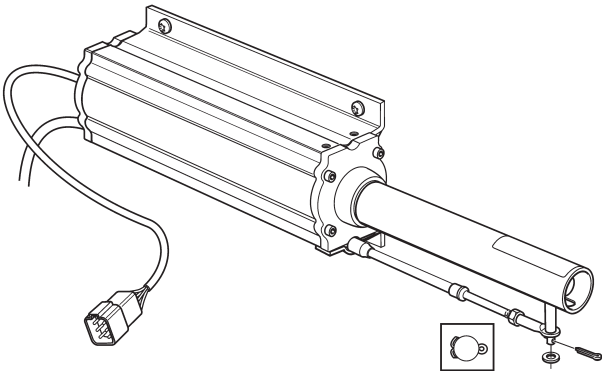
2. Install the actuator using four suitable screws.

NOTE! The shift cable pin (1) must always point downwards. Adjust its position and cover the upper slot with the self adhesive protective sticker (2).



3. Install the washer (1) and the shift cable with clamp (2) and screws along the underside of the gear shift actuator.

NOTE! It is possible to install the control cable on either side of the gear shift actuator. This is to facilitate installation of the gear shift actuator in the boat. Pin must however always be installed downwards.

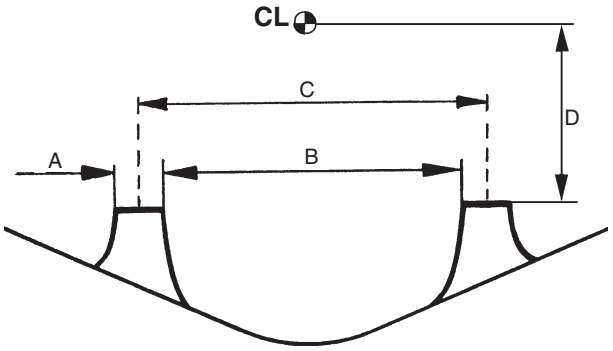


4. Screw the threaded section of shift cable into the adapter. Lock the adapter to the shift cable pin with a cotter pin.

⚠ **IMPORTANT!** Do not forget to power up the EVC system before attaching the shift cable to the drive. This is done to ensure that the actuator is accurately aligned in the neutral N position.

Aquamatic applications
Engine foundation

For information about Jack shaft installation, please refer to the chapter ***Volvo Penta Jack shaft Installation***.

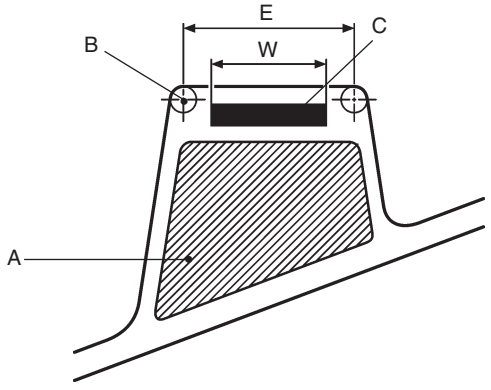


1. The engine bed should be built in accordance with the following measurements.

A	B	C	D
125 mm (5.0")	449 mm (17.7")	572 mm (22.5")	83 mm (3.3")

Measurement (**D**) crankshaft centerline (CC) – engine bed should be 83±8 mm (3.25±0.3").

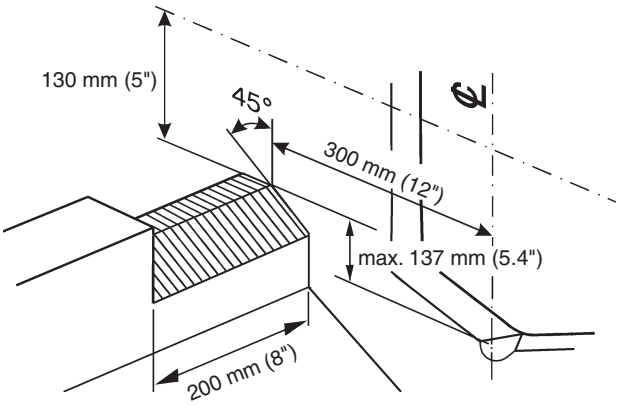
Build in drain channels to allow water to drain to the location of the bilge pump.



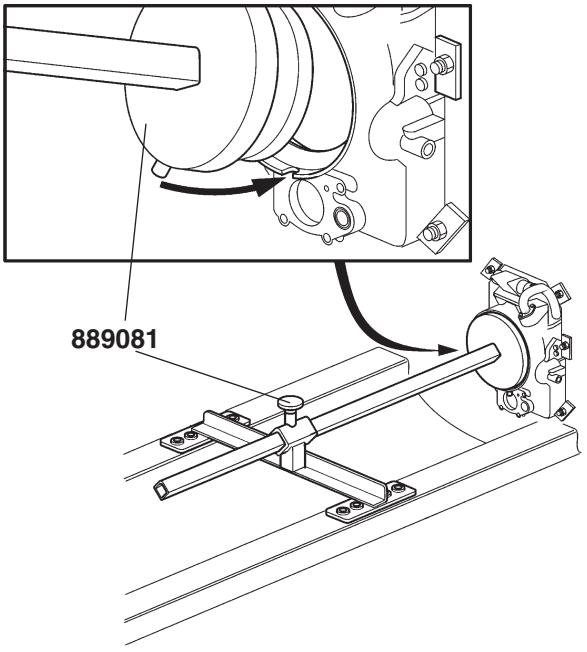
A = Spacer material, preferably high density material
B = Fiberglass, approx. 10–15 mm (0.4–0.6")
C = Flat bar, galvanized, approx. 10 mm (0.4"), min. width: 80 mm (3")
W = Flat bar width
E = Engine bed min. width: 112 mm (4.4")

The engine bed should be filled, to reduce noise and vibration.

Build up the engine bed with spacer material (A) so that the underside of the engine mountings/ engine rubber mountings almost rest against the bed. There must be room for flat bars and fiberglass.

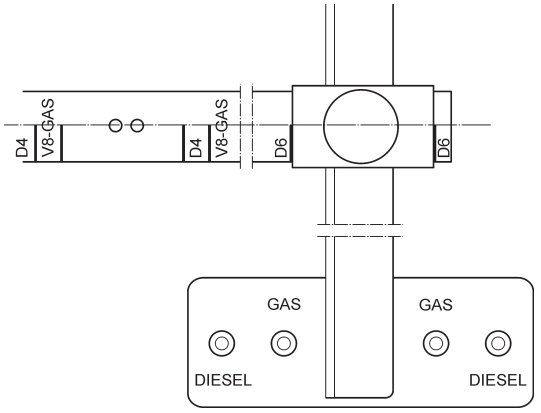


2. Cut a recess in the aft and starboard side of engine bed to make space for the exhaust pipe. Please refer to the figure.



3. Install the engine bed drill jig, special tool 889081.

NOTE! The notch for positioning the tool. Be careful to ensure that the plate of the tool is correctly fitted to the shield.

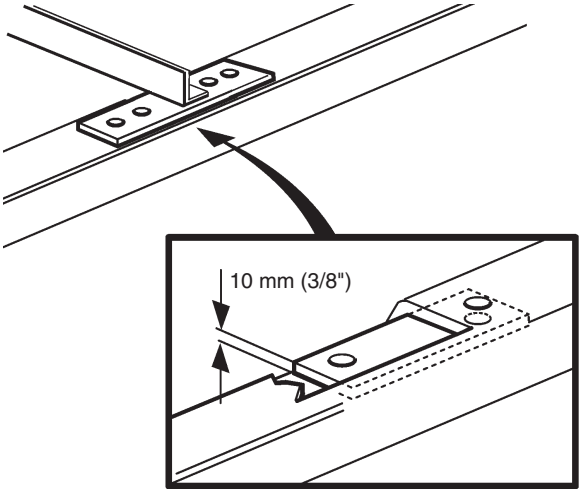


4. The drill jig, special tool **889081**, is suitable for Volvo Penta D4, D6 and V8 engines with DPH and DPR sterndrive packages.

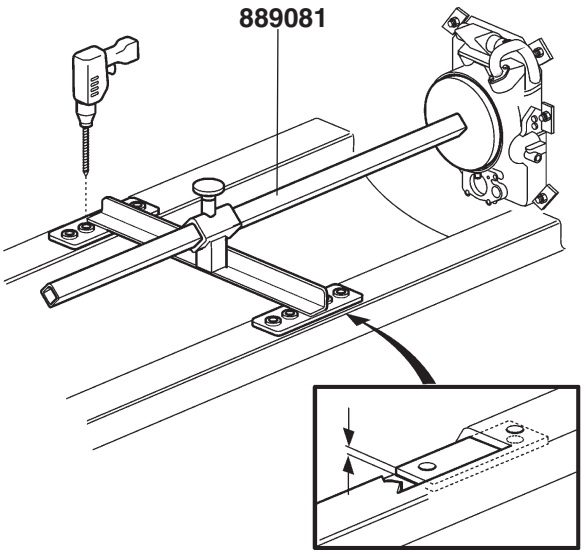
The positions on the rod are marked:
D4 - D6 - V8GAS.

The drill bushings on the plates are marked:
DIESEL - GAS.

The figure shows the drill jig in position D6.



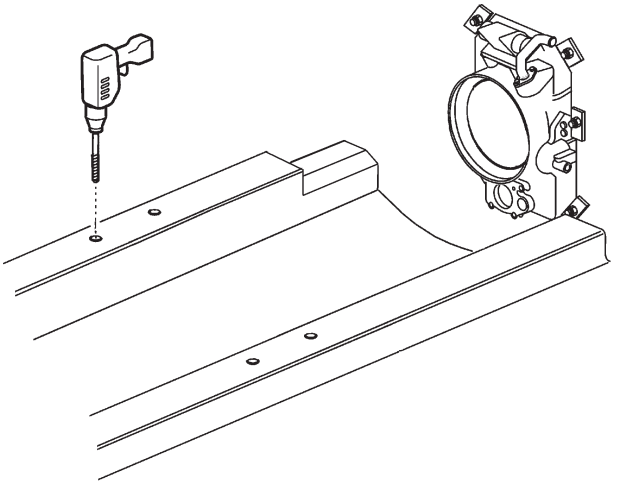
5. Design the engine bed so that the under side of the tool plates rest on top of the bed. Build in a flat bar of galvanized steel, with a thickness of approx. 10 mm (3/8") and a minimum length of 250 mm (10") and a minimum width of 80 mm (3").



6. Fit the flexible drill jig at the correct position for the relevant engine type, **D4** or **D6**.

7. Mark the bed with holes, 6mm (1/4") for the flexible engine mountings. Use drill bushings marked DIESEL.

Then remove the special tool.

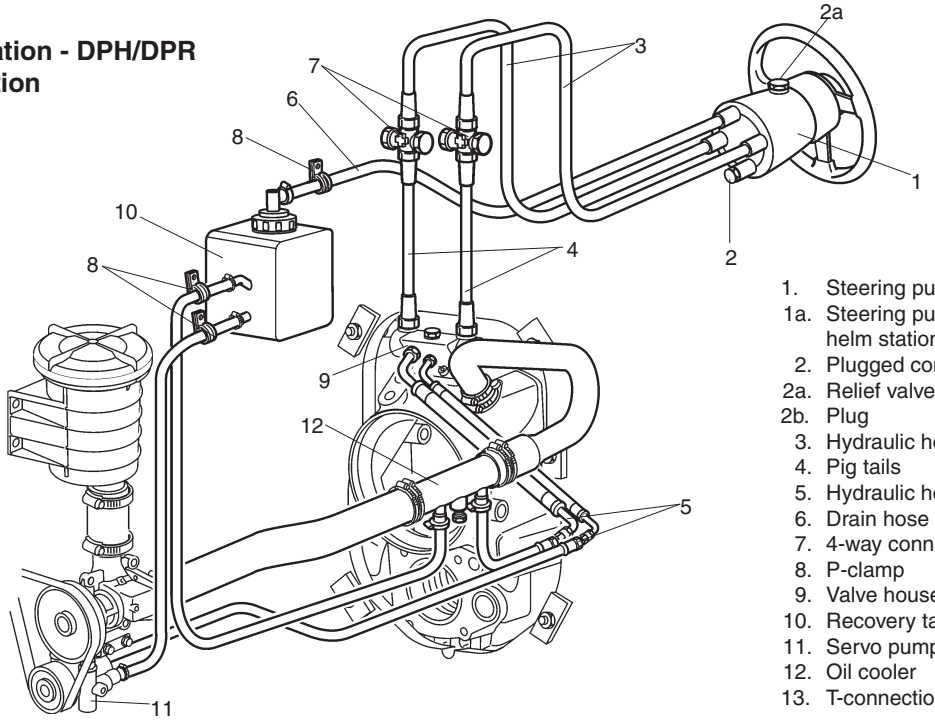


8. Drill and tap the holes with a thread tap. Dimension: M12 mm (1/2"UNC) or equivalent.

Aquamatic applications
Steering system

NOTE! Note that no hydraulic tie bar connections are described in the illustrations. For information about the hydraulic tie bar system, please refer to the chapter ***Tie bar installation***.

Single installation - DPH/DPR
One helm station

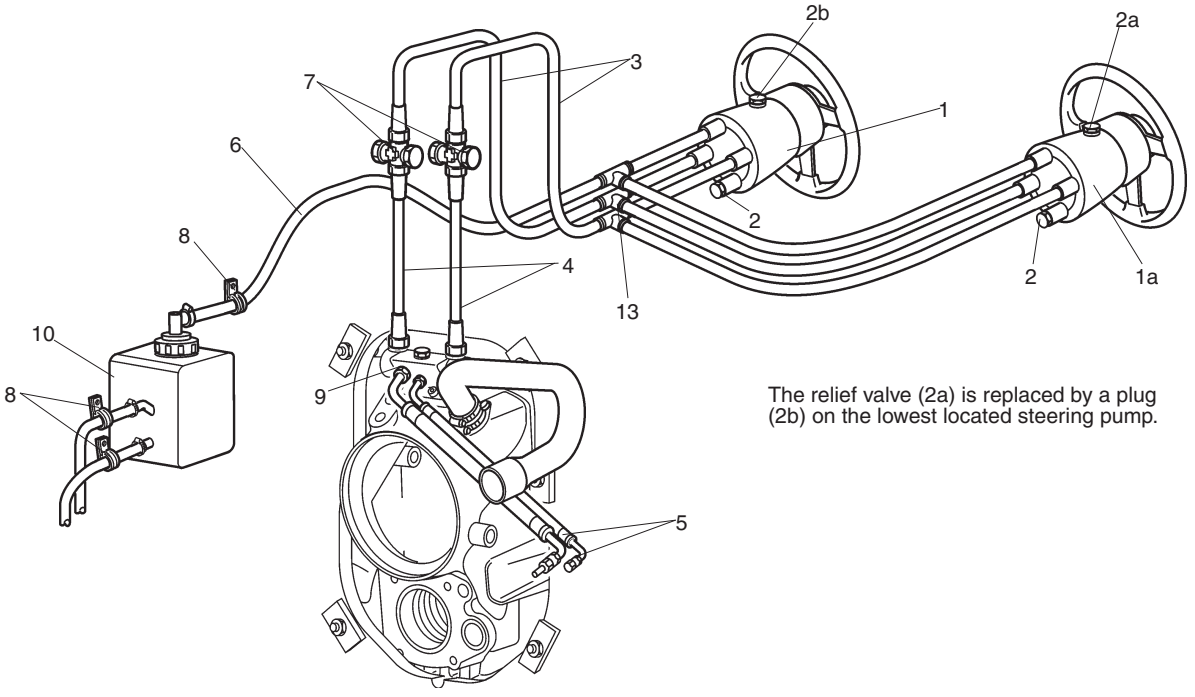


1. Steering pump
1a. Steering pump, secondary helm station
2. Plugged connection
2a. Relief valve
2b. Plug
3. Hydraulic hoses, low pressure
4. Pig tails
5. Hydraulic hoses, high pressure
6. Drain hose
7. 4-way connections
8. P-clamp
9. Valve house
10. Recovery tank (reservoir)
11. Servo pump
12. Oil cooler
13. T-connections

⚠ **IMPORTANT!** Plug no. 2 must never be used, this to ensure correct oil level in steering pump

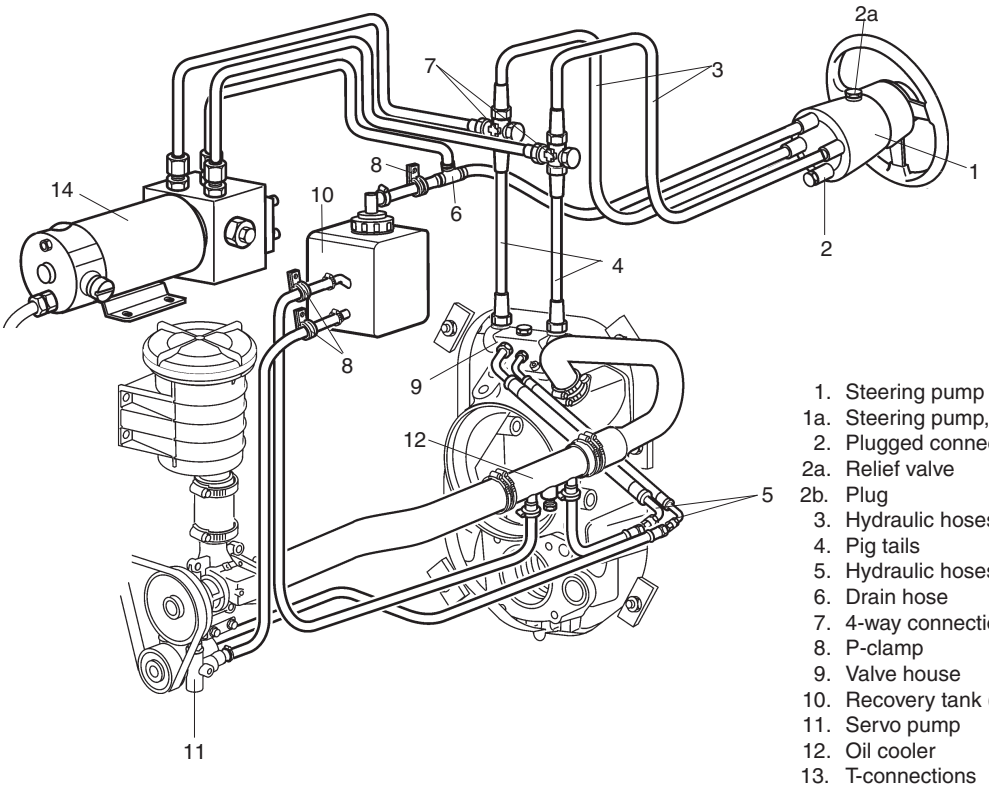
Single installation - DPH/DPR
Main and secondary helm station

Connections to oil cooler and servo pump not shown.
Please refer to figure above.



The relief valve (2a) is replaced by a plug (2b) on the lowest located steering pump.

Single installation - DPH/DPR
One helmstation
Autopilot installed

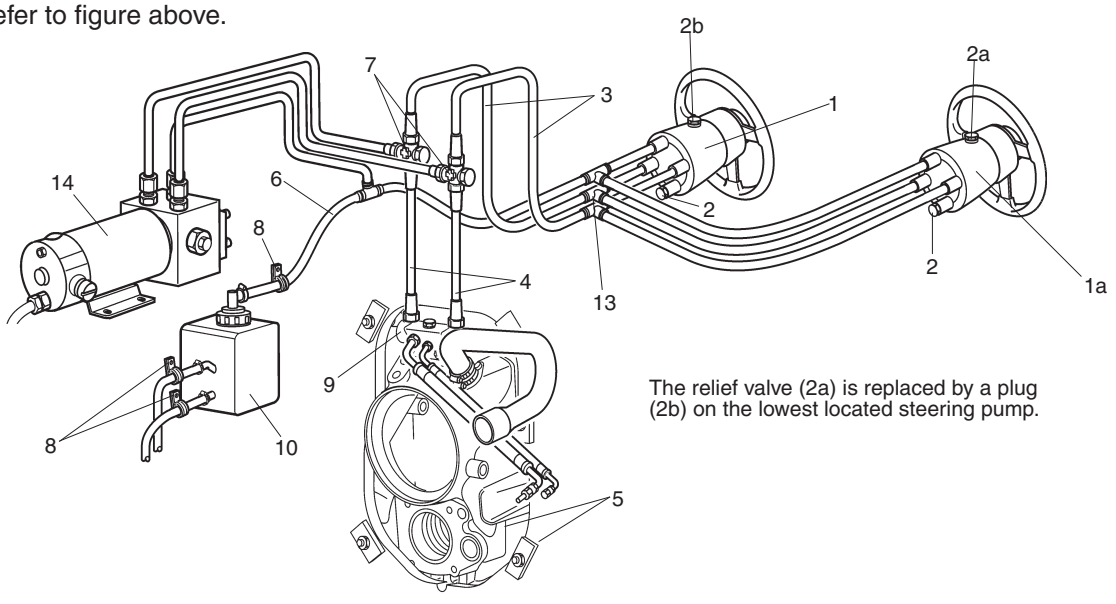


1. Steering pump
1a. Steering pump, secondary helm station
2. Plugged connection
2a. Relief valve
2b. Plug
3. Hydraulic hoses, low pressure
4. Pig tails
5. Hydraulic hoses, high pressure
6. Drain hose
7. 4-way connections
8. P-clamp
9. Valve house
10. Recovery tank (reservoir)
11. Servo pump
12. Oil cooler
13. T-connections
14. Autopilot

⚠ **IMPORTANT!** Plug no. 2 must never be used, this to ensure correct oil level in steering pump

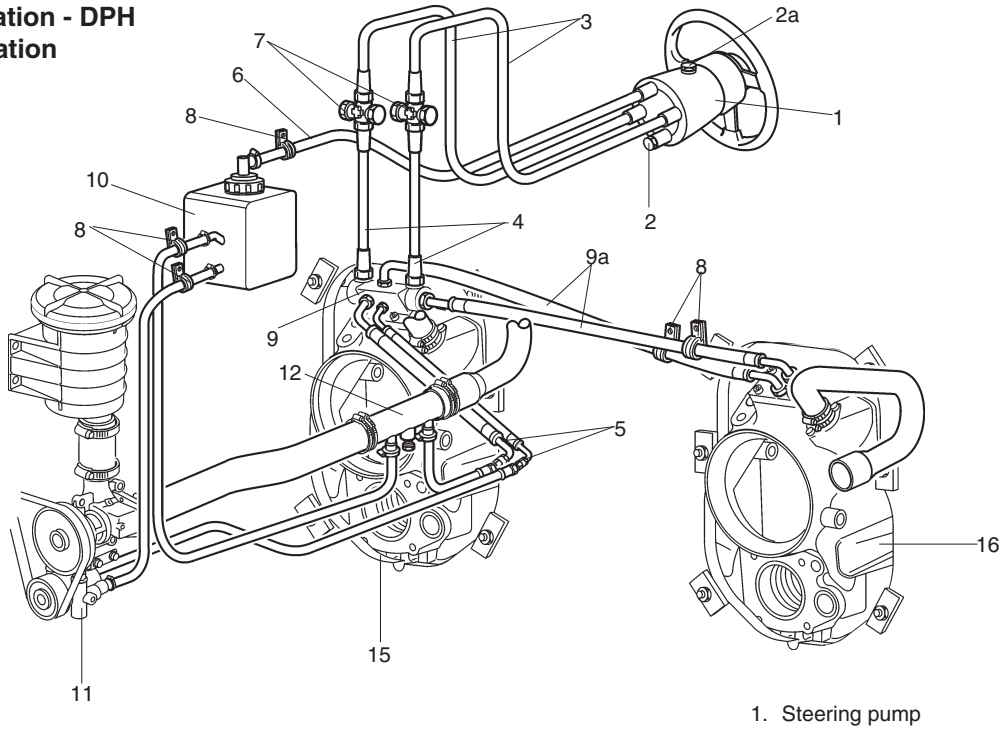
Single installation - DPH/DPR
Main and secondary helmstation
Autopilot installed

Connections to oil cooler and servo pump not shown.
Please refer to figure above.



The relief valve (2a) is replaced by a plug (2b) on the lowest located steering pump.

Twin installation - DPH
One helmstation

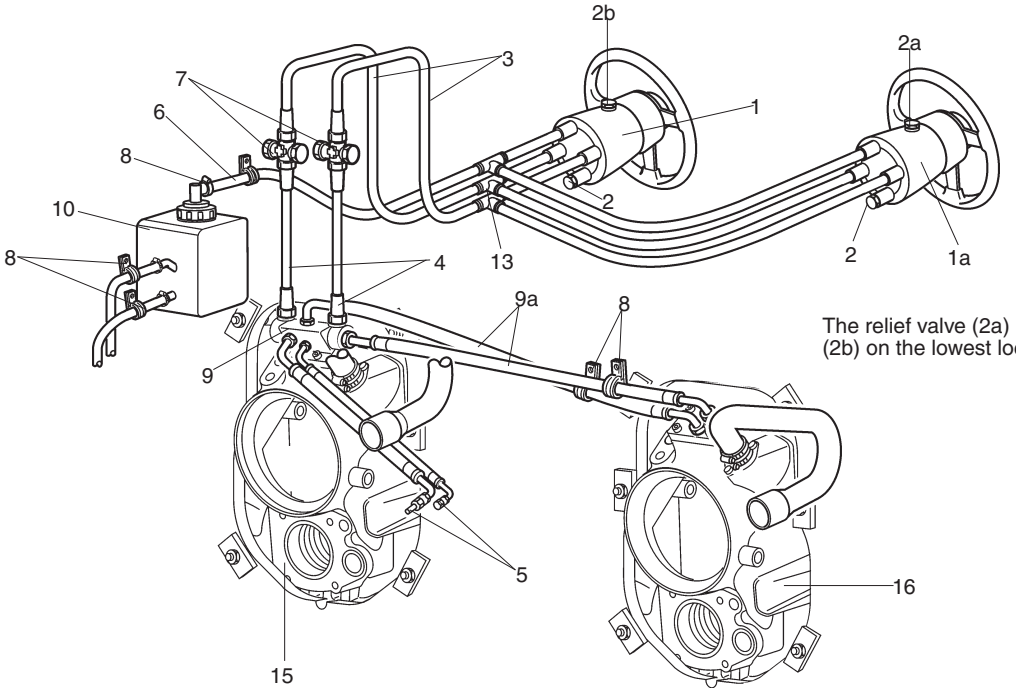


⚠ **IMPORTANT!** Plug no. 2 must never be used, this to ensure correct oil level in steering pump

1. Steering pump
1a. Steering pump, secondary helm station
2. Plugged connection
2a. Relief valve
2b. Plug
3. Hydraulic hoses, low pressure
4. Pig tails
5. Hydraulic hoses, high pressure
6. Drain hose
7. 4-way connections
8. P-clamp
9. Valve house
9a. Hoses from port drive
10. Recovery tank (reservoir)
11. Servo pump
12. Oil cooler
13. T-connections
14. —
15. Starboard shield
16. Port shield

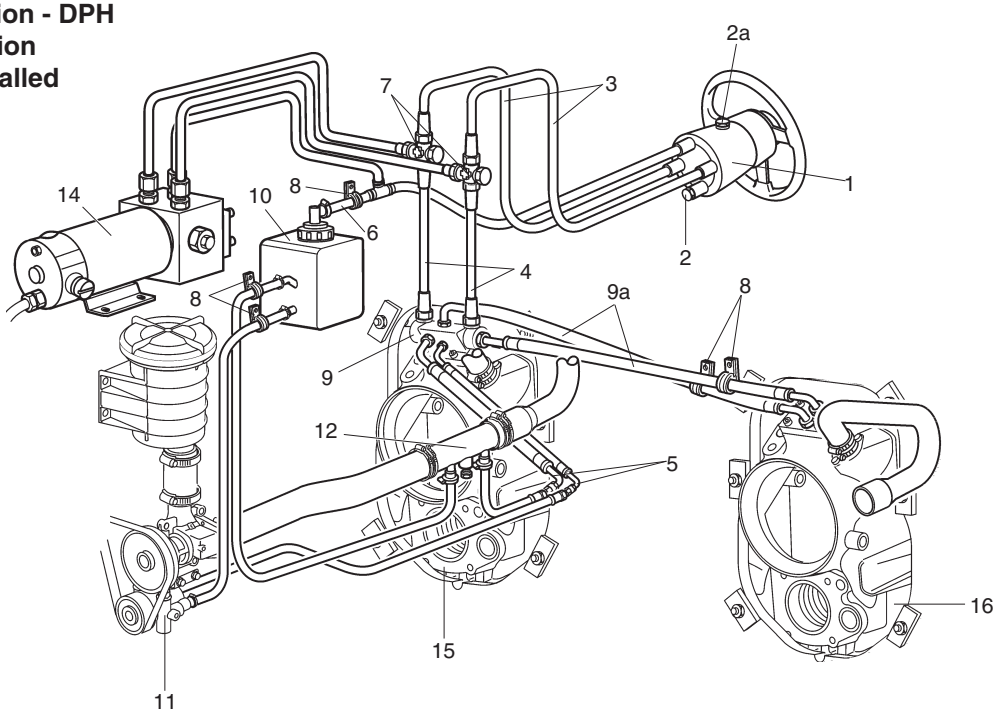
Twin installation - DPH
Main and secondary helmstation

Connections to oil cooler and servo pump not shown.
Please refer to figure above.



The relief valve (2a) is replaced by a plug (2b) on the lowest located steering pump.

Twin installation - DPH
One helmstation
Autopilot installed

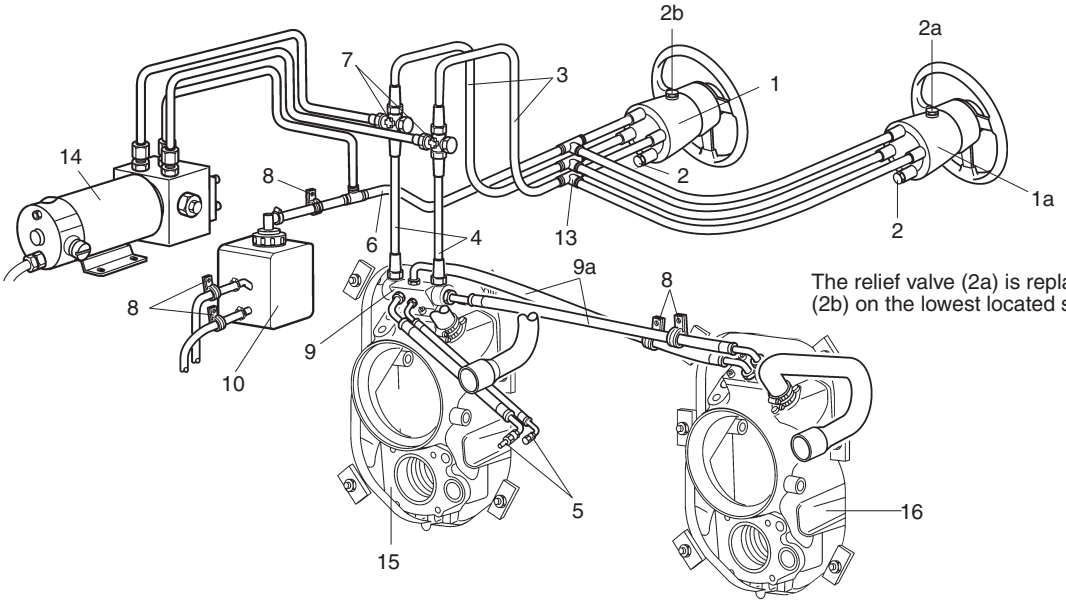


⚠ **IMPORTANT!** Plug no. 2 must never be used, this to ensure correct oil level in steering pump

1. Steering pump
1a. Steering pump, secondary helm station
2. Plugged connection
2a. Relief valve
2b. Plug
3. Hydraulic hoses, low pressure
4. Pig tails
5. Hydraulic hoses, high pressure
6. Drain hose
7. 4-way connections
8. P-clamp
9. Valve house
9a. Hoses from port drive
10. Recovery tank (reservoir)
11. Servo pump
12. Oil cooler
13. T-connections
14. Autopilot
15. Starboard shield
16. Port shield

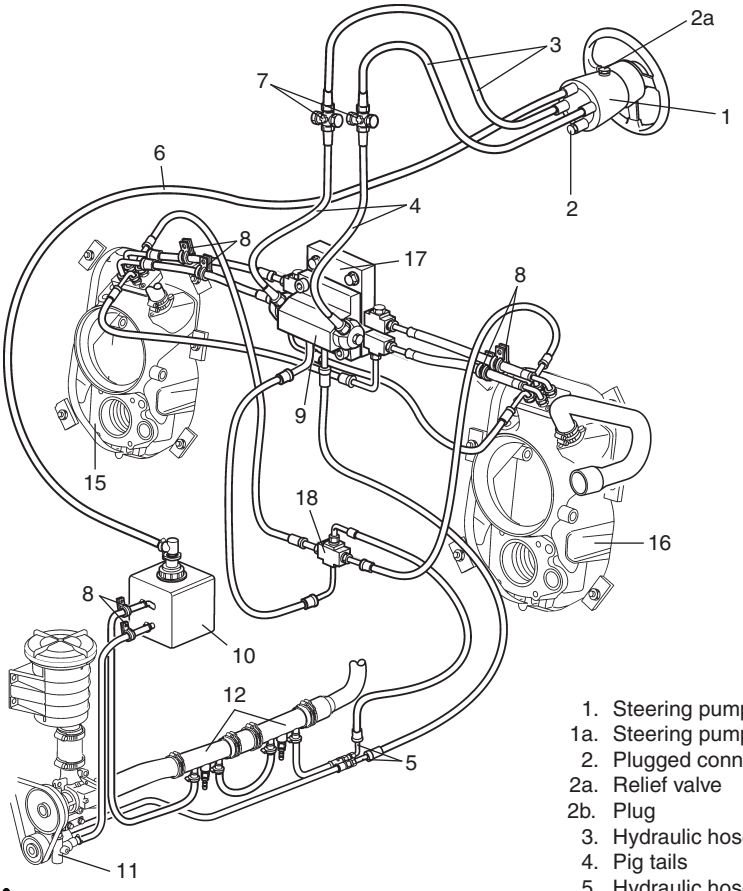
Twin installation - DPH
Main and secondary helmstation
Autopilot installed

Connections to oil cooler and servo pump not shown.
Please refer to figure above.



The relief valve (2a) is replaced by a plug (2b) on the lowest located steering pump

Twin installation - DPR
One helmstation

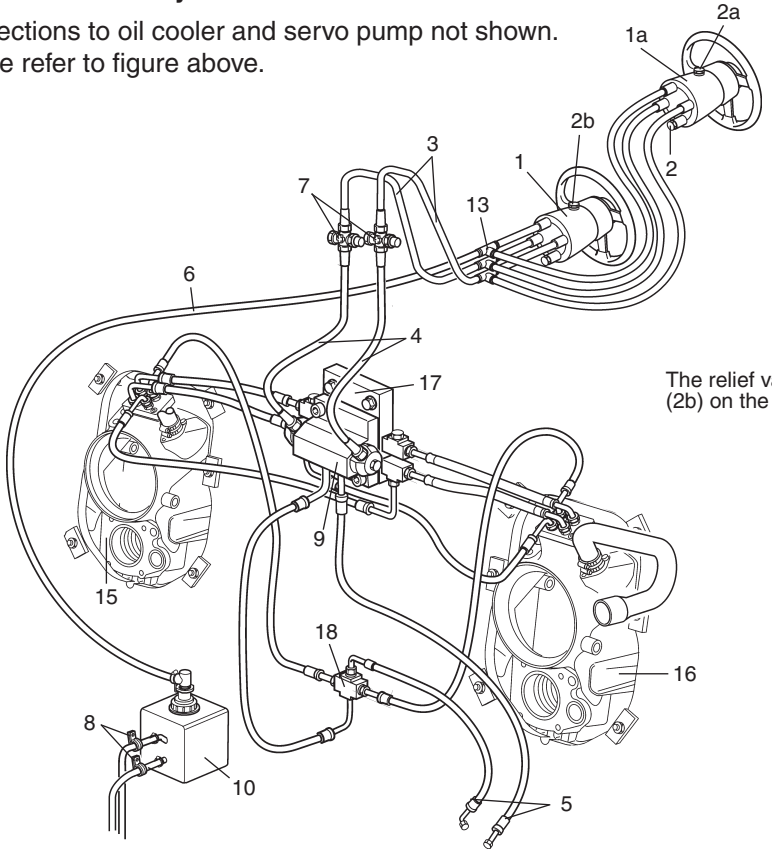


⚠ **IMPORTANT!** Plug no. 2 must never be used, this to ensure correct oil level in steering pump

1. Steering pump
1a. Steering pump, secondary helm station
2. Plugged connection
2a. Relief valve
2b. Plug
3. Hydraulic hoses, low pressure
4. Pig tails
5. Hydraulic hoses, high pressure
6. Drain hose
7. 4-way connections
8. P-clamp
9. Valve house
9a. —
10. Recovery tank (reservoir)
11. Servo pump
12. Oil cooler
13. T-connections
14. —
15. Starboard shield
16. Port shield
17. Manifold
18. Nipple, 4-way

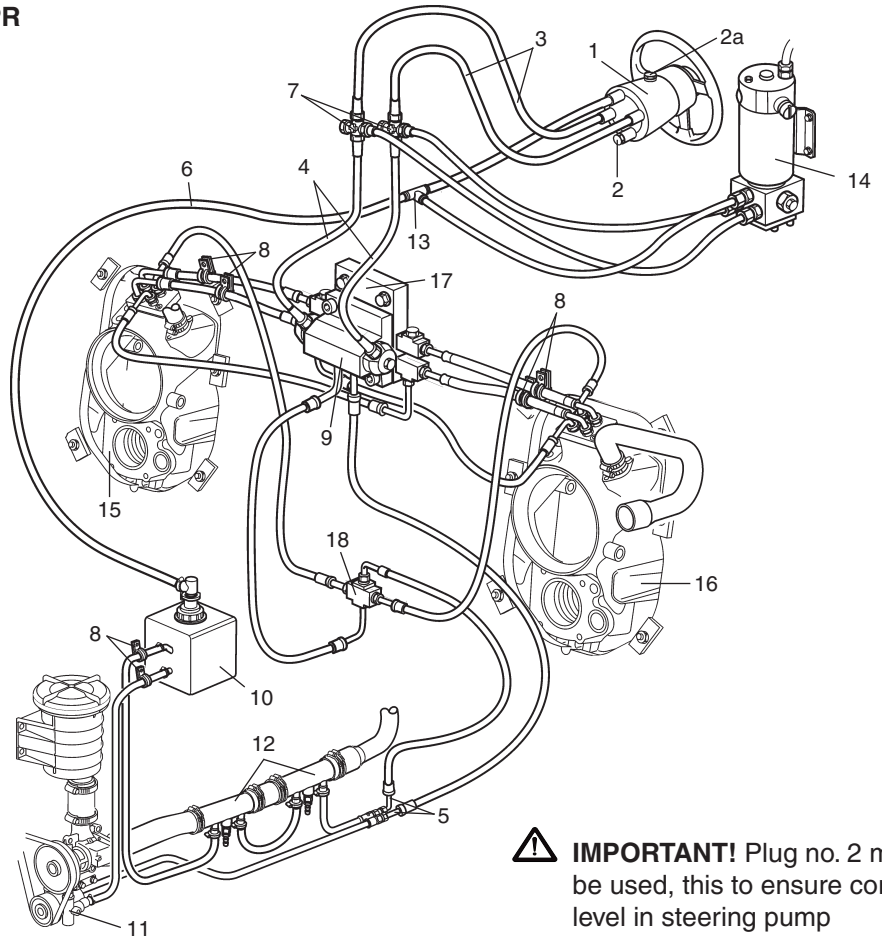
Twin installation - DPR
Main and secondary helmstation

Connections to oil cooler and servo pump not shown. Please refer to figure above.



The relief valve (2a) is replaced by a plug (2b) on the lowest located steering pump.

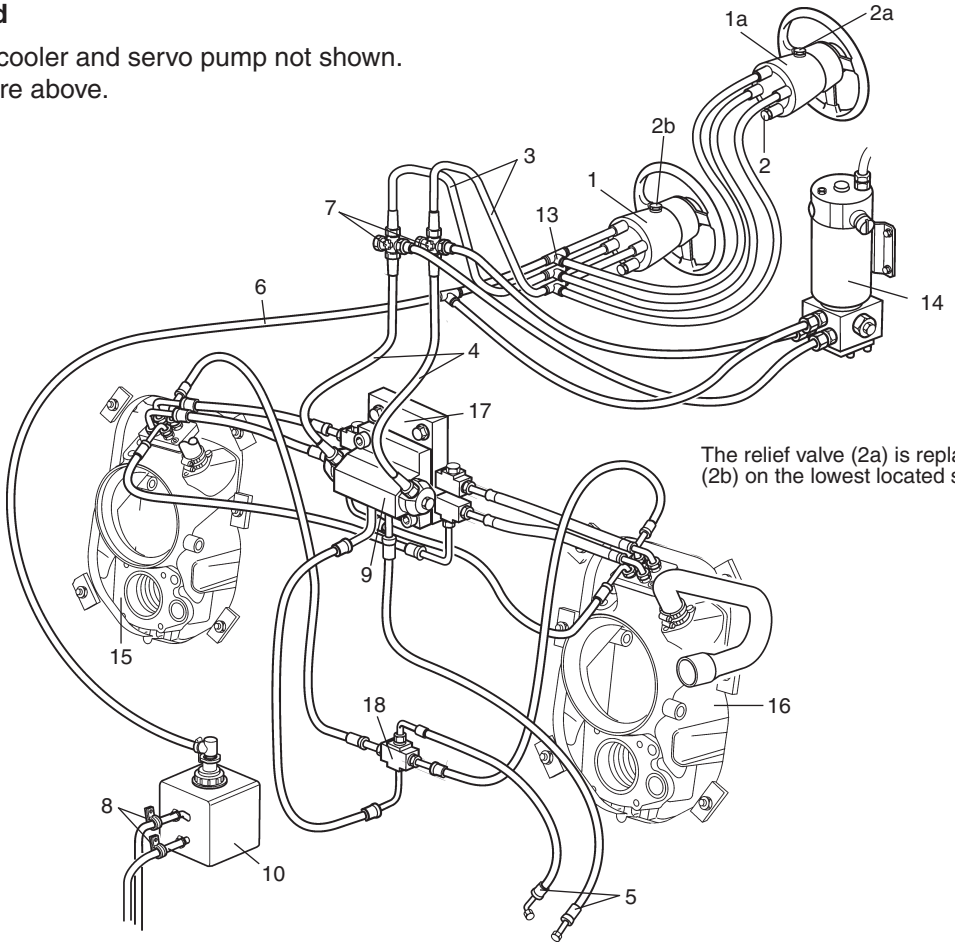
Twin installation - DPR
One helmstation
Autopilot installed



⚠ **IMPORTANT!** Plug no. 2 must never be used, this to ensure correct oil level in steering pump

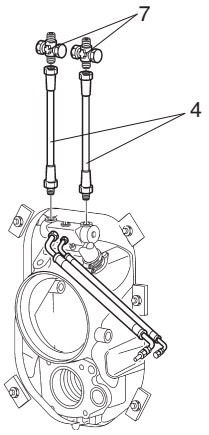
Twin installation - DPR
Main and secondary helmstation
Autopilot installed

Connections to oil cooler and servo pump not shown.
Please refer to figure above.

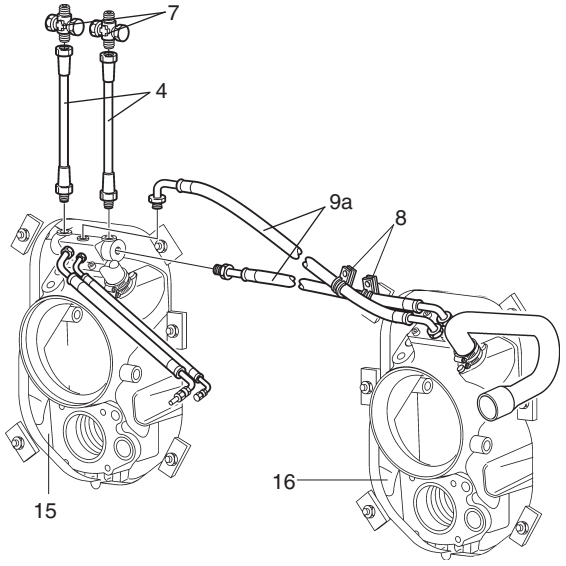


The relief valve (2a) is replaced by a plug (2b) on the lowest located steering pump

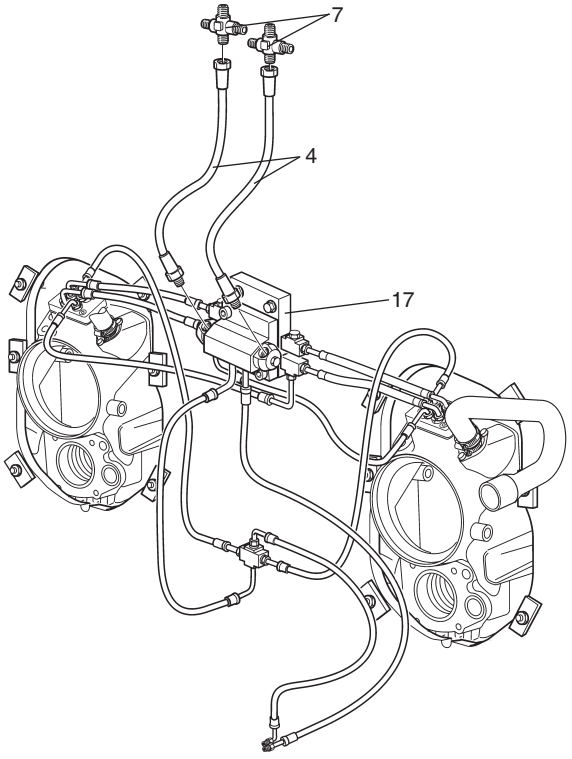
Single installation - DPH/DPR



Twin installation - DPH



Twin installation - DPR



Installation procedure

⚠ **IMPORTANT**! Be very careful with cleanliness when working with the steering system hydraulics. Clean components thoroughly on the outside before disassembly. The work area should be clean and well lit.

⚠ **IMPORTANT**! Always use Volvo Penta hydraulic hoses to achieve acceptable steering characteristics.
Make sure that the hoses do not come into contact with hot surfaces.
Fix the hoses with suitable clamps. Distance between clamps approx. 250 mm (10").

Before the engine is installed, step 1–2

Single installations:

1. Install pig tails (4) and 4-way connections (7).
Tightening torque: **22 Nm (16.2 lbf.ft)**.

Twin installations - DPH:

2. Connect the hoses (9a) coming from the shield on the port side (16) to the valve housing (9) on the starboard shield.

Tightening torque: **21 Nm (15.5 lbf.ft)**.

⚠ **IMPORTANT!** Clamp all hoses properly.

Twin installations - DPR:

2a. Remove valve house from starboard shield and the hydraulic manifold on the port shield.

2b. Install the new hydraulic manifold on port shield and fasten the larger manifold on the transom bulkhead.

2c. Connect the hoses coming from the shields to the larger manifold (17).

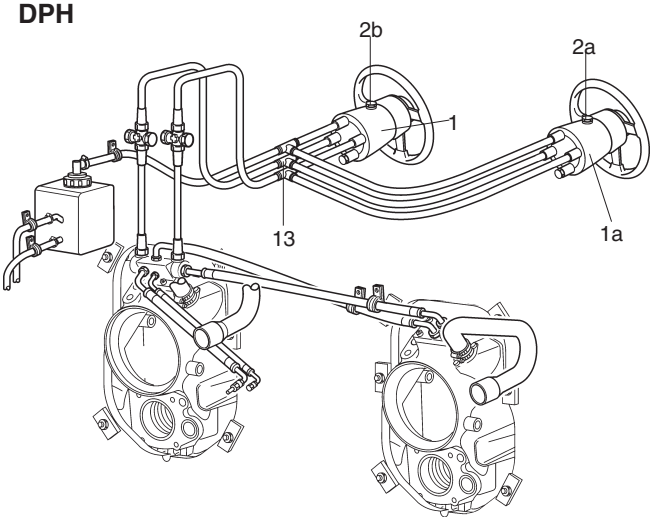
2d. Replace disc and the old ground strap on port shield. Install inner steering cylinder on port shield.

Tightening torque: **21 Nm (15.5 lbf.ft)**.

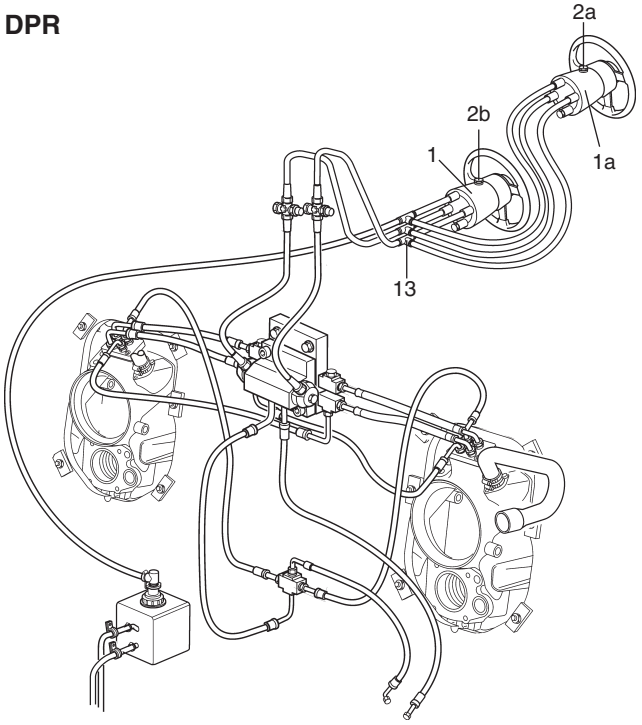
⚠ **IMPORTANT!** Clamp all hoses properly.

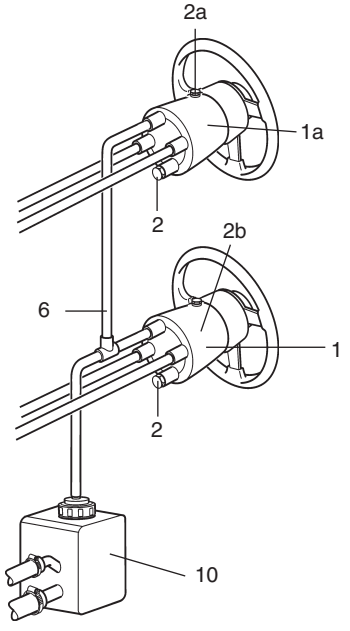
Example

DPH



DPR





The following steps, 3–6 can be carried out when engine is installed

3. Route hoses to the main helm station. Install the helm pump (1) and connect the hoses to the pump according to figures.

Tightening torque, hose nipples in the rear of helm pump:

Finger tighten and then 1½–2½ turns, depending on desired orientation of the nipple. Max torque 17.5 Nm (13 lbf.ft).

⚠ **IMPORTANT!** Clamp all hoses properly.

Second helm station, if included

4. Install T connections (13) and helm pump (1a) to second helm station according to figure. Connect and clamp the hoses.

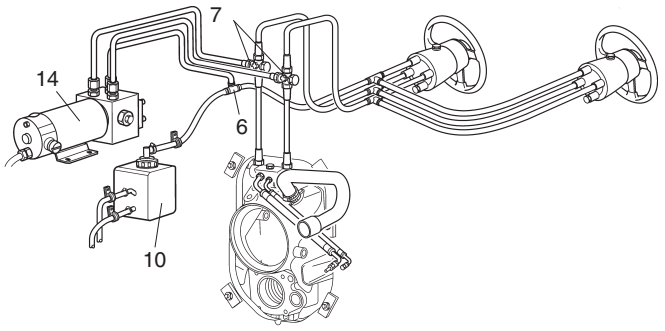
Connect the drain hose (6) to the recovery tank (10). Position (2) is a plug.

Tightening torque, T connections: **22 Nm (16.2 lbf.ft).**

Tightening torque, hose nipples in the rear of the helm pump: **Finger tighten and then 1½–2½ turns depending on desired orientation of the nipple. Max torque 17.5 Nm (13 lbf.ft)**.

⚠ **IMPORTANT!** Clamp all hoses properly.

5. Replace the relief valve (2a) on the lowest located steering pump by a sealing plug (2b). In this case the lowest located steering pump is the one on the main helm station.



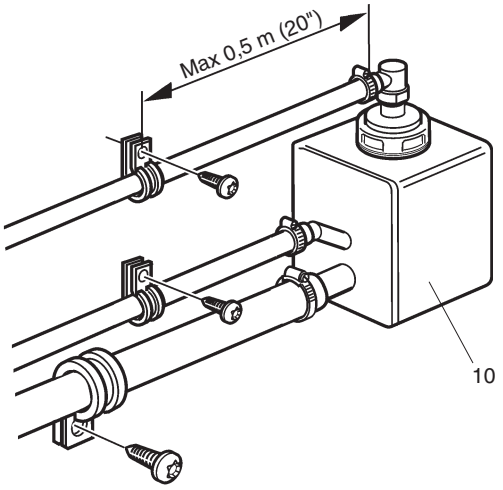
Autopilot, if included

6. Install the autopilot (14). Install a T connection on the drain hose (6) leading to the recovery tank (10).

Connect the hoses from the autopilot to the existing 4-way connections (7) on the pigtails and to the T connection on the drain hose (6).

⚠ **IMPORTANT!** Clamp all hoses properly.

The 4-way connections are also used for purging.



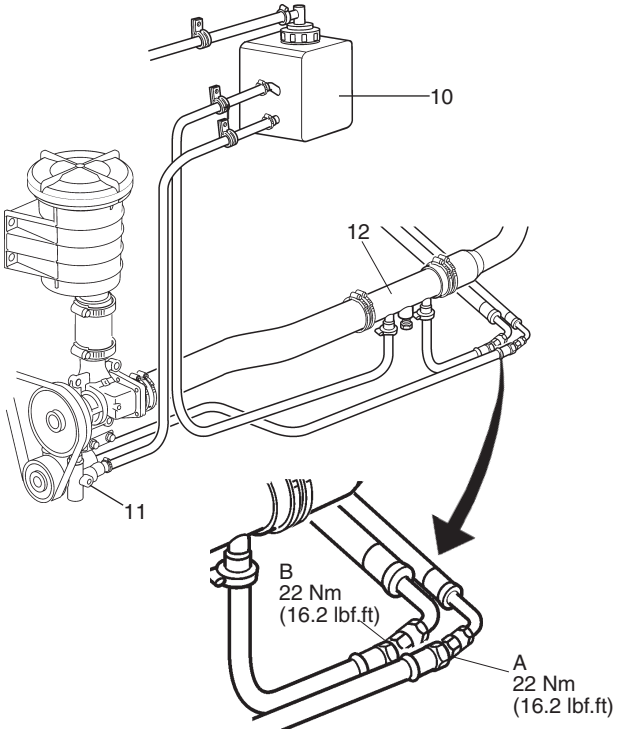
After the engine is installed, step 7–10

7. When engine installation is completed; install the recovery tank (10) on a suitable place such as on a bulkhead.

NOTE! The tank must not be installed on the engine. Connect the return hoses from helm pump and autopilot to the recovery tank.

⚠ **IMPORTANT**! Due to their weight, all three hoses from recovery tank must be supported and clamped on a bulkhead or similar according to the figure.

DPH/DPR - Single installation
DPH - Twin installation



8. Connect the two high pressure hoses (A and B) from the valve housing:

Hose connection (A) to the engine power steering pump (11). Tightening torque: **22 Nm (16.2 lbf.ft)**.

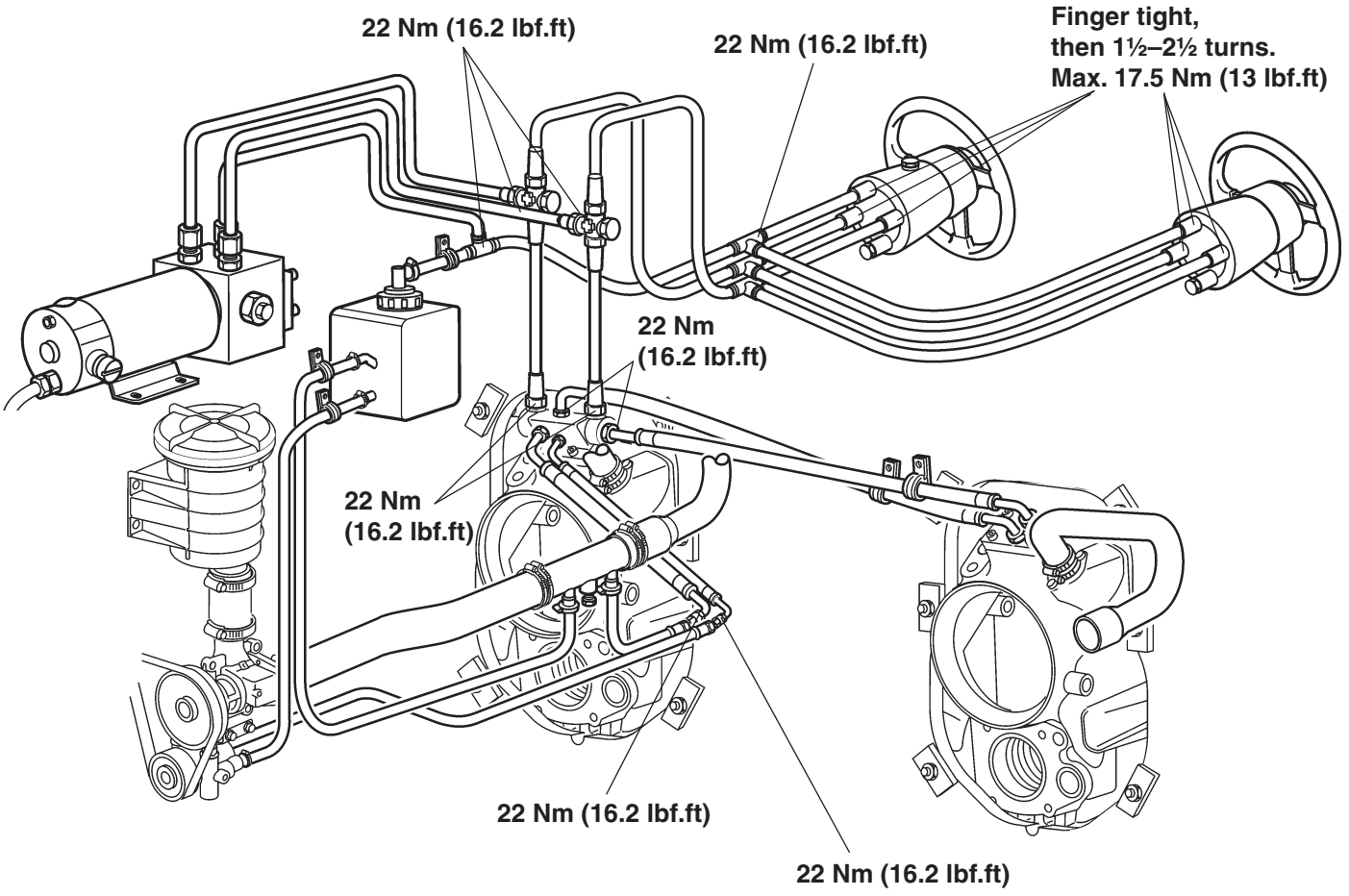
Hose connection (B) to the steering system oil cooler (12). Tightening torque: **22 Nm (16.2 lbf.ft)**.

NOTE! There are two steering system oil coolers in a twin DPR-installation.

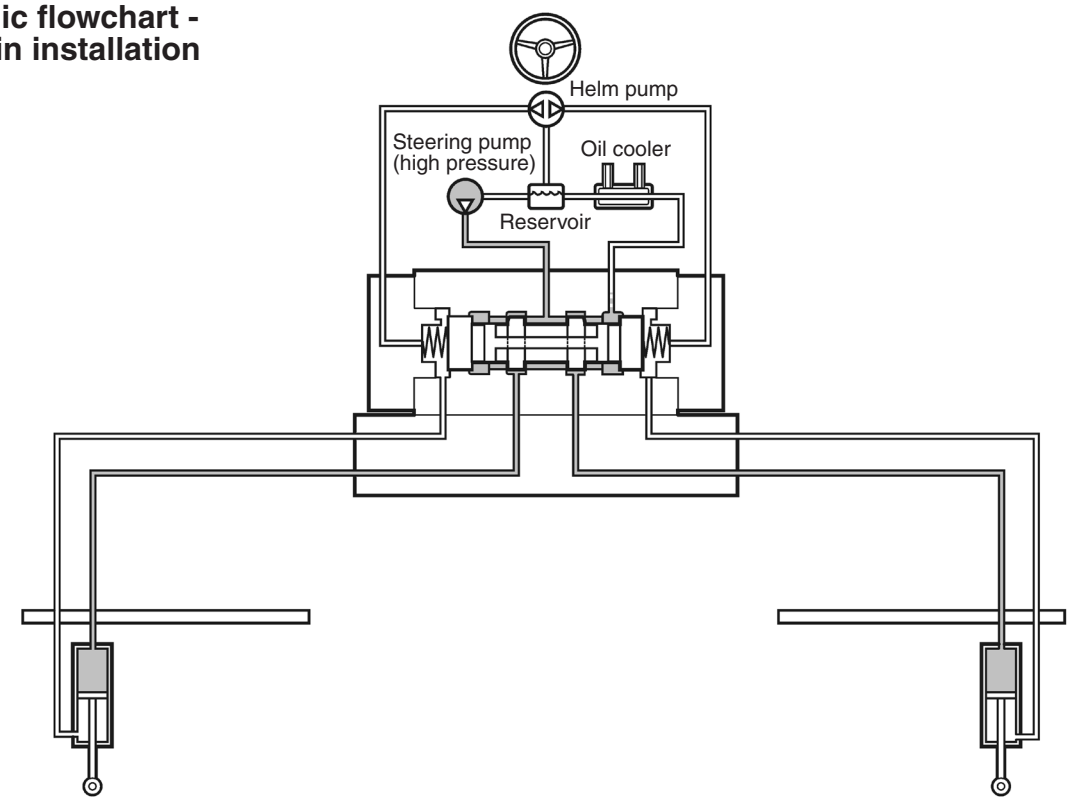
9. Fill the system with **ATF** oil type Dexron II or III. Volvo Penta part no. 1161995 is recommended.

10. Purge the steering system. Please refer to the section ***Filling and purging the system***.

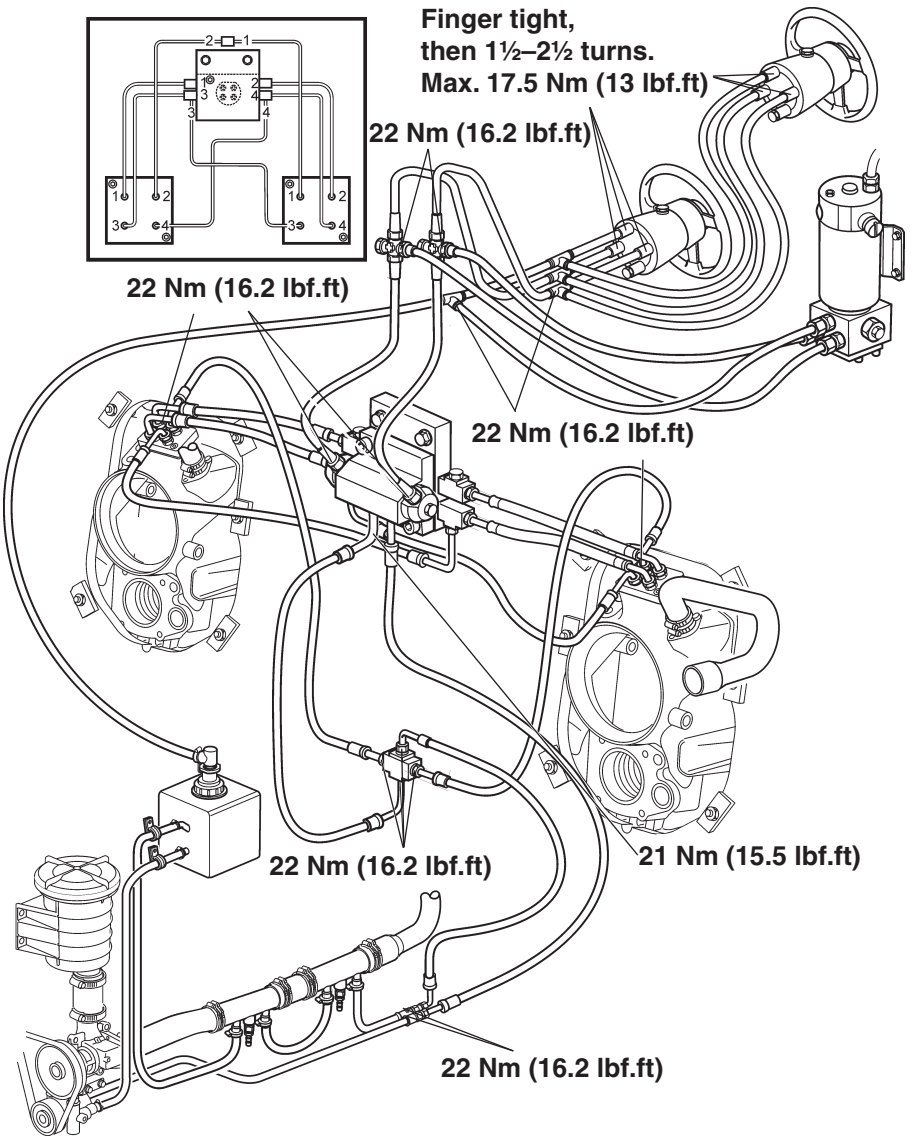
Overview of hose connections - DPH twin installations
Tightening torques



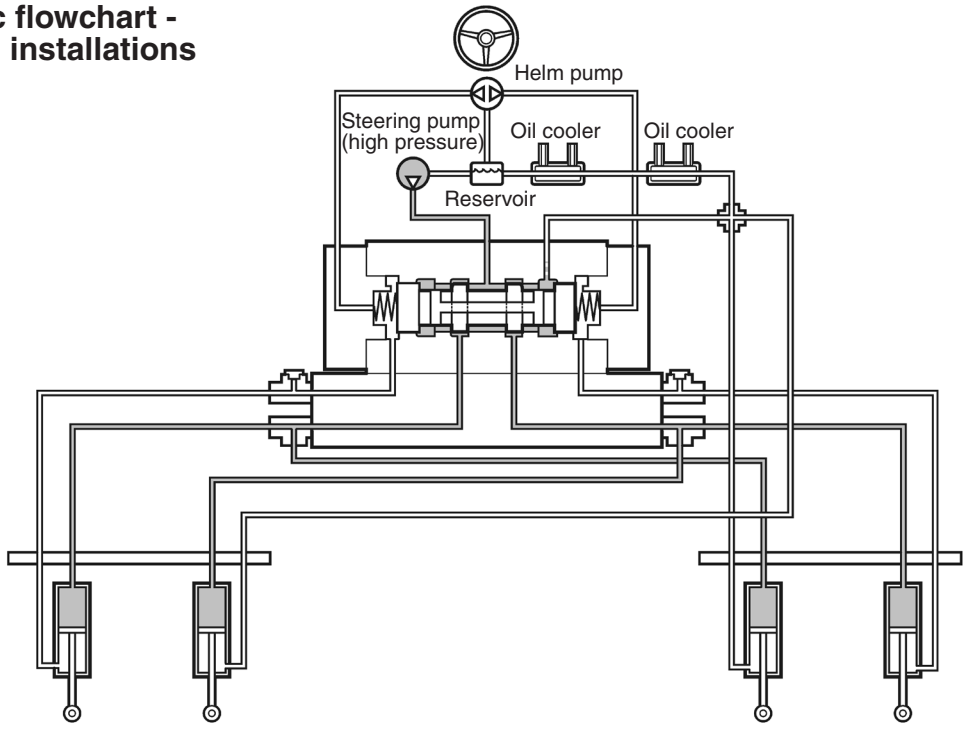
Hydraulic flowchart -
DPH twin installation



Overview of hose connections - DPR twin installations
Tightening torques



Hydraulic flowchart - DPR twin installations



Filling and purging the system

NOTE! This section applies to both DPH and DPR applications although figures describe only DPH systems.

⚠ **IMPORTANT**! Be very careful with cleanliness when working with the steering system hydraulics. Clean components thoroughly on the outside before disassembly. The work area should be clean and well lit.

Steering system fluid

The recommended fluid for the steering system is ATF oil type Dexron II or III, Volvo Penta part no. 1161995.

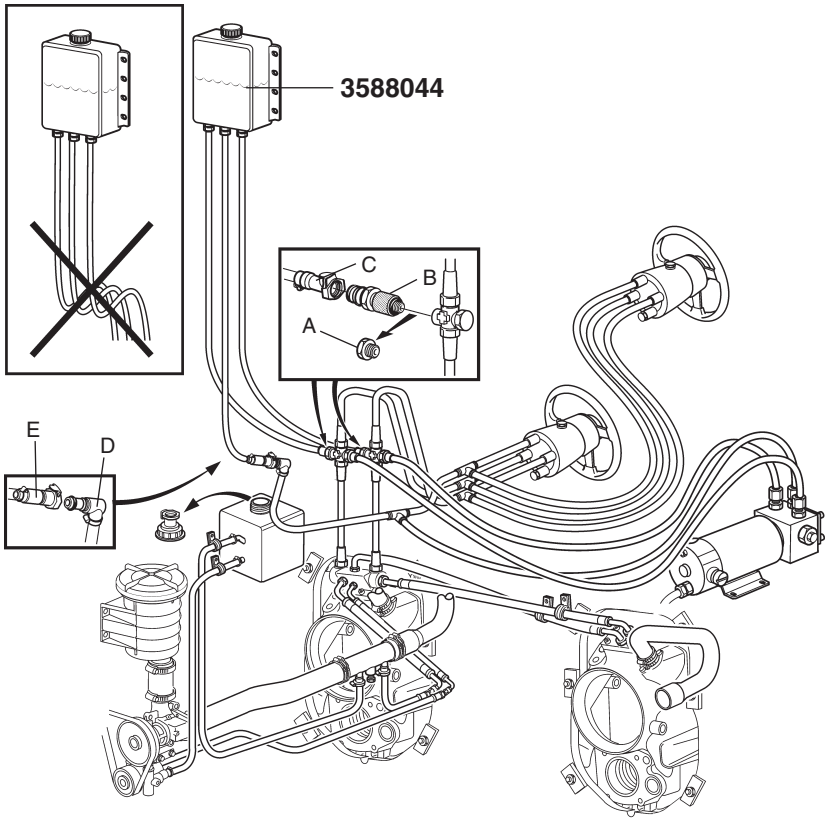
⚠ **WARNING!** Never use brake fluid or hydraulic oil. Any non-approved fluid may cause irreparable damage, loss of steering and cancellation of warranty.

⚠ **IMPORTANT**! In case of extreme emergency, any non-toxic, non-flammable fluid may provide temporary steering.

Autopilot filling and purging

The Autopilot should be connected to the 4-way connections and it is filled and purged together with the VP steering system.

Engine installed



1. Check that the steering system hoses and connections are correctly installed.

⚠ **IMPORTANT**! Make sure the hoses from the filling tank to the 4-way connections have continuos fall with no coils or loops and that the fittings face upwards or to the side. This will speed up the purging process.

2. Position the filling tank/purging tool (special tool 3588044) as high as possible, so that the hoses have a continous fall down to the 4-way connections. Remove the plugs (A) on the 4-way connections and install the two adapters (B) fitted on the purging tool tubes. Connect the two fittings (C) from the purging tool to the adapters.

3. Remove the power steering recovery tank cap and disconnect the quick release fitting (D) from the recovery tank cap. Connect the return hose fitting using the provided female quick release fitting (E).

4. Helm and hose purging

One helm station

Turn the steering wheel starboard about 150 turns or if the filling tank is visible, until no large bubbles/air are seen in tubes connected to the filling tank. The hoses between the 4-way connections and the helm will now be filled.

Two helm stations

⚠ **IMPORTANT!** When filling an installation with a secondary helm station (flybridge), turn the wheel on the lower station first and the upper station after.

First turn the steering wheel at **lower station**, about 60 turns starboard.

Then turn the steering wheel at **upper station**, about 150 turns starboard.

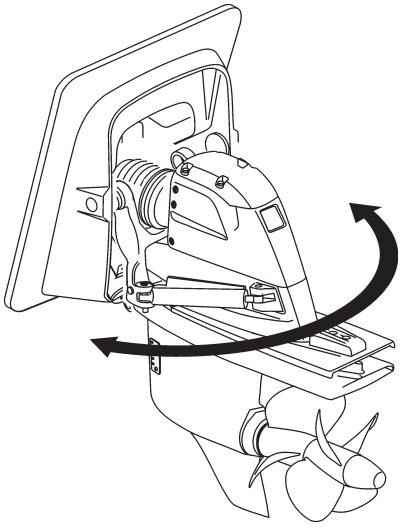
5. Autopilot purging

Run autopilot starboard for at least 1 minute. Then run autopilot port for at least 1 minute.

NOTE! Please refer to autopilot manufacturer documentation for operational limitations.

6. Steering cylinder purging

NOTE! Rapid drive or cylinder movement may cause oil to overflow from recovery tank.

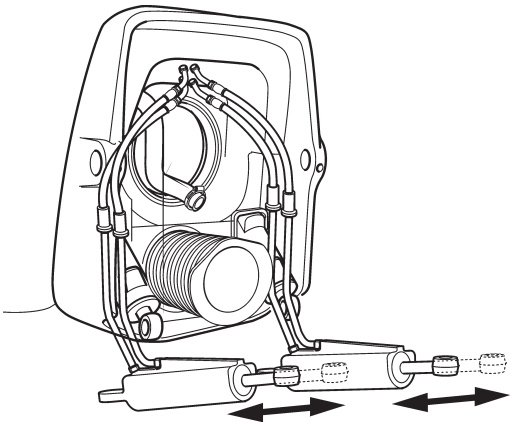


Drive installed

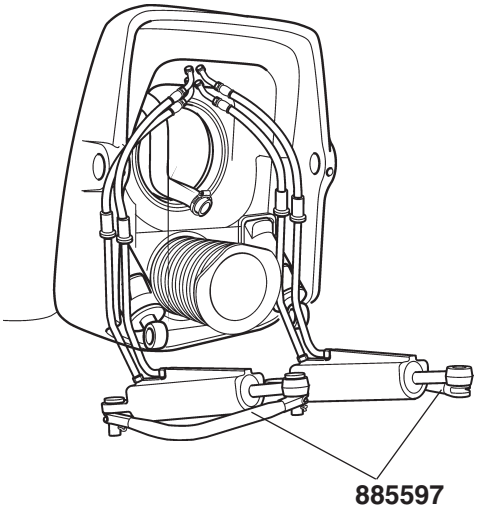
First push the drive to full port steering angle. Wait about five seconds. Then push the drive to full starboard steering angle. Wait about 15 seconds. Repeat four more times.

Drive not installed

If the drives are not installed, extend and retract the cylinder rods manually. Repeat five times and make sure to retract one cylinder rod when the other is extended to simulate drive installation.



NOTE! Make sure that the cylinders are left in straight ahead position, the pin to pin distance is 337 mm (13.3"). It is possible to lock the cylinders by installing handles, special tool 885597. If both cylinders are left fully retracted or extended it will be impossible to install the drive.



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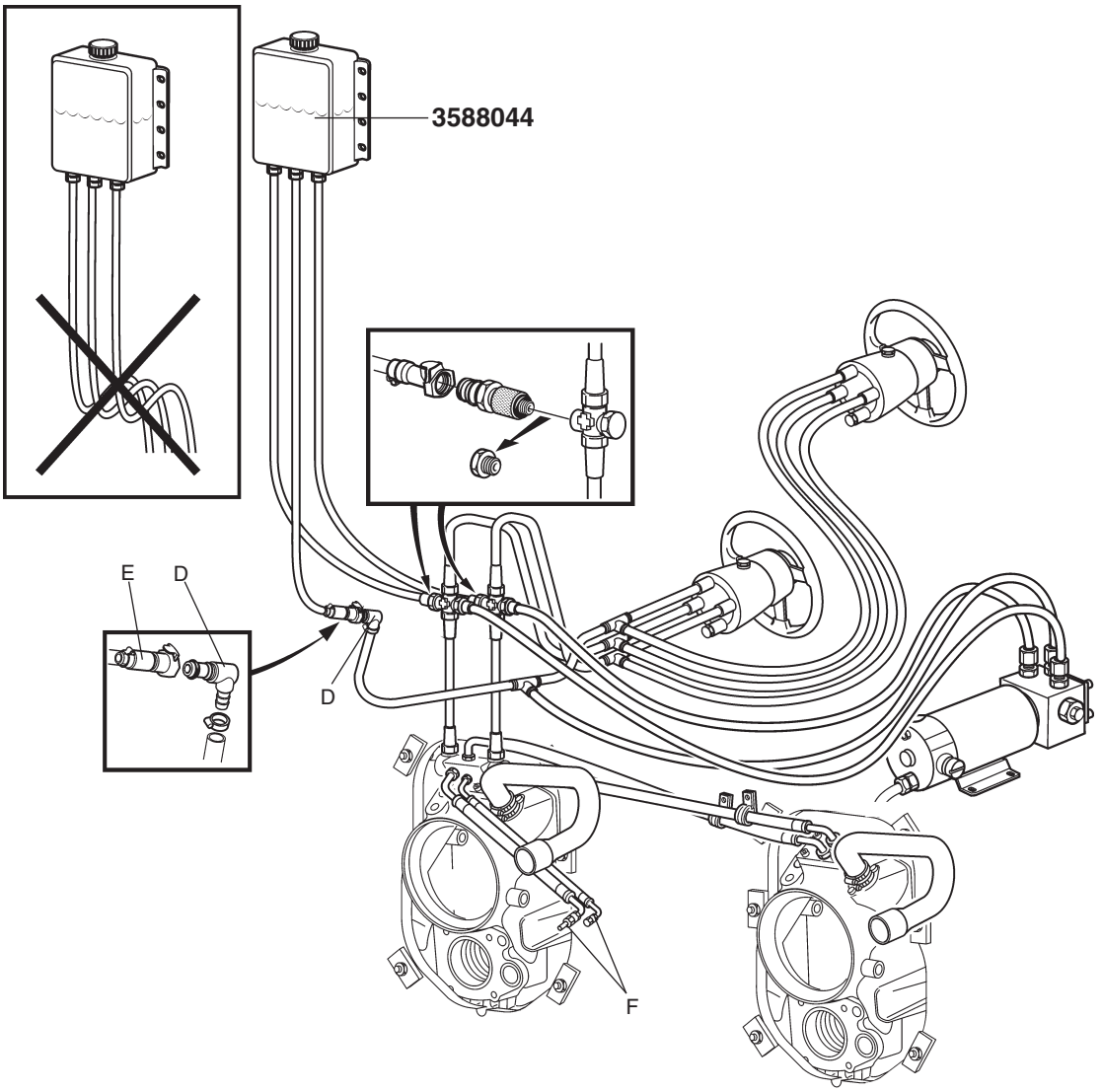
7. To minimize oil spill, first disconnect both quick release fittings (C). Then disconnect adapters (B) from the 4-way connections. Hold a rag under the adapters to catch oil which is trapped in fittings. Plug the two 4-way connections.

Tightening torque: **22 Nm (16.2 lbf.ft)**.

8. Disconnect the hose from the filling tank to the power steering recovery line. Install the recovery tank cap and re-connect the line to the recovery tank cap.

NOTE! To ensure proper venting for the steering system, top fill the oil and start the engine to purge the system. Top fill the system if needed after engine stop. Additional top fill may be required if the boat has remained unused for some time after initial purging of the system.

Engine not installed



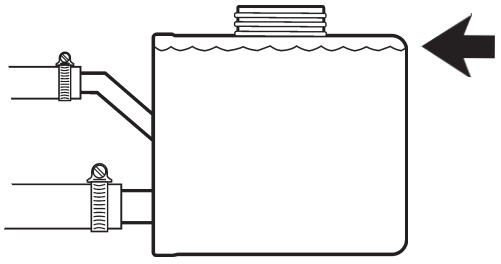
1. Carry out the filling and purging procedure according to the method described earlier in the section ***Engine Installed***.

NOTE! Use quick release fitting (D) from the recovery tank cap to connect the female quick release fitting (E) from filling tank **3588044**. The recovery tank and cap are included in the engine kit.

NOTE! Leave the two plugs (F) in place in the hose connections.

2. When the engine is installed and the steering system is purged, top up the recovery tank so that it is filled to right below the neck of the reservoir. Please refer to the section ***Topping up when engine is installed***.

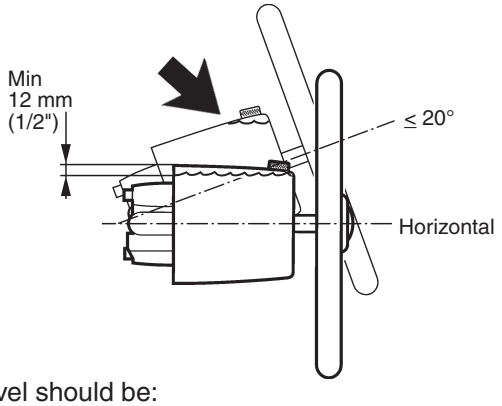
Topping up when engine is installed



1. Top up the power steering recovery tank so that it is filled to right below the neck of the tank.

2. Top up the helm pump (only the highest placed helm pump).

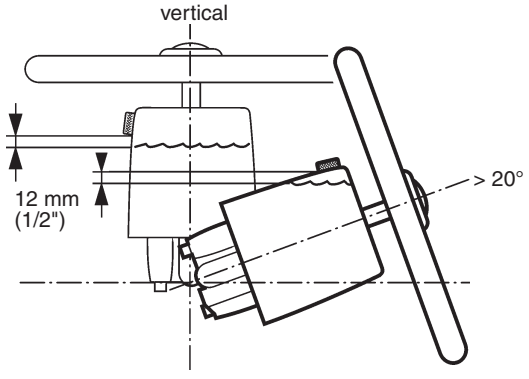
Pumps located with steering shaft horizontal and up to 20°:



Oil level should be:

- min.12 mm (1/2") under the lower edge of the filling hole
- max. lower edge of the filling hole

Pumps aligned at >20° angle and the steering shaft up to vertical:



Oil level should be approximately 12 mm (1/2") below lower edge of filling hole.

NOTE! Always check and top up oil in helm pumps and recovery tank after sea trials.

Checking the steering system

Check the steering system for proper connection of tubes and fittings, possible leaks and proper purging.

1. Disconnect the filling and purging tool tubes and connections from the steering system and plug the T connections.

Tightening torque: **22 Nm (16.2 lbf.ft)**.

2. Turn the steering wheel, all the wheels in a multi steering system and pressurize very hard to port. Apply enough force to the wheel to exceed the pressure relief valve pressure. The helm pump slips and falters when the relief valve pressure is exceeded. You will not harm the helm or the system during this procedure.

3. While pressure is maintained on the steering wheel, check all port fittings and connections.

4. Repeat the procedure by turning the wheel to **starboard**.

5. Watch the oil level in the helm pump when pressurizing the steering wheel in both hard over positions.

If there is no obvious drop in oil level:

Air has been removed.

If there is an obvious drop in oil level:

Air is compressed in the system and further filling and purging is required.

If no leaks are obvious, the system is ready for use.

⚠ **IMPORTANT**! If leaks are found, repair before using. Failure to correct a leak can lower the oil level in the system and result in loss of steering ability.

Troubleshooting guide

Most faults occur when the installation instructions are not followed and usually show up immediately upon filling the system. The most common faults encountered and their likely causes and solutions are listed below.

Sometimes, when returning the wheel from a hard over position, a slight resistance may be felt and clicking noise may be heard. This should not be mistaken as a fault, as it is a completely normal situation, which is caused by the lock spool in the system releasing.

⚠ **WARNING**! Whenever a solution in the text below calls for removal from the vessel and/or dismantling of steering system components, this work must only be carried out by a qualified marine hydraulic mechanic. Volvo Penta offers the following as a guide only and is not responsible for any consequences resulting from incorrect dismantling or repairs.

Fault	Cause	Solution
1. Steering is very easy and more turns from lock to lock than usual are seen. VP standard pump, 3½ turns from lock to lock.	• Air in system	• Top off oil in helm and recovery tank. Review filling and purging instructions.
2. During filling, the helm becomes completely jammed.	• Blockage in the line between the helm(s) and the cylinder(s).	• Make certain that the hose/tubing has not collapsed during installation. If so, the collapsed section must be removed and replaced by a new piece, using tube connectors. Check the fittings for badly drilled holes. Fittings with badly drilled holes are not common, however.
3. The system is very difficult to fill. Air keeps burping out the top of the helm even after the system appears full.	• Air in system.	• Review filling and purging instructions.
4. Steering is stiff and hard to turn, even when the vessel is not moving.	• Restrictions in hoses or fittings. • Air in system. • The wrong type of oil has been used to fill steering system.	• Find restriction and correct. **NOTE!** A kinked hose is enough to cause restrictions. • Review filling and purging instructions. • Drain system and fill with recommended oil.
5. One helm unit in system is very bumpy and requires too many turns from hardover to hardover.	• Air in system. • Dirt in inlet check of helm pump.	• Review filling and purging instructions. • Dismantle helm pump and remove contaminant from make-up checks.

Fault	Cause	Solution
6. Steering is easy to turn at the dock, but becomes hard to turn when vessel is under way.	• Steering wheel is too small.	• Fit larger wheel if possible, please refer to the installation instructions. If the problem cannot be rectified by the above mentioned solution, proceed with next cause and solution or consult factory.
	• Incorrect setting of power trim on sterndrive.	• Adjust sterndrive trim.
7. Boat drifts to port or starboard while vessel is under way, even when wheel is not being turned.	• Air in system.	• Review filling and purging instructions.
	• Dirt in check valves.	• Remove check valve plugs. These are the larger plugs on either side on rear of helm. Clean ball seats and balls. Re-assemble. **NOTE:** Be prepared to lose a certain amount of oil during this procedure. Have a small can available. Refill system when check balls have been re-assembled.
8. Turning one wheel causes second steering wheel to rotate.	• Please refer to fault no. 6.	• Please refer to fault no. 6.
9. Seals will sometimes leak if steering system is not vented at uppermost helm.		• The helm has a field replaceable wheel shaft seal which can readily be replaced by removing the steering wheel and seal cover held in place by three small screws.

Aquamatic applications
Controls

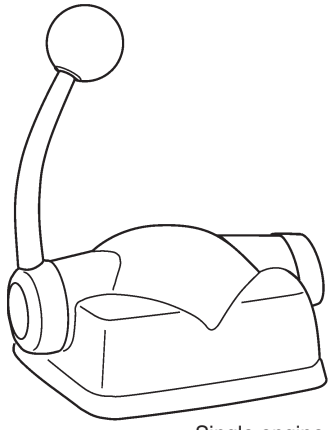
General

If the boat is to be maneuvered and operated in a convenient and safe manner, then the operating station should be arranged in such a way that the controls, steering and instruments, navigational equipment and alarm systems are located practically. This applies to each operating station.

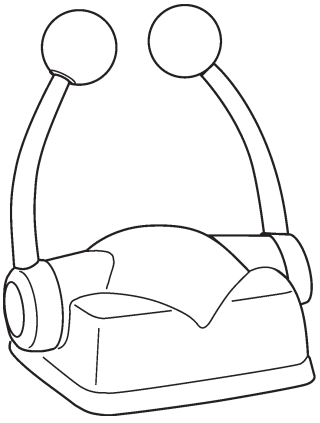
Controls for EVC engines, (Electronic Vessel Control)

When installing controls and other components for the EVC system, please refer to ***Installation, Electronic Vessel Control EVC D4, D6***.

Top mounted electronic controls

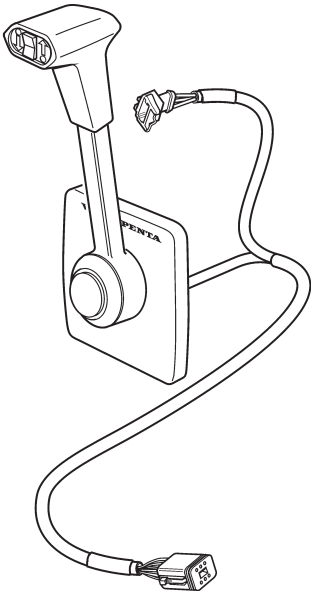


Single engine, single lever control, EVC



Twin engine, single lever control, EVC

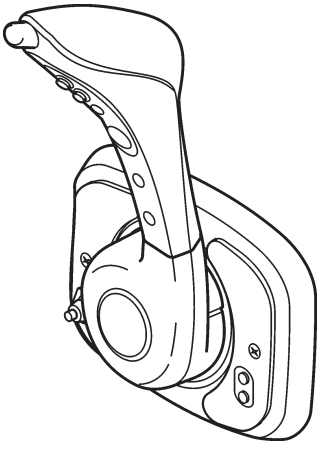
Side mounted electronic control



The figure shows a single engine, single lever control EVC, including wire harness for speed control/ gear shifting and PowerTrim.

The control is also available without PowerTrim wire harness and switch for inboard applications.

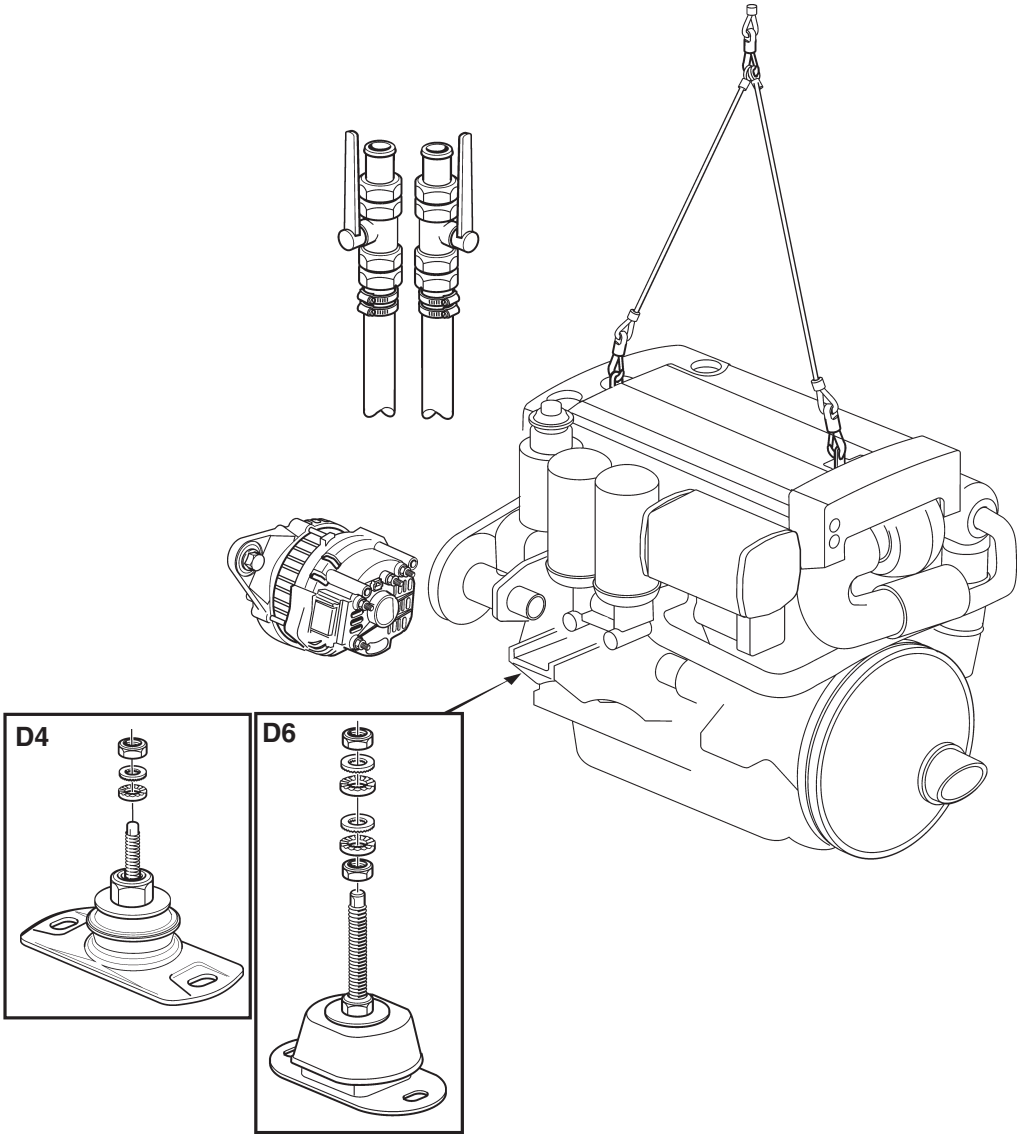
Side mounted electronic control with interlock



This control has an interlock function, a mechanical catch that locks the control lever in the neutral position. The control also has integrated power trim maneuvering buttons and cables.

Aquamatic applications
Engine installation

Preparing the engine



NOTE! Installations in the engine room for the fuel system, steering system, electrical system, etc. should be as complete as possible before the engine is installed.

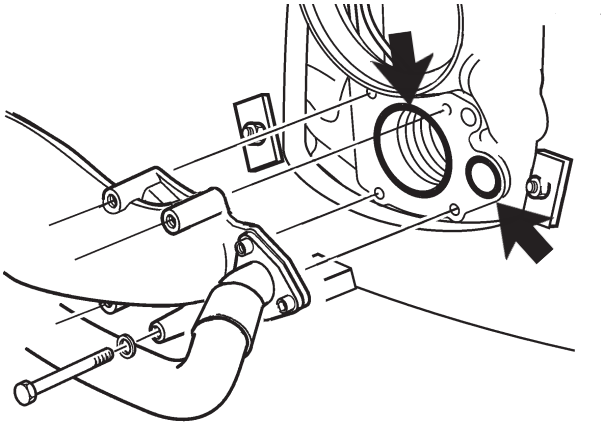
Install optional equipment and accessories on the engine, such as extra alternator, hot water outlet, power take-off etc. before the engine is installed.

NOTE! All engines are delivered from Volvo Penta without engine oil and coolant. Check that the oil plug and draining cocks for coolant, hot water cocks etc. are closed.

Fill oil and coolant. Check for leakage.

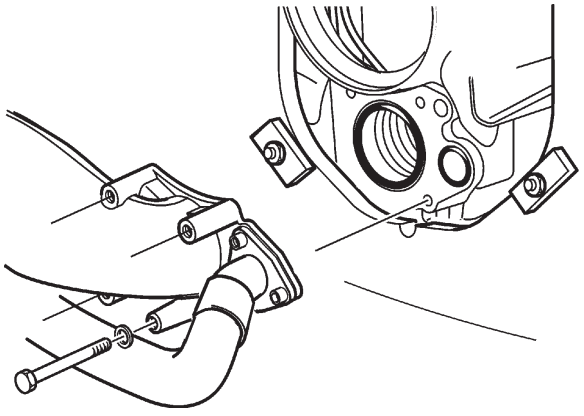
⚠ **WARNING!** Always use both lifting eyes when lifting the engine.

Installing the exhaust pipe



1. **NOTE!** Check that the large and the small O-rings are in place in the shield. The O-rings are factory fitted (glued) in place.

2. Install the exhaust pipe and tighten the bolts.

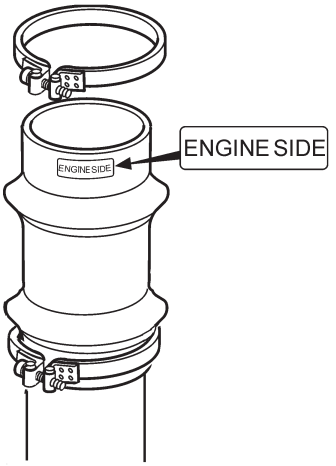


40 Nm (30 lb.ft)

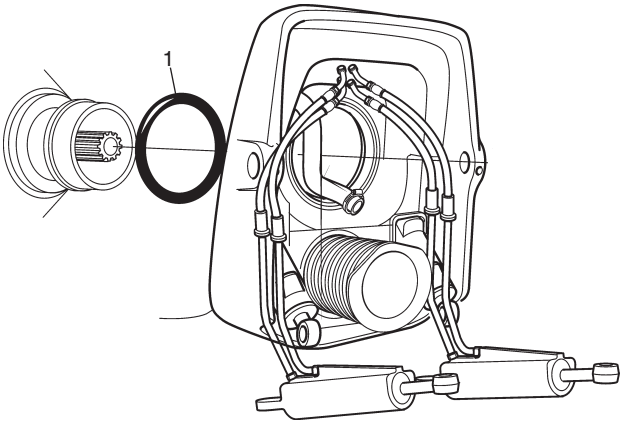
Tightening torque: **40 Nm (30 lb.ft)**.

Check the by-pass hose fitting to the exhaust pipe.

Installing the engine



3. Hang a stainless steel hose clamp on the exhaust hose.



4. Install the big rubber ring (1) on the neck of the rear flywheel housing.

5. Install the flexible engine mountings on the engine brackets.

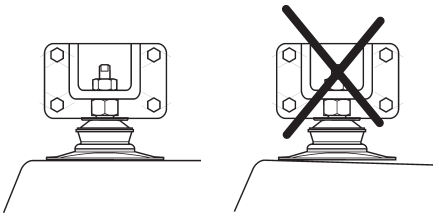
NOTE! Apply grease Volvo Penta part no. **828250** on the threads.

Use the special lifting eyes on the engine and attach a lifting device to lift the engine.

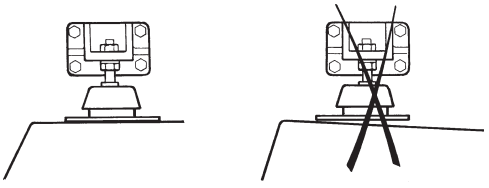
The engine beds on which the engines are located shall be on one plane.

Check that the surface of the engine bed, where the engine mountings are supported, is parallel to the base plates of the engine mountings, and that the bed inclination is correct (use a graded angle spirit level).

D4



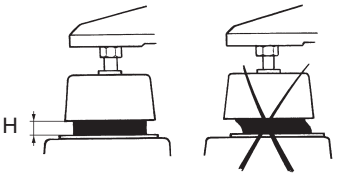
D6



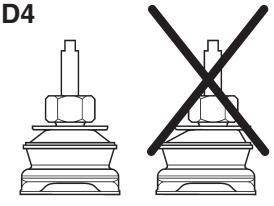
NOTE! Before adjustments can be made to engine mountings for **D6** applications, the engine must rest on the rubber mountings for at least twelve hours.

Never use rubber mountings other than those intended for the relevant engine type.

D6



D4

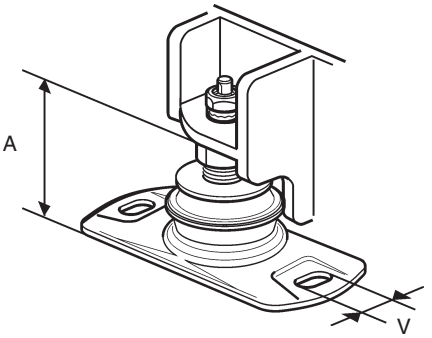


NOTE! Make sure that the rubber mounts are installed so that no pre-load or side forces occur when the engine has been installed.

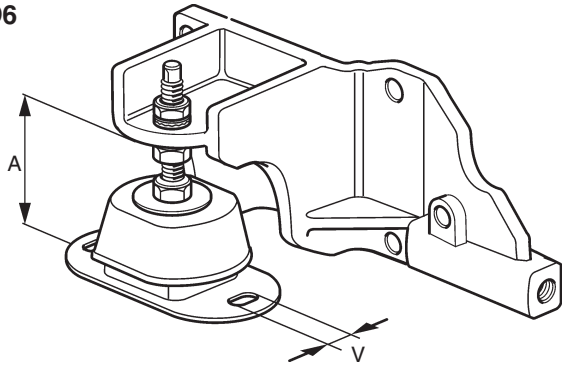
When the engine is installed, the loading on the front mounts shall be equal as well as the loading on the rear mounts. Check loading on the rubber mounts for **D6** applications by measuring the distance (**H**) between the attachment plates and the housing.

Adjustable engine mounts shall have their basic position mid way along the length of the fastening plate holes. The fastening plates have elongated holes for adjusting. These can be turned facing forward or backwards, whichever allows the best accessibility.

D4



D6

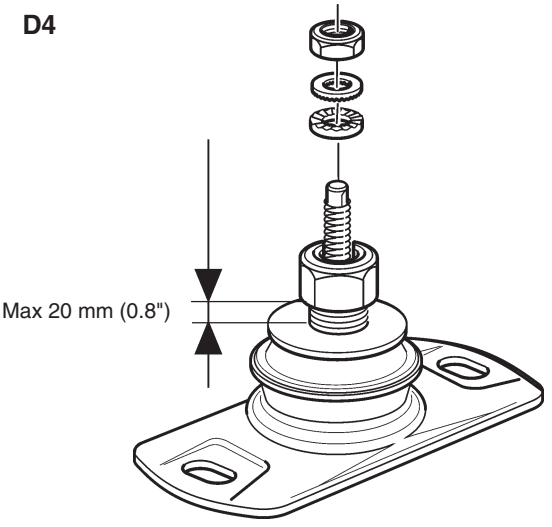


Nominal height measured from underside of engine mount base plate: **D4**: 116 mm (4.6"), **D6**: 122 mm (4.8")

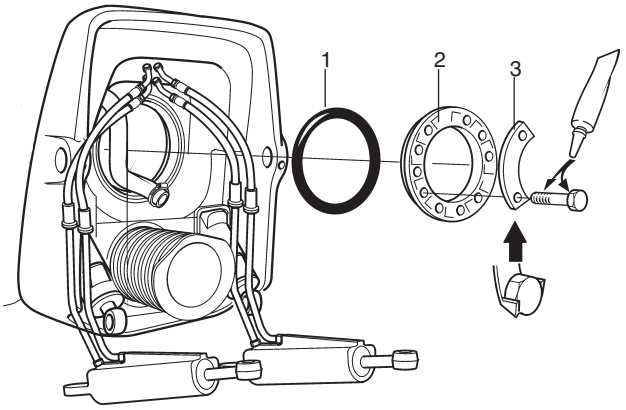
A = Nominal height ± adjustment **D4/D6**: ± 8 mm (0.3")

V = Sideways adjustment **D4**: ± 7 mm (0.3"), **D6**: ± 5 mm (0.2")

D4



NOTE! The measurement between the washer nut and the lower edge of the middle adjustment nut must never exceed 20 mm (0.8").

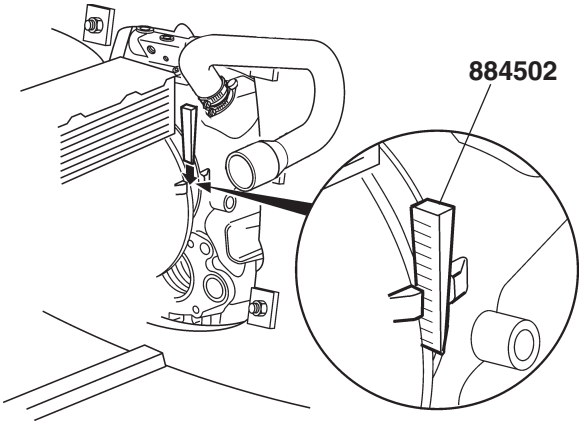


6. Lower the engine and center the neck of the flywheel housing. Push the engine towards the rear. Install the rubber ring (1) on the clamping ring (2) and connect it to the flywheel housing using the three locking plates (3). Tighten the engine and the clamping ring to each other, using the six bolts.

Tightening torque: **35 Nm (25 lbf.ft)**.

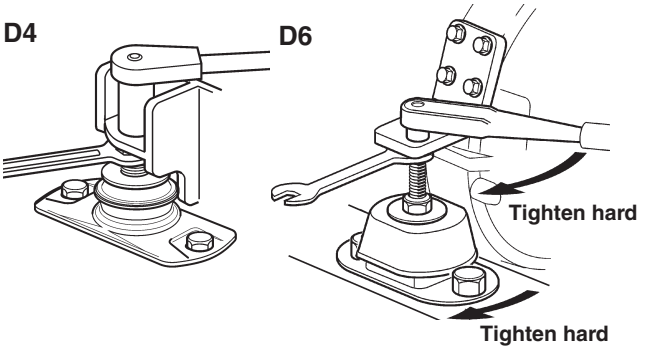
⚠ **IMPORTANT**! Do not forget to grease the bolt threads and the underside of bolt heads. Lock the bolts by folding the locking plates against the bolt heads.

Lower the engine onto the engine bed. Attach the bolts holding the mountings to the bed without tightening them.



7. Align the engine using the special tool **884502** to make sure it is at right angles to the transom shield.

Adjust the height with the flexible engine mountings. Compare the distance at each pair of shoulders located at the top and sides of the flywheel housing/transom shield split. The distance between each marking on the wedge corresponds to 1 mm. A difference of 2 mm can be accepted.

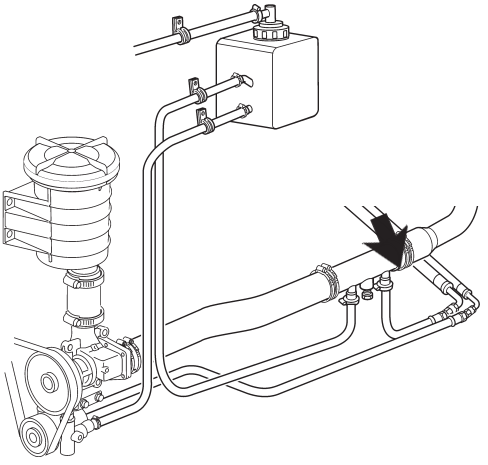


8. Tighten the bolts holding the mountings to the bed and the adjustment nuts on the mountings. Use a counterhold on the nuts.

Tightening torque, bolts in engine bed:
Tighten hard

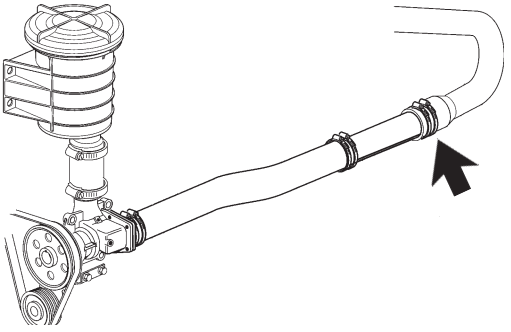
Tightening torque, adjustment nuts:
Tighten hard

9. **Engine with Power Steering**:



Connect the inlet seawater hose to steering system oil cooler.

⚠ **IMPORTANT**! Use two hose clamps

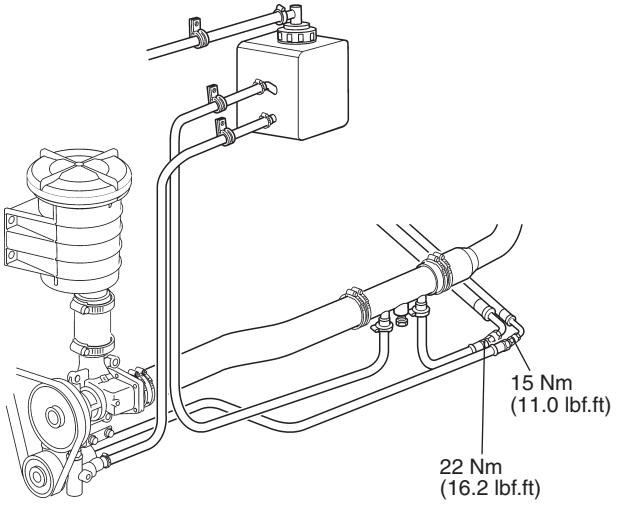


Port engine, twin installation:

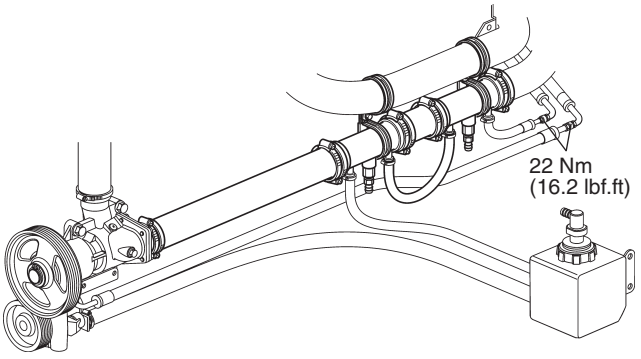
Connect the inlet seawater hose to the union on seawater pump hose.

⚠ **IMPORTANT!** Use two hose clamps.

DPH - twin installation

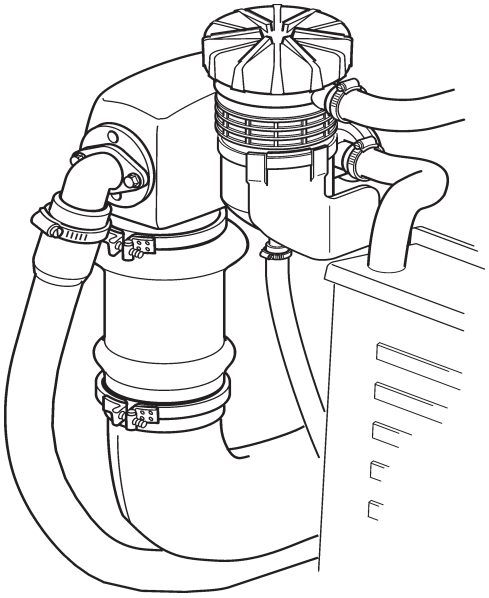


DPR - twin installation



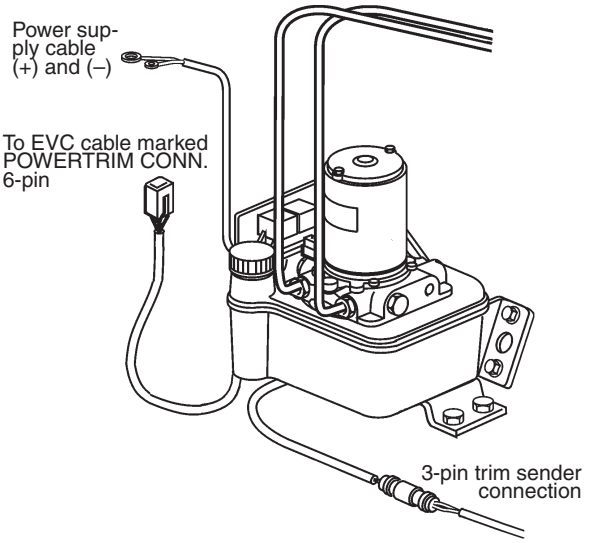
10. Connect the two steering system hydraulic hoses and oil cooler (DPR has two oil coolers).

Tightening torque, oil cooler:
22 Nm (16.2 lbf.ft)
Tightening torque, power steering pump:
15 Nm (11.0 lbf.ft)



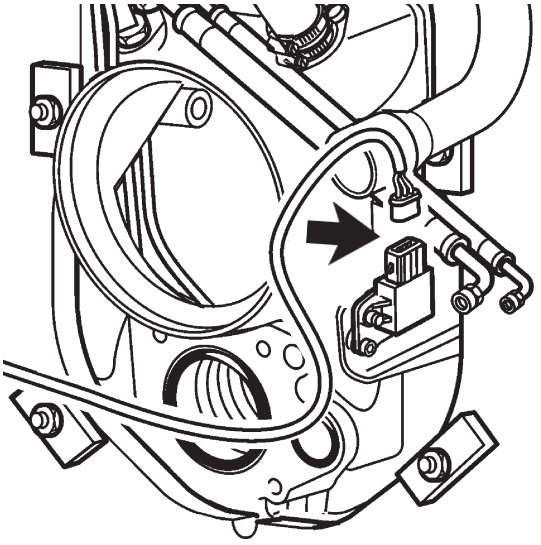
11. Connect the exhaust hose to the exhaust elbow or riser if fitted.

Connect the by-pass hose to the exhaust elbow.

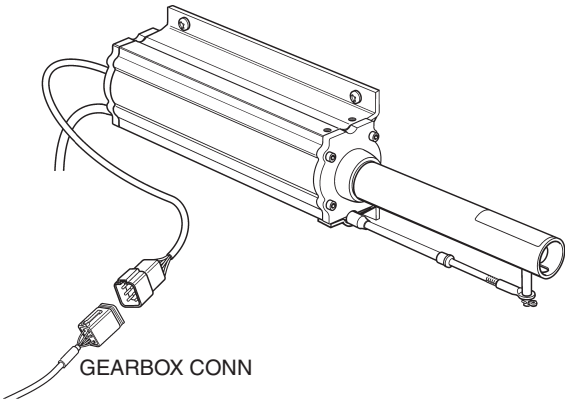


12. Connect the 6-pin connector from the PowerTrim pump harness to the engine and transmission cable connector marked POWERTRIM CONN.

Connect the trim sender cable to the trim pump 3-pin connector.

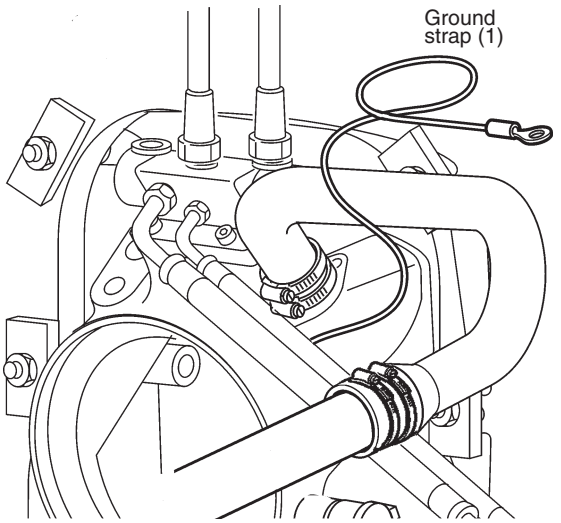


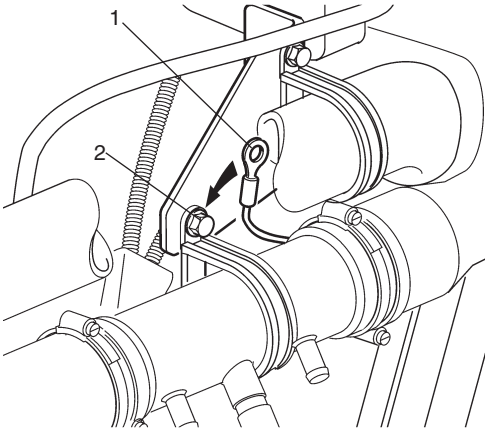
13. Connect the trim sender cable to the trim sender. Clamp the cable properly.



14. Connect the gear shift actuator to the EVC system.

⚠ **IMPORTANT!** Do not forget to power up the EVC system before attaching the shift cable to the drive. This is done to ensure that the actuator is precisely in the neutral N position.

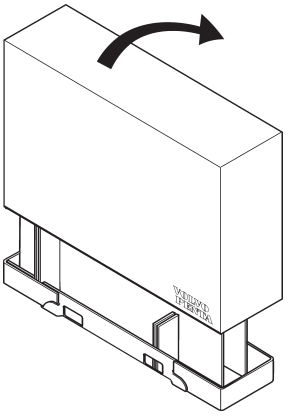




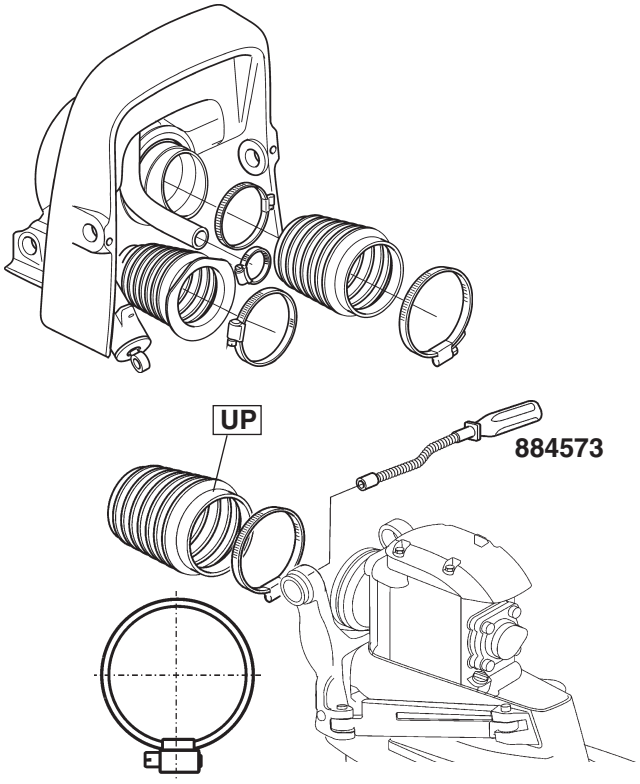
15. Connect the ground (earth) strap (1) fitted on the shield to the bolt (2) holding the power steering oil cooler/seawater union clamp.

Aquamatic applications
Sterndrive installation

Preparations

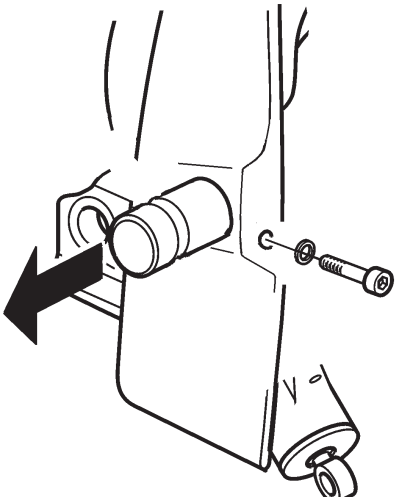


1. Open the package by lifting off the top.

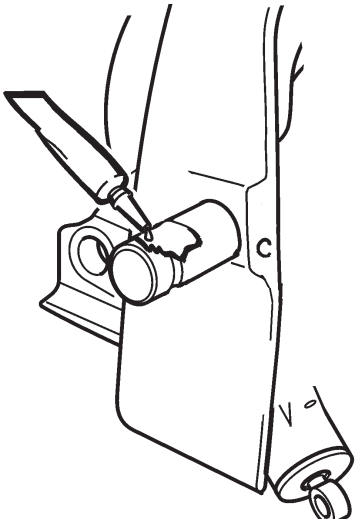


2. Install the universal joint bellows on the neck of the upper gear housing. Hang the hose clamp onto the universal joint int bellows and install it. Locate the hose clamp housing at the **6 o'clock** position with the screw head facing to starboard and tighten the clamp. Use flexible screw driver **884573**.

⚠ **IMPORTANT**! Note the position of the "**UP**" marking.



3. Remove the locking bolts and washers. Pull out the pivot pins.



4. Grease the pivot pins. Use Volvo Penta water resistant grease, part no. 828250. Push them back again to make them flush with the inside of the transom shield.

Assembling the sterndrive on the transom shield

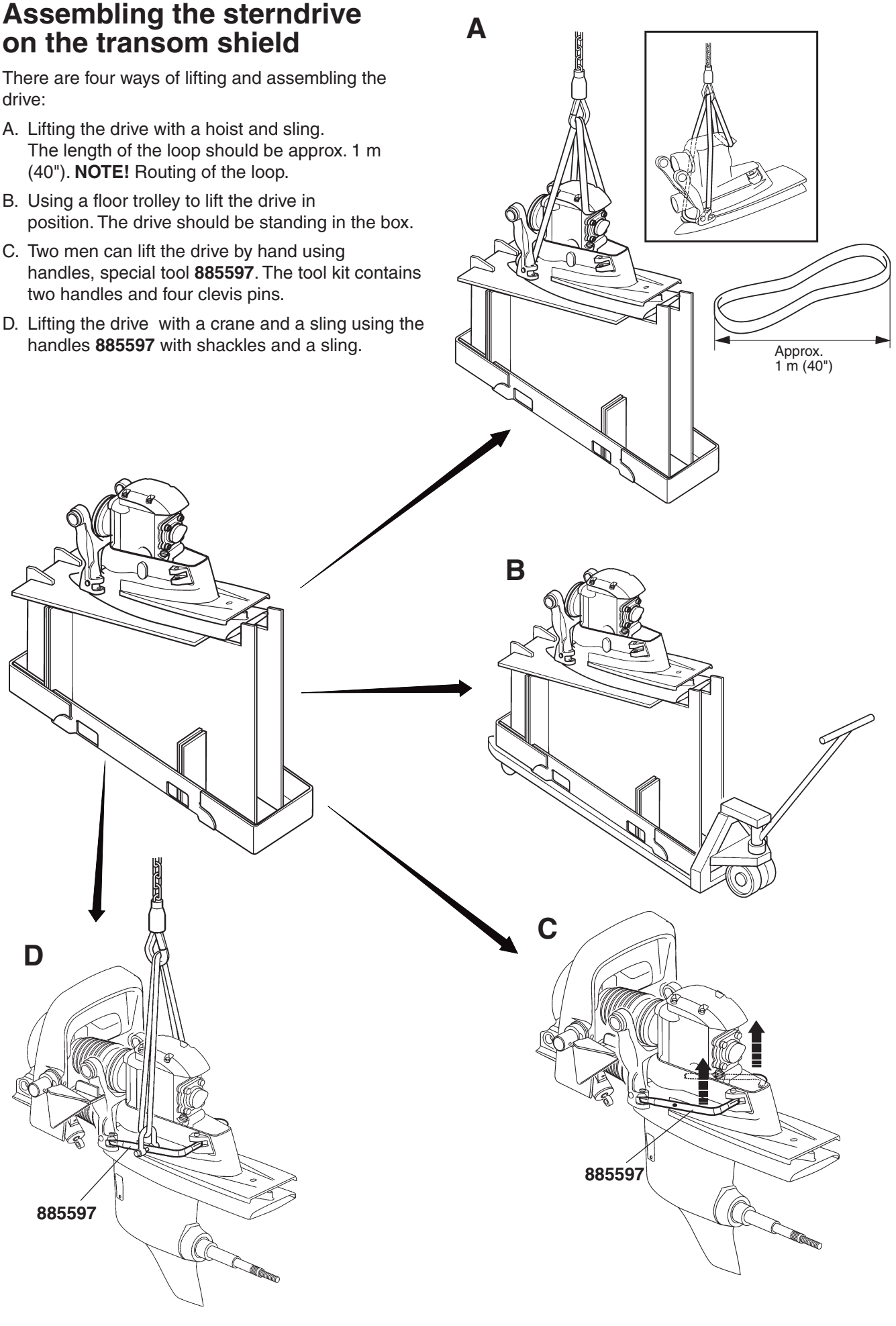
There are four ways of lifting and assembling the drive:

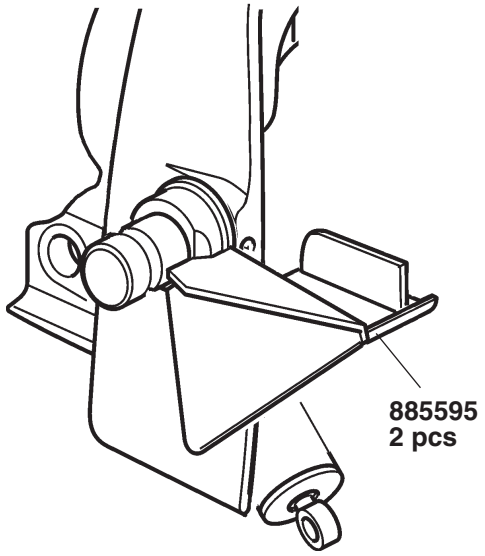
A. Lifting the drive with a hoist and sling. The length of the loop should be approx. 1 m (40"). **NOTE!** Routing of the loop.

B. Using a floor trolley to lift the drive in position. The drive should be standing in the box.

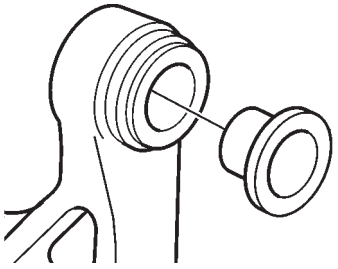
C. Two men can lift the drive by hand using handles, special tool **885597**. The tool kit contains two handles and four clevis pins.

D. Lifting the drive with a crane and a sling using the handles **885597** with shackles and a sling.



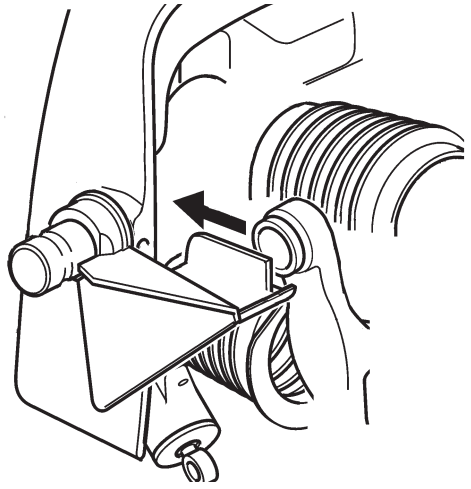


1. Attach the pivot sliding shelves, special tool 885595, on each side of the transom using the pivot pins.

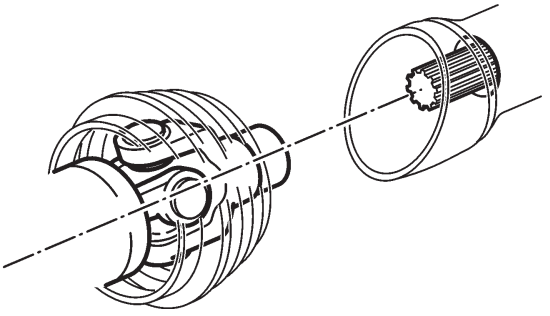


2. Install bushings in the suspension yoke.

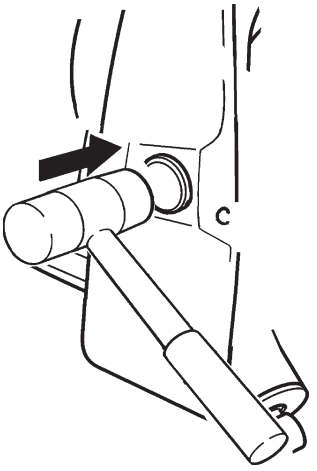
3. Hang a hose clamp onto the bellows.



4. Lift the sterndrive onto the pivot sliding shelves attached to the transom shield.



5. Push the sterndrive forwards against the drive shaft and at the same time turn the Universal joint to allow the splines of the drive shaft to enter the corresponding recess in the Universal joint. A small guiding recess in the Universal joint facilitates finding the correct position.

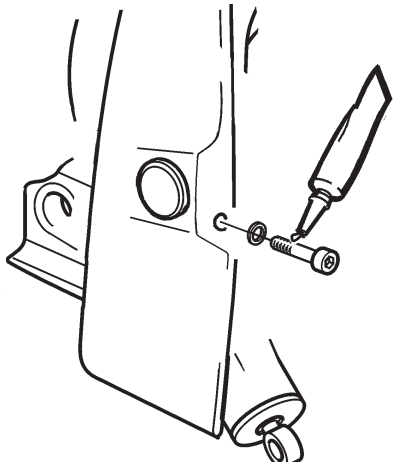


6. Align the suspension yoke so that the pivot pins line up with the holes in the suspension yoke.

Make sure the pivot pins are well greased. Use a plastic faced mallet and tap the pins into their position, ends flush with the transom shield.

NOTE! Never use an ordinary hammer. This could damage the pivot pins and make them difficult to remove.

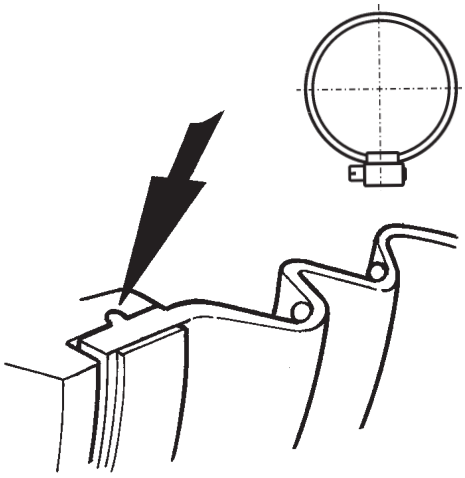
Remove the pivot sliding shelf.



7. Grease the locking screws and install them. Use Volvo Penta water resistant grease, part no. 828250

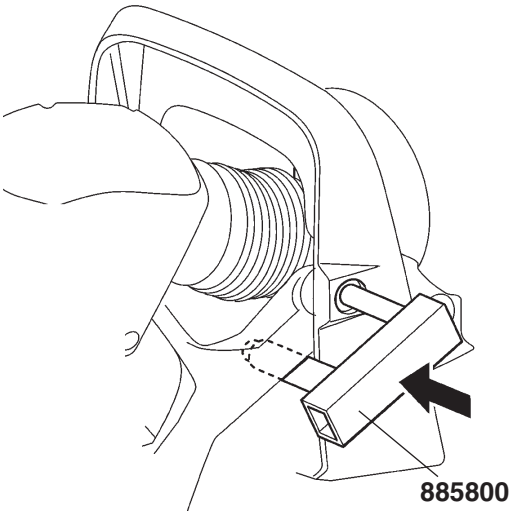
NOTE! Do not forget the washers underneath the screw heads.

Tightening torque: **24 Nm (17 lbf.ft)**.



8. Install the Universal joint bellows on the neck of the flywheel housing. Carefully check that the rubber bellows has been correctly installed.

Tighten the hose clamp with the screw in the **6 o'clock** position. Screw head facing to starboard.



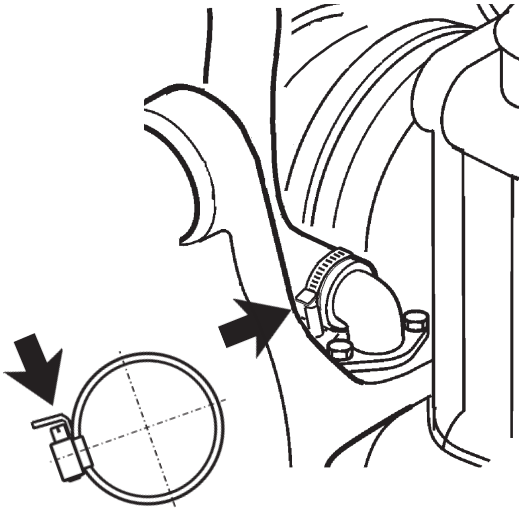
9. **NOTE!** When working under the sterndrive, always use the suspension tool, special tool **885800**.

The suspension tool locks the sterndrive in its raised position.

Install the suspension tool as follows:

Lift the sterndrive by hand. Hold the sterndrive in this position and install the suspension tool on the starboard side in accordance with the picture.

⚠ **WARNING!** Do not overload the suspension tool by **standing** on the raised sterndrive for example! Make sure that the tool is correctly installed, so that the drive cannot fall down and cause personal injury.



10. Turn the drive to starboard. Put a hose clamp on the seawater inlet hose.

Attach the hose to the hose nipple. Note that the clamp screw is in the **8 o'clock** position, screw head facing upwards.

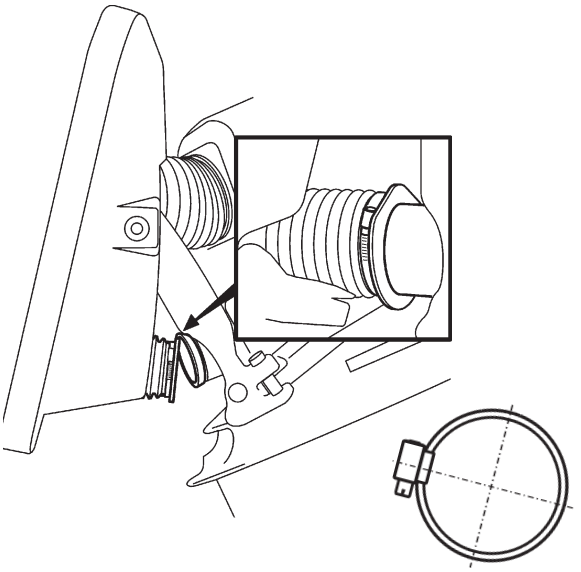
⚠ **IMPORTANT!** Bend the end of clamp to protect the bellows according to figure.

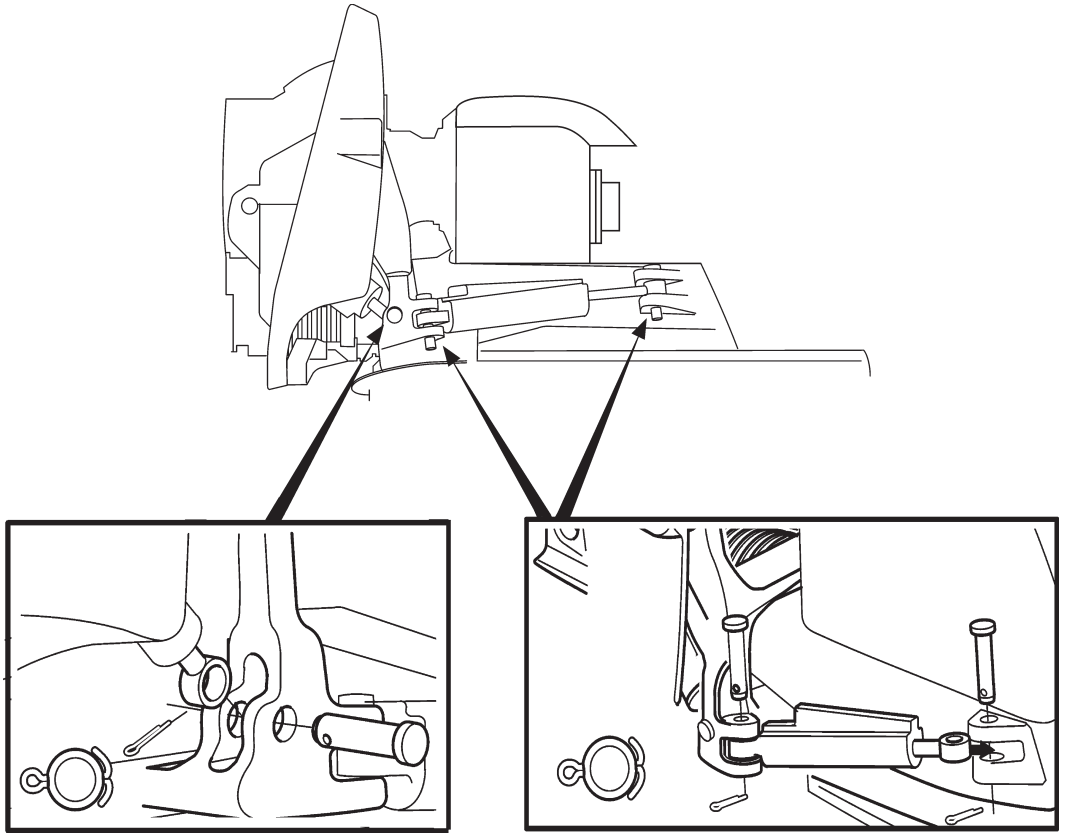
11. Install the exhaust bellows with a hose clamp on the drive. Carefully check that the bellows have been correctly installed.

The exhaust bellows are factory fitted to the shield.

Tighten the hose clamp with the clamp screw in position **10 o'clock** and the screw head facing down.

Remove suspension tool 3588771 from drive.

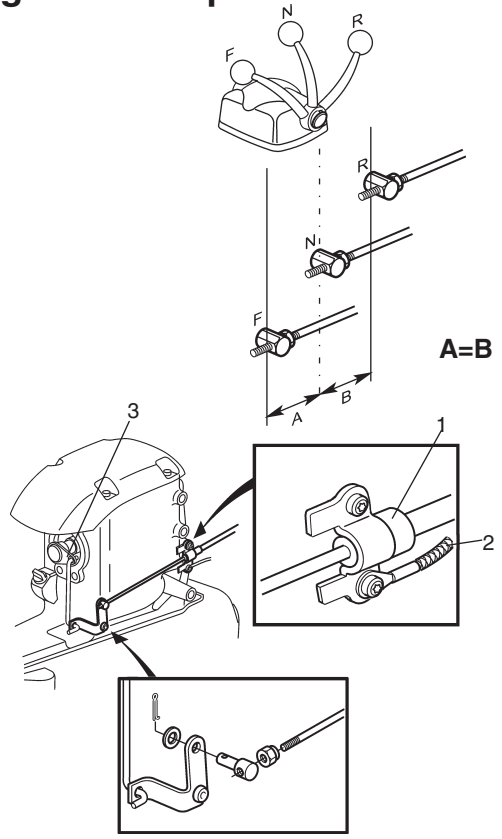




12. Fit the trim cylinders in the suspension yoke. Grease the clevis pins. Center the holes and install the pins. Lock the pins with cotter pins and carefully bend the cotter pin legs as shown in the figure.

13. Install the steering cylinders in the suspension yoke and on the drive. Grease the clevis pins. Center the holes and install the pins. Lock the pins with cotter pins and carefully bend the cotter pin legs as shown in the figure.

Connection of shift cable and ground strap



⚠ **IMPORTANT!** Do not forget to power up the EVC system before attaching the shift cable to the drive. This is done to ensure that the actuator is precisely in the neutral N position.

14. Fit the shift cable casing using the cable clamp (1).

NOTE! The clamp can be attached in only one way.

Adjust the shift cable.

Position the control lever in neutral and the shift lever on the sterndrive(3) in a horizontal position.

Any clearance in the shift cable must be checked and adjusted as follows:

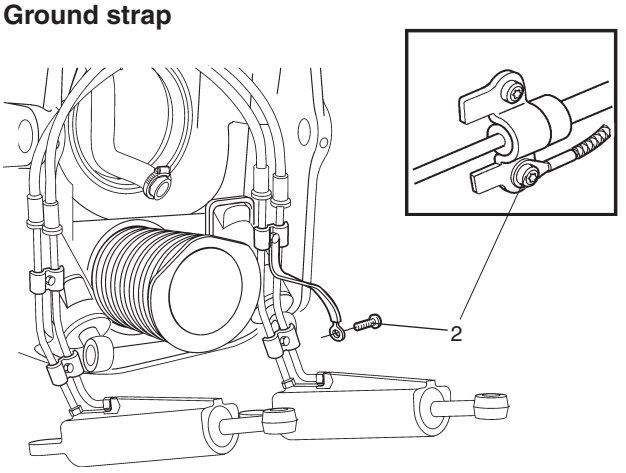
Push the shift cable in as much as possible and then pull it out as much as possible.

Push the shift cable in again, a distance equal to half the travel.

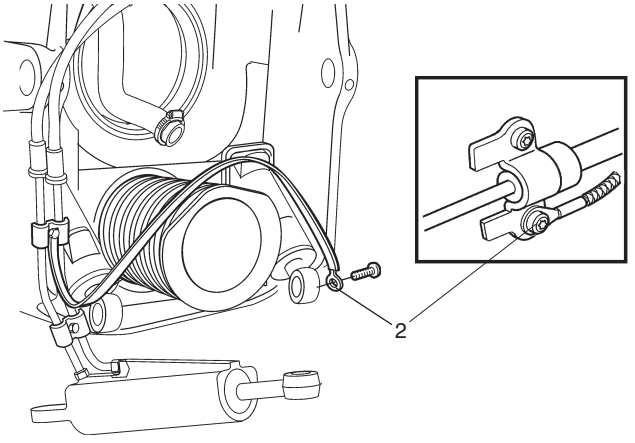
Install the locking nut and the swivel on the shift cable, at a position on the cable which allows the swivel to be attached to the shift lever without bending or seizing with the shift cable in position.

Attach the swivel to the shift lever using the washer and the cotter pin. Bend the cotter pin correctly.

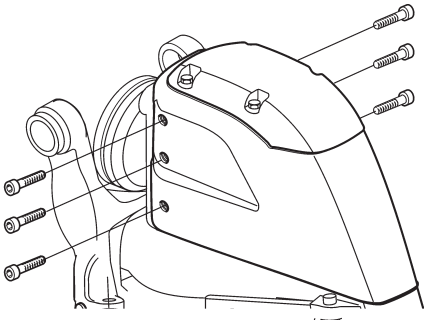
Ground strap



Ground strap, twin installation port side



15. **NOTE**! Also fit the ground (earth) strap (2) using one of the clamp screws. In a twin installation the port drive ground strap should be routed above the exhaust bellows.



16. Fit the cover with the six screws.

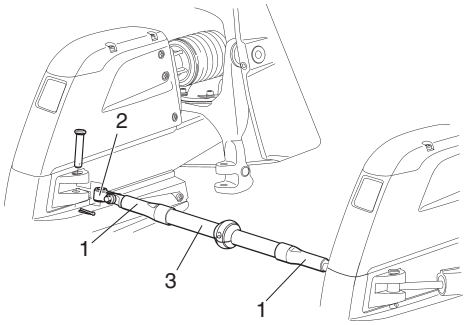
Tie bar installation

In a twin installation, an external tie bar must be fitted between the drives. Volvo Penta offers two types of tie bar, mechanical and hydraulic.

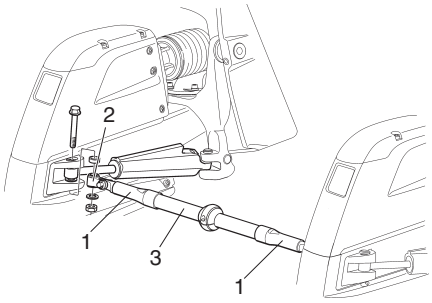
Mechanical tie bar

The mechanical tie bar can be adjusted for an engine crankshaft centerline distance of 800–1000 mm (31.5 – 39.5")

DPH



DPR



1. Put both drives in the straight forward position. Loosen the sleeves (1) on the tie bar and tighten both the end fittings (2) into the tie bar as far as possible.

2 - **DPH only**. Apply grease, Volvo Penta part no. 828250 on the pins. Put one end of the tie bar into the steering cylinder socket on one of the drives. Install the clevis pin and lock it with a cotter pin. Bend the cotter pin carefully.

NOTE! Clevis pins and cotter pins are delivered with the drive. Adjust the length of the tie bar by turning the middle section (3) while keeping the free end in a fix position.

2 - **DPR only**. Put one end of the tie bar under the steering cylinder socket on one of the drives. Install the bolt and washers and lock it with a nut.

NOTE! Adjust the length of the tie bar by turning the middle section (3) while keeping the free end in a fix position.

3. Adjust the length of the tie bar until the end fitting ends up in a correct position relative the steering cylinder socket on the other drive.

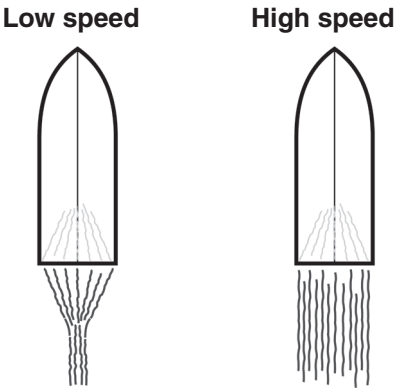
Install clevis pin and cotter pin. Bend the cotter pin carefully.

Check the "toe-in" angle.

Also please refer to the **Installation instructions** included in the tie bar kit.

"Toe-in" angle

In order to obtain good tracking and speed characteristics, the "toe in" angle is adjusted in twin installations. Adjust the tie bar to set the sterndrives up in the positions indicated in the figure "toe-in angle".



As the waterflow after the transom is different depending on hull design and boat speed, the toe-in setting can be adjusted to optimise for top speed or cruising speed. To select the best toe-in, each new boat design needs to be tested with different settings by the boat manufacturer.

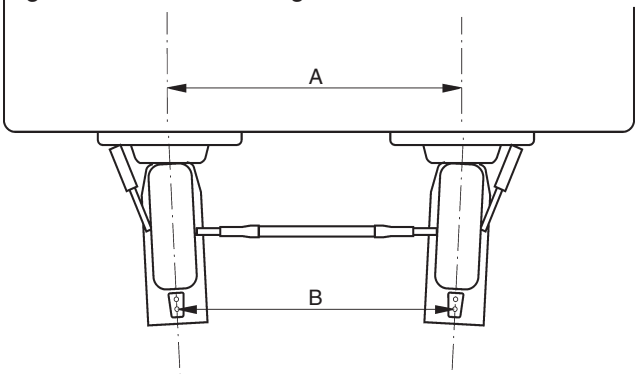
- Deeper V on a hull, less toe-in (Drives positioned straighter).
- High speed, less toe-in (Drives positioned straighter).

Standard recommendation:

For most planing boat models (30 - 40 knots), the following toe-in will give good results, however best setting can only be found by testing.

Adjust until B (measured at rear anode screw) equals **A minus 5 mm (0.2")**.

Figure shows "toe in" angle:



4. Lock the tie bar by tightening the two sleeves.

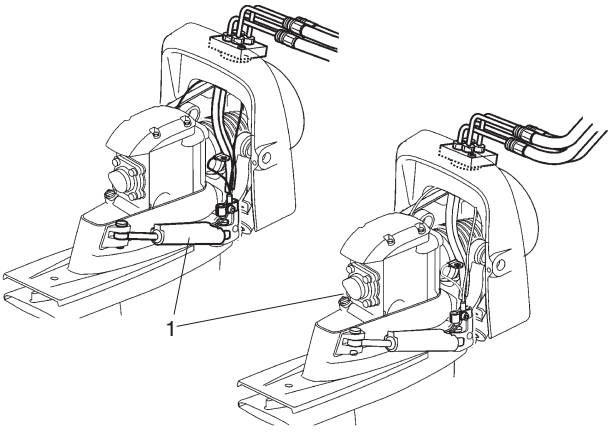
⚠ **WARNING**! Before tightening the sleeves, check that no threads are visible outside the sleeves (1).

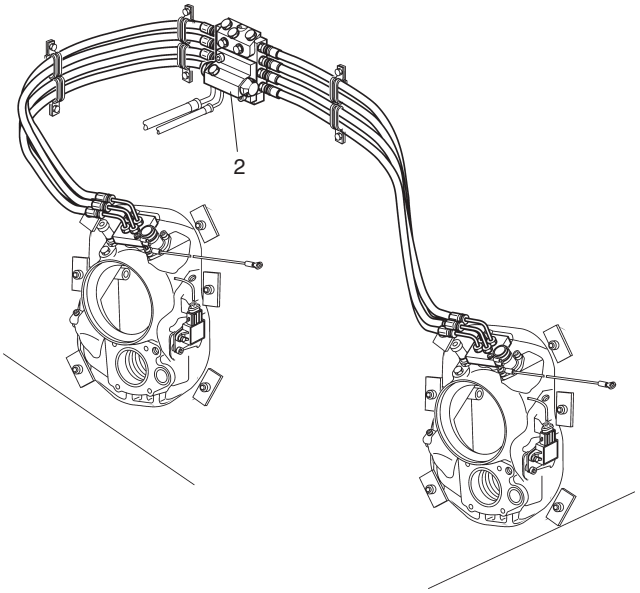
Tighten the sleeves.

Tightening torque: **125±5 Nm (92.1±4 lb ft)**.

Hydraulic tie bar (DPH only)

In the hydraulic tie bar concept hydraulic cylinders (the inner "steering cylinders") (1) are mounted on each drive and hydraulically connected through the valve house (2).





Installation and purging instructions, please refer to the ***Installation instructions*** included in the hydraulic tie bar kit.

Rudder indicator and autopilot interface

NOTE! Rudder indicator cable should always be mounted on starboard side of single/starboard drive.

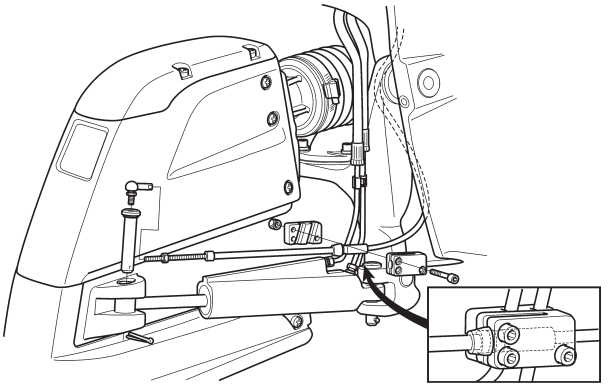
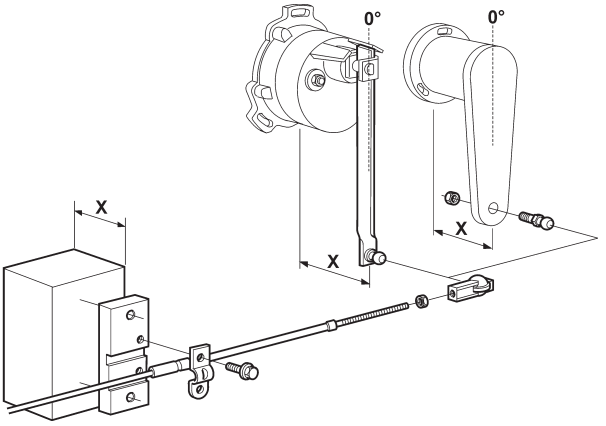


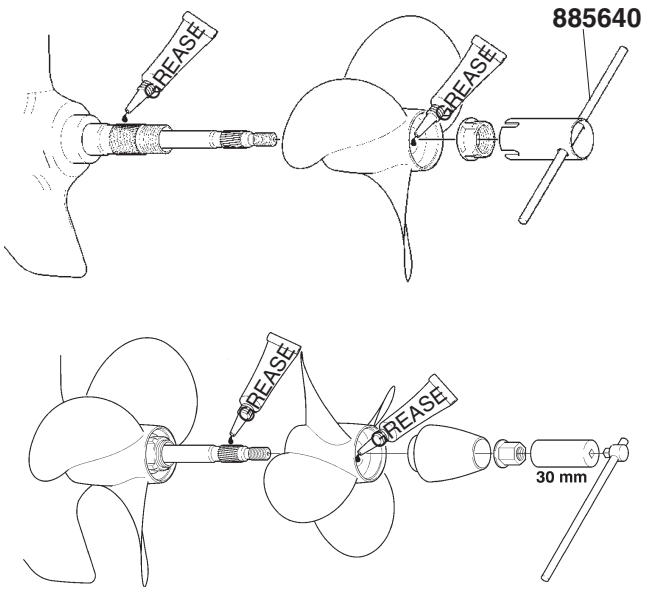
Figure shows the rudder indicator push-pull cable mounted on the drive steering cylinder.



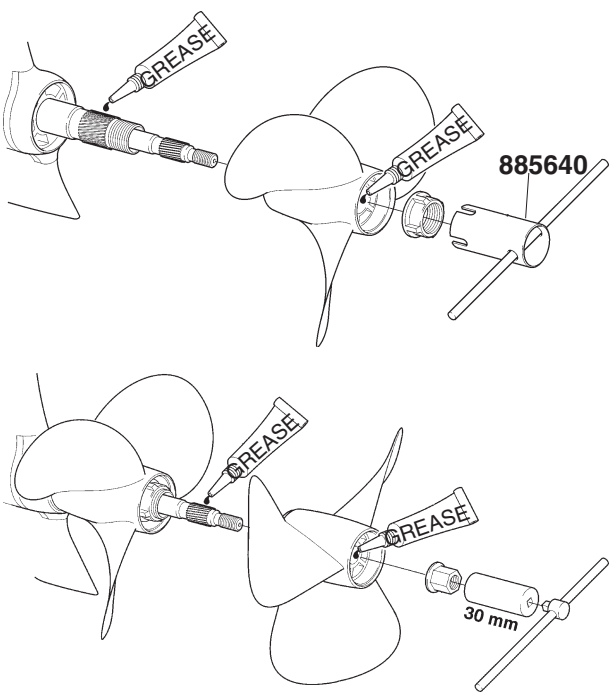
Connection of the cable to a rudder indicator/autopilot interface.

Propeller installation

DPH



DPR



Install the propellers as follows:

1. Grease the propeller shaft using Volvo Penta water resistant grease, part no. 828250 and fit the inner propeller.

2. Lock the propeller shaft. This can be done in two ways:
a) Disconnect the shift cable from the drive. Put the drive in gear by hand.

⚠ **IMPORTANT!** Never use the EVC controls to put the drive in gear.

b) Gear in **"NEUTRAL"**. Place a wooden piece between the cavitation plate and one of the propeller blade.

3. Tighten the nut using special tool **885640**. Tightening torque: **Tighten hard**.

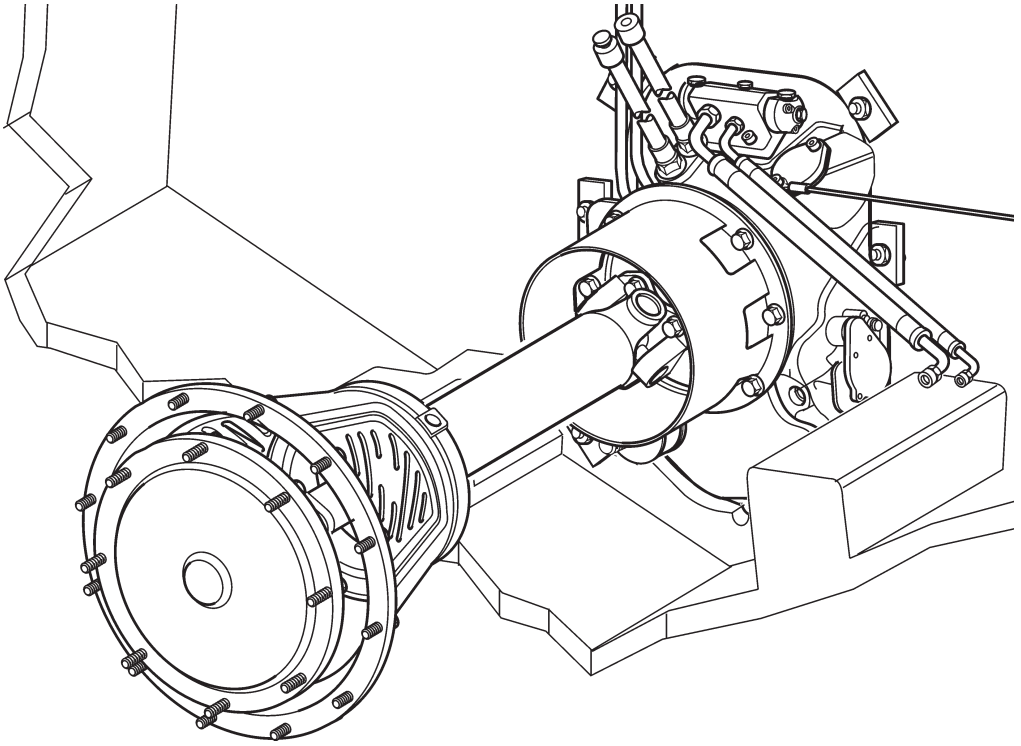
4. Then install the outer propeller. Propeller shaft should be locked according to point 2a or 2b.
DPH only: Place the propeller cone on the shaft. (DPR has no propeller cone).

Fit and tighten the nut using a 30 mm socket wrech.

Tightening torque: **Tighten hard**.

5. Set the gear in position **"NEUTRAL"** prior to starting the engine.

Aquamatic applications
Jack shaft installation



General

In some installations, you might want to move the engine forwards in the boat while retaining the benefits of a sterndrive. Two reasons might be to keep the aft deck flat, to be utilized for sports fishing etc. or to move the center of gravity forwards.

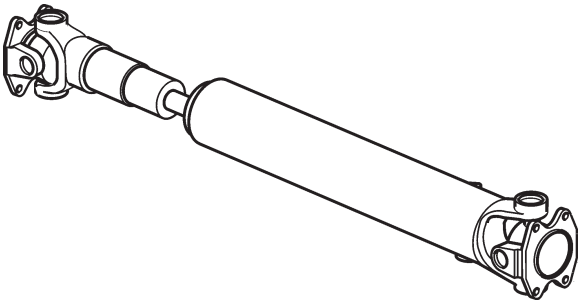
A jack shaft may be used between the sterndrive and engine to achieve this.

When starting a jack shaft installation, the engine and transom must be in place and the boat removed from water.

⚠ **WARNING**! Working on or near a jack shaft when the engine is running is extremely dangerous and should be avoided. You can snag clothes, skin, hair, hands etc. This can cause serious injury.

Shut off engine before working on the jack shaft. Do not run engine with the guard removed.

Jack shaft selection



A SAE 1410 series cardan shaft shall be used. The shaft must have a tube outer diameter of 88.9 mm (3.5") and a wall thickness of minimum 2.1 mm (0.08").

Recommended maximum length from flange to flange is 1600 mm (63.0").

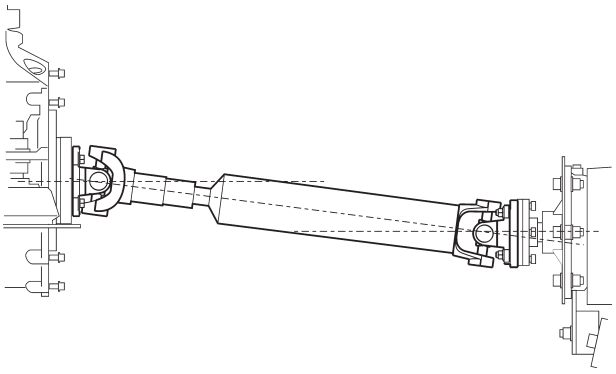
This gives a maximum distance of 1888 mm (74.3") from the flywheel housing plane on the engine to the intersection of the crank shaft axis and the outer surface of transom.

If the engine needs to be mounted further forward than recommended above, a two-piece cardan shaft with a center support bearing is required. These two-piece shafts are not supplied by Volvo Penta.

Alignment

The engine flywheel flange must be aligned with the intermediate bearing housing connection flange on the shield. This can be done using a laser alignment tool kit **3863099**.

Universal joint operating angles



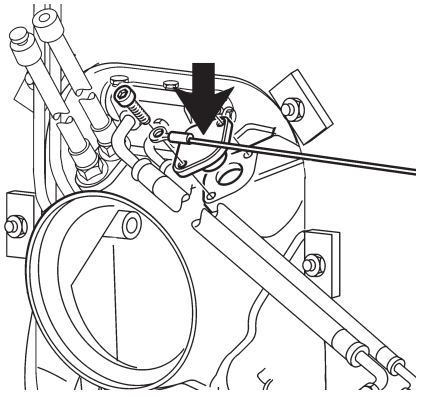
When installing a jack shaft, follow the basic rules that apply to universal joint angles:

- Universal joint operating angles on each end of the drive shaft should always be equal within one degree of each other.
- Universal joint operating angles should not be larger than 3 degrees. For larger operating angles, please refer to the ***Installation Instructions*** included in the jack shaft kit.

Cooling system

Water block-off kit (optional)

The water block-off kit is utilized when a through-hull seawater intake is used instead of leading water through the sterndrive.



The block-off cover replaces the water intake pipe and hose supplied with the transom shield as standard.

Through-hull seawater intake

Hose diameters:

D4 38 mm (1½")
D6 50 mm (2")

Taking seawater through the drive

If preferred, the cooling water can be taken through the drive. Hoses and tubes are included in the kit, but in some cases additional hoses have to be supplied by the boat builder.

⚠ **IMPORTANT**! The hose used should be a reinforced marine wet exhaust type hose able to withstand temperatures up to 100°C and vacuum down to –50 kPa. Also complying with ISO 13363.2 or SAE J200R2 DN.

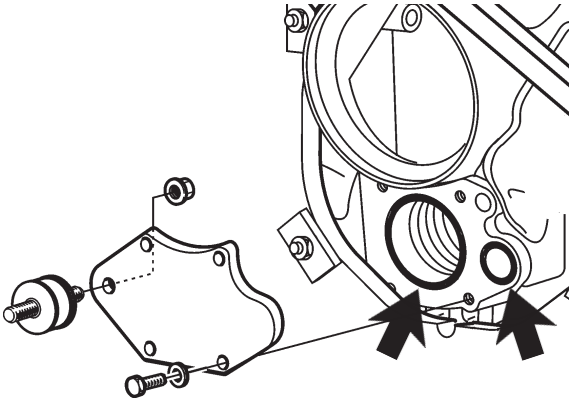
For further descriptions, please refer to the ***Installation Instructions*** included in the jack shaft kit.

Exhaust system

Install the exhaust block-off kit

No option is available for directing the engine exhaust through this product if there is a jack shaft installation.

Please refer to the chapter ***Inboard Applications, Exhaust System***.



Before installing the exhaust block-off kit, ensure that the exhaust and water seal O-rings on the transom shield are in place and not damaged.

Volvo Penta IPS applications
General

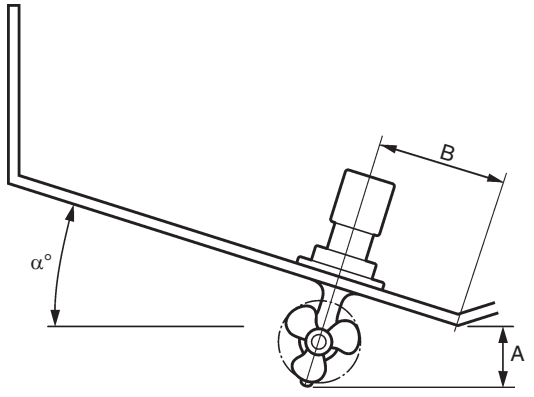
Boats suitable for Volvo Penta IPS

- Monohulls, V-shaped with a deadrise of 5°–24°
- Planing hulls
- Boat length 35–50 feet
- No keel
- The area around the Volvo Penta IPS propulsion unit needs to be flat and free from steps etc. Perpendicular installation.
- Top speed of a suitable boat is 25–45 knots.
- For larger boats with triple or quadruple engine installations, contact your Volvo Penta representative.

Installation advantages

- One supplier
- Less engine room space, more space for accomodation
- Faster to install
- No propeller shaft line up is needed
- Integrated seawater pickup
- Integrated exhaust system
- Integrated steering system
- Rudder indicator integrated in the system
- Part of system integrated
- Less components to handle in plant

Boat transportation



The measurement (A) is to be considered when transporting a complete hull. Measurement varies, depending on dead rise angle (α°).

A - Distance from boat bottom to lowest point on Propulsion unit.

B - Distance from keel line to centerline of propulsion unit measured along boat bottom

NOTE! To facilitate transportation, the emergency steering tool may be used to adjust angle of drives

NOTE! The Volvo Penta IPS propulsion unit may also be removed for transportation. Please note that calibration is required after re-installation.

Template used

α° deadrise	A mm (")	B mm (")
5	524 (20.6)	680 (26.8)
6	511 (20.1)	680 (26.8)
7	498 (19.6)	680 (26.8)
8	485 (19.1)	680 (26.8)
9	472 (18.6)	680 (26.8)
10	458 (18.0)	680 (26.8)
11	445 (17.5)	680 (26.8)
12	431 (17.0)	680 (26.8)
13	417 (16.4)	680 (26.8)
14	404 (15.4)	680 (26.8)
15	390 (15.8)	680 (26.8)
16	375 (14.8)	680 (26.8)
17	361 (14.2)	680 (26.8)
18	347 (13.7)	680 (26.8)
19	332 (13.1)	680 (26.8)
20	318 (12.5)	680 (26.8)

Constant cc-measurement of 1100 mm (26.8")

α° deadrise	A mm (")	B mm (")
5	532 (20.9)	582 (22.9)
6	521 (20.5)	589 (23.2)
7	508 (20.0)	596 (23.5)
8	496 (19.5)	603 (23.7)
9	483 (19.0)	611 (24.1)
10	469 (18.5)	618 (24.3)
11	455 (17.9)	626 (24.6)
12	441 (17.4)	635 (25.0)
13	426 (16.8)	643 (25.3)
14	410 (16.1)	652 (25.7)
15	395 (15.6)	661 (26.0)
16	378 (14.9)	670 (26.4)
17	362 (14.3)	679 (26.7)
18	344 (13.5)	689 (27.1)
19	326 (12.8)	699 (27.5)
20	308 (12.1)	709 (27.9)
21	289 (11.4)	720 (28.3)
22	270 (10.6)	731 (28.8)
23	250 (9.8)	742 (29.2)
24	229 (9.0)	753 (29.6)

Volvo Penta IPS applications
Accessibility

Accessibility for maintenance and repairs

When you design the engine installation, always pay attention to the access needed for correct engine service. Also ensure that the complete engine can be removed without damage to the boat structure.

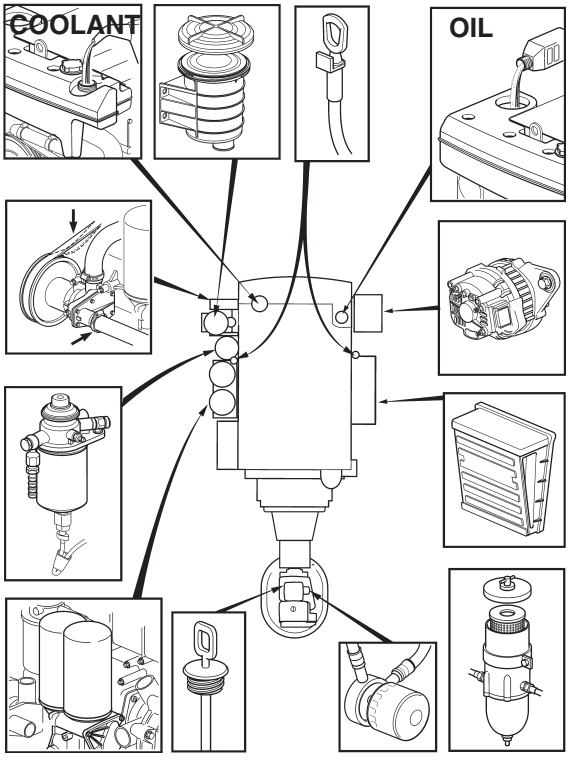
NOTE! There must also be sufficient space for the sound proofing material. The recommended minimum distance from sound proofing materials is 180 mm (7") and 200 mm (8") please refer to fig.

Study the installation drawing of the relevant engine carefully.

Accessibility for maintenance

Areas that normally require access for maintenance:

- Oil change and refill (engine, power steering and power trim)
- Changing filters, (oil, fuel, air, & crankcase vent.)
- Change/Adjust drive belts and belt tension
- Removing the valve cover
- Changing the impeller, seawater pump
- Cleaning the water filter



Accessibility for repairs

Areas that may require access for repairs:

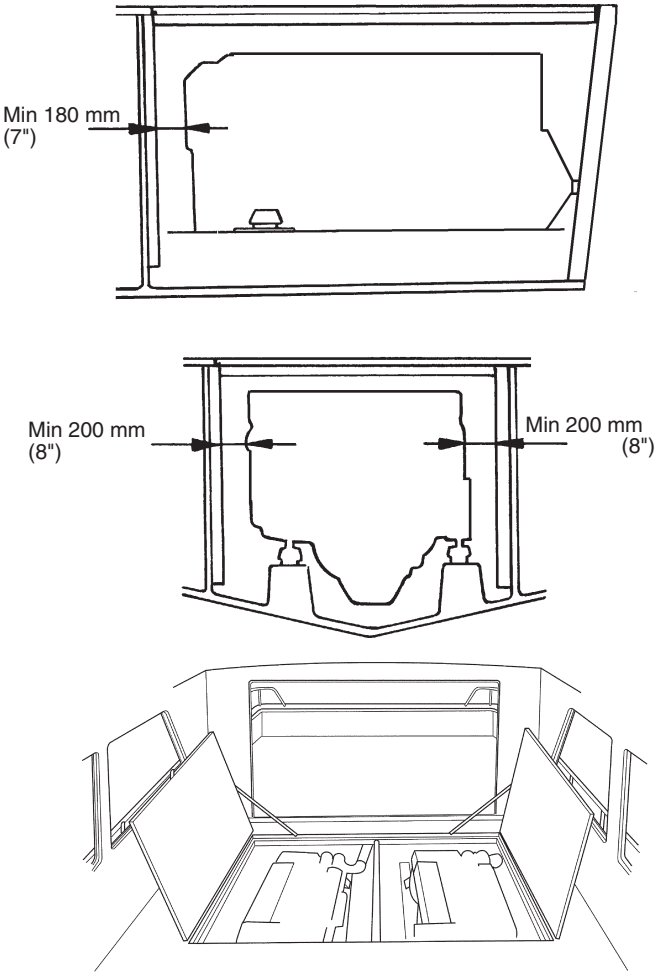
- Removal of injectors, cyl. head, coolers, etc.
- Removal or replacement of electrical components
- Removing the flywheel and vibration damper
- Removing or changing steering equipment
- Engine removal

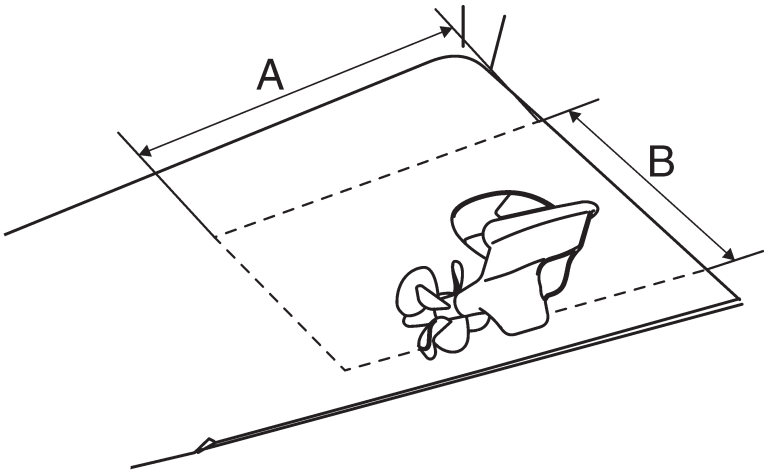
Removal of complete engine package

If the entire engine package needs to be removed, it is the installers (boat builders) responsibility to provide reasonable methods of removal and re-installation. This means, within reasonable time, with normal resources and methods available in the trade, to limit cost and downtime.

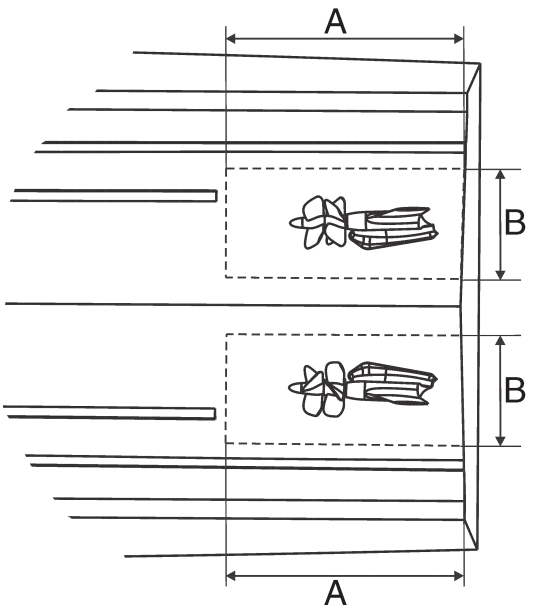
For the sake of high demands at high season on yards etc. the vessel manufacturers instruction should be followed.

It is the policy of Volvo Penta to avoid unresonable installations driving additional cost for the boat owners during the vessels service life.





Side view



Bottom view

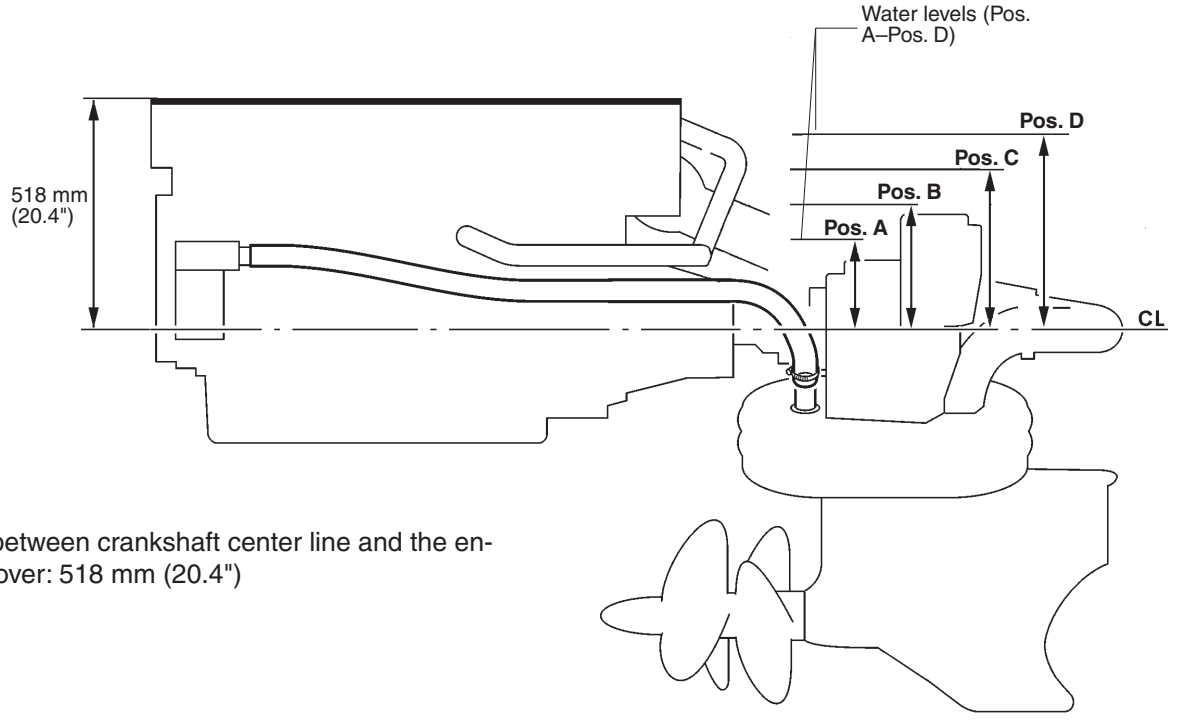
Dist A mm (inch) ..... min 2200 (87)
Dist B mm (inch) ..... min 640 (25)

NOTE! Make sure there is nothing in the near vicinity of the drives that can create turbulence in front of the propellers, i.e. no protruding objects should be located within the "dashed" area.

Refer to table for measurements A and B.

Volvo Penta IPS applications
Maximum water levels

Determine and check the water level in the design study



Distance between crankshaft center line and the engine top cover: 518 mm (20.4")

Water level distance at different load conditions, excluding and including an exhaust riser

Position	Load description	Water level above crankshaft center line (CL)
A No riser	Full fuel and water One crew No extra load	Maximum 173 mm (6.8")[1)]
B With riser	Full fuel and water One crew No extra load	Maximum 288 mm (11.3")[2)]
C No riser	To the approved CE regulation level *)	Maximum 283 mm (11.1")[1)]
D With riser	To the approved CE regulation level *)	Maximum 398 mm (15.7")[2)]

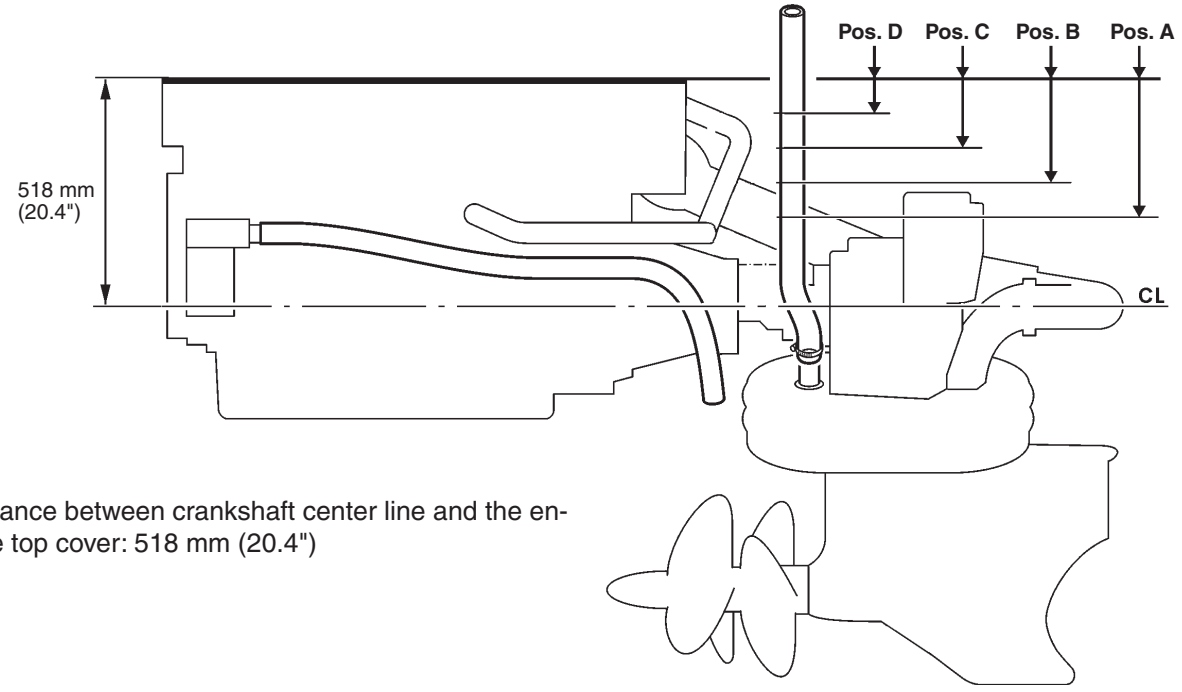
*) ⚠ **IMPORTANT!** Crew must be located astern and other weight positioned at the boat's center of gravity.

⚠ **IMPORTANT**! For each load case ensure that maximum water level is not exceeded regardless of weight distribution.

1) A riser is needed when max. measurement is more than 173 mm (6.8"), pos A and 283 mm (11.1"). pos C. The riser gives a 115 mm (4.5") lift at recommended 45° mounting angle.

2) If distance is more than 288 mm (11.3"), pos B and 398 mm (15.7"), pos D, redesign of engine installation or hull is necessary.

Checking water level when the boat is launched



Distance between crankshaft center line and the engine top cover: 518 mm (20.4")

Loosen water hose from the incoming water connection.
NOTE! The risk of water entrance. Have a transparent hose ready.

Attach the transparent hose to the connection.

Measure from engine top cover down to water level.

NOTE! The riser gives a 115 mm (4.5") lift at recommended 45° mounting angle.

Water level distance at different load conditions, excluding and including an exhaust riser

Position	Load description	Water level below engine top cover
A No riser	Full fuel and water One crew No extra load	Minimum 345 mm (13.5")[1)]
B With riser	Full fuel and water One crew No extra load	Minimum 230 mm (9.0")[2)]
C No riser	To the approved CE regulation level *)	Minimum 235 mm (9.3")[1)]
D With riser	To the approved CE regulation level *)	Minimum 120 mm (4.7")[2)]

*) ⚠ **IMPORTANT!** Crew must be located astern and other weight positioned at the boat's center of gravity.

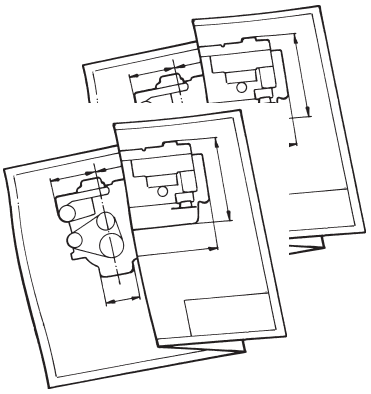
⚠ **IMPORTANT**! For each load case ensure that maximum water level is not exceeded regardless of weight distribution.

1) A riser is needed when min. measurement is less than 345mm (13.5"), pos A and 235 mm (9.3"). pos C. The riser gives a 115 mm (4.5") lift at recommended 45° mounting angle.

2) If distance is less than 230 mm (9.0"), pos B and 120 mm (4.7"), pos D, redesign of the engine installation or hull is necessary.

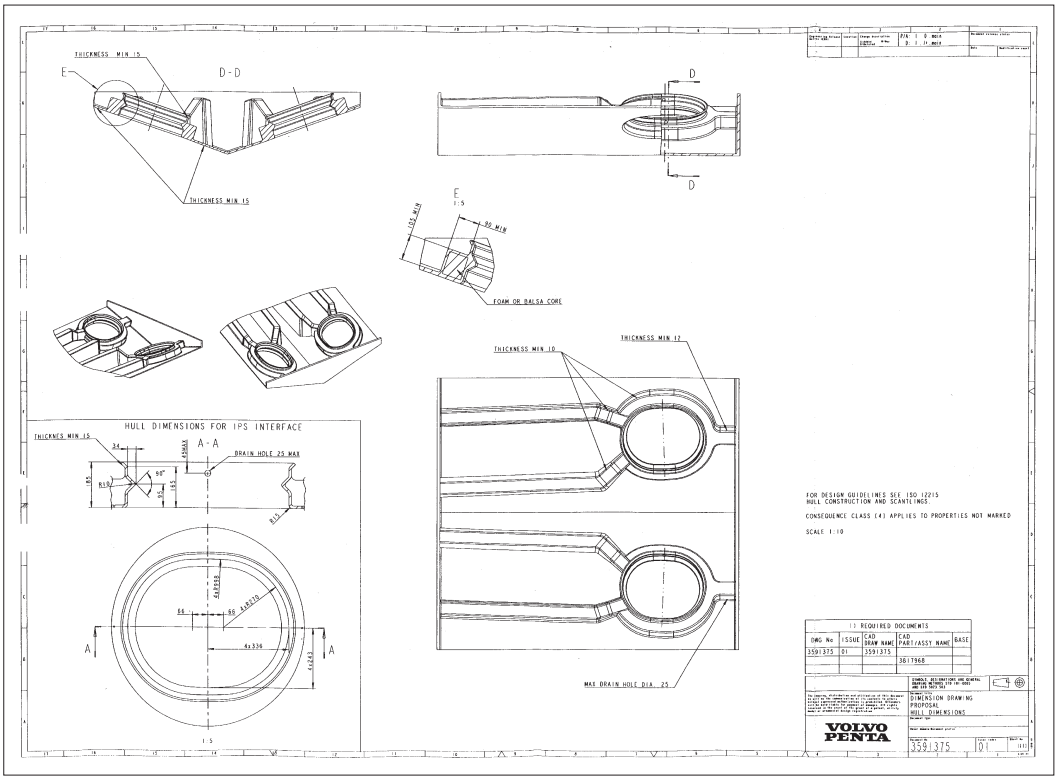
Volvo Penta IPS applications
Hull inserts and engine foundations

Hull mold integrated inserts



Hull mold plugs are recommended. However in some cases hull mold inserts may be required due to production circumstances.

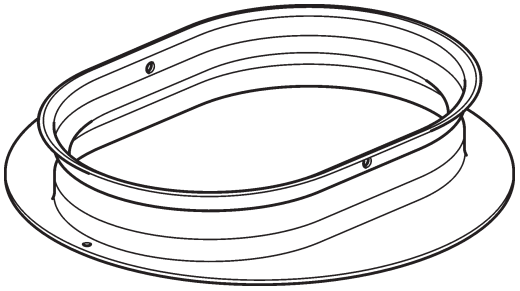
All necessary drawings for positioning and dimensioning the inserts, the reinforcements and the engine beds are supplied by Volvo Penta.



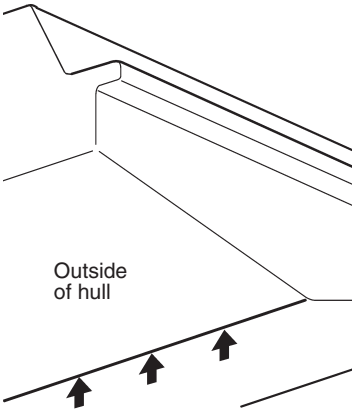
Use drawing no. 3591073 for dimension requirements. The drawing can be ordered from Volvo Penta.

For other design guidelines, please refer to **ISO12215 Hull constructions and scantlings**.

Pre-molded hull insert

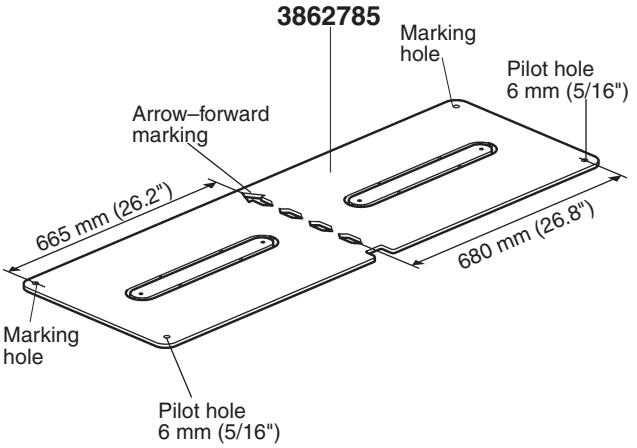


Pre-molded inserts are used for prototype, one-off or re-power installations. These inserts are not recommended for serial productuion.

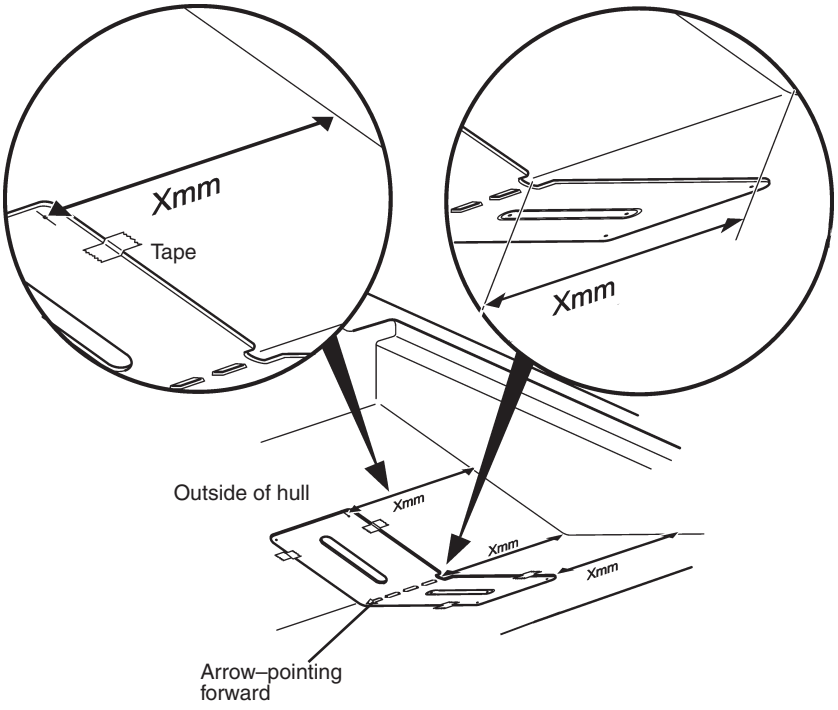


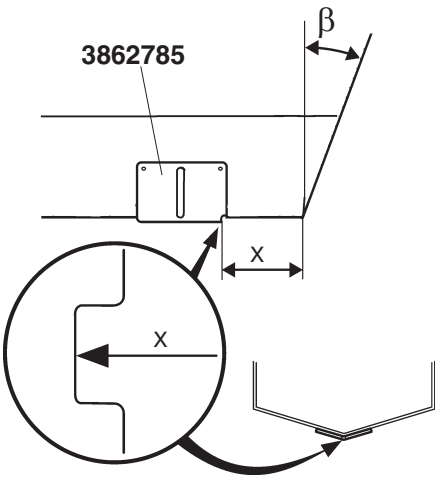
1. Start by marking up the keel line to get a distict reference line for positioning of the plastic template, special tool **3862785**.

Template, special tool 3862785



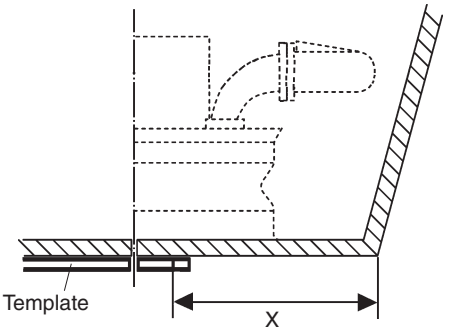
Positioning of template





Template position (X) at different transom angles

Angle (β)	Position X
0–5°	620 mm
6–10°	580 mm
11–15°	550 mm



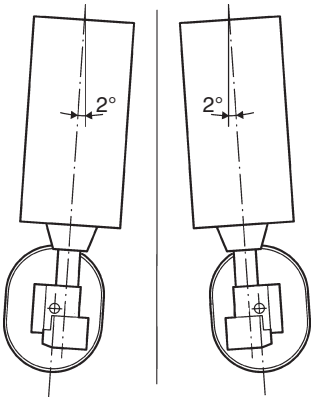
NOTE! All standard installations, drive shaft length 385 mm (15"), should be made with a driveline "toe-in" of 2°. (The driveline includes both engines and propulsion units.)

These installations give a maximum starboard and port steering angle.

In jack shaft installations, the drivelines are set parallel to the keel line.

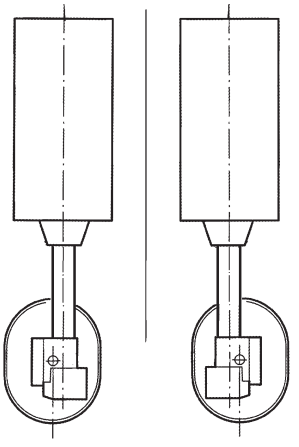
When template **3862785** is used, correctly positioned on the hull, this automatically gives a toe-in angle of 2°. When jack shaft drivelines are installed, the template has to be adjusted. Please refer to the next page.

Standard installation:



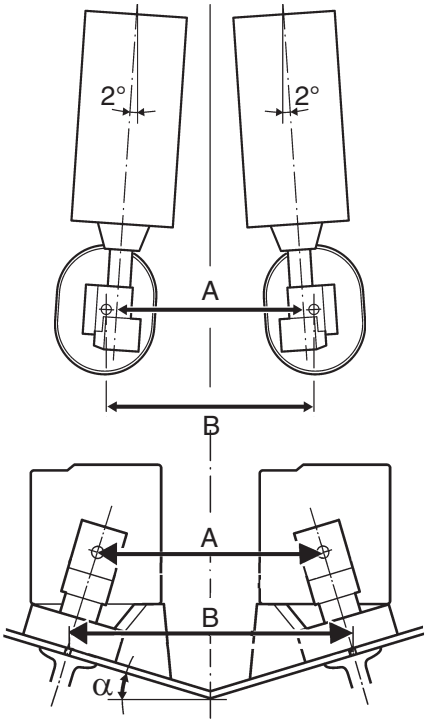
Standard installation, drive line "toe-in" = 2°

Jack shaft installation:



Jack shaft installation, drive lines in parallel

Distance between engines/Volvo Penta IPS propulsion units when using template 3862785



Distance (A) between crank shaft/propulsion unit center lines at different deadrise angles, when using the template.
Distance (B) between center of hull inserts at different deadrise angles.

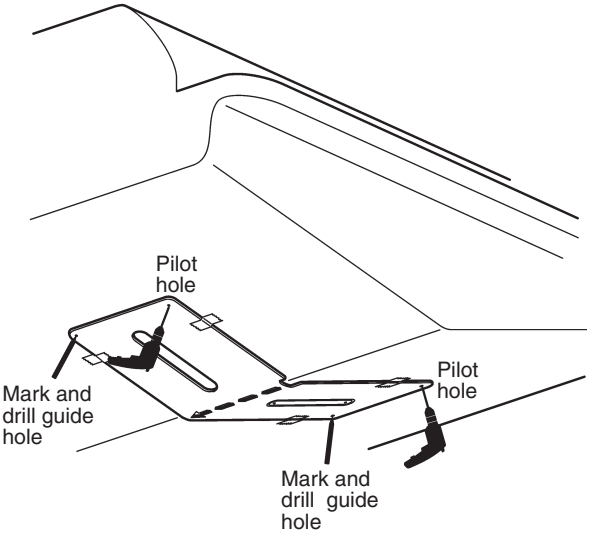
Deadrise (α)	Distance (A) mm (")	Distance (B) mm (")
5°	1295 (51.0)	1355 (53.3)
6°	1285 (50.6)	1355 (53.3)
7°	1270 (50.0)	1350 (53.1)
8°	1255 (49.4)	1350 (53.1)
9°	1240 (48.8)	1345 (53.0)
10°	1225 (48.2)	1340 (52.8)
11°	1205 (47.4)	1335 (52.6)
12°	1190 (46.9)	1330 (52.4)
13°	1175 (46.3)	1325 (52.2)
14°	1155 (45.5)	1320 (52.0)
15°	1140 (44.9)	1315 (51.8)
16°	1120 (44.0)	1310 (51.6)
17°	1100 (43.3)	1300 (51.2)
18°	1085 (42.6)	1295 (51.0)
19°	1064 (41.9)	1290 (50.8)
20°	1045 (41.1)	1280 (50.4)

NOTE!
Min. center distance (A): 1045 mm (41.1").
Min. center distance for Volvo Penta IPS 350 is 1030 mm (40.5").

Max. center distance (A) is only limited by the hull design.

If higher angles are needed do not use template. Measure according to minimum B-distance.

Standard installation:

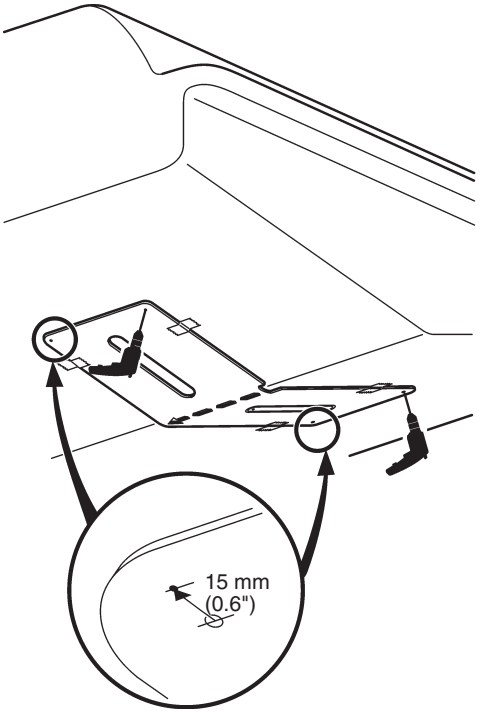


2. Drill two *pilot holes* 6 mm (1/4").

Mark and drill the two *guide holes*.

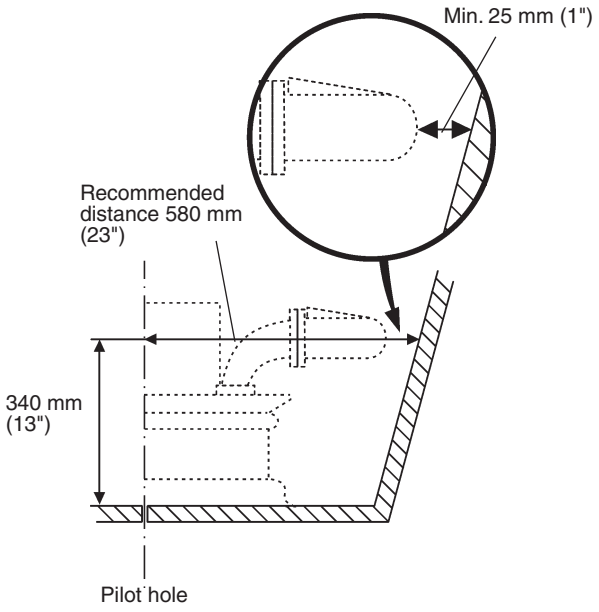
Use holes in template.

Jack shaft installation:



⚠ **IMPORTANT!** To set the drive lines parallel, move the marks 15 mm (0.6").

Check position to transom

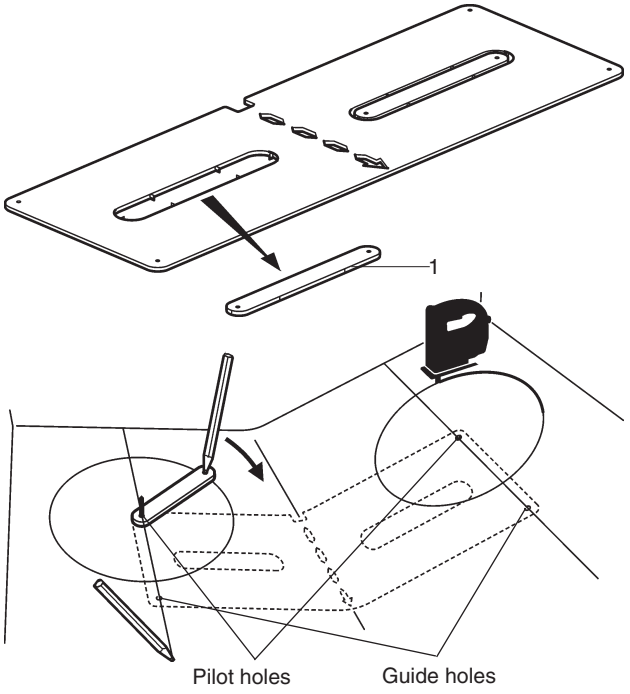


3. Measure the distance from the pilot hole (port and starboard) to the transom.

NOTE! Measure at a height of 340 mm (13").

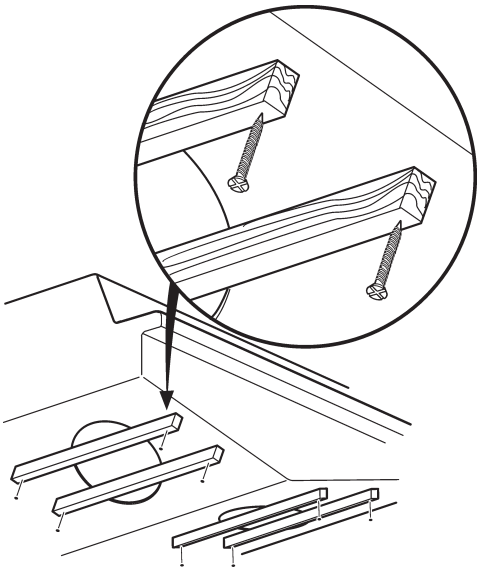
If the distance is less than 580 mm (23") it is recommended that the pilot holes and guide hole markings are moved forwards.

NOTE! Pay attention to reinforcements, bullkheads etc.

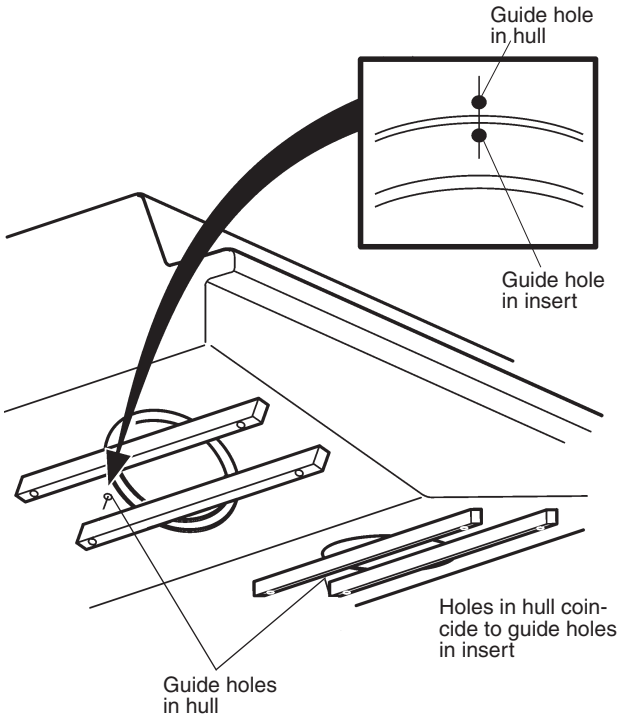


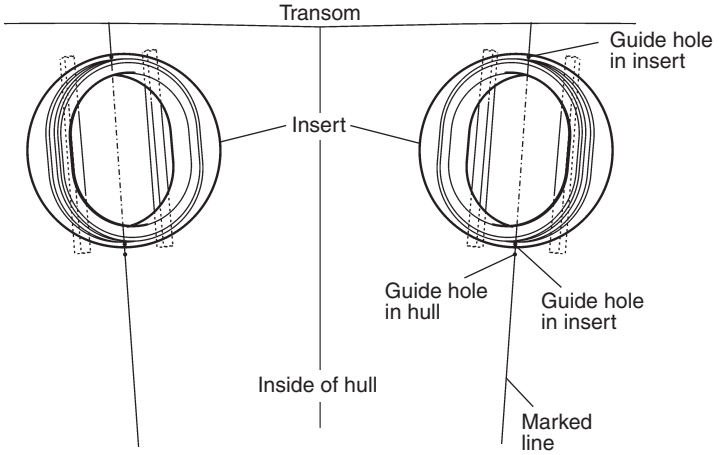
4. Cut out one of the compasses (1) from the template and use it to draw cutting-out circles from inside the hull. The pilot hole is used as the center of the circle.

NOTE! Mark a line from the guide hole through the pilot hole to the back of the transom. This line can be used for extra accuracy for insert alignment.



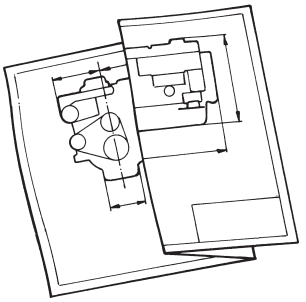
5. Fit temporary support beams from outside the hull.





Fiberglass and layer specifications

Please refer to the installation drawings regarding lamination and reinforcement for Volvo Penta IPS.



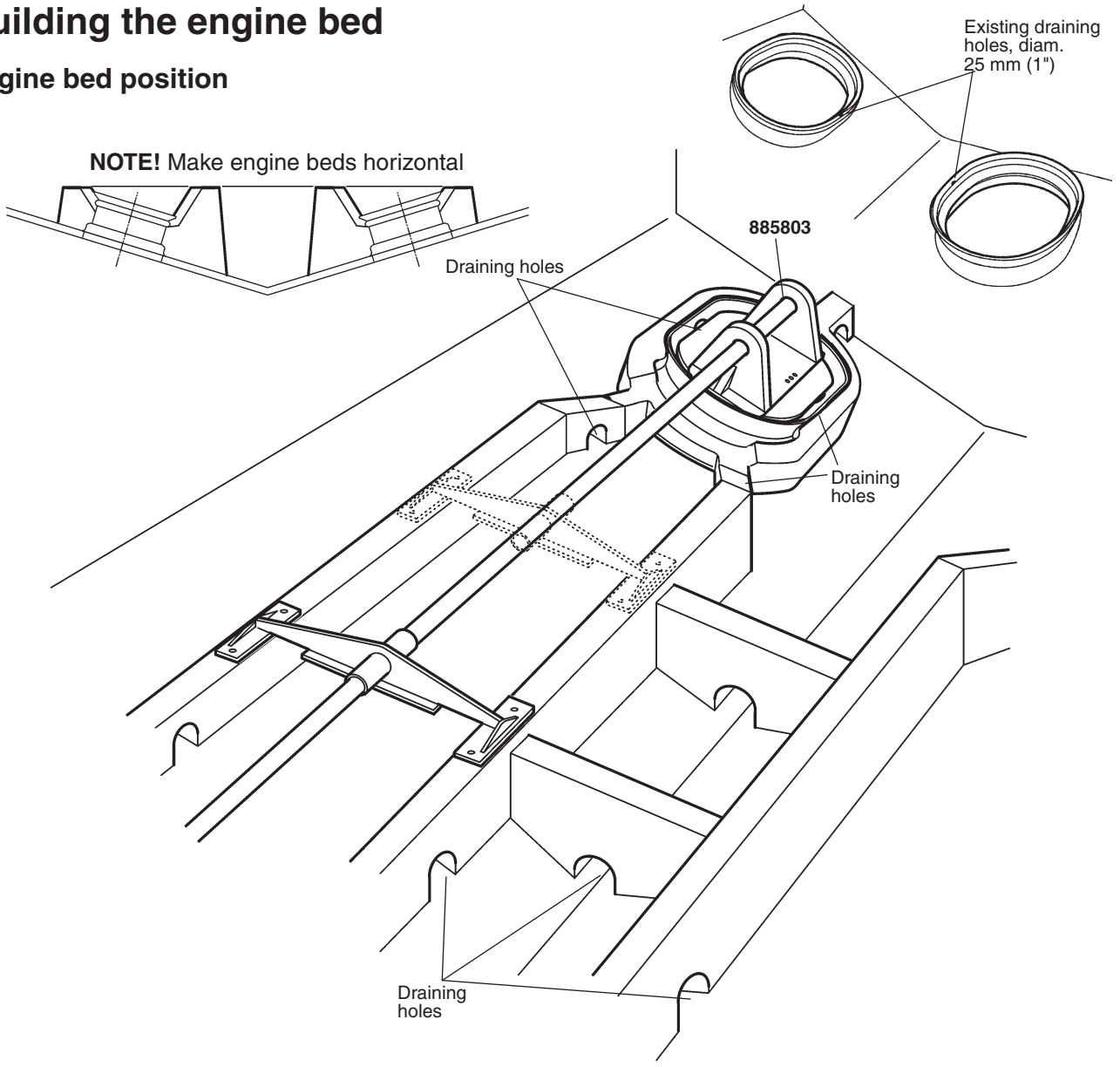
6. Place the inserts in the cutouts. Align them so that the guide holes in the insert coincides with the guide hole in the hull and the marked line.

Fix the insert to the hull temporarily, by using C-clamps or similar.

NOTE! Check that the inserts are correctly aligned against the hull.

Building the engine bed

Engine bed position



1. Use special tool **885803** to measure up the engine beds. The beds must be horizontal. Reinforcements must be made between the beds and from the insert beds to the transom. The beds shall end up against the insert beds by building stringers.

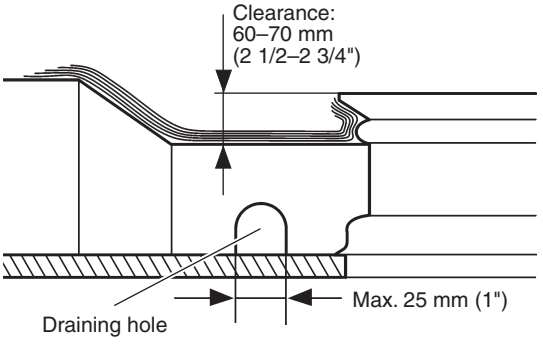
Draining holes shall be made according to figure, diameter approx. **25 mm (1").**

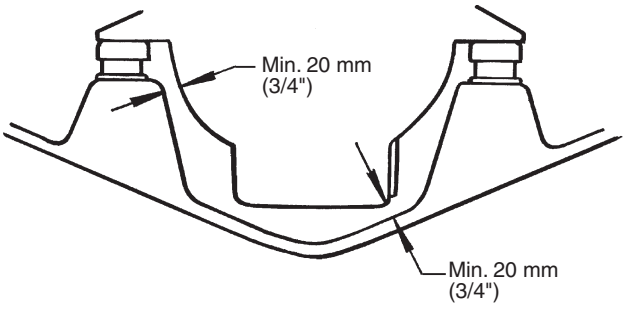
Keep the existing draining holes, 25 mm (1") in insert open.

Stringers between engine bed and insert:

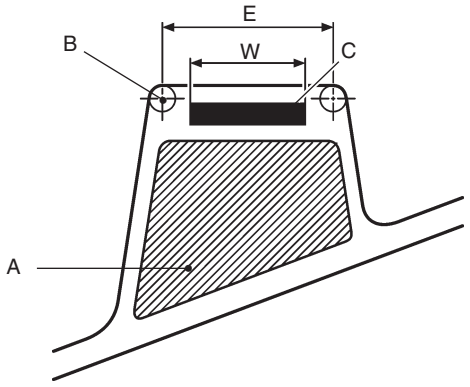
Clearance: 60-70 mm (2 1/2-2 3/4")

Width: 125 mm (5")





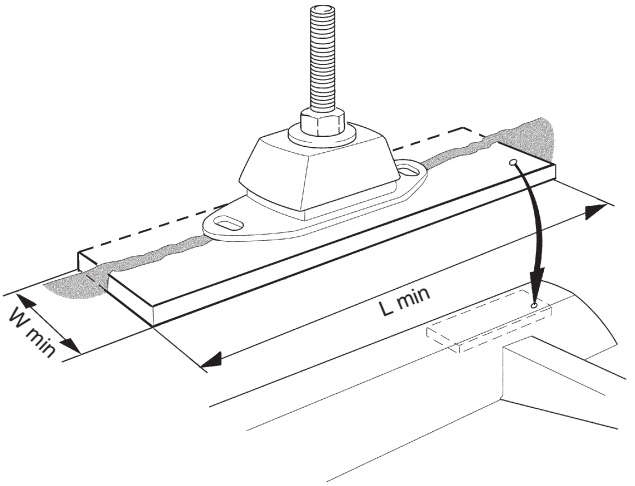
2. When the engine bed is designed, make sure that the space for the flywheel housing, the bottom and sides of the sump, etc. have a recommended clearance of at least 20 mm (3/4").



A = Spacer material, preferably high density material
B = Fiberglass, approx. 10–15 mm (0.4–0.6")
C = Flat bar, galvanized, approx. 10 mm (0.4"), min. width: 80 mm (3")
W = Flat bar width
E = Engine bed min. width: 112 mm (4.4")

3. To reduce noise and vibration, the engine bed should be filled. Make sure the material does not absorb water. Generally high density material (A) is better for noise reduction.

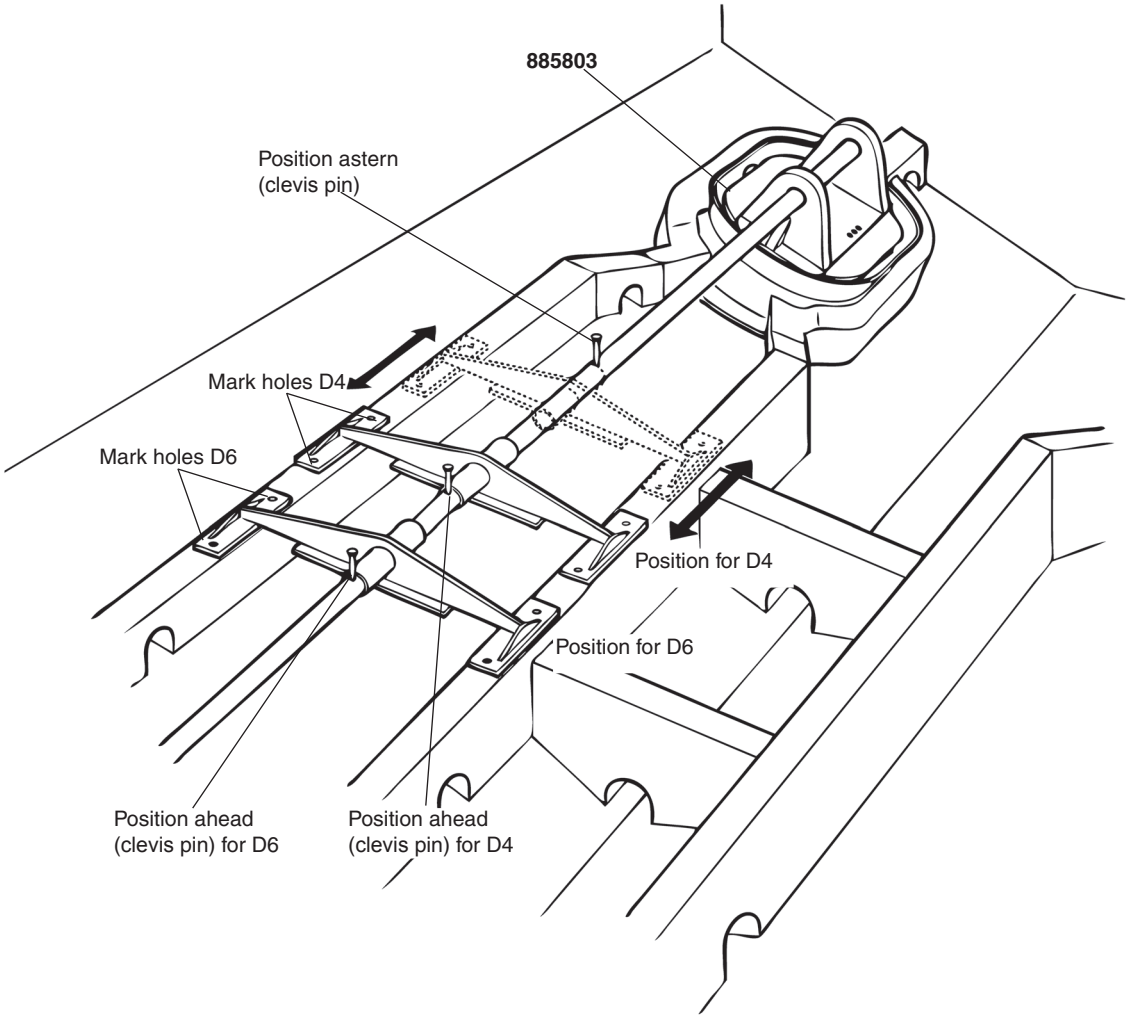
Build up the engine bed with spacer material (A) so that the underside of the engine mountings/ engine rubber mountings almost rest against the bed. There must be room for flat bars and fiberglass.



4. A 10–12 mm (0.4–0.5") thick galvanized flat bar with a minimum length (L min) of 250 mm (10") and a minimum width (W min) of 80 mm (3") should be built into the engine bed.

Build in drain channels to allow water to drain to the location of the bilge pump.

Rubber engine mounting positions



5. Use special tool **885803** with the engine bed drill jig. Place the drill jig against the clevis pins for ahead and astern positions.

For D4: Use the position astern and the position ahead for D4. The position for clevis pin for D4 must be drillled. Drill the clevis pin position 236 mm (9.3") from the position ahead for D6.

For D6: Use the position astern and the position ahead for D6.

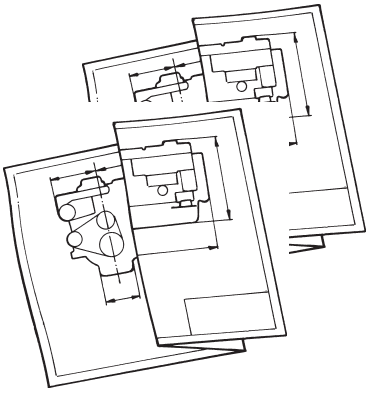
Mark the bed with holes 6 mm (1/4") by drilling through the drill bushings. Then remove the special tool.

6. Drill and tap the holes.

Dimension: M12 (1/2"UNC) or equivalent.

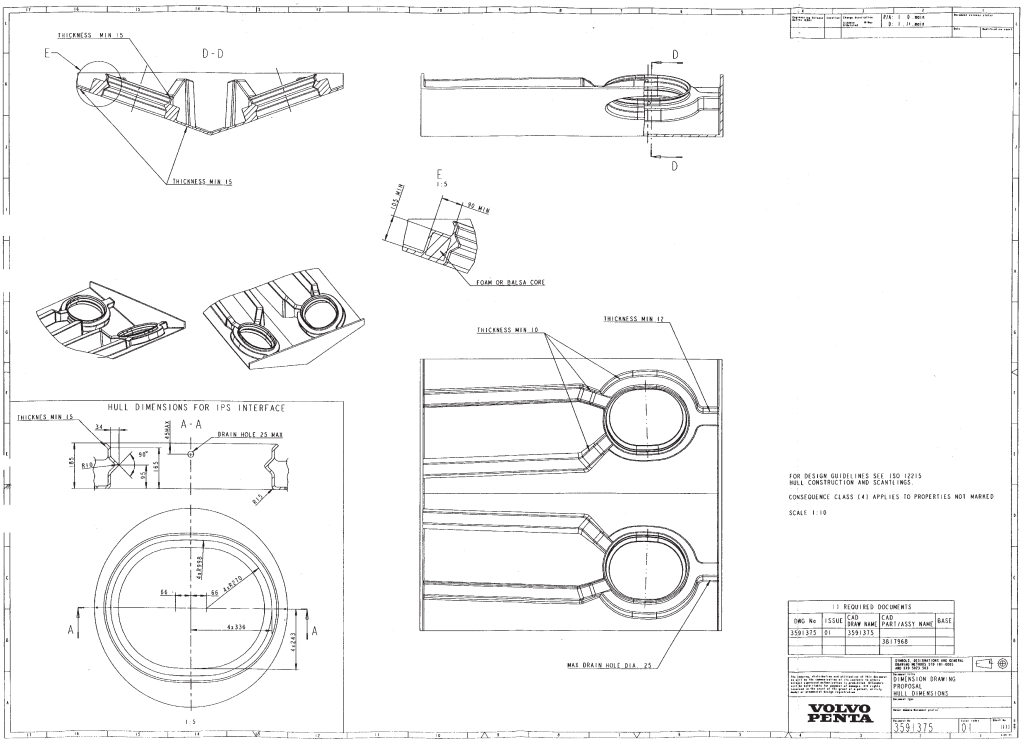
Volvo Penta IPS applications
Hull plugs and engine foundations

Hull mold plug



Hull mold plugs are recommended. However in some cases hull mold inserts may be required due to production circumstances.

All necessary drawings for positioning and dimensioning the inserts, the reinforcements and the engine beds are supplied by Volvo Penta.



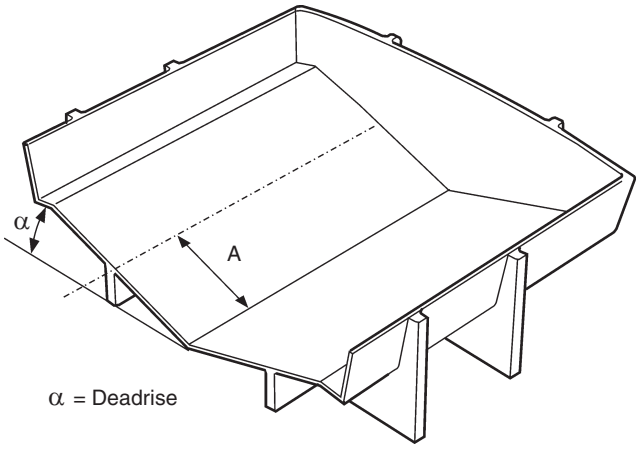
Use drawing no. 3591073 for dimension requirements. The drawing can be ordered from Volvo Penta.

For other design guidelines, please refer to **ISO12215 Hull constructions and scantlings**.

Positioning and fitting of hull plug, Twin

Marking of "plug center line" measured from keel line

⚠ **IMPORTANT**! Figures shows a hull mold.

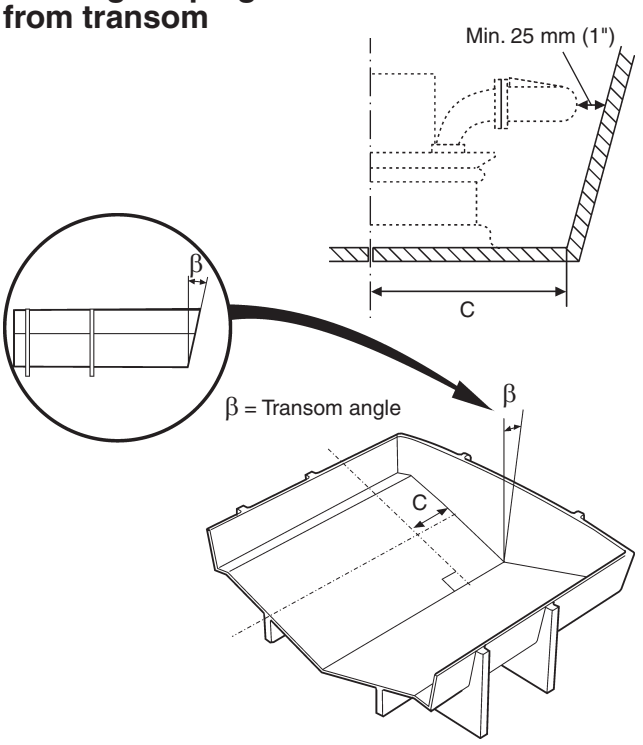


Mark a straight line parallel to the keel line at distance (A) depending on the deadrise of the hull.

Distance (A) measured from keel line to plug center line at different deadrise angles.

Deadrise (α)	Distance (A) mm (")
5°	585 (23.0)
6°	590 (23.2)
7°	600 (23.6)
8°	605 (23.8)
9°	610 (24.0)
10°	620 (24.4)
11°	630 (24.8)
12°	635 (25.0)
13°	645 (25.4)
14°	655 (25.8)
15°	660 (26.0)
16°	670 (26.4)
17°	680 (26.8)
18°	690 (27.2)
19°	700 (27.6)
20°	710 (28.0)
21°	720 (28.3)
22°	730 (28.7)
23°	745 (29.3)
24°	755 (29.7)

Marking of "plug center line" measured from transom



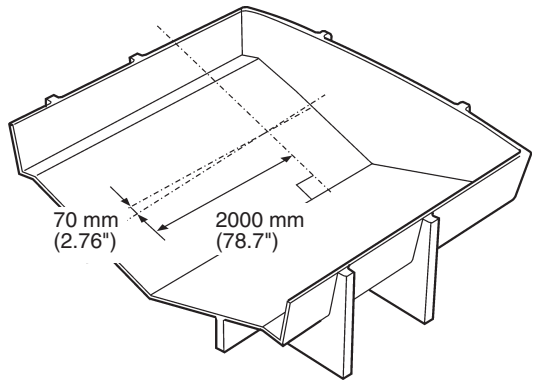
Mark a straight line parallel to the transom at distance (C) depending on the transom angle.

Distance (C) measured from transom to plug center line at different transom angles.

Transom angle (β)	Distance (C) mm (")
0°	590 (23.2)
1°	585 (23.0)
2°	580 (22.8)
3°	575 (22.6)
4°	570 (22.4)
5°	565 (22.2)
6°	555 (21.9)
7°	550 (21.7)
8°	545 (21.5)
9°	545 (21.5)
10°	545 (21.5)
11°	545 (21.5)
12°	545 (21.5)
13°	545 (21.5)
14°	545 (21.5)
15°	545 (21.5)

NOTE!
Pay attention to reinforcements, bulkheads etc.
If necessary, the distance (C) may need to be increased to clear the exhaust bend.

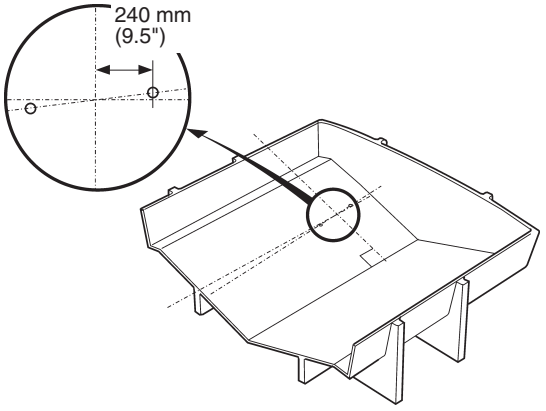
Marking of "toe-in" line



Mark a line, at a slight angle, in comparison to the straight line. At a distance of 2000 mm (78.7") the end points should be 70 mm (2.8") apart to create the desired 2° angle.

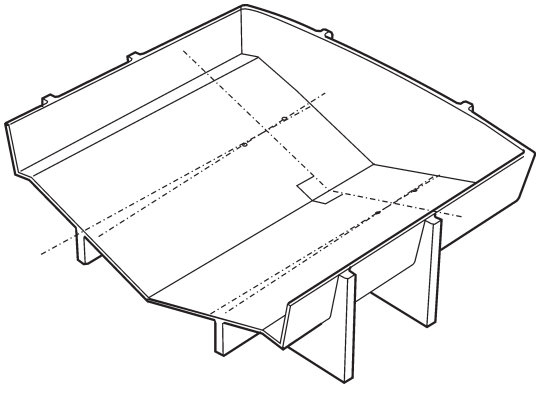
⚠ **IMPORTANT**! If the installation is a jack shaft type no "toe-in" line should be made. The IPS propulsion units should be installed parallel to the keel line.

Drill holes on "toe-in" line



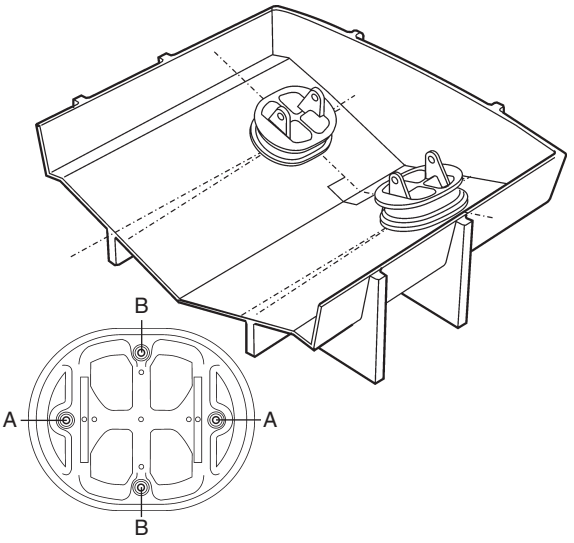
Drill bolt holes on the "toe-in" line at 240 mm (9.5") from the center intersection.

Mirror the procedure



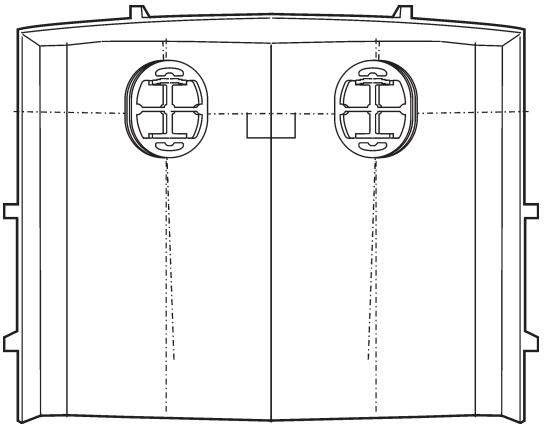
Mirror the procedure for the port side of the hull mold.

Place hull plugs and drill additional holes



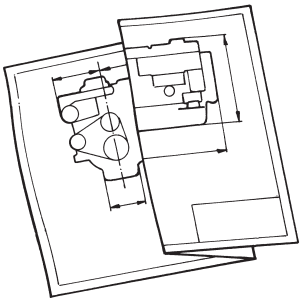
Place the hull plugs according to the drilled holes (A) and bolt the plugs to the hull mold. Mark, drill and bolt additional two holes (B) for each plug.

Final result, hull mold



Fiberglass and layer specifications

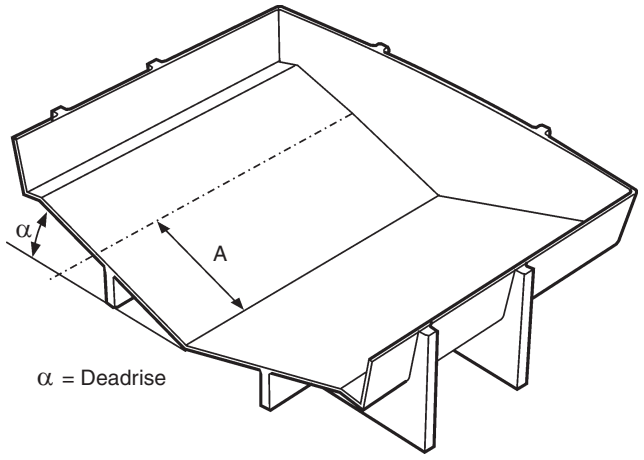
Please refer to the installation drawings regarding lamination and reinforcement for Volvo Penta IPS.



Positioning and fitting of hull plug, Triple

Marking of "plug center line" measured from keel line

⚠ **IMPORTANT**! Figures shows a hull mold.

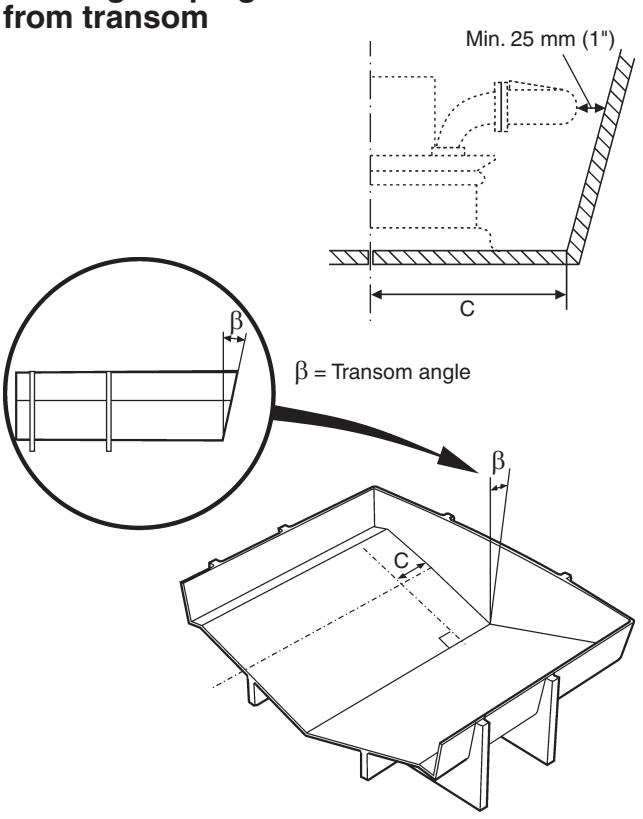


Mark a straight line parallel to the keel line at distance (A) depending on the deadrise of the hull.

Distance (A) measured from keel line to plug center line at different deadrise angles.

Deadrise (α)	Distance (A) mm (")
5°	1035 (40.7)
6°	1045 (41.1)
7°	1050 (41.3)
8°	1060 (41.7)
9°	1070 (42.1)
10°	1080 (42.5)
11°	1085 (42.7)
12°	1095 (43.1)
13°	1105 (43.5)
14°	1120 (44.1)
15°	1130 (44.5)
16°	1140 (44.9)
17°	1150 (45.3)
18°	1165 (45.9)
19°	1175 (46.3)
20°	1190 (46.9)

Marking of "plug center line" measured from transom



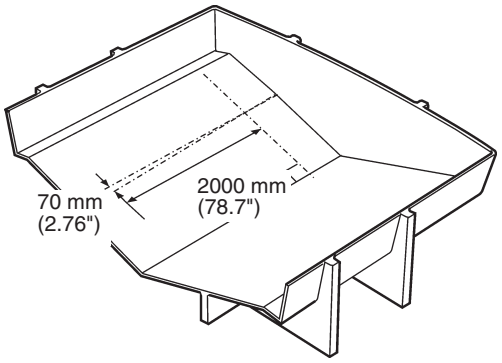
Mark a straight line parallel to the transom at distance (C) depending on the transom angle.

Distance (C) measured from transom to plug center line at different transom angles.

Transom angle (β)	Distance (C) mm (")
0°	590 (23.2)
1°	585 (23.0)
2°	580 (22.8)
3°	575 (22.6)
4°	570 (22.4)
5°	565 (22.2)
6°	555 (21.9)
7°	550 (21.7)
8°	545 (21.5)
9°	545 (21.5)
10°	545 (21.5)
11°	545 (21.5)
12°	545 (21.5)
13°	545 (21.5)
14°	545 (21.5)
15°	545 (21.5)

NOTE!
Pay attention to reinforcements, bulkheads etc. If necessary, the distance (C) may need to be increased to clear the exhaust bend.

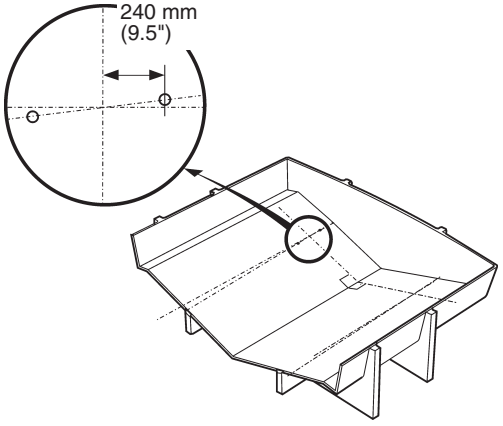
Marking of "toe-in" line



Mark a line, at a slight angle, in comparison to the straight line. At a distance of 2000 mm (78.7") the end points should be 70 mm (2.8") apart to create the desired 2° angle.

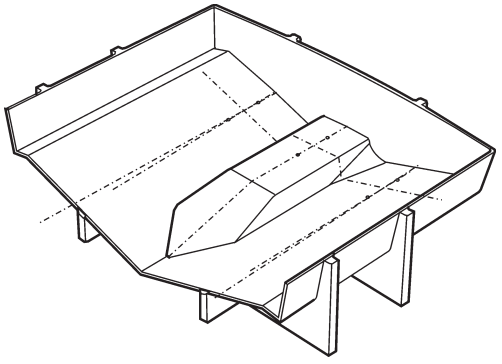
⚠ **IMPORTANT**! If the installation is a jack shaft type no "toe-in" line should be made. The IPS propulsion units should be installed parallel to the keel line.

Drill holes on "toe-in" line and mirror the procedure



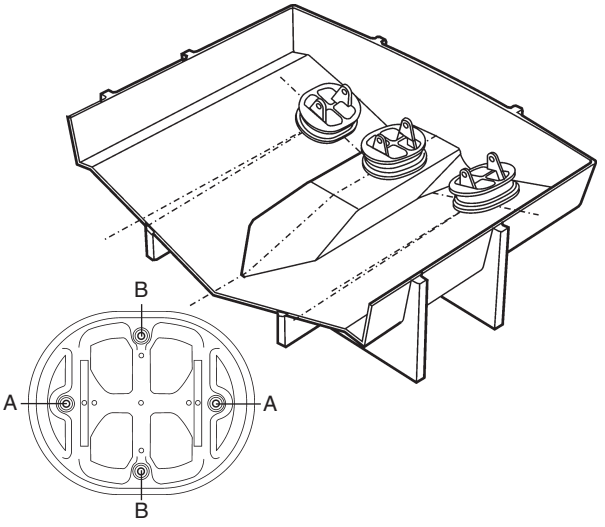
Drill bolt holes on the "toe-in" line at 240 mm (9.5") from the center intersection. Mirror the procedure for the port side of the hull mold.

Build and place a hull tunnel plug. Mark "plug center line" and drill holes



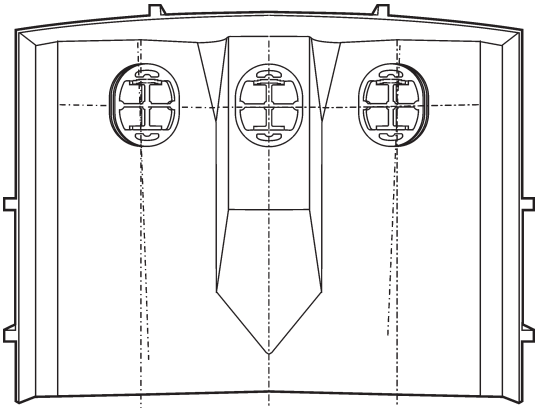
Build a hull tunnel plug according to installation drawings. Mark a "plug center line". Drill bolt holes on the line ar 240 mm (9.5") from the intersection.

Place hull plugs and drill additional holes



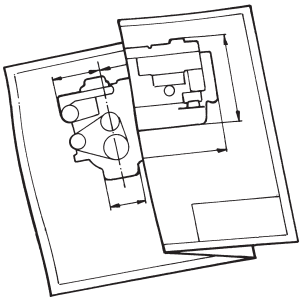
Place the hull plugs according to the drilled holes (A) and bolt the plugs to the hull mold. Mark, drill and bolt additional two holes (B) for each plug.

Final result, hull mold



Fiberglass and layer specifications

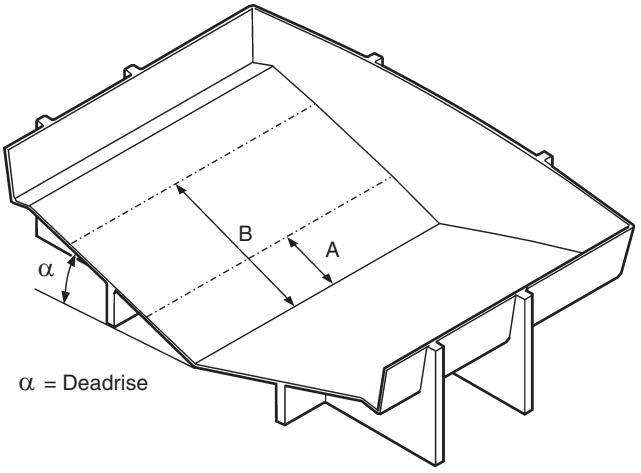
Please refer to the installation drawings regarding lamination and reinforcement for Volvo Penta IPS.



Positioning and fitting of hull plug, Quadruple

Marking of "plug center lines" measured from keel line

⚠ **IMPORTANT**! Figures shows a hull mold.

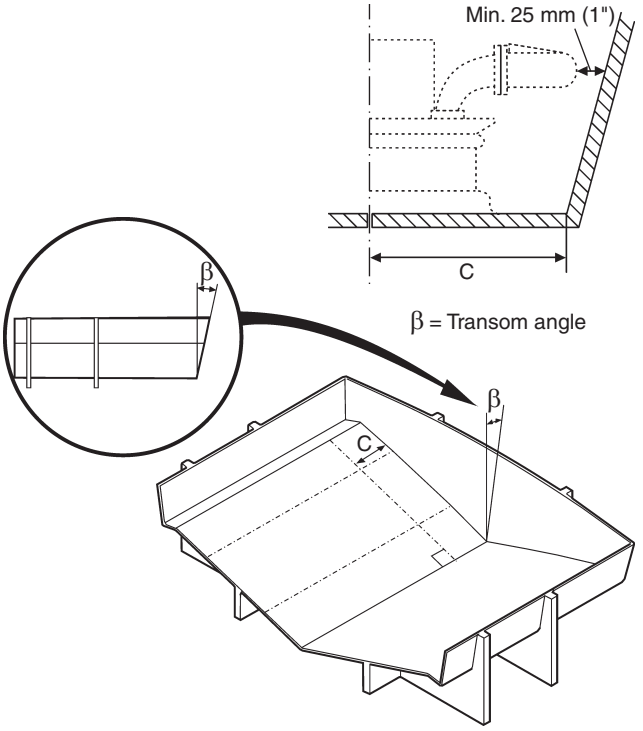


Mark two straight lines parallel to the keel line at distance (A) and (B) depending on the deadrise of the hull.

Distance (A) measured from keel line to plug center line at different deadrise angles.
Distance (B) measured from keel line to plug center line at different deadrise angles.

Deadrise (α)	Distance (A) mm (")	Distance (B) mm (")
5°	535 (21.1)	1490 (58.7)
6°	540 (21.3)	1495 (58.9)
7°	550 (21.7)	1505 (59.3)
8°	555 (21.9)	1515 (59.6)
9°	565 (22.2)	1525 (60.0)
10°	570 (22.4)	1535 (60.4)
11°	580 (22.8)	1545 (60.8)
12°	585 (23.0)	1555 (61.2)
13°	595 (23.4)	1570 (61.8)
14°	605 (23.8)	1580 (62.2)
15°	610 (24.0)	1595 (62.8)
16°	620 (24.4)	1610 (63.4)
17°	630 (24.8)	1625 (64.0)
18°	640 (25.2)	1640 (64.6)

Marking of "plug center line" measured from transom



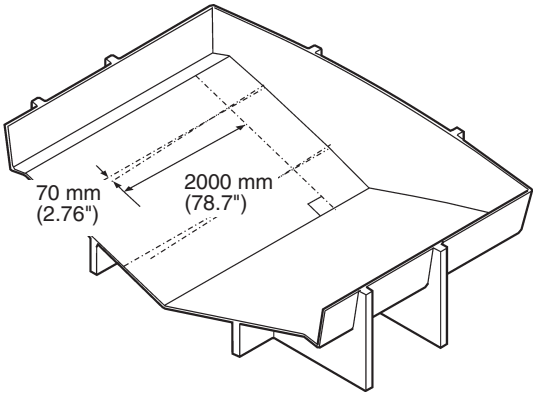
Mark a straight line parallel to the transom at distance (C) depending on the transom angle.

Distance (C) measured from transom to plug center line at different transom angles.

Transom angle (β)	Distance (C) mm (")
0°	590 (23.2)
1°	585 (23.0)
2°	580 (22.8)
3°	575 (22.6)
4°	570 (22.4)
5°	565 (22.2)
6°	555 (21.9)
7°	550 (21.7)
8°	545 (21.5)
9°	545 (21.5)
10°	545 (21.5)
11°	545 (21.5)
12°	545 (21.5)
13°	545 (21.5)
14°	545 (21.5)
15°	545 (21.5)

NOTE!
Pay attention to reinforcements, bulkheads etc.
If necessary, the distance (C) may need to be increased to clear the exhaust bend.

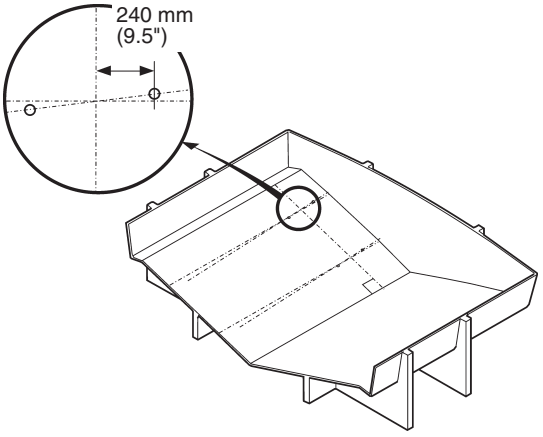
Marking of "toe-in" lines



Mark two lines, at a slight angle, in comparison to the straight lines. At a distance of 2000 mm (78.7") the end points should be 70 mm (2.8") apart to create the desired 2° angle.

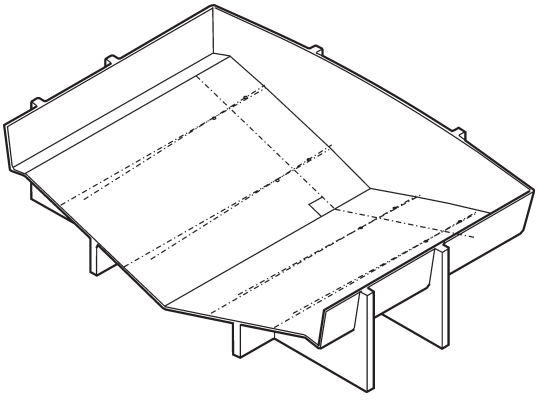
⚠ **IMPORTANT**! If the installation is a jack shaft type no "toe-in" line should be made. The IPS propulsion units should be installed parallel to the keel line.

Drill holes on "toe-in" lines



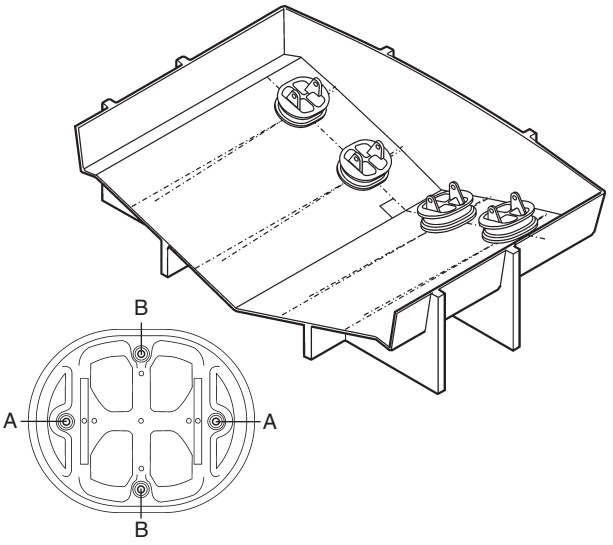
Mirror the procedure

Drill bolt holes on the "toe-in" lines at 240 mm (9.5") from the center intersection.



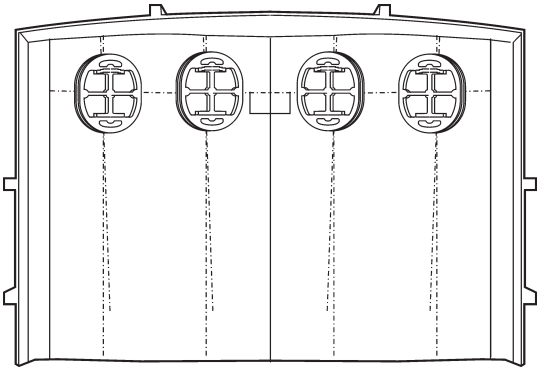
Mirror the procedure for the port side of the hull mold.

Place hull plugs and drill additional holes



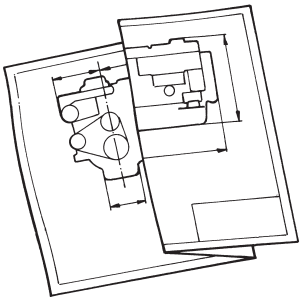
Place the hull plugs according to the drilled holes (A) and bolt the plugs to the hull mold. Mark, drill and bolt additional two holes (B) for each plug.

Final result, hull mold



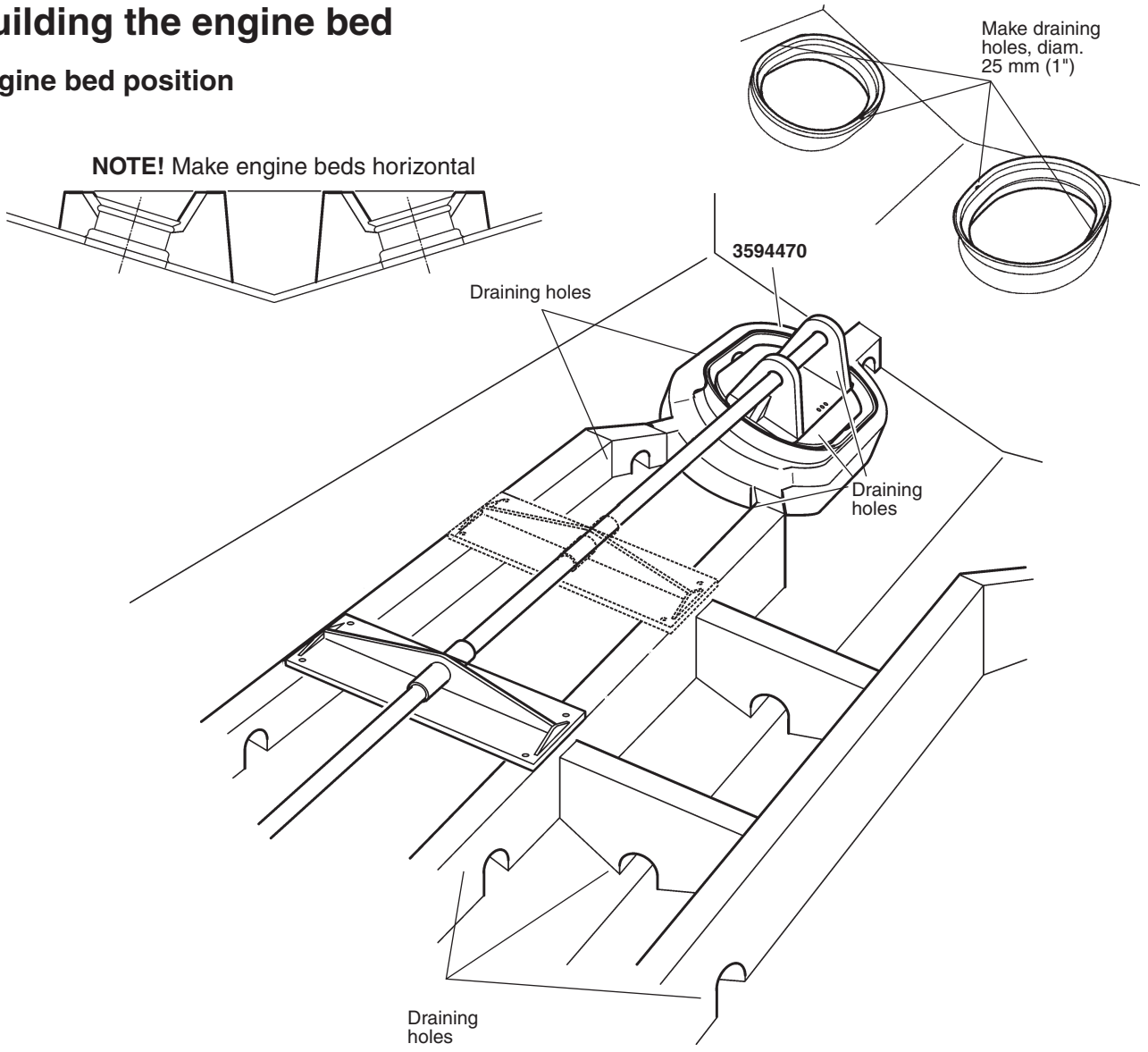
Fiberglass and layer specifications

Please refer to the installation drawings regarding lamination and reinforcement for Volvo Penta IPS.



Building the engine bed

Engine bed position



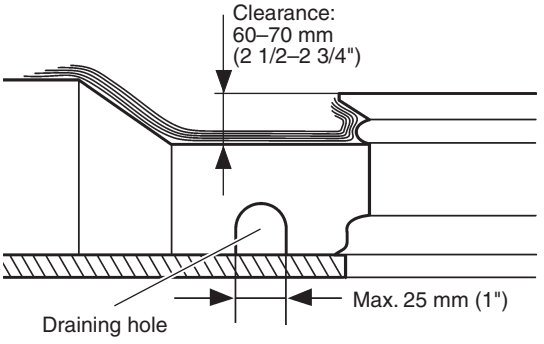
1. Use special tool **3594470** to measure up the engine beds. The beds must be horizontal. Reinforcements must be made between the beds and from the insert beds to the transom. The beds shall end up against the insert beds by building stringers.

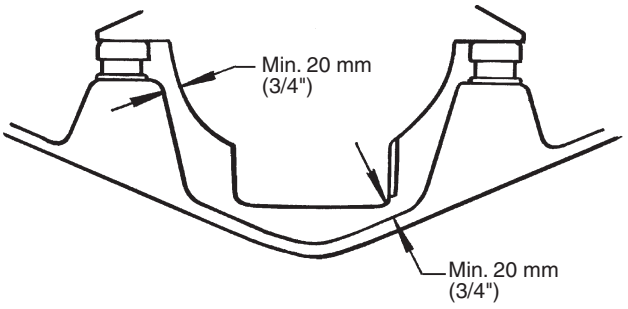
Draining holes shall be made according to figure, diameter approx. **25 mm (1").**

Stringers between engine bed and hull plug lamination:

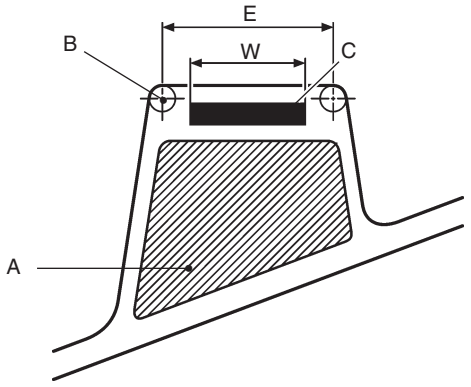
Clearance: 60-70 mm (2 1/2-2 3/4”)

Width: 125 mm (5”)





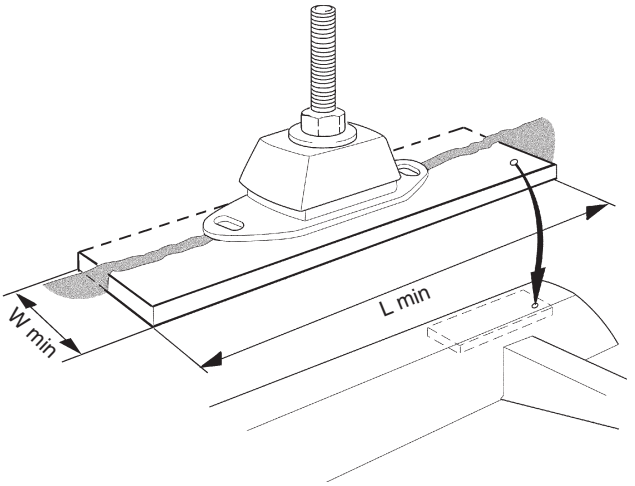
2. When the engine bed is designed, make sure that the space for the flywheel housing, the bottom and sides of the sump, etc. have a recommended clearance of at least 20 mm (3/4").



A = Spacer material, preferably high density material
B = Fiberglass, approx. 10–15 mm (0.4–0.6")
C = Flat bar, galvanized, approx. 10 mm (0.4"), min. width: 80 mm (3")
W = Flat bar width
E = Engine bed min. width: 112 mm (4.4")

3. To reduce noise and vibration, the engine bed should be filled. Make sure the material does not absorb water. Generally high density material (A) is better for noise reduction.

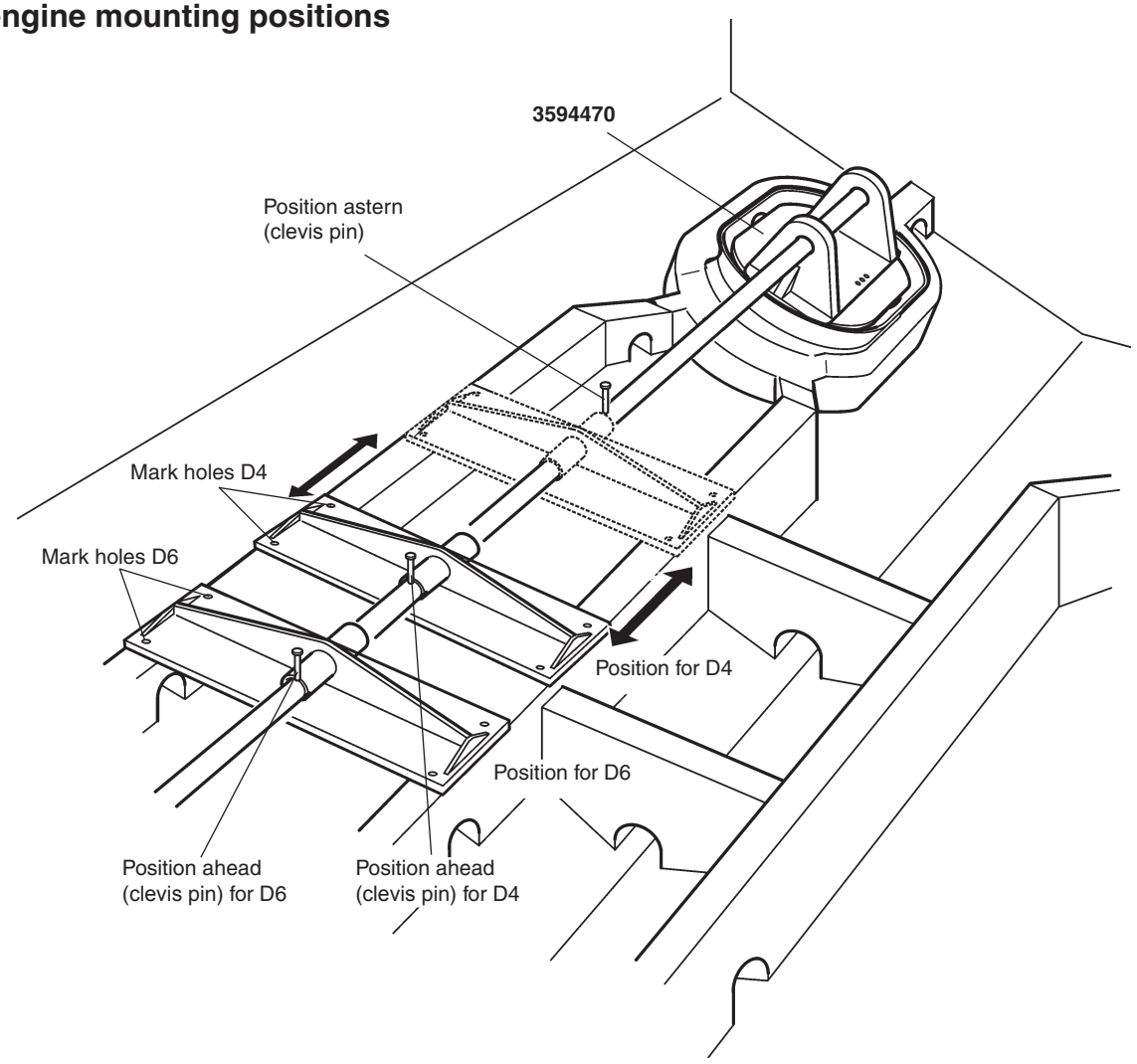
Build up the engine bed with spacer material (A) so that the underside of the engine mountings/ engine rubber mountings almost rest against the bed. There must be room for flat bars and fiberglass.



4. A 10–12 mm (0.4–0.5") thick galvanized flat bar with a minimum length (L min) of 250 mm (10") and a minimum width (W min) of 80 mm (3") should be built into the engine bed.

Build in drain channels to allow water to drain to the location of the bilge pump.

Rubber engine mounting positions



5. Use special tool **3594470** with the engine bed drill jig. Place the drill jig against the clevis pins for ahead and astern positions.

For D4: Use the position astern and the position ahead for D4. The position for clevis pin for D4 must be drillled. Drill the clevis pin position 236 mm (9.3") from the position ahead for D6.

For D6: Use the position astern and the position ahead for D6.

Mark the bed with holes 6 mm (1/4") by drilling through the drill bushings. Then remove the special tool.

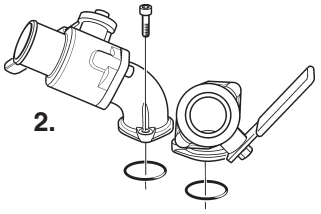
6. Drill and tap the holes.

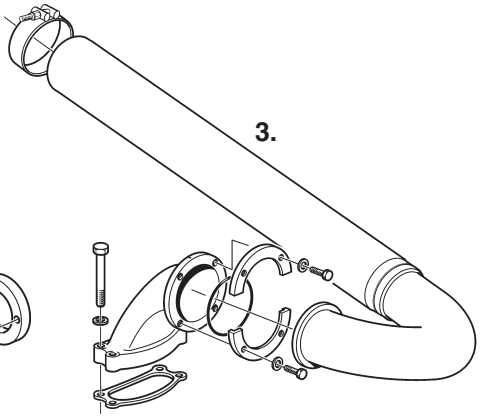
Dimension: M12 (1/2"UNC) or equivalent.

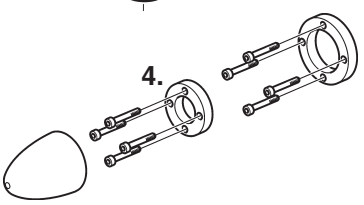
Volvo Penta IPS applications
Propulsion unit and engine installation

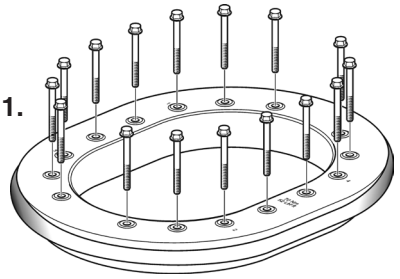
Installation kits

1. Clamp rings, sealing rings and bolts
2. Water inlet and outlet cocks (not for Volvo Penta IPS 350)
3. Exhust bends and hoses
4. Propeller attachement parts
5. Protective anode kit
6. Tool kit (for emergency steering)



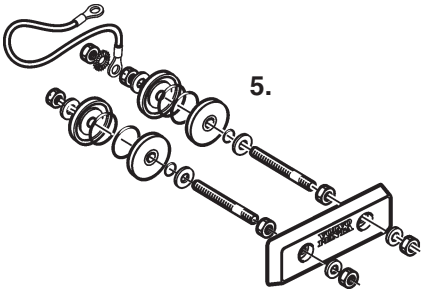






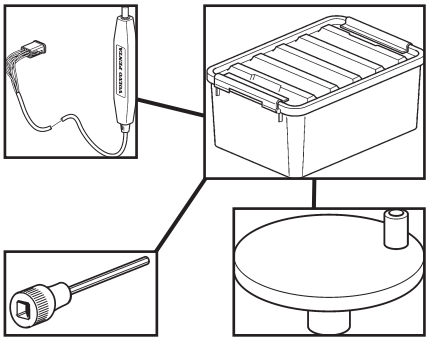
Anode kit

Delivered in pairs, one anode for each drive unit.



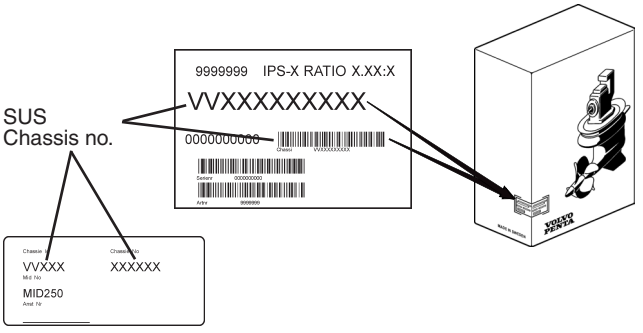
Tool kit emergency steering

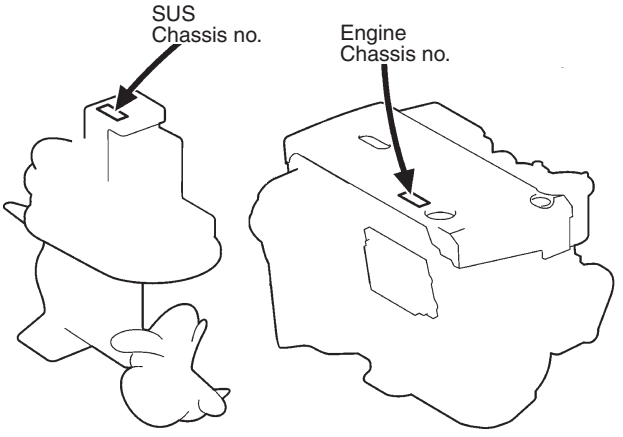
⚠ **IMPORTANT!** Tool kit for emergency steering must be delivered with the boat.



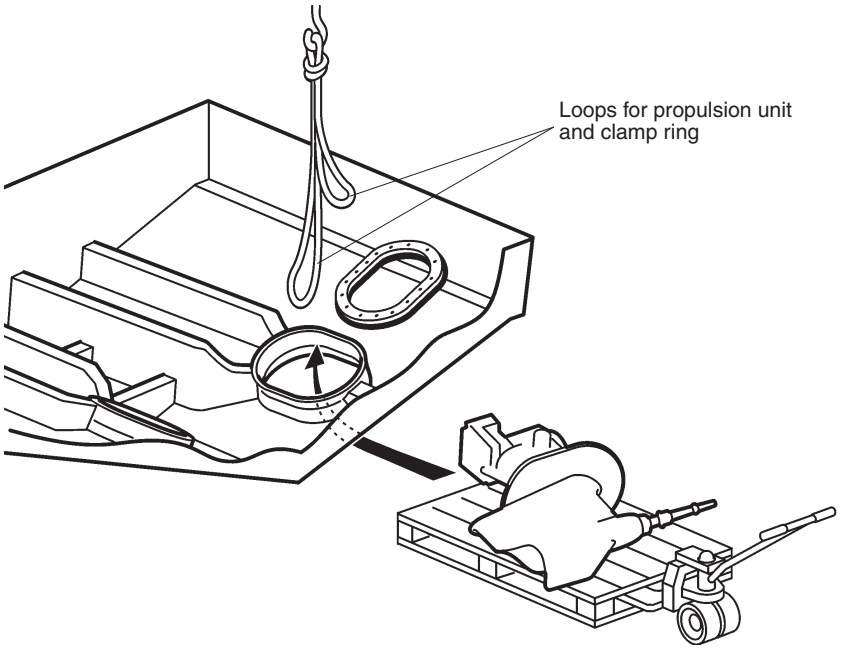
⚠ **IMPORTANT!** Check that the engine **chassis no.** and the Servo Unit Steering (SUS) **chassis no.** are identical.

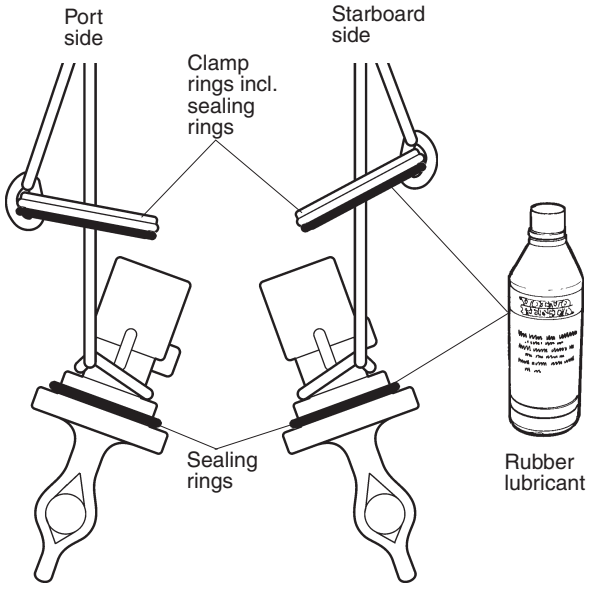
The engine chassis no. is located on the engine top cover and the SUS chassis no. is located on a label outside the packing box and on top of the SUS.

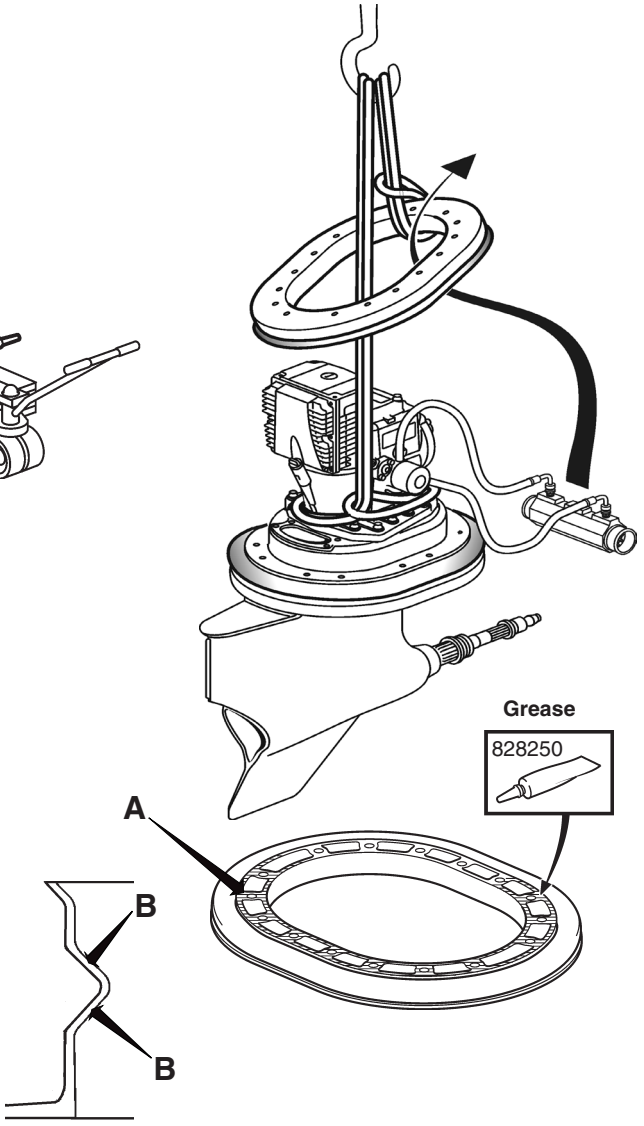




Fitting the propulsion unit to the hull







1. Clean/wipe rubber sealing rings and apply rubber lubricant on the rings.

⚠ **WARNING!** Only use rubber lubricant, Volvo Penta part no. **3817243**.
Never use grease, Vaseline or similar!

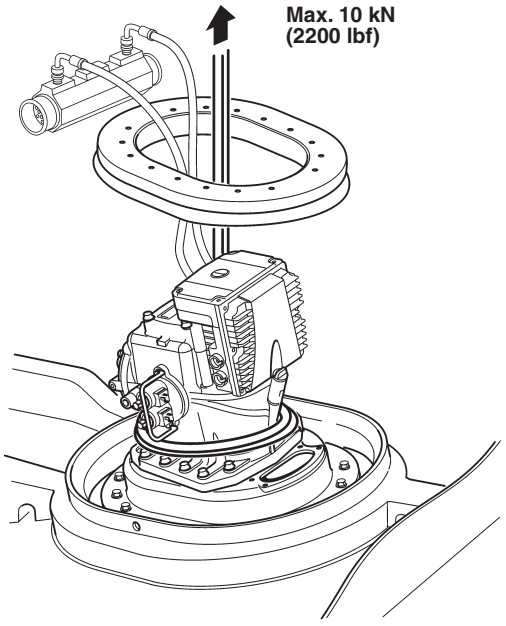
2. Take good care of the oil cooler and thread it through the clamp ring as shown in figure.

NOTE! The sealing rings shall be in place on the drive leg and on the clamp ring.

3. Apply grease, Volvo Penta part no. **828250** on the clamp ring contact surface (A).

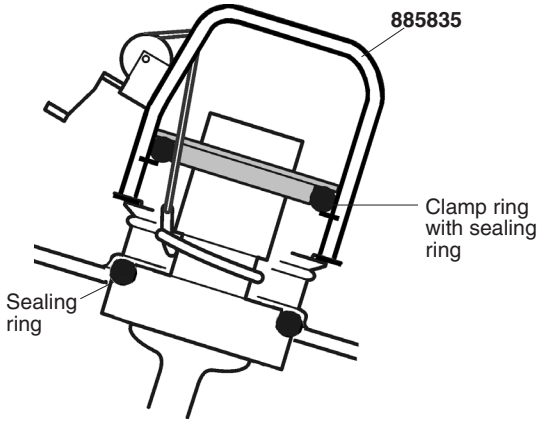
NOTE! The sealing rings shall be in place on the drive leg and on the clamp ring.

⚠ **IMPORTANT!** Keep the sealing rings and the sealing ring contact surfaces (B), inside the propulsion unit bed free from grease!

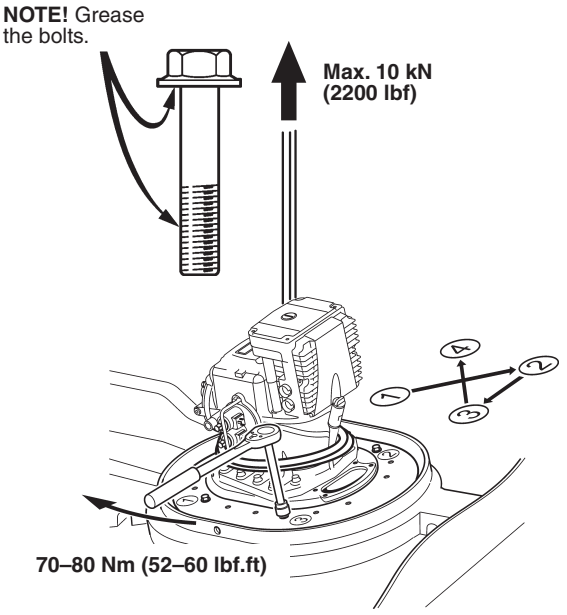


4. Lifting force: **Max. 10 kN (2200 lbf)**

⚠ **WARNING!** Do not exceed the maximum lifting force. There is a risk that the boat hull will be lifted up and the lifting device will be damaged.



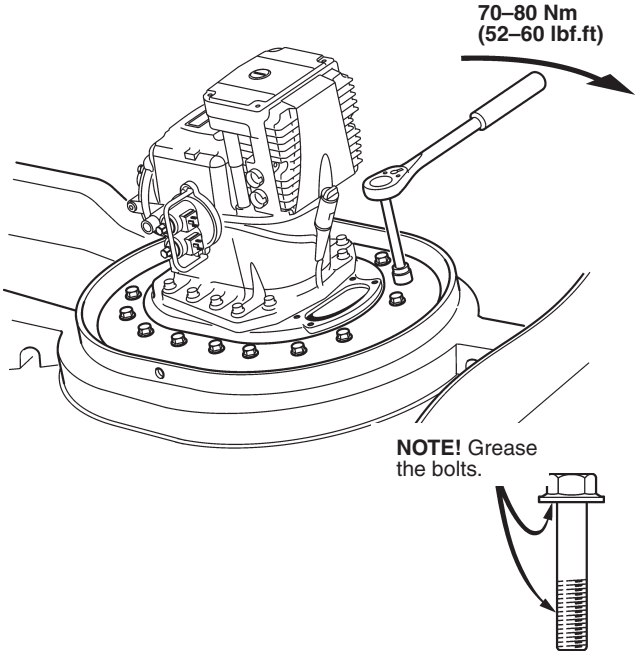
5. Alternative lifting device, special tool **885835**, mounted on the hull insert. Note the position of the clamp ring with the sealing ring.



6. Install four M12 screws, positioned according to figure. Grease the bolts.

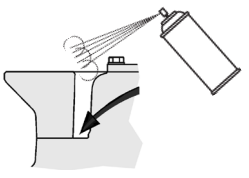
Tighten the screws. Tighten alternately, 5 mm at a time.

Final torque: **70–80 Nm (52–60 lbf.ft)**



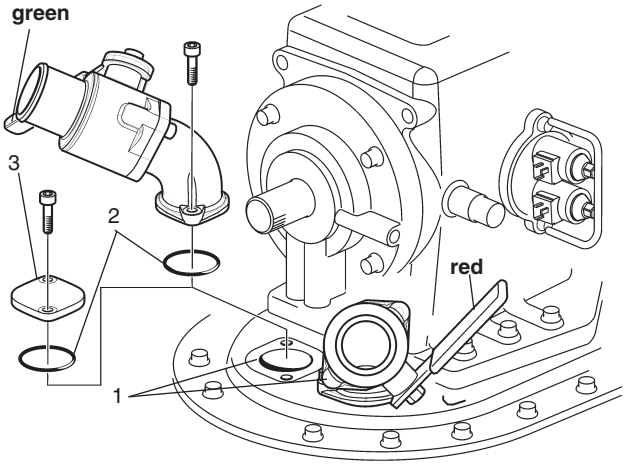
7. Install and tighten the remaining 12xM12 screws. Grease all the bolts.

Tightening torque: **70–80 Nm (52–60 lbf.ft)**



8. Apply corrosion protection, Volvo Penta part no. **9510227** in the area between clamp ring and gear housing.

Installing the inlet and outlet sea water cocks



1. Clean (wipe) the water pipe contact surfaces (1) on the propulsion unit.

2. Place the O-rings (2) in the gear housing.

NOTE! The cocks are marked red (port side) and green (starboard side) on each drive unit.

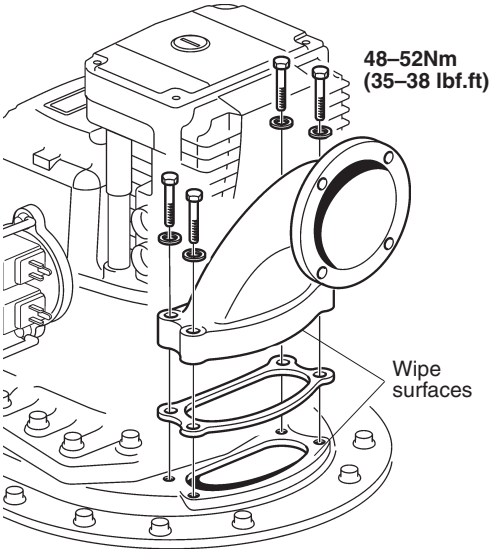
3. Install the cocks.

NOTE! On Volvo Penta IPS 350, the port side (green) is not used. Connection should be blinded (3).

4. Tighten the screws.

Tightening torque: **24–28 Nm (18–21 lbf.ft)**

Installing the exhaust outlet



1. Clean (wipe) attachment surfaces on bend and gear housing.

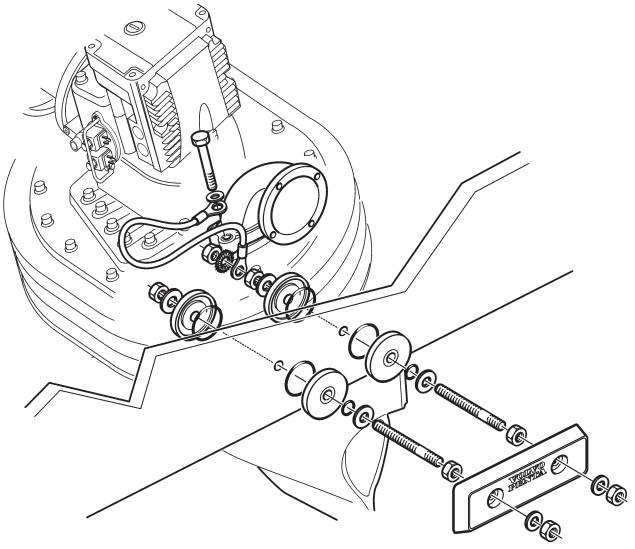
2. Install gasket and four screws with washers.

⚠ **IMPORTANT!** Also mount bonding wire for transom mounted protection anode.

3. Tighten the screws.

Tightening torque: **48–52 Nm (35–38 lbf.ft)**

Transom mounted anode

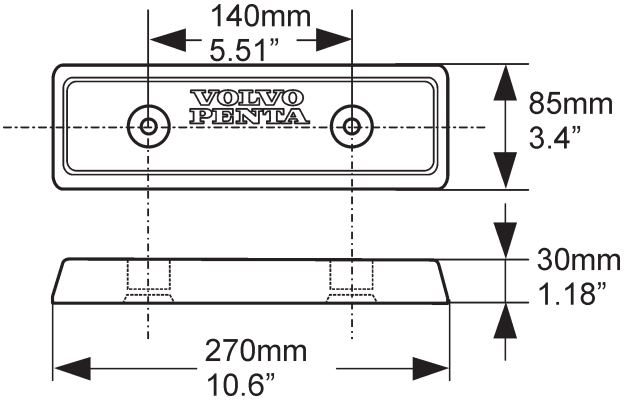


Mount included protective anode on the transom, well below the water line. Attach bonding wire to one of the exhaust manifold bolts.

⚠ **IMPORTANT!** Do not bond the propulsion units together.

⚠ **IMPORTANT!** Do not bond the propulsion units to the engine or any other item onboard.

⚠ **IMPORTANT!** Do not bond any other equipment to the transom mounted anode.



Installing the engines

Preparing

NOTE! Install optional equipment and accessories on the engine, such as an extra alternator, hot water outlet, power take-off etc. before the engine is installed.

NOTE! No engines or Volvo Penta IPS units contain any oil and coolant when delivered from Volvo Penta. Check that the oil plug and drain cocks for coolant, hot water cocks etc. are closed.

Fill oil and coolant. Please refer to the chapters ***Coolant /Filling with coolant***.

NOTE! Check for leakage.

Installing

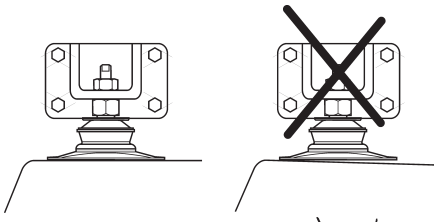
⚠ **WARNING**! Always use both lifting eyes when lifting the engine.

The engine beds on which the engines are located shall be on one plane.

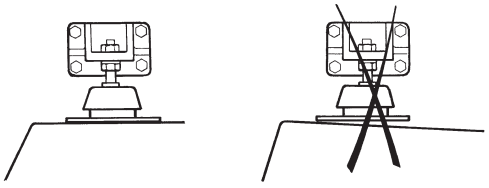
Check that the surface of the engine bed, where the engine mountings are supported, is parallel to the base plates of the engine mountings, and that the bed inclination is correct (use a graded angle spirit level).

NOTE! Apply grease Volvo Penta part no. **828250** on the threads.

D4



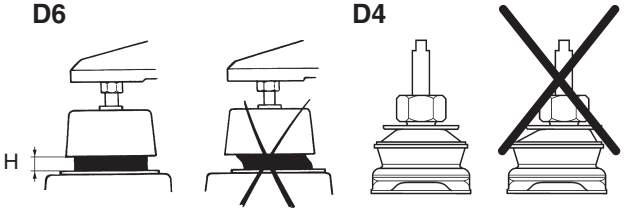
D6



NOTE! Before adjustments can be made to engine mountings for **D6** applications, the engine must rest on the rubber mountings for at least twelve hours.

Never use rubber mountings other than those intended for the relevant engine type.

D6 **D4**

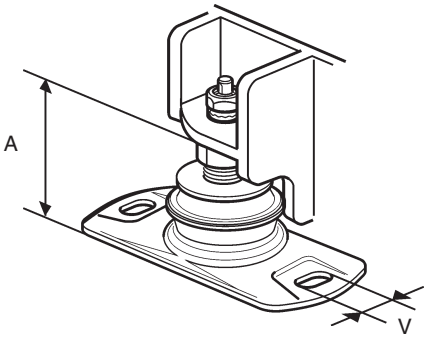


NOTE! Make sure that the rubber mounts are installed so that no pre-load or side forces occur when the engine has been installed.

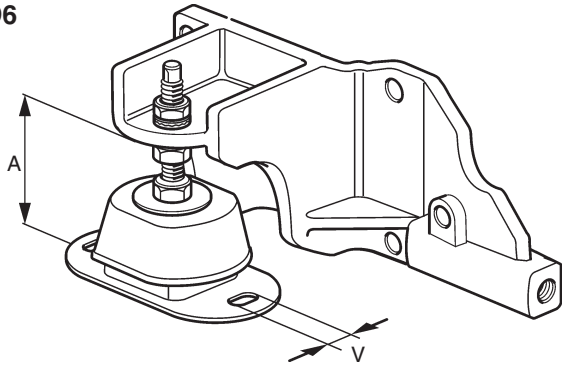
When the engine is installed, the loading on the front mounts shall be equal as well as the loading on the rear mounts. Check loading on the rubber mounts for **D6** applications by measuring the distance (**H**) between the attachment plates and the housing.

Adjustable engine mounts shall have their basic position mid way along the length of the fastening plate holes. The fastening plates have elongated holes for adjusting. These can be turned facing forward or backwards, whichever allows the best accessibility.

D4



D6

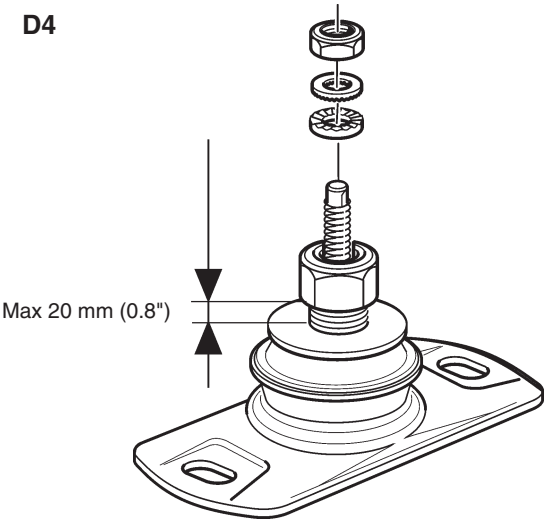


Nominal height measured from underside of engine mount base plate: **D4**: 116 mm (4.6"), **D6**: 122 mm (4.8")

A = Nominal height ± adjustment **D4/D6**: ± 8 mm (0.3")

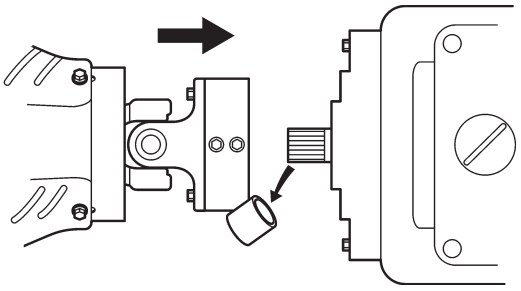
V = Sideways adjustment **D4**: ± 7 mm (0.3"), **D6**: ± 5 mm (0.2")

D4



NOTE! The measurement between the washer nut and the lower edge of the middle adjustment nut must never exceed 20 mm (0.8").

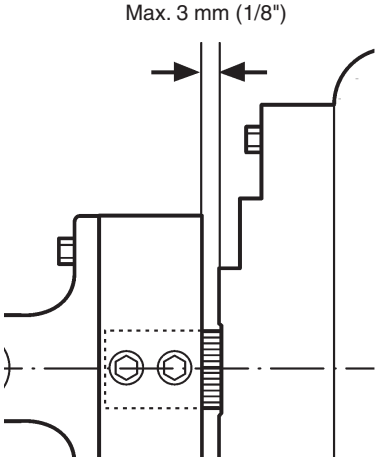
Connecting the drive shaft



1. Remove the protection cap from the input shaft on the propulsion unit.

NOTE! No lubricant on the shaft splines.

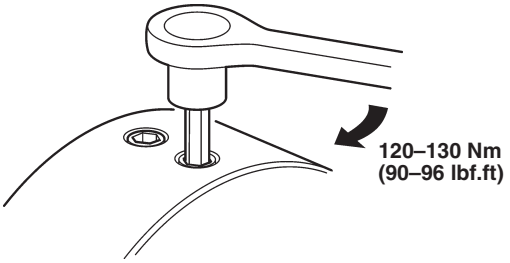
Push the drive shaft coupling onto the input shaft spines.



2. Check the distance between drive shaft coupling and gearbox housing.

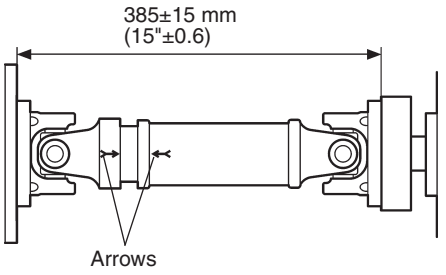
Distance: Max. **3 mm (1/8")**.

NOTE! Ensure there is play between drive shaft coupling and gear box housing.



3. Tighten the two socket cap screws.

Tightening torque: **120–130 Nm (90–96 lbf.ft)**



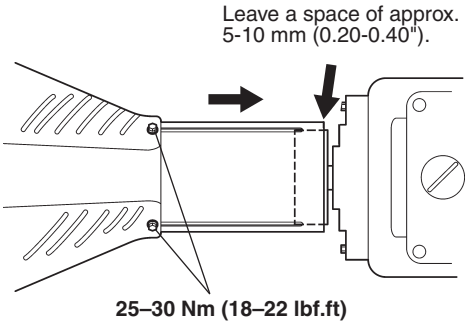
4. Check drive shaft flange-to-flange distance according to figure.

Shaft length shall be **385 ±15 mm (15"±0.6)**.

Adjust the engine if necessary.

⚠ **IMPORTANT!** Check alignment of the two arrows on the splines coupling. The figure above shows the correct position–arrows pointing towards each other.

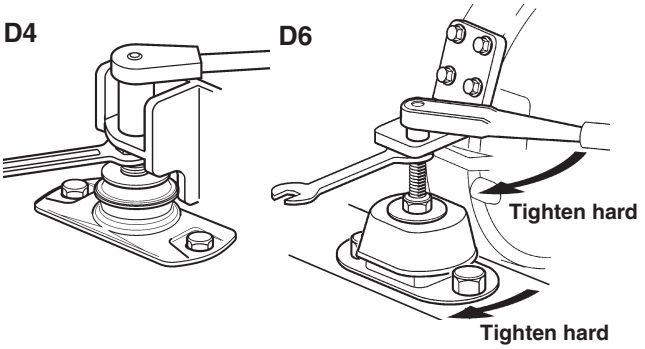
If the splined coupling is mounted incorrectly, there is a great risk of vibration problems!



5. Slide the protective cover over the drive shaft and coupling. Tighten the two screws.

Tightening torque: **25–30 Nm (18–22 lb.ft.)**.

⚠ **IMPORTANT!** Make sure there is no contact between the protective cover and the Volvo Penta IPS unit. Leave a space of approx. 5-10 mm (0.20-0.40").

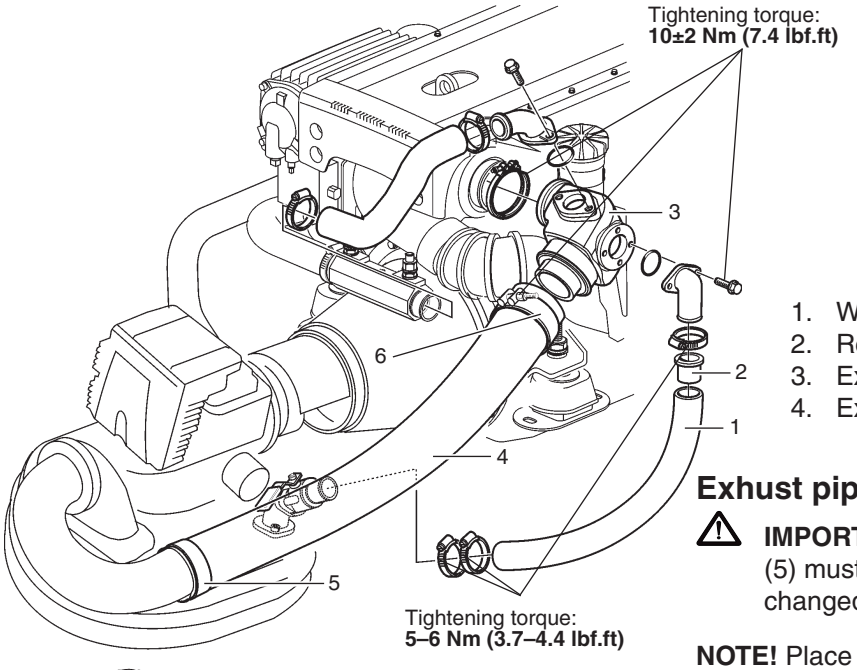


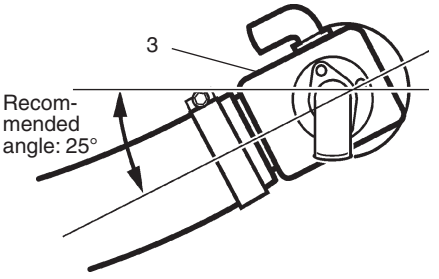
6. After verification of engine bed parallelism and loading on the mounts – tighten the upper nut on all four engine mounts.

Tightening torque, bolts in engine bed:
Tighten hard

Tightening torque, adjustment nuts:
Tighten hard

Installing exhaust line and water by-pass and inlet hoses





1. Water by-pass hose
2. Reducing insert
3. Exhaust elbow
4. Exhaust hose
5. Hose clamp
6. Hose clamp
7. O-ring
8. Screw

Exhust pipe elbow

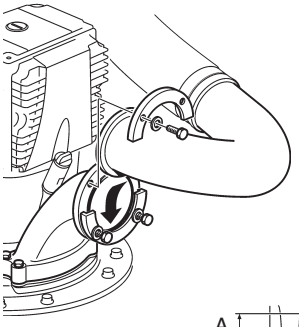
⚠ **IMPORTANT!** The factory installed hose clamp (5) must not, under any circumstances, be changed or removed.

NOTE! Place reducing insert (2) in by-pass hose.

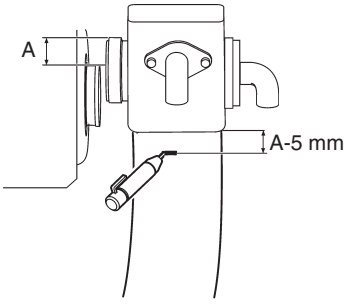
1. Remove exhaust pipe bend (3).

2. Install exhaust hose (4) temporarily on IPS drive.

3. Thread hose onto exhaust pipe elbow. Measure difference (A) between exhaust pipe elbow and turbo flange.
Mark hose (A minus 5 mm). Remove hose and exhaust pipe elbow.



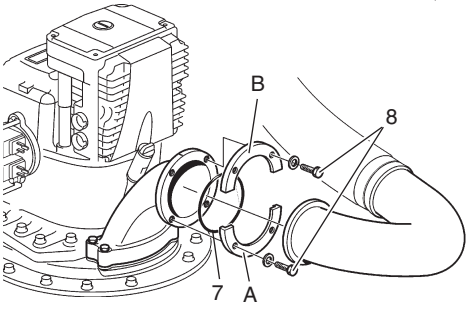
4. Use hose clamp to mark around entire hose. Saw the hose and cut steel spirals.



⚠ **IMPORTANT!** Make sure no steel spirals project out from the hose.

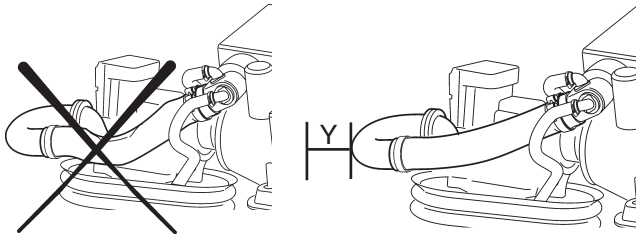
5. Lubricate O-ring (7) with vaseline and fit in the groove on the exhaust outlet.
Install the lower part of the split flange (A). Do not tighten the screws.

6. Slide the bend onto the flange. Install the upper part of the split flange (B).
Tighten screws (8), tightening torque 48-52 Nm (35-38 lbf.ft).



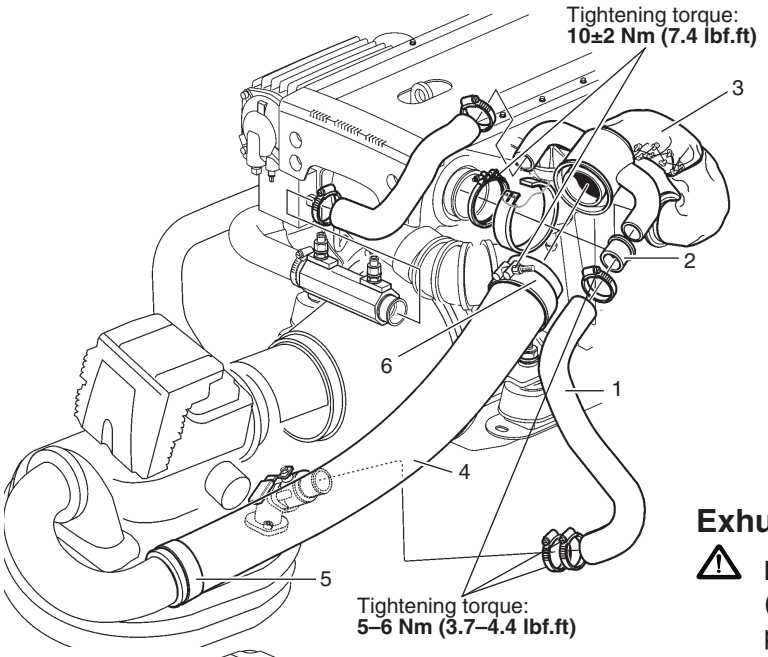
7. Lubricate inside of hose with rubber lubricant, Volvo Penta part no. 3817243.
Mount hose on exhaust elbow.
Tighten hose clamp (6), tightening torque 20-25 Nm (15-18 lbf.ft)

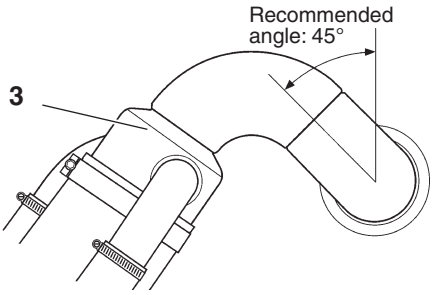
8. Install exhaust elbow on turbo flange.
Tightening torque 8 -12 Nm (6-9 lbf.ft).



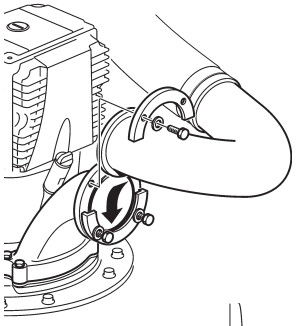
⚠ **IMPORTANT!** Refer to picture for correct installation of the hose.

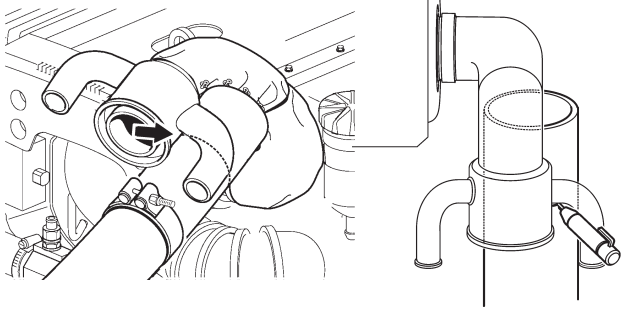
⚠ **IMPORTANT!** Minimum distance between exhaust bend and inside of transom (Y): **25 mm (1")**.

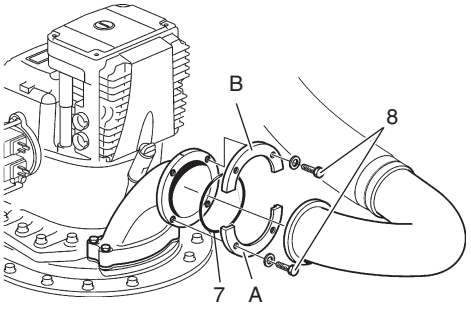


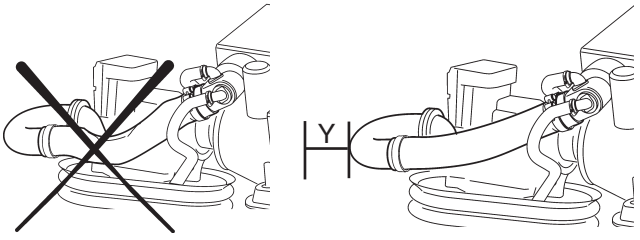


1. Water by-pass hose
2. Reducing insert
3. Exhaust riser
4. Exhaust hose
5. Hose clamp
6. Hose clamp
7. O-ring
8. Screw









Exhust riser

⚠ **IMPORTANT!** The factory installed hose clamp (5) must not, under any circumstances, be replaced or removed.

NOTE! Place reducing insert (2) in by-pass hose.

1. Install exhaust riser (3) temporarily.

2. Install exhaust hose (4) temporary on IPS drive.

3. Measure length of hose needed by placing hose under exhaust riser, add 5 mm and mark.

Note! Make sure the hose is 5 mm longer than measured.

4. Use hose clamp to mark round entire hose, saw the hose and cut steel spirals off.

⚠ **IMPORTANT!** Make sure no steel spirals project out from the hose.

5. Lubricate O-ring (7) with vaseline and fit in the groove on the exhaust outlet.
Install the lower part of the split flange (A). Do not tighten the screws.

6. Slide the bend onto the flange. Install the upper part of the split flange (B).
Tighten screws (8), tightening torque 48-52 Nm (35-38 lbf. ft).

7. Lubricate inside of hose with rubber lubricant, Volvo Penta part no. 3817243.
Mount hose on exhaust riser.
Tighten hose clamp (6), tightening torque 20-25 Nm (15-18 lbf ft)

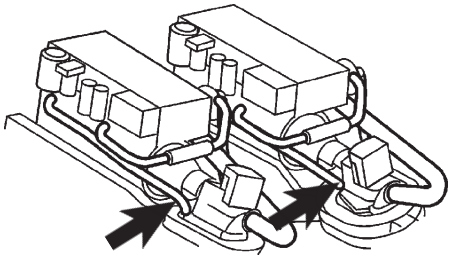
8. Install exhaust riser on turbo flange.
Tightening torque 8 -12 Nm (6-9 lbf.ft).

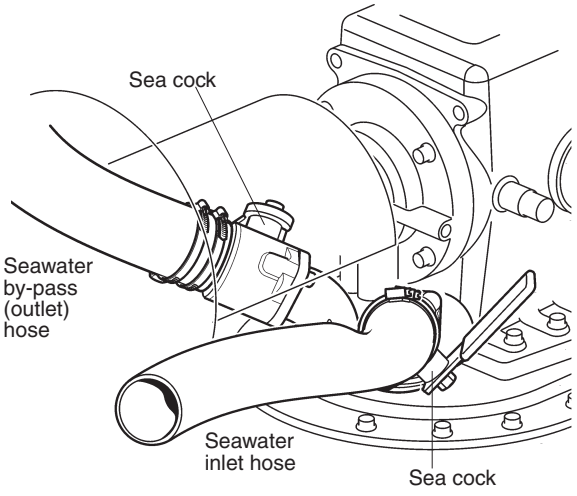
⚠ **IMPORTANT!** Refer to picture for correct installation of the hose.

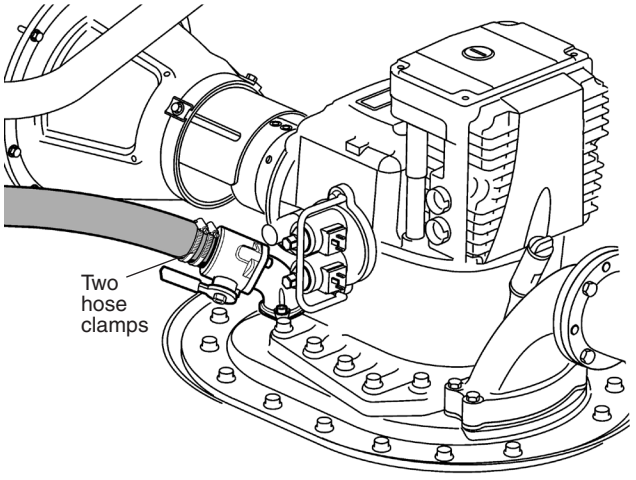
⚠ **IMPORTANT!** Minimum distance between exhaust bend and inside of transom (Y): **25 mm (1")**.

Cooling system

Connecting the water inlet hoses







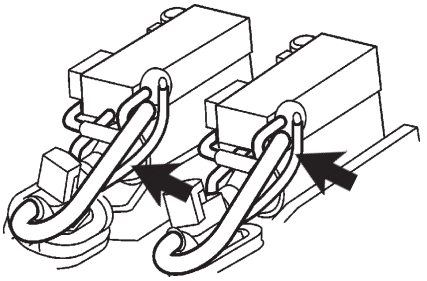
1. Connect the water inlet house to the sea-water cock.

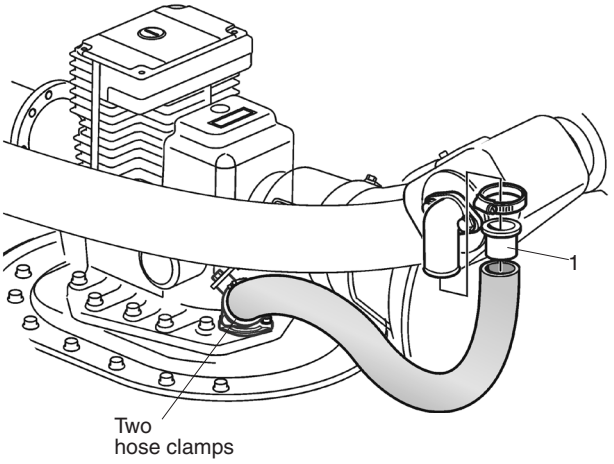
⚠ **IMPORTANT!** Always use two hose clamps.

Hose clamps tightening torque:
5–6 Nm (3.7–4.4 lb.ft)

Connecting the water by-pass (outlet) hoses

NOTE! For Volvo Penta IPS 350, the water by-pass hose is not used. See previous section ***Installing the inlet and outlet sea water cocks***. The figures in this section show the water by-pass hose.





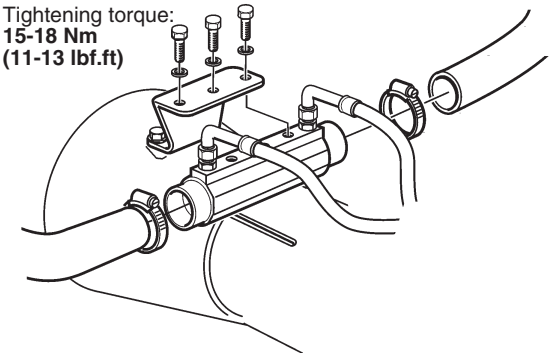
2. Connect the water by-pass (outlet) hose to the sea-water cock.

NOTE! Place the reducing insert (1) in hose.

⚠ **IMPORTANT!** Always use two hose clamps.

Hose clamp tightening torque:
5–6 Nm (3.7–4.4 lb.ft)

Installing the oil cooler

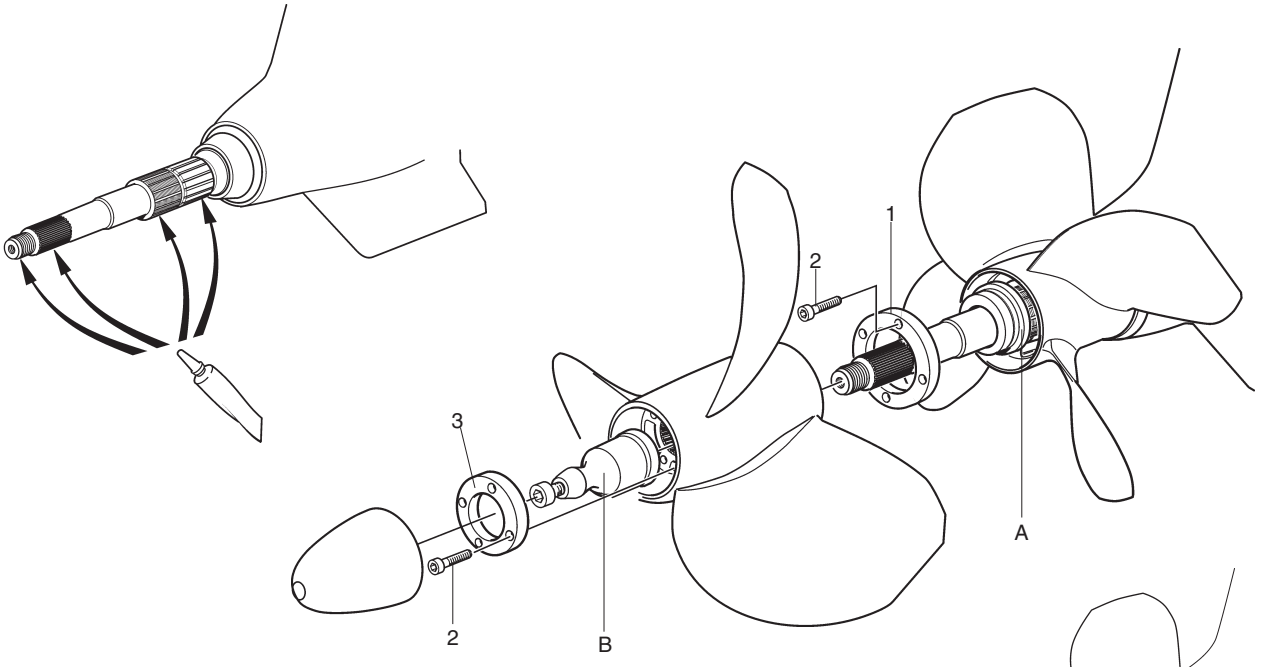


3. Install the Volvo Penta IPS unit oil cooler on the existing bracket on the flywheel housing. Use the three screws and washers fitted in the cooler.

Tightening torque: **15–18 Nm (11–13 lbf.ft)**

Hose clamps tightening torque:
5–6 Nm (3.7–4.4 lb.ft)

Propeller installation



1. Remove nuts (A) and (B).

2. Apply water-resistant grease, Volvo Penta part no. 828250 to the splines and the threads on the aft propeller shaft. Also grase all screw threads.

3. Install the aft propeller. Then install the aft nut (A) and tighten it by hand until it bottoms. Install locking ring (1). Tighten the locking ring using special tool **3863070**, a torque wrench and four socket cap screws (2).

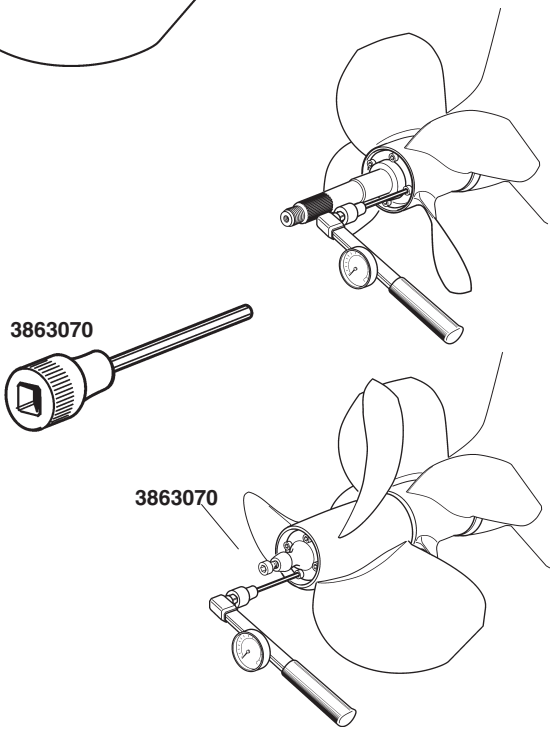
Tightening torque: **25±3 Nm (18.5±2.2 lbf ft)**.

4. Apply water-resistant grease, Volvo Penta part no. 828250 to the splines and the threads on the forward propeller shaft.

5. Install the forward propeller on the propeller shaft. Install nut (B) and locking ring (3). Tighten the locking ring using special tool **3863070**, a torque wrench and four socket cap screws (2).

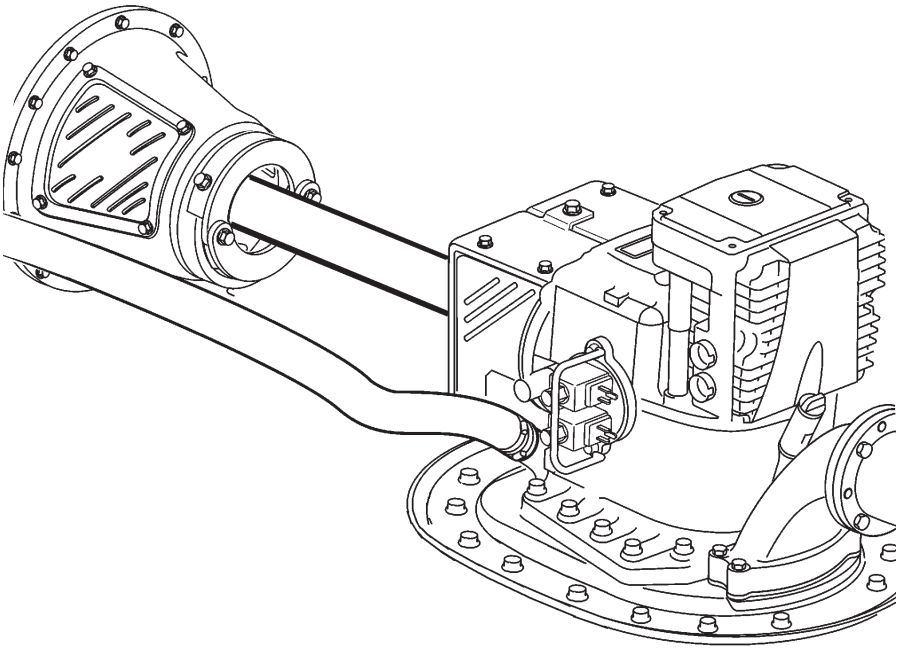
Tightening torque: **25±3 Nm (18.5±2.2 lbf ft)**.

6. Install the rubber cone.



NOTE! The propeller surface finish may differ between propeller sizes due to different suppliers.

Volvo Penta IPS applications
Jack shaft installation



General

In some installations, it is an advantage to move the engine forwards in the boat. Two reasons might be to keep the aft deck flat, to use the boat for sports fishing etc. or to move the center of gravity forwards.

A jack shaft may be used between the Volvo Penta IPS propulsion unit and the engine to achieve this.

When starting a jack shaft installation the engine and drive unit shall be in place and the boat removed from water.

⚠ **IMPORTANT!** The engine and drive unit must be installed parallel to the keel, not with a toe-in of 2° as in standard installations.

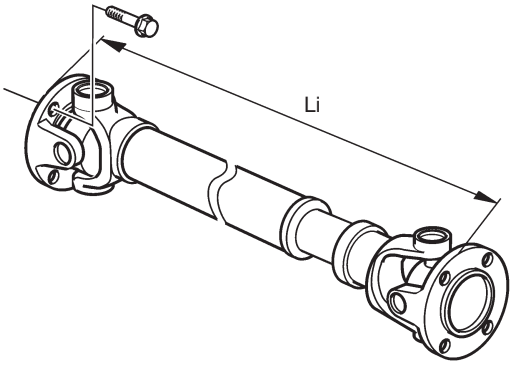
⚠ **WARNING!** Working on or near a jack shaft when the engine is running is extemely dangerous and should be avoided. You can snag clothes, skin, hair, hands etc. This can cause serious injury.

Shut off engine before working on the jack shaft.
Do not run engine with catches removed.

Installation

Drive shaft

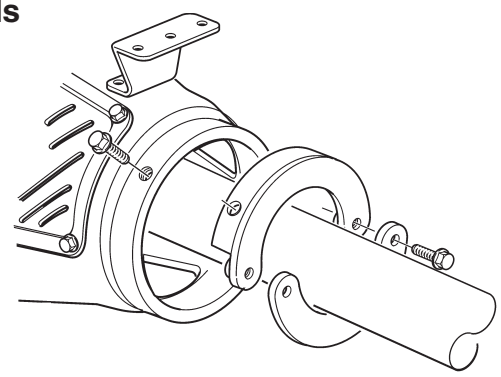
SAE1500 size 2025



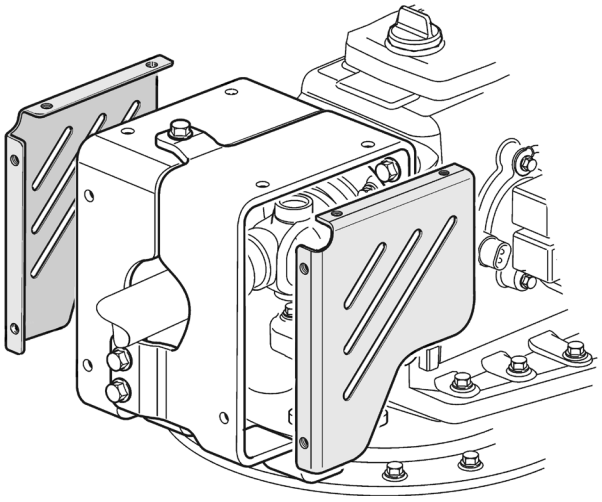
The drive shaft can be ordered in various lengths, installed length (Li) as follows:

570–650 mm	(22.4–25.6")
670–750 mm	(26.4–29.5")
770–850 mm	(30.3–33.5")
870–950 mm	(34.3–37.4")
970–1050 mm	(38.2–41.3")
1070–1150 mm	(42.1–45.3")
1170–1250 mm	(46.1–49.2")
1270–1350 mm	(50.0–53.1")
1370–1450 mm	(53.9–57.1")
1470–1550 mm	(57.9–61.0")
1570–1650 mm	(61.8–65.0")
1670–1750 mm	(65.7–68.9")

Shields



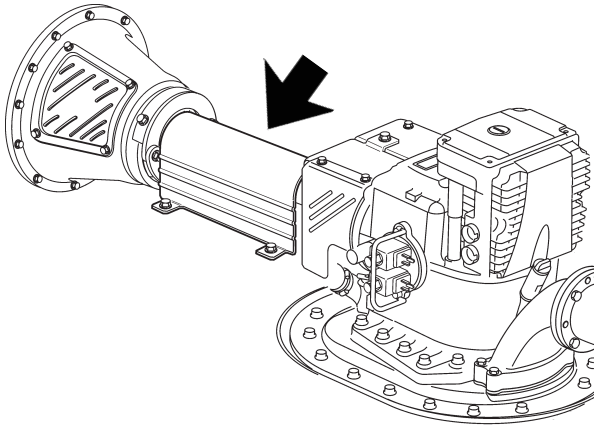
Front end shaft shields have to be installed in the fly-wheel protecting casing.



Rear end shaft shields shall be installed on the gear box housing.

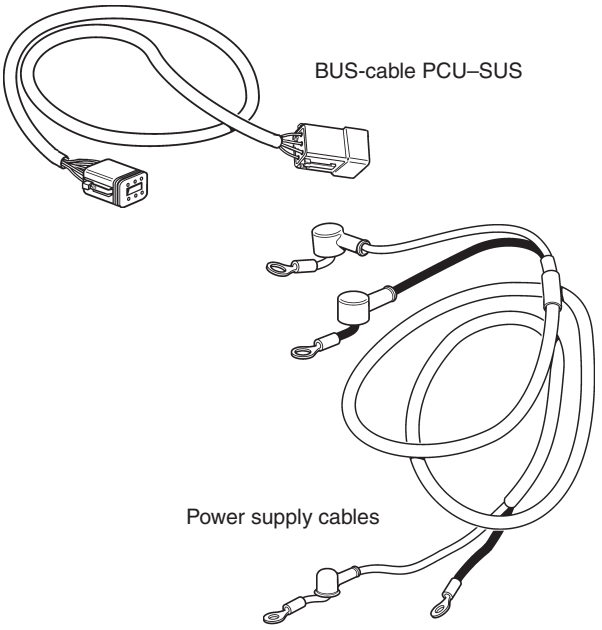
Shields are included in the jack shaft installation kits.

Example of a shaft protection shield



Shaft shields are not supplied by Volvo Penta. These shields have to be tailor made by the boat builder and designed according to local and legal regulations.

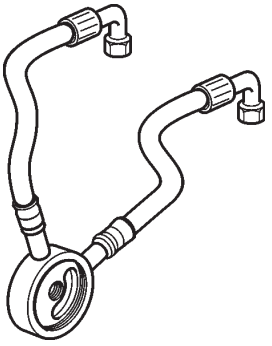
Electrical equipment



Electrical connections and harnesses:

- steering BUS cable PCU to SUS
- power supply cables engine to SUS are included in the jack shaft installation kits.

Hoses



Complete oil hoses from oil cooler to gear box are included in the jack shaft installation kits.

NOTE! Exhaust hoses and water inlet and by-pass hoses are available in standard dimensions and have to be ordered separately, depending on the drive shaft length.

Exhaust hose diam. 125 mm (5")

Water inlet hose diam. 50 mm (2")

Water outlet (by-pass) hose diam. 50 mm (2")

Installation instructions

For further information, please refer to the poster entitled ***Installation Reference Volvo Penta IPS, Jack shaft mounting***.

Volvo Penta IPS applications
Controls and steering

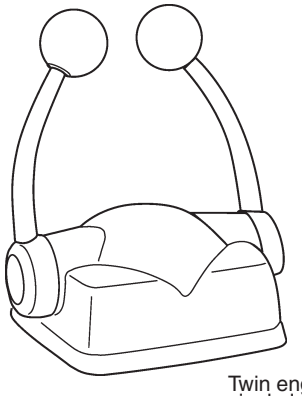
General

If the boat is to be maneuvered and operated in a convenient and safe manner, the helm station should be arranged in such a way that the controls, steering and instruments, navigational equipment and alarm systems are located practically. This applies to each helm station.

Controls for EVC engines, (Electronic Vessel Control)

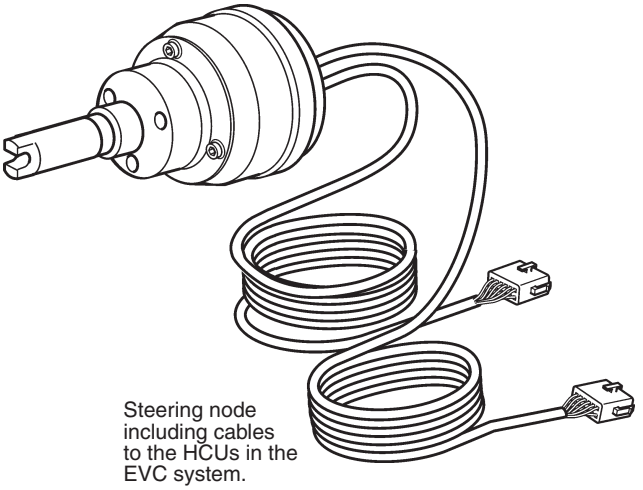
Please refer to the manual ***Installation, Electronic Vessel Control EVC Volvo Penta IPS*** when installing controls and other components for the EVC system.

Top mounted electronic controls

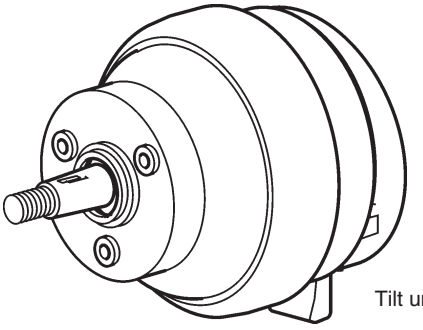


Twin engine, single lever control, EVC

Steering node including tilt unit



Steering node including cables to the HCUs in the EVC system.



Tilt unit

⚠ **IMPORTANT!** Tilt units are mandatory for the Volvo Penta IPS.

Installation instructions

Please refer to the manual ***Installation, Electronic Vessel Control EVC Volvo Penta IPS*** when installing the steering node and tilt unit.

Volvo Penta IPS applications
Drive leg calibration

Calibration, drive leg positions

For a new or an overhauled Volvo Penta IPS installation it is necessary to carry out two different calibration routines:

- Drive leg factory setting calibration
- Drive leg parallel calibration

You will find a survey of the calibration procedure below, and a description of how to handle the special tools needed.

More information about setting and calibration of the Volvo Penta IPS propulsion units is available in the VODIA system.

⚠ **IMPORTANT!** If Drive leg factory setting calibration or Drive leg parallel calibration has not been performed, gear cannot be engaged.

⚠ **WARNING!** Drive leg calibration must always be carried out in accordance with the instructions given.

Preconditions

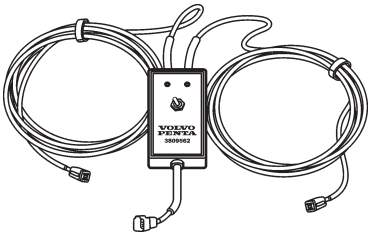
The boat must be out of the water

The batteries should be fully charged or on external power charge

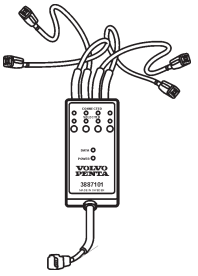
There should not be any persons or objects within operational range of the drive legs.

Special tools and equipment

VODIA
Diagnostic Scan Tool
part no. **3838619**



3809562



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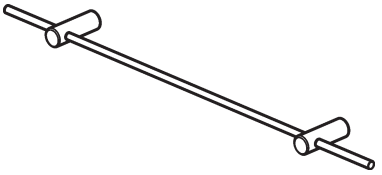
Switch box,
part no. **3809562 & 3887101**

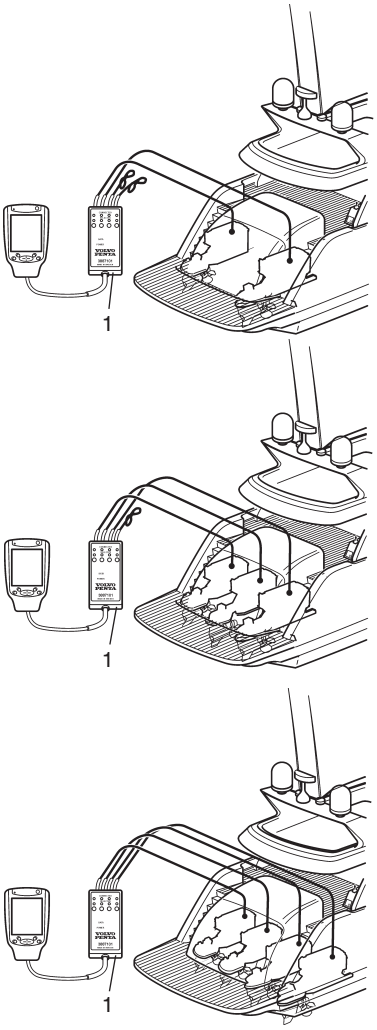


Drive leg center positioning tool,
part no. **3808507**

Calibration, drive leg factory setting

The Volvo Penta IPS units are always calibrated when delivered from the factory or warehouse. Factory setting calibration is generally performed only when a unit has been replaced or when a vital part of the system is changed, such as a drive leg or a resolver (part of the steering system).

The calibration procedure is used for setting the end positions of the starboard and port drive legs.



NOTE! A complete Volvo Penta IPS drive leg calibration procedure always starts with this operation.

The **switch box** (1) is connected to the starboard and port engine(s) diagnostic connectors and the VODIA tool is connected to the switch box. The switch box makes it possible to change between the drive legs during the operation.

The drive legs are then set and calibrated by following the Volvo Penta IPS operation procedures in the VODIA system.

⚠ **IMPORTANT**! This operation must always be followed by the ***Drive leg parallelism calibration*** procedure.

Calibration, drive leg parallelism

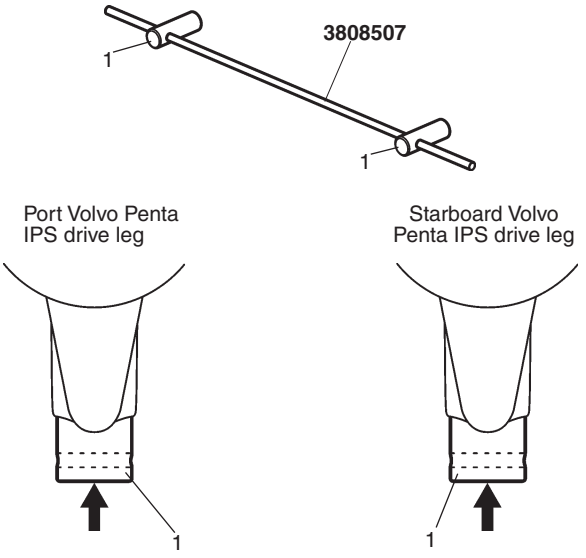
This calibration routine is carried out after the factory setting is done. It is used to calibrate the relative position between starboard and port drive legs (drive legs parallel to the boat keel).

The boat must be out of water and you need a switch box and the special drive center position tool to carry out this routine.

The **switch box** is connected to the starboard and port engine diagnostic connector and to the VODIA tool.

The **drive center positioning tool** is used when positioning the drive legs in parallel and parallel to the keel of the boat.

The drive legs are then set and calibrated by using the Volvo Penta IPS operation procedures in the VODIA system.

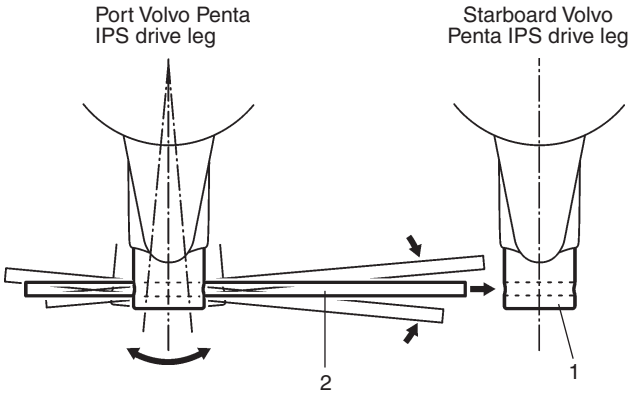


Using the positioning tool, 3808507

NOTE! The following procedure describes the drive leg calibration for twin IPS installation.

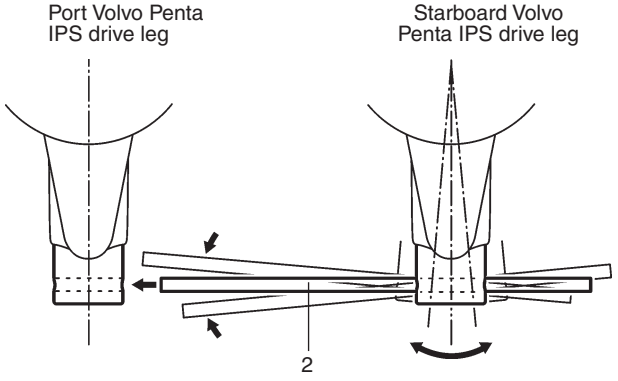
1. When calibrating, push the plastic cylinders (1) into the exhaust outlets on the drive legs.

NOTE! The cylinders must be pushed all the way to the bottom of the outlet holes.

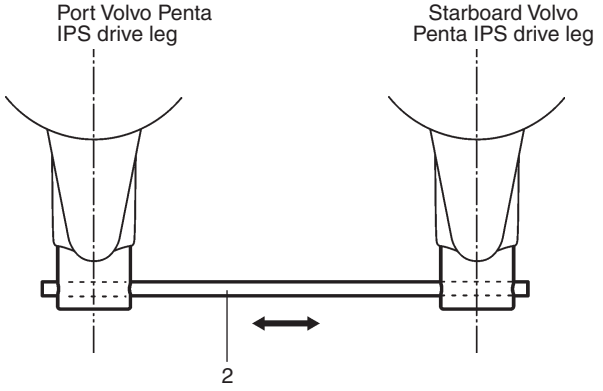


2. Place the aluminum bar (2) in the port cylinder and use it as an "aligning tool" as shown in the illustration.

Carefully position the drive with the bar until the bar aligns with the hole in the starboard cylinder (1).



3. Then move the bar (2) to the starboard cylinder and repeat the steps above until the bar aligns with the port cylinder hole.



4. When the bar (2) can easily be moved through the cylinder holes without any resistance the drive legs are parallel and parallel to the boat keel.

NOTE! The cylinders must be in place, that is against the bottom of the exhaust outlet holes.

Drive leg calibration for triple/quadruple IPS installation

The same procedure as for twin IPS installations is applied for triple and quadruple IPS installations but carried out in several steps. In a triple IPS installation is the drive legs calibration first done for port and center drive leg and then again for center and starboard drive legs. In a quadruple IPS installation is the drive leg calibration first done for the inner drive legs, then the two starboard drive legs and finally for the two port drive legs. Detailed instructions are found in the VODIA tool when performing the drive leg calibration.

Report calibration to VODIA website

⚠ **IMPORTANT!** After finished calibration procedure connect to VODIA website and report Volvo Penta IPS calibration.
If this calibration has been reported a new calibration is not needed after future updates.

Steering angle, setting

It is the responsibility of the boat builder to select the steering setting best fitted for his particular type of boat. The setting must be evaluated during a sea trail of the first boat produced of a particular type.

There are three settings: **MIN, MEDIUM** and **MAX**. The default value is MIN. In general, the MIN setting may be preferred for boats with a flybridge, high center of gravity or large hull deadrise angle. The MIN setting will give the boat a safe and mild response to quick turns at high speed.

The MAX setting may be preferred for boats with a low center of gravity and small to moderate hull deadrise angles. The MAX setting will give the boat a fast and aggressive response to quick turns at high speed. The MEDIUM setting is somewhere in the middle between MIN and MAX.

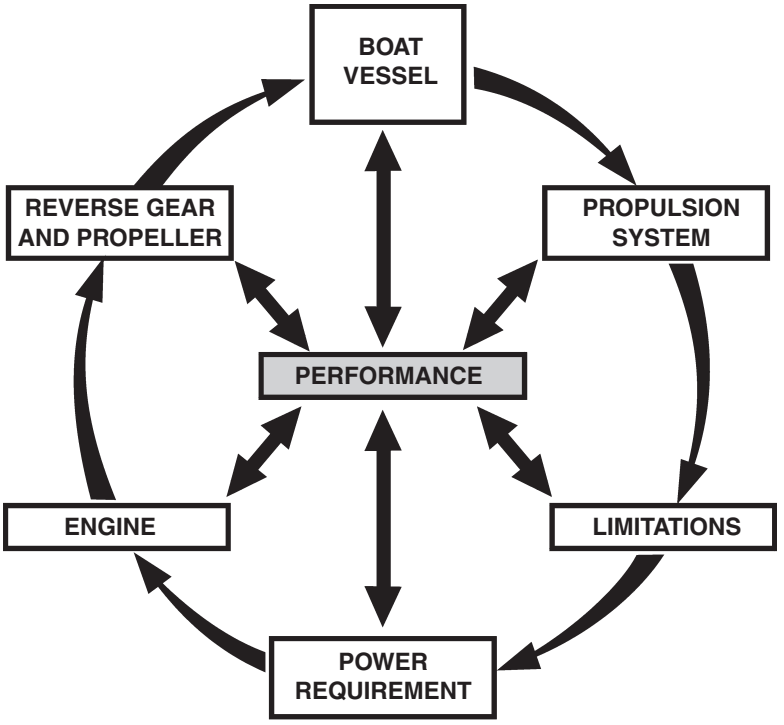
At low speed, all settings give the same steering behavior.

The settings are made using the VODIA tool.

Inboard applications
General arrangement and planning

Choice of engine

It is important to elaborate and iterate the information shown in the illustration below to provide the best performance and characteristics of an installation. Trial and error is often needed to finally find the essential set of "performance" requirements the installation aims to meet. Analysis of each contribution may vary depending on the dominating priorities, such as top speed, economy, safety, etc. Plese consult the Volvo Penta literature and computer programs or contact the Volvo Penta organization for assistance.



Performance requirements

What are the top speed and cruising speed requirements?

The boat/vessel

Define the hull category:

- Displacement
- Semi-planing
- Planing

Consider the boat size and estimate its weight, LCG (Longitudinal Center of Gravity) etc. Drawing information (line drawings) is requested, and preferably hydrodynamic drag data from tank tests.

Propulsion system

Search for the most suitable propulsion system and engine geometry. Think about the characteristics of different propulsion systems.

Limitations

Consider possible limitations, such as engine and propeller dimensions.

Power requirement

Use the data to define the power required. Do not forget to consider power losses due to PTOs, climate, fuel qualities etc.

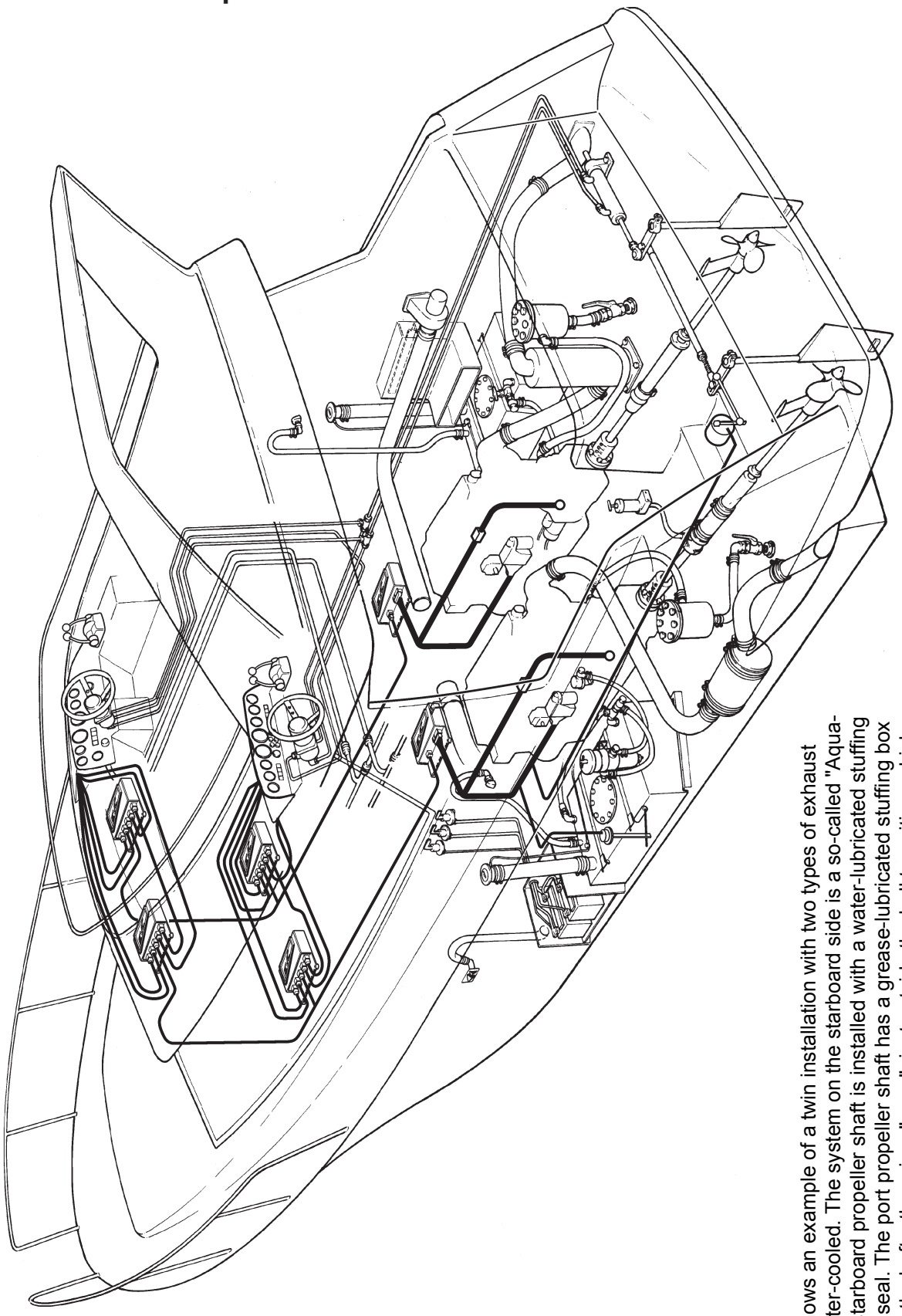
Engine

Consult Volvo Penta sales literature for the corresponding engine, giving minimum required power at the correct duty rating. Check the available reverse gear ratios.

Reverse gear and propeller

Calculate the optimum gear ratio as well as propeller type and size.

Installation example



The illustration shows an example of a twin installation with two types of exhaust systems, both water-cooled. The system on the starboard side is a so-called "Aqua-lift" system. The starboard propeller shaft is installed with a water-lubricated stuffing box and a rubber seal. The port propeller shaft has a grease-lubricated stuffing box as the seal. On both shafts, there is a "vane", just outside the hull transition, which reinforces the water stream entering the stuffing box.

The engines are equipped with the Volvo Penta EVC system (Electronic Vessel Control) and the boat has a hydraulic steering system with a Volvo Penta steering pump, hydraulic cylinder and tie bar .

Plan the engine room so that maintenance can be carried out easily. Compare with the instruction book and make sure that all filter replacements, oil changes and other service work can be done normally. Also ensure that it is possible to install and remove the engine.

Before starting any installation work, make sure that up-to-date dimensioned drawings for the engine and its equipment are used. Dimensioned drawings provide all the necessary measurements for installation, such as the distance from the center of the crankshaft to the engine brackets (reverse gear brackets) and to the center line of the propeller shaft.

Note that the small silhouette drawings on leaflets and brochures should not be used for this purpose.

The engine and driveline should be installed in such a way as to minimize noise and vibration, i.e. airborne noise and structural noise (vibration).

Vibration from the engine and propeller is transmitted into the hull via the engine mountings and engine bed. Other paths are via the exhaust pipe, coolant pipes, fuel pipes, cabling, and control cables.

Pressure impulses from the propeller are transmitted through the water into the hull. Pulsating force on the propeller enters the hull via the support brackets, bearings and seals.

If the propeller is at a large angle, this pulsating pressure and force can be considerable. Use of an incorrect propeller can result in cavitation, which also causes noise and vibration.

Torsional vibration from correctly selected components in the drive package is often negligible.

NOTE! Always consider international and local requirements.

1. Engine room layout

Only use updated and approved dimensioned drawings. Study the drawings carefully. Consider soundproofing material, engine movement when running and accessibility for servicing and repairs.

For twin installations, the distance between the engines should be sufficient to allow easy inspection and service work.

2. Weight distribution

Consider the weight distribution of the boat. Ensure that it is evenly distributed even with different levels of fuel and water in the tanks. Position heavy units so that the boat is balanced around the center of gravity, according to the designer's recommendations.

NOTE! Pay special attention to obtaining the best center of gravity possible. This has a major influence on performance in planing boats.

3. Fuel system

Determine the type of fuel system. Choose whether to use fuel hoses or fuel pipes. Consider classification rules.

Decide where to place extra water separating fuel filters and plan for routing of fuel hoses and pipes, fuel filler and venting hoses, shut off devices etc. Fuel feed and return hoses or pipes should be placed low in the engine room so that they do not transmit extra heat to the fuel.

4. Cooling system

Choose where to place seawater intakes and seawater filters. Plan hose routing.

In boats where the engine is located low in relation to the water line, an anti-siphon valve should be considered.

5. Exhaust system

Choose the type of exhaust system, wet or dry. Plan the installation of the exhaust line components, such as the silencer and hoses.

6. Electrical system

Plan cable routing and check the length of instrument cable harnesses. Decide where to place fuse boxes and main switches.

Avoid joints and cable connections where there is a risk of moisture or water. Do not make any joints or connections behind fixed bulkheads or similar which are difficult to reach after the boat is finished.

7. Electrochemical corrosion

The potential problem of galvanic and stray current corrosion must be considered when planning the electrical installation and choosing the equipment to be used. Plan to use protective anodes.

8. Air supply, ventilation and soundproofing

Carefully study duct sizes to give sufficient area and pay attention to optimizing the design of air inlets. Plan the routing of the ducts (hoses) for the engine air consumption and ventilation so that they do not impede installation of the batteries, fuel tanks, etc.

Sound insulation in the engine room is of great importance for keeping the sound level as low as possible. Sufficient space for soundproofing material must also be planned for. The best way to achieve good noise reduction is to use a sealed engine room with ducts as the only openings.

9. Controls and steering

Plan the routing of control cables, steering systems, Dual station units (DS–units), etc. Allow accessibility for servicing and replacement.

When mechanical control cables are used, it is of great importance to route the cables with as few bends as possible to achieve smooth operation.

10. Power take-off

Power take-offs can be powered from an additional pulley to operate miscellaneous small items of auxiliary equipment.

If greater output is needed, a mechanical power take-off can be fitted on the front end of the crankshaft.

Propeller theory

To get the best performance out of your boat, you need to select the propeller and gearing that will suit your particular boat, engine and speed range.

A brief description of propeller systems design is given below. It is not just the engine capacity which determines the speed of the boat. It depends just as much on the efficiency of the reverse gear and the propeller system. Using the right propeller system will not only give you good fuel economy and higher speed, but you will also experience greater comfort, with less noise and vibration.

The following description is very general and only describes superficially how propellers are designed. The propeller manual, ***Propellers publ. no. 7739174***, gives more detailed information.

Propeller and performance computer program

During the past year, Volvo Penta has developed computer programs for calculating speed, gear ratios and propellers. These programs are excellent for predicting speed and propellers simply and safely.

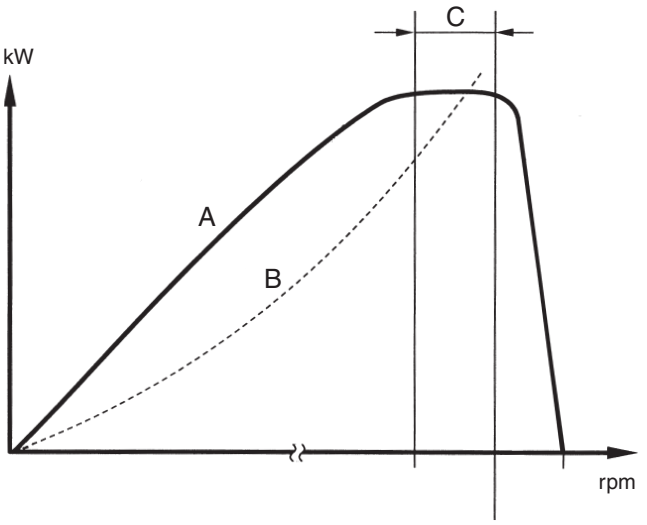
The estimated speed in each computer program is based on the experience gained from a number of installations.

Propeller calculations

Theoretical speed and propeller calculations are made using well-established methods and a number of practical test results, but are still the result of approximations and estimations. We believe that they can give you a reasonable good estimation for a standard type of boat, provided that correct and complete input is available. However, the Volvo Penta organization can not accept any responsibility for the final result which can only be established during sea trials.

Propeller selection

The combination of reduction gear ratio, shaft diameter and propeller size can be calculated by using the ***Volvo Penta computer program***. Calculation of the correct propeller size can be done by the Volvo Penta organization if so desired. In this case, all details of the boat (preferably drawings) must be provided in good time.



A = Engine full load curve
B = Propeller load curve (propeller OK)
C = Recommended max operating range

The propeller should be chosen with the greatest of care. Consider the space between the hull and skeg. Refer to propeller recommendations and propeller shaft angles, and the recommendation for free space between the propeller and hull. Please refer to information on the following page.

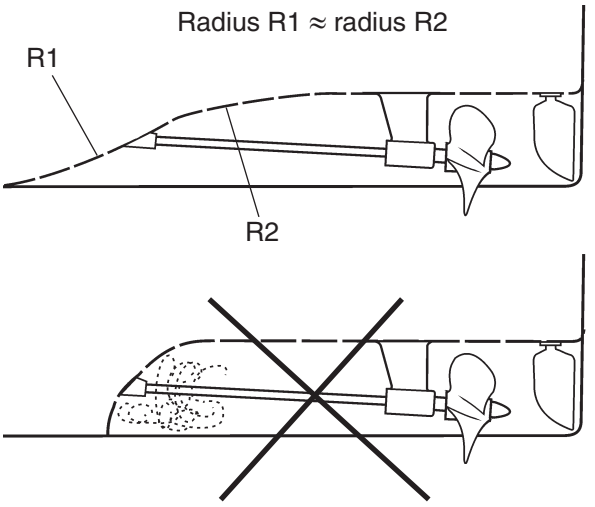
On planing boats the bottom above the propeller is often rather flat. The hull can be reinforced on the inside to reduce noise and vibration caused by the propeller blade pulses.

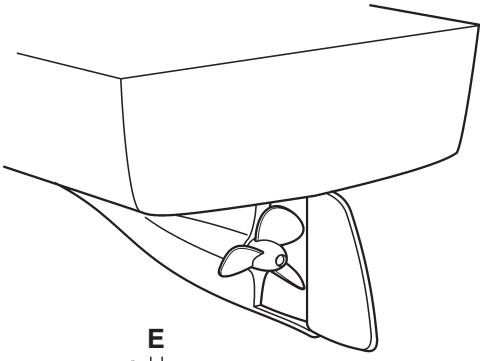
For the best propeller efficiency, the angle of the propeller shaft in relation to the water line should be as small as possible. The larger the shaft angle the lower the efficiency. Shaft angles exceeding 12° should be avoided if possible. This means that with the boat lying still, the propeller angle should not exceed 12°. This especially applies to planing boats. Larger shaft angles may affect speed, sound and vibration negatively.

Check the shaft angle. If the shaft angle exceeds 12°, the use of a smaller propeller should be considered. This can be compensated by more blades or larger blade area.

The keel or the propeller shaft brackets in front of the propeller should have a profile creating a minimum of drag and turbulence. The shape of a tunnel is also very important. A poor tunnel design can create a lot of turbulence before and around the propeller which is negative for the performance. It is vital that the radius (R1) creating the entrance of the tunnel is large enough to avoid turbulence into the propeller.

Ensure that there is sufficient space between the propeller, hull, keel, skeg and the rudder. It should be possible to move the propeller shaft at least 200 mm (8") aft to allow the removal of the reverse gear or coupling. Also make sure that no transverse bulkhead impedes its removal. Sufficient clearance, approx. 1 x the shaft diameter, must be provided between the propeller and the stern bearing to prevent the propeller from pressing against the stern bearing. Allowance should also be made for rope cutters if they are to be fitted. Please refer to figures on this page, position (E).





The minimum distances to the hull, keel, skeg and rudder.

∅= Propeller diameter

A = 0.10 x ∅

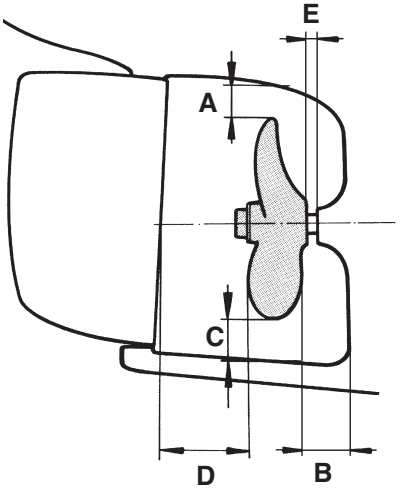
B = 0.15 x ∅

C = 0.10 x ∅

D = 0.08 x ∅

E = Approx. 1 x shaft diameter

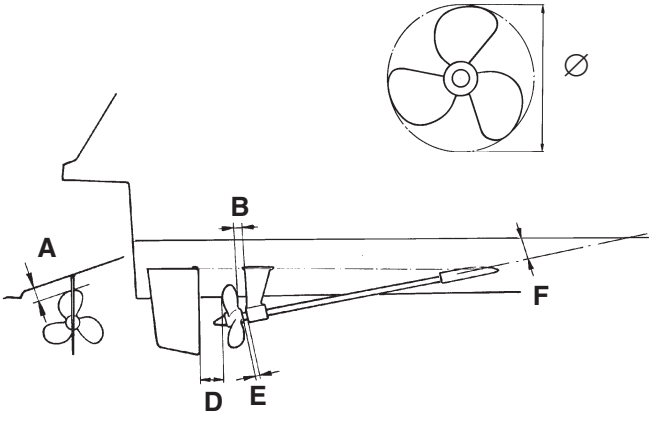
F = Shaft angle. Shaft angles exceeding 12° should be avoided.



Example: The measurement (**A**) for a boat with a propeller diameter 30" (762 mm) is 0.10 x 762 = 76 mm

(0.10 x 30" = 3") minimum.

Measurement (**A**) must never be less than 50 mm (2"). The requirements of the classification body must be complied with when the boat is classified.



Single and twin installations

The most effective method of propulsion is generally achieved with a single installation. If more power is required, two engines, each with a separate propeller shaft can be installed.

Improved maneuvering is gained with twin installations and separate propellers as the power output can be controlled separately and independently for each engine. One engine can be run in reverse and the other ahead when maneuvering at low speed, for example.

Choice of reduction ratio

The propeller shaft usually rotates at lower speed than the engine. This is normally achieved by the reduction in the reverse gear.

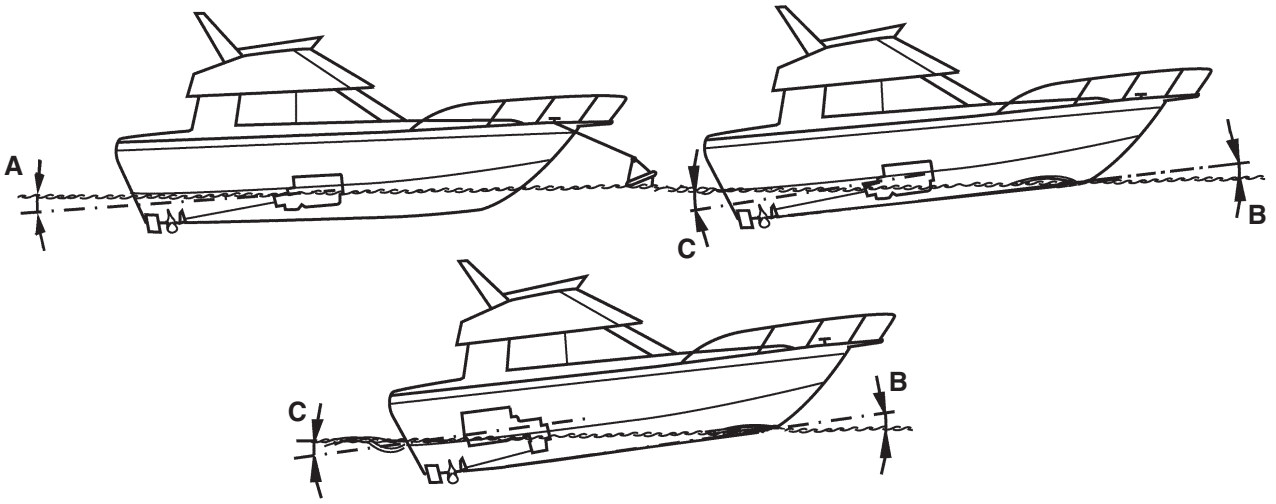
As a rule, the largest possible ratio should be chosen for slow-going displacement boats. It then follows that the propeller diameter can also be relatively large, with high thrust in the applicable speed range. Depending on the hull type and speed range, a smaller ratio can be chosen for higher speed, if required. Please refer to the table. This is to obtain highest thrust within the chosen speed range. If the ratio is chosen outside of the recommendations, the thrust can be lower than the optimum calculated power. The boat's top speed will not necessarily be affected.

A check must always be done to ensure that the hull has sufficient space for the propeller according to the information on the previous page.

Engine revolution range 3000–3500 rpm with convernsional shaft/propeller system

Engine D4 Rated rpm 3000	**Engine D4/D6 Rated rpm 3500**	**Main type of operation range**	**Boat speed**
2.0:1–3.0:1	2.5:1–3.5:1	Work boats Dispalacements boats Low speed planing boats, mainly free run	7–15 knots
1.5:1–2.0:1	2.0:1–2.5:1	Semi-planing to planing boats, Patrol boats, Sport fishing and Pleasure boats	16–30 knots
	1.5:1–2.0:1	Planing boats, Patrol boats, Sport fishing, and Pleasure boats	25–40 knots

Engine inclination



To ensure that the engine is sufficiently lubricated and cooled, it is important that the maximum engine inclination is not exceeded. The engine inclination must be checked.

Care should be taken to avoid having the front end lower than the flywheel end, i.e. in excess of the permitted negative inclination, since this can affect lubrication of the engine and venting of the cooling system.

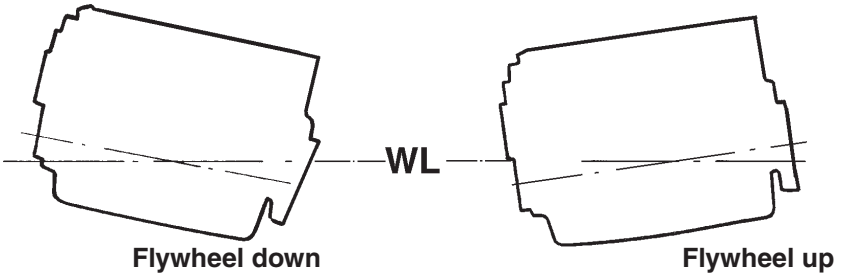
Each engine type has a maximum **permitted engine inclination** while the boat is under way. This inclination includes both the installation inclination and the trim angle that the boat assumes when in motion at various speeds through the water.

A = Static engine inclination.

B = Boat trim angle under way.

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

Max. engine inclination



Max inclination measurements

Standard lubrication system	Flywheel down Max. inclination	Flywheel up Max. inclination
Under way	20°	10°
Static	10°	0°

Weight distribution

General

It is of major importance for the top speed running attitude etc. to locate the LCG properly. Generally, a boat with high top speed should have the LCG further aft than a slower boat.

The center of gravity has a major influence on the boat's static and dynamic stability. It is therefore important to consider this for both cases, when loaded and not loaded.

Planing and semi-planing hulls

Especially for planing and semi-planing hulls, it is important that heavy equipment such as engines, fuel tanks, water tanks and batteries should be positioned so as to obtain the best possible boat trim when in the water.

Fuel and water tanks should be located as close to the LCG as possible to keep the LCG steady when fuel and water levels change.

It is an advantage to install the fuel tanks away from the hot engine room. The batteries should be placed in a separate, well ventilated area if possible.

Figure A

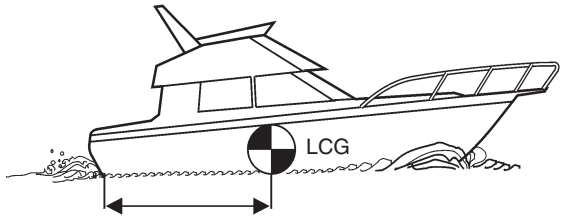
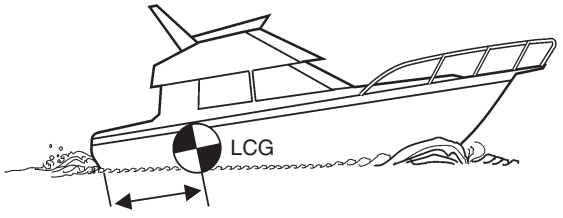


Figure B

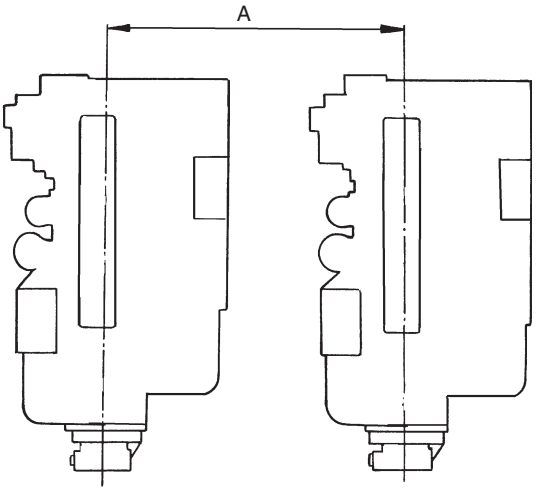


LCG = Longitudinal Center of Gravity

Figure A represents an installation with good weight distribution and with a good trim angle.

Figure B represents an incorrect type of installation with a subsequent bad running attitude.

Engine center distance, twin installation



For twin installations, consideration must be given to the minimum distance between the engine center lines to allow sufficient access for service work. A larger distance also gives better maneuvering capacity.

Check for a suitable distance by using the dimensioned drawing.

Generally, the recommended minimum distance between the engine centerlines (**A**) is: **950 mm (37½")**.

Accessibility for maintenance and repairs

When you design the engine installation, always pay attention to the access needed for correct engine service. Also ensure that the complete engine can be removed without damage to the boat structure.

NOTE! There must also be sufficient space for the sound proofing material. The recommended minimum distance from sound proofing materials is 180 mm (7") and 200 mm (8") please refer to fig.

Study the installation drawing of the relevant engine carefully.

Accessibility for maintenance

Areas that normally require access for maintenance:

- Oil change and refill (engine, power steering)
- Changing filters, (oil, fuel, air, & crankcase vent.)
- Change/Adjust drive belts and belt tension
- Removing the valve cover
- Changing the impeller, seawater pump
- Cleaning the water filter

Accessibility for repairs

Areas that may require access for repairs:

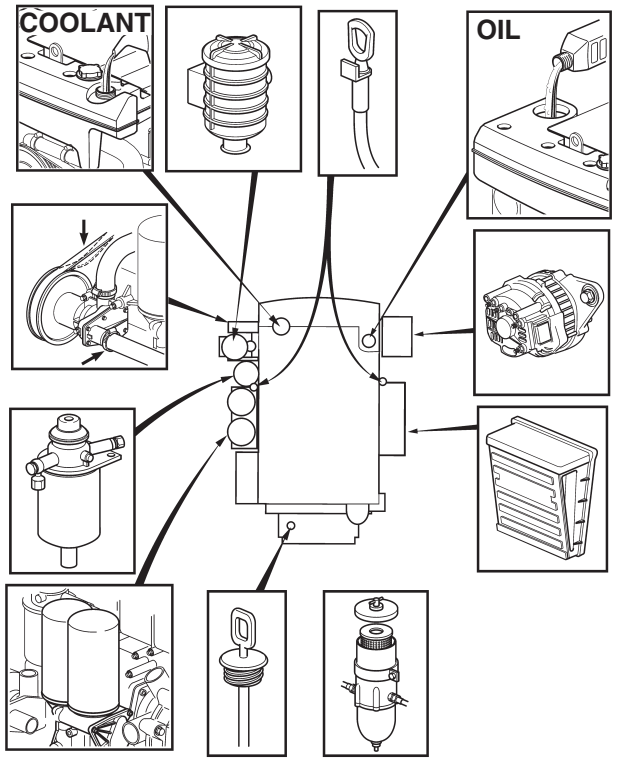
- Removal of injectors, cyl. head, coolers, etc.
- Removal or replacement of electrical components
- Removing the flywheel and vibration damper
- Removing or changing steering equipment
- Engine removal

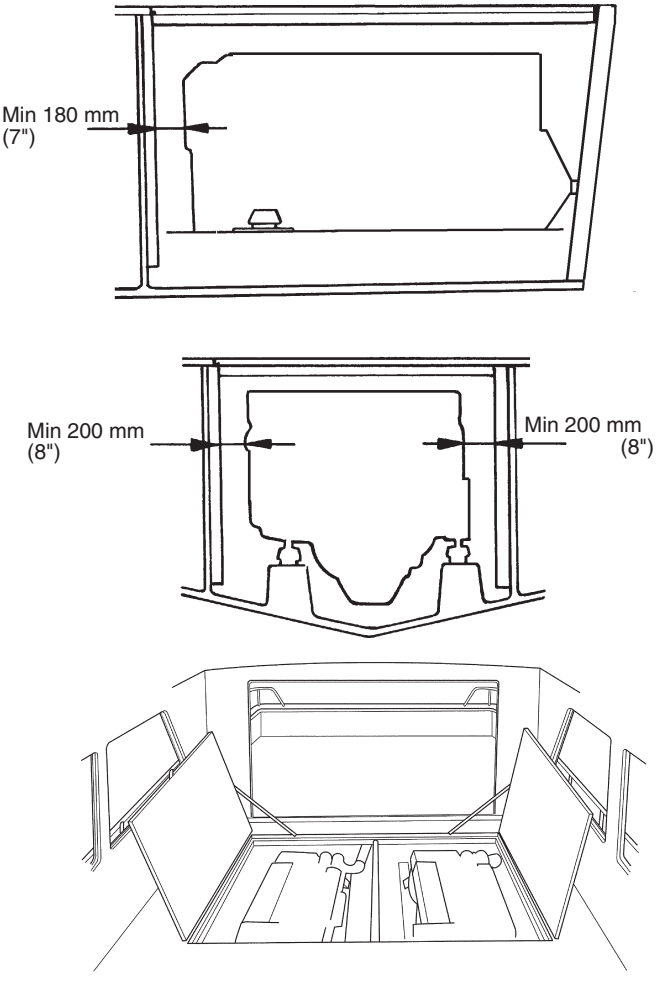
Removal of complete engine package

If the entire engine package needs to be removed, it is the installers (boat builders) responsibility to provide reasonable methods of removal and re-installation. This means, within reasonable time, with normal resources and methods available in the trade, to limit cost and downtime.

For the sake of high demands at high season on yards etc. the vessel manufacturers instruction should be followed.

It is the policy of Volvo Penta to avoid unresonable installations driving additional cost for the boat owners during the vessels service life.

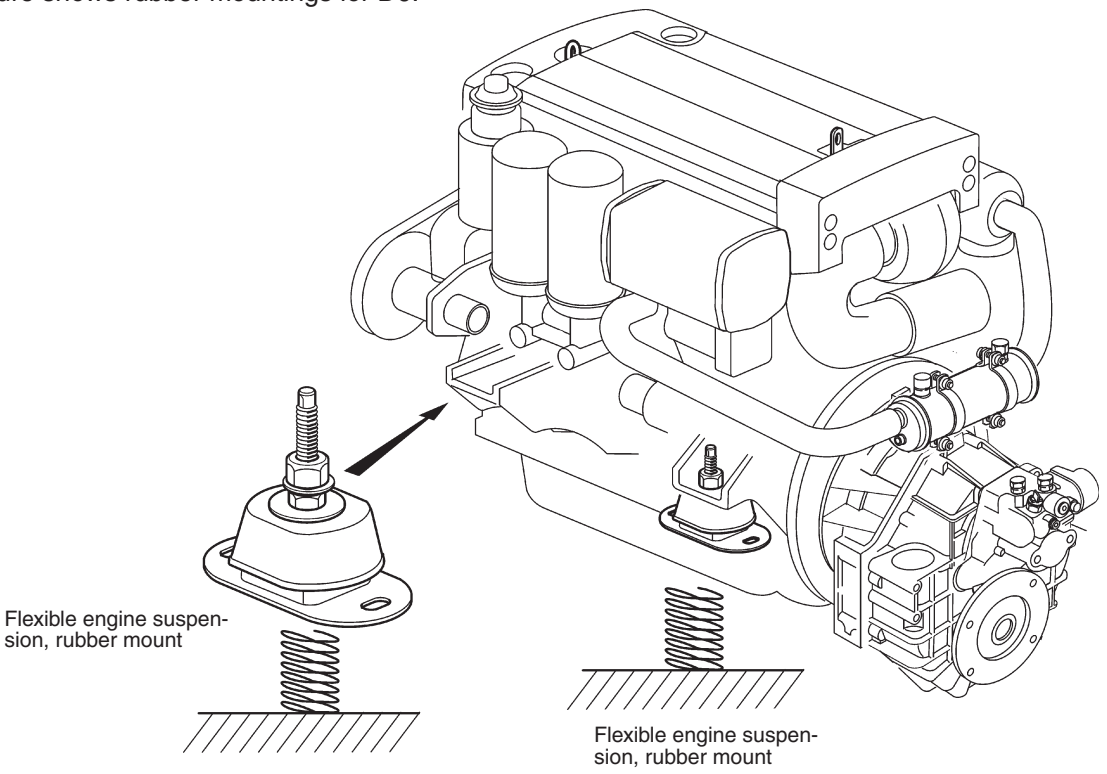




Selection of engine mountings

There are two types of engine mountings; flexible mounting with rubber mountings and rigid mounting. Flexible mounting is recommended for this type of engine.

NOTE! Picture shows rubber mountings for D6.



Flexible mounting

One requirement for rubber mountings to work as effective vibration dampers is that the engine bed is sufficiently rigid. The bed must also be parallel to the engine feet to prevent tension from being built into the engine mounting. Tension can increase the vibration level and also shorten the life span of the mountings.

NOTE! The elasticity of the rubber mountings must never be utilized to compensate for an inclined bed.

Flexible engine mountings provide good insulation from vibration between the engine and the bed frame, thus contributing to a low noise level. Dimensions for flexible mountings, please refer to page 127–128.

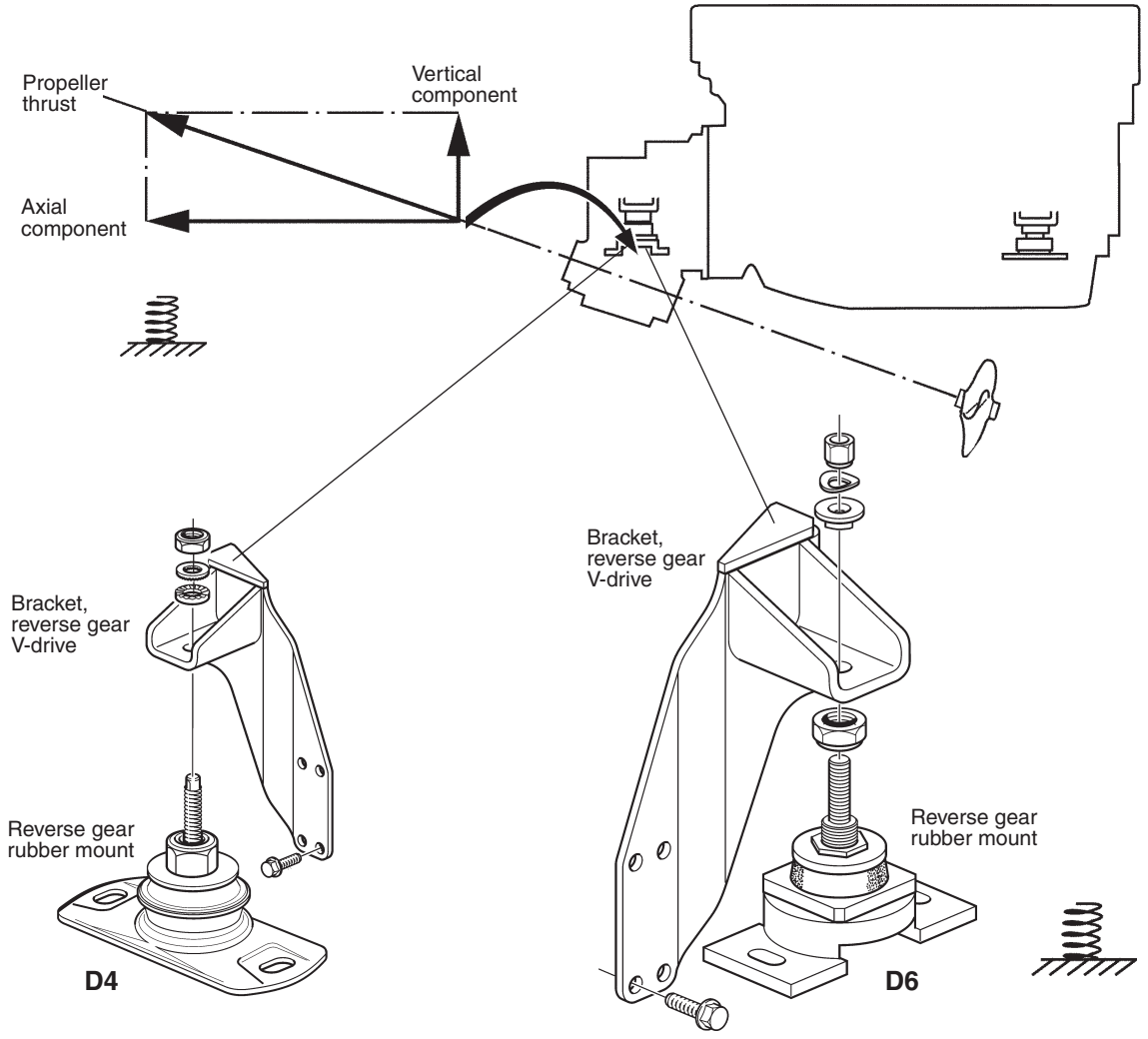
NOTE! The rubber mountings for **D6** applications are compressed and settle after installation. For this reason, the engine should rest on the rubber mountings for 12 hours before the height is adjusted.

Always follow Volvo Penta recommendations when selecting the engine mountings. The use of incorrect rubber mountings can result in abnormal vibration, which in turn can cause damage to engine components and also reduce the degree of comfort.

NOTE! When flexible engine mounting is selected, all component connections to the engine must be flexible. The propeller shaft must also have a flexible stuffing box or a flexible shaft coupling.

Engine connections for fuel lines, exhaust and coolant must be flexible.

V-drive



In all installations with a down angle propeller shaft there, there will be a lifting force transmitted from the propeller shaft. When an engine is installed with a V-drive, this force could be higher than that from the weight of the engine and gear box.

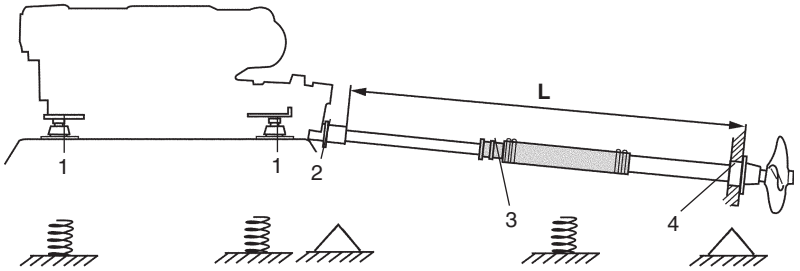
This will create a lifting force on the engine mountings fitted at the same end as the gear box. For this reason, all engines with a close coupled V-drive must be equipped with mountings at the reverse gear end which are designed for this type of application.

Engine suspension and propeller shafts

NOTE! A flexible shaft coupling must never be fitted together with a flexibly mounted stuffing box. This can cause vibration problems.

Stainless steel propeller shafts are available in different diameters. The choice of shaft dimension should be based on the engine power output, gear ratio, distance between support points and propeller shaft material.

The following installation alternatives and combinations are recommended:

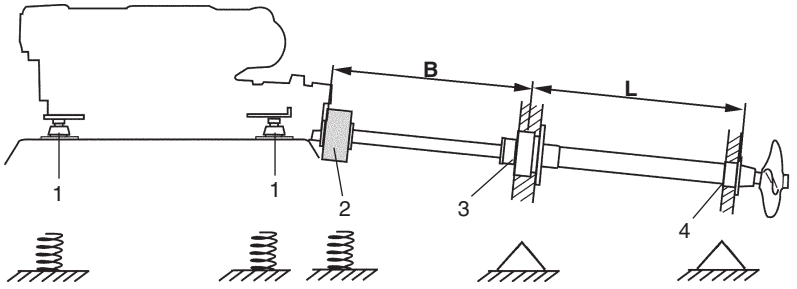


1. Engine with flexible mountings and flexible shaft seal

In this case, a flexible shaft coupling should not be installed.

1. Flexible engine mountings
2. Fixed shaft coupling
3. Flexible mounted shaft seal
4. Water lubricated stern bearing

L. Maximum distance between support points. For calculation please refer to page 126–127.



2. Engine with flexible mountings and fixed shaft seal

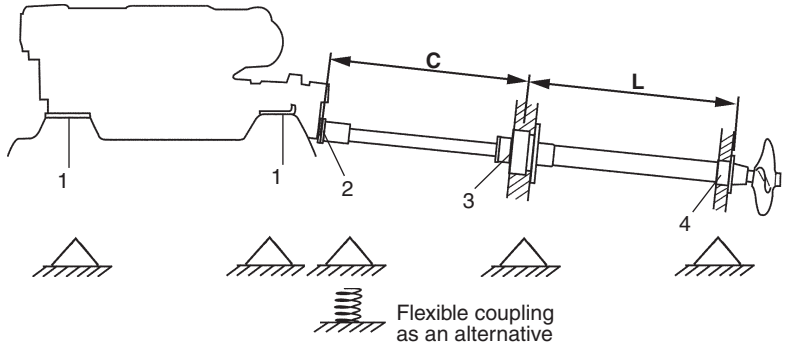
1. Flexible engine mountings
2. Flexible shaft coupling
3. Fixed front stern bearing and shaft seal
4. Water lubricated stern bearing

L. Distance between support points. For calculation L max please refer to page 126–127.

B. Distance between reverse gear flange – support point.

Recommended B min is 6-10 x shaft diameter.

B max is calculated in the same way as L max.



3. Engine with fixed mountings and fixed shaft seal

1. Fixed engine mountings
2. Fixed shaft coupling. (Flexible coupling as an alternative.)
3. Fixed front stern bearing and shaft seal
4. Water lubricated stern bearing

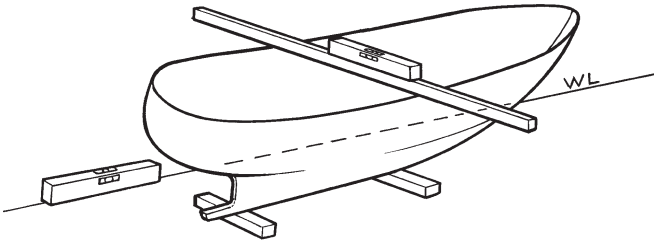
L. Distance between support points. For calculation of L max, please refer to pages 126–127.

C. Distance reverse gear flange – support point.

C max is calculated in the same way as L max.

Inboard applications
Engine bed

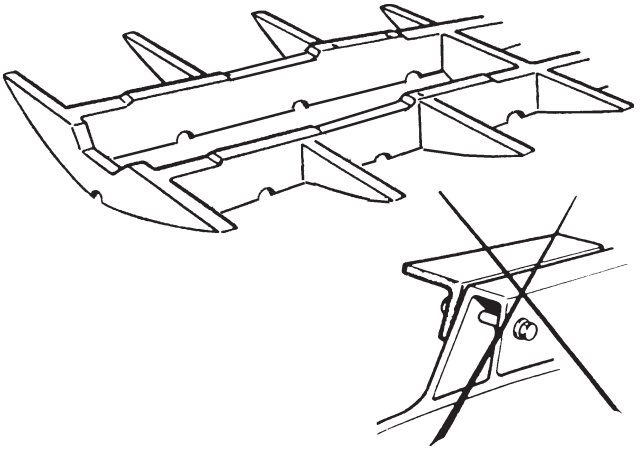
Aligning the boat



Installation work is made easier if the hull is aligned horizontally before starting. Block up the hull so that the calculated water lines, both longitudinal and transverse, are parallel with the horizontal plane. A spirit level is a good help.

Check when manufacturing the bed that the upper bed plane, the mating plane, is parallel and correctly positioned in relation to the center line of the propeller shaft. A guide sleeve with the same diameter as the propeller shaft can be used in the stern tube to help with the alignment of the bed.

General



The engine bed should be dimensioned so that it is rigid in all directions, to distribute the load as much as possible into the hull. The greatest possible area of the engine bed, and its cross members, must be fastened to the hull to give the best noise and vibration insulation.

Design

The bed should have a design basis that enables it to absorb the engine torque, the propeller thrust and the dynamic forces (mass forces) that occur during movement in rough sea by an adequate margin.

When the bed is designed it is important that there is sufficient space under the engine for the movement of the engine, and that there is also access to the inspection covers (certain engine versions).

If possible, the bed should be designed so that the reverse gear and flexible coupling can be dismantled and lifted out separately.

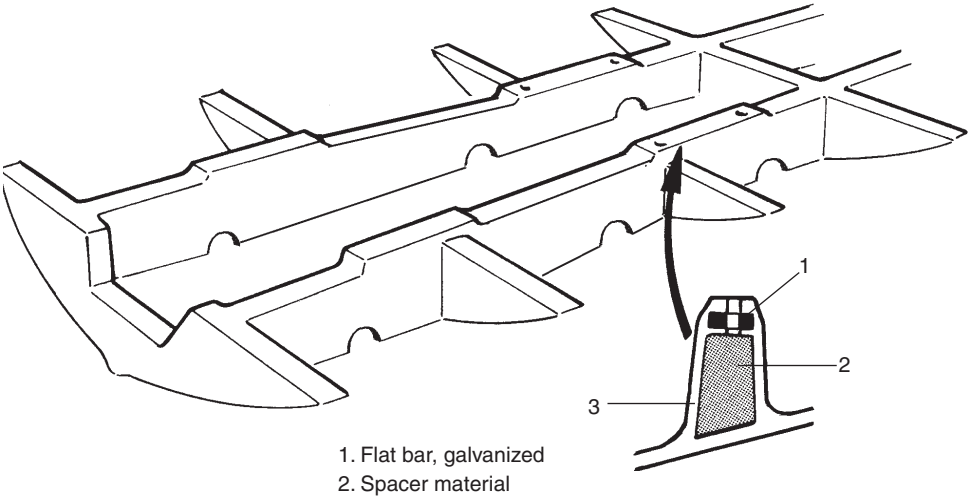
When the bed is designed, the dimensioned drawings for the engine and the boat should be used if possible, to check the space round the engine and the height and position of the bed in relation to the propeller shaft. The height depends on whether a flexible engine mounting is to be used or whether the engine is to have a rigid suspension, and the inclination of the bed should correspond with the inclination of the propeller shaft. The height should include a shim of 10 mm (0.4") to prevent the bed from being too high.

It is important to drain any water around the engine bed to the location of the bilge pump.

The figure on the left shows an example of a well-designed engine bed.

Fiberglass hull

Example of an engine bed in a fiberglass hull.



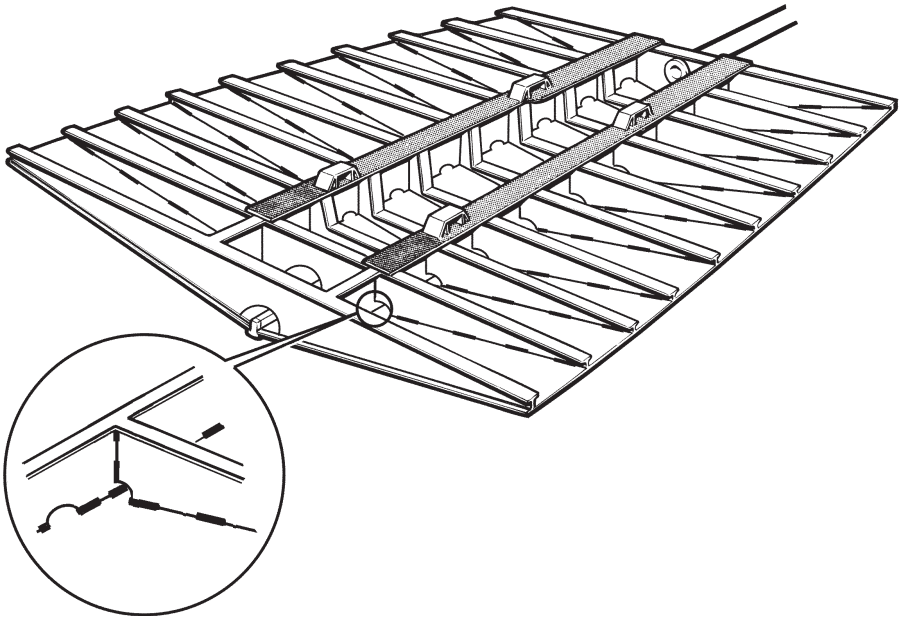
1. Flat bar, galvanized
2. Spacer material
3. Fibreglass

A fiberglass engine bed should be designed so that it is rigid, both vertically, longitudinally and transversely, to distribute the load to the hull over the greatest possible area. The bed is often built as a box structure. As much of possible of the engine bed, including cross members, should be attached to the hull to ensure the lowest possible noise and vibration level.

The engine bed can be built up separately and then carefully measured and bonded to the hull, or it can be built up directly in the hull. It is important that bed connections to the hull are made with a large radius, built up with several layers of fiberglass.

Steel, aluminum or wooden hull

Example of engine bed in a steel or aluminum hull.



The bed frame in a steel or wooden boat should be designed as a welded steel structure. The sheet metal thickness should be sufficient to achieve a dimensionally stable structure.

In a steel boat, the engine bed plane is welded to each frame along its entire length.

In a wooden boat, the bed should be bolted to the frame ribs with nuts and bolts.

The length of the engine bed should be extended as far as possible to distribute the load.

If the engine has an extra PTO at the front that requires extra support, the bed should be designed to accommodate this support. There must be space in front of the PTO so that it can be dismantled.

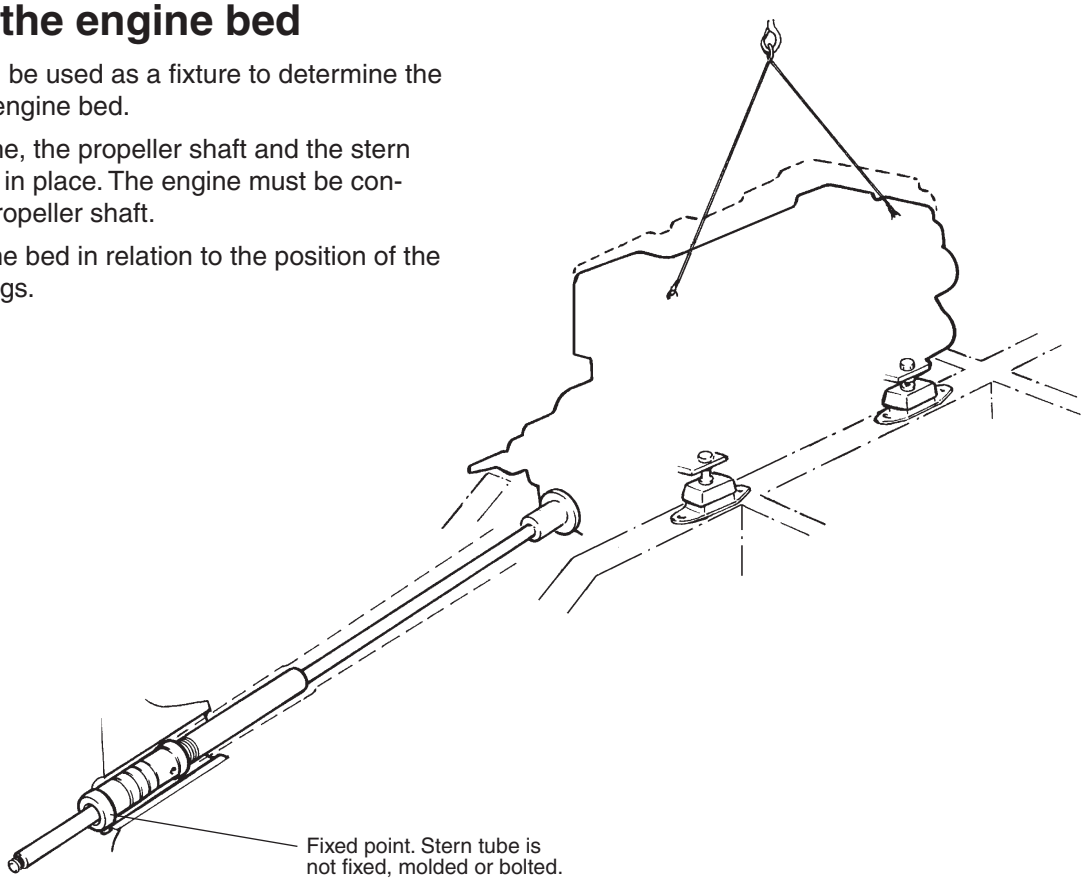
Consider and calculate brackets and beds etc. for other systems, fuel and exhaust systems etc., and for auxiliary equipment.

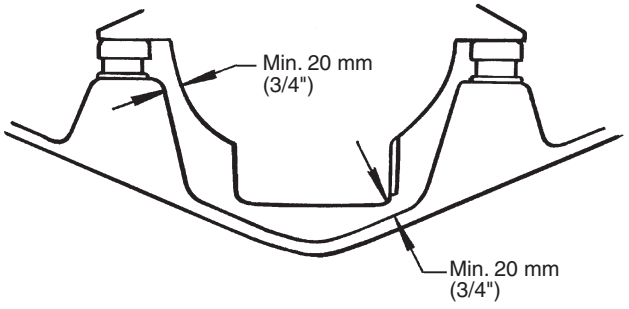
Building the engine bed

The engine can be used as a fixture to determine the position of the engine bed.

Install the engine, the propeller shaft and the stern bearing loosely in place. The engine must be connected to the propeller shaft.

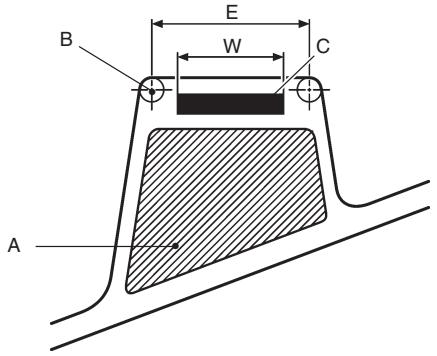
Start building the bed in relation to the position of the engine mountings.





When the engine bed is designed, make sure that the space for the flywheel housing, the bottom and sides of the sump, etc. have a recommended clearance of at least 20 mm (3/4").

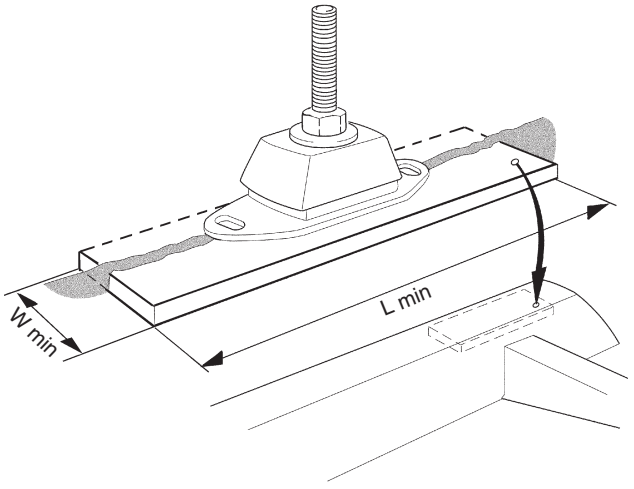
Fibreglass engine bed



A = Spacer material, preferably high density material
B = Fiberglass, approx. 10–15 mm (0.4–0.6")
C = Flat bar, galvanized, approx. 10 mm (0.4"), min. width: 80 mm (3")
W = Flat bar width
E = Engine bed min. width: 112 mm (4.4")

To reduce noise and vibration, the engine bed should be filled. Make sure the material does not absorb water. Generally high density material (A) is better for noise reduction.

Build up the engine bed with spacer material (A) so that the underside of the engine mountings/ engine rubber mountings almost rest against the bed. There must be room for flat bars and fiberglass.



A 10–12 mm (0.4–0.5") thick galvanized flat bar with a minimum length (L min) of 250 mm (10") and a minimum width (W min) of 80 mm (3") should be built into the engine bed.

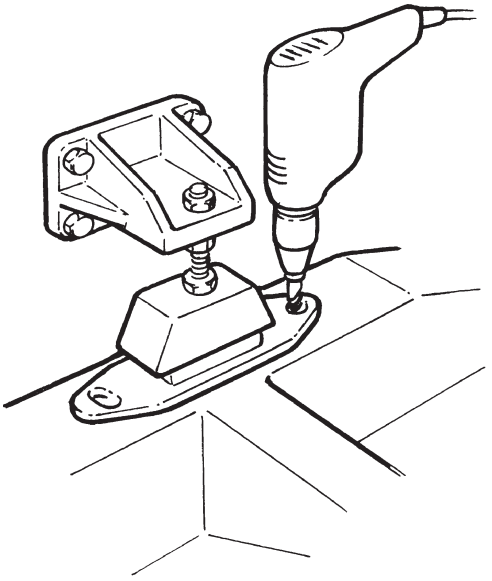
Build in drain channels to allow water to drain to the location of the bilge pump.

Drilling holes for engine mountings

Bolt holes could, of course, be drilled and tapped (threaded) by accurate measurements and fixtures at other stages of construction than outlined in this chapter. In mass production and other frequent installations, more sophisticated methods may be desirable and may be used.

NOTE! If the engine and engine mountings are used as a drill jig, the holes for the engine mountings/rubber mountings should be drilled in conjunction with installing the engine in the boat.

Also please refer to the chapter ***Engine installation***.



Align the engine with the propeller shaft and mark up for the engine mounting holes.

Drill and tap holes in the bed and flat bars.

The recommended bolt diameter for Volvo Penta D4 and D6 flexible mountings is **M12 or 1/2" UNC**.

Inboard applications
Propeller shaft systems

Propeller shafts

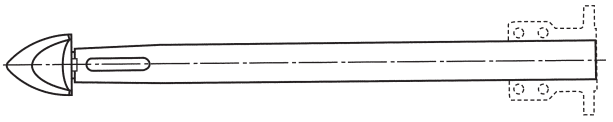
When a propeller shaft is selected for a particular application, there are many points to be taken into consideration. Shaft material and shaft sizes must suit the individual vessel designs and application.

The shaft material must have good strength and be corrosion resistant. A stronger material is beneficial in many sport cruiser applications, because a smaller diameter results in less underwater resistance and turbulence to the propeller.

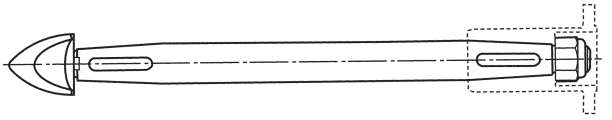
Depending on the length, the shaft may need to be supported by bearings. The minimum distance between the propeller shaft coupling to the first rigid bearing should be 6–10 x the shaft diameter. The distance should be sufficient to allow engine movement without excessive stresses in the shaft system. The maximum distance between bearings is determined by the critical shaft speed. This can be calculated on the basis of the type of installation and shaft properties.

During installation of the shaft, it is of great importance to protect the precision straightness and fine surface finish. When shafts are lifted it is best to use slings with spreaders to distribute weight more evenly to avoid straightness problems.

Always check the straightness of the propeller shaft. The run-out of the shaft from 100 % straightness must not exceed 0.3 mm per meter (0.0036" per foot).



Single tapered shaft



Double tapered shaft

Shafts that are tapered at both ends, double tapered shafts, can be machined to be reversible. This effectively doubles the life of the shaft as it can be turned around when seals and bearings have made wear marks in the shaft.

Before the shaft is installed, check the fit of the coupling to the shaft taper.

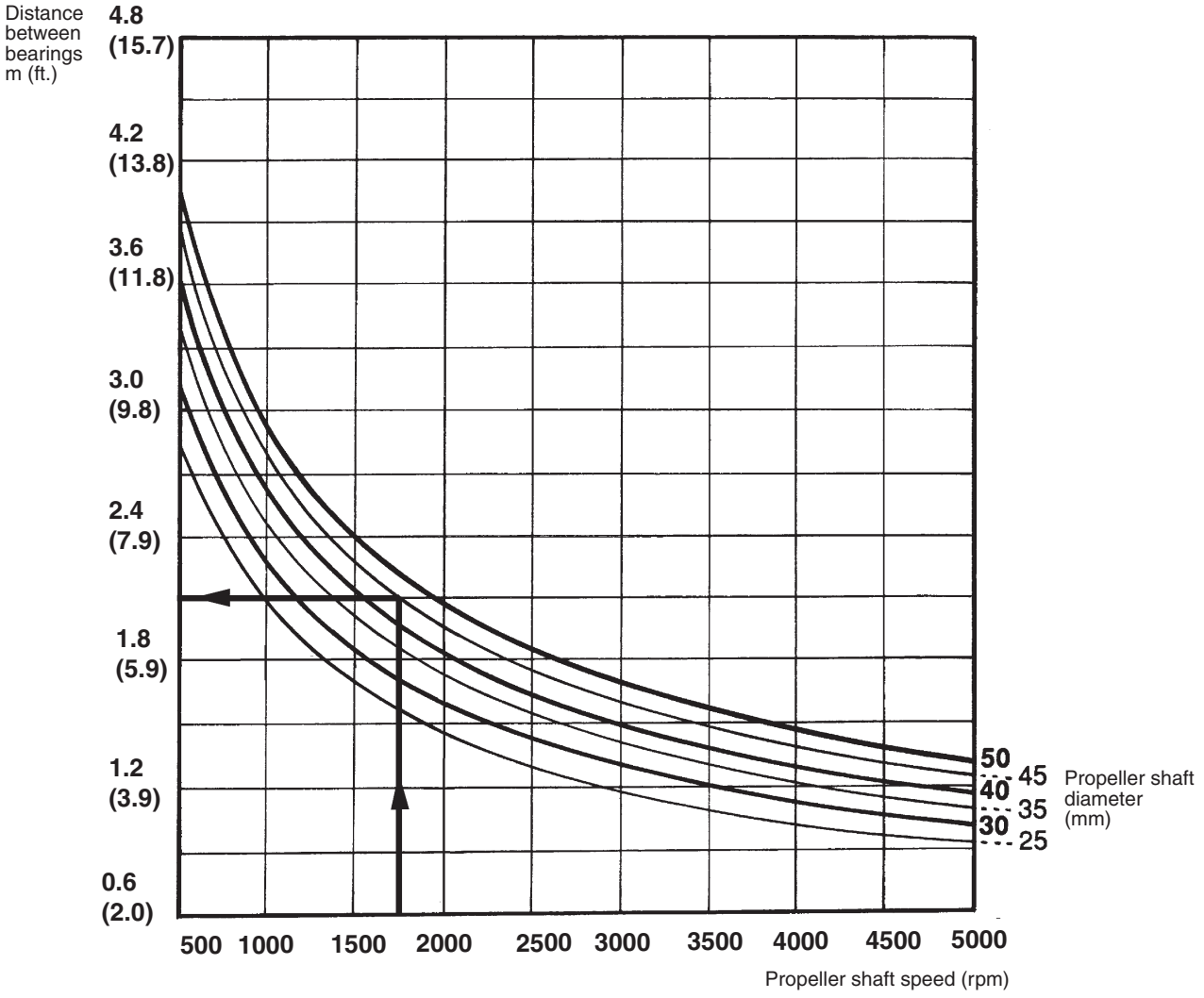
Propeller shaft dimensions and bearing distances

The propeller shaft will be subject to both bending and torsional forces and must be dimensioned with regard to this. A certain safety margin must also be applied. The maximum bearing distance has a major influence on the shaft dimension calculation.

To determine the propeller shaft dimension and bearing distance, use the nomogram below, the Volvo Penta computer program or consult the shaft supplier.

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

This nomogram is valid for stainless steel SIS 2324-02 or equivalent.

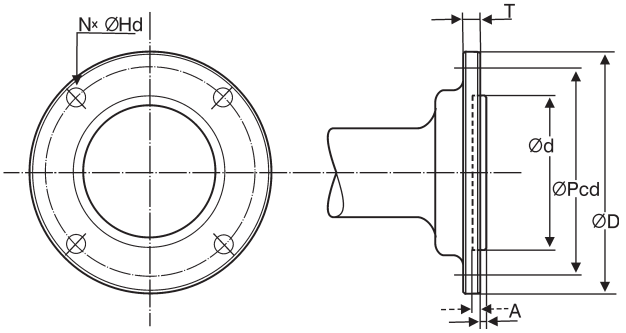


Example:

Engine:	D4, 210 hp
Engine rpm:	3500
Gear ratio:	2.04:1
Shaft dia:	45 mm
Material:	Stainless steel SIS 2324-02
Type of installation:	Please refer to figure, alternative 1 on page 120.

1. Calculate the propeller shaft speed: 3500/2.04 = 1715 rpm (approximately).
2. Follow the diagram from the right hand side to the 45 mm diameter curve.
3. Follow the curve until it crosses the propeller shaft speed line (1715 rpm).
4. From this point, draw a straight line out to the left hand side (length in meters).
5. We get the distance of 2.1 meters (6.9 ft) between the bearings.

Reverse gear flange



Dimensions in mm

Reverse gear	D	Pcd	d	T	A	N x Hd
HS45AE	127	108±0.2	63.5H8	10	–4.0*	4 x 11.5
HS63AE	127	108±0.2	63.5H8	10	–4.0*	4 x 11.5
HS63VE	133	108±0.1	63.5H8	9.5	–4.0*	4 x 11.5
HS80AE	146	120.65±0.2	76.2g7	14	4.0	6 x 16.3
HS80VE	146	120.65±0.2	76.2g7	16	3.2	6 x 13.0
HS85AE	146	120.65±0.2	76.2g7	16	3.2	6 x 13.0
HS85VE	146	120.65±0.2	76.2g7	16	3.2	6 x 13.0

*) Female coupling, recessed in flange plane. Dashed line in figure.

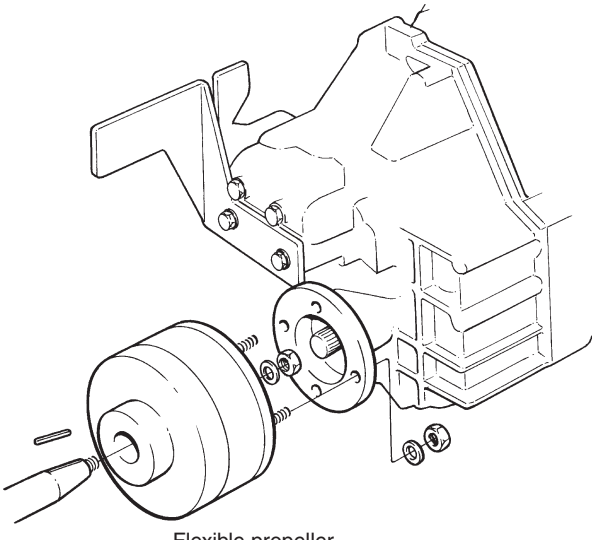
Flywheel housing connection:
SAE 4

Flexible propeller shaft coupling

If there is a flexibly mounted engine and a fixed stuffing box, the propeller shaft must be fitted with a flexible propeller shaft coupling. Please refer to alternatives on page 120.

NOTE! The alignment of the engine is just as important with the above propeller equipment as for a rigid shaft connection. The flexible stuffing box and propeller shaft coupling are not designed to absorb a constant angle deviation.

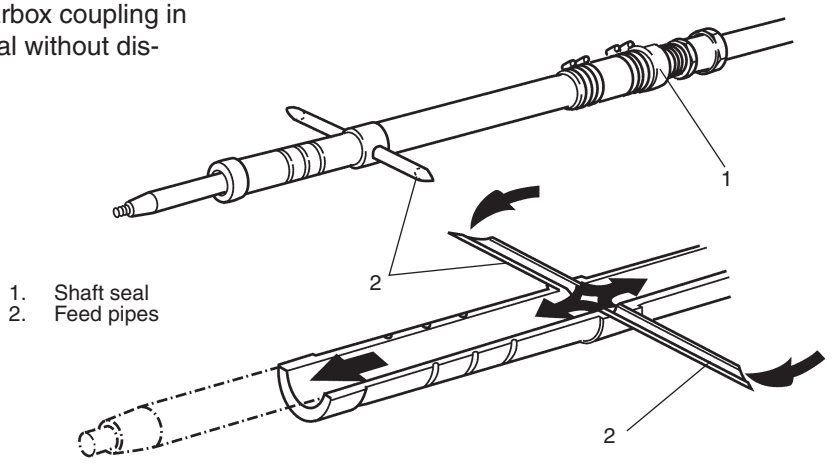
The flexible propeller shaft coupling could be installed as shown in the figure.



Flexible propeller shaft coupling

Shaft seals

There are several methods of lubricating the shaft seal. The two most common ones are water and grease lubricated seals. Ensure easy access for maintenance and inspection of the seal. Some seals require a certain clearance to the gearbox coupling in order to permit replacement of the seal without disconnecting the shaft.



1. Shaft seal
2. Feed pipes

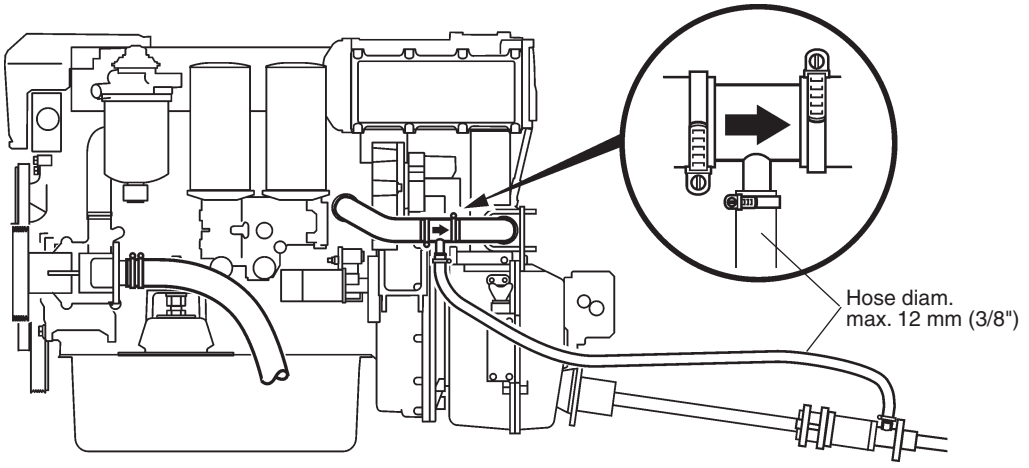
Water lubricated shaft seal

With a water lubricated seal the water has two purposes, lubricating and cooling the seal. Water can be supplied to the water lubricated shaft seal in several ways.

One way, which is suitable in displacement boats, is to feed it from water pick up pipes in the stern tube.

The feed pipes should be designed to build up pressure due to the motion of the boat in water.

It is important to check that the water lubrication is also adequate at full speed, while test running a new installation. Make sure that the pipes (2) allow enough water to flow in.



Another way, which is common in planing boats, is to feed the shaft seal with water taken from the engine cooling system. Make sure not to bleed off too much water. If too much water is lost through the outlet to the shaft seal, the exhaust hose might be overheated.

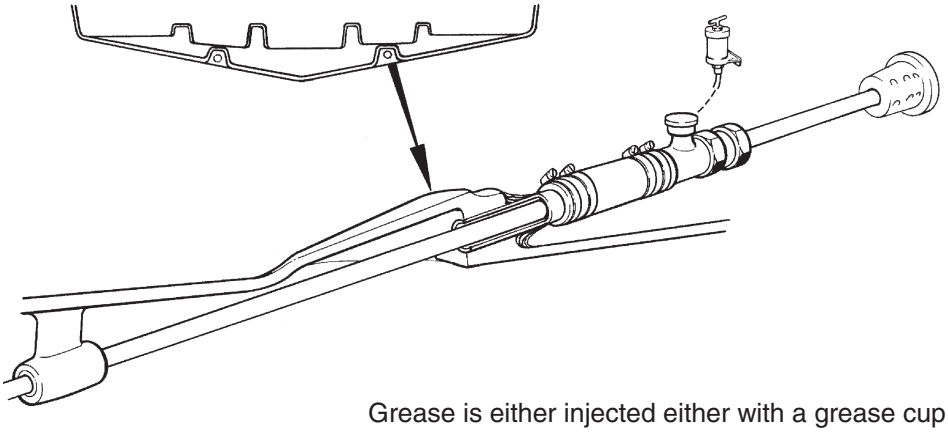
Cut the seawater hose to the reverse gear oil cooler and place the T connection in the hose using two hose clamps.

NOTE! Check the direction of the arrow marking on the T connection prior to installation.

Connect a hose, diameter max. 12 mm (½") to the T connector and lead it to the propeller shaft seal.

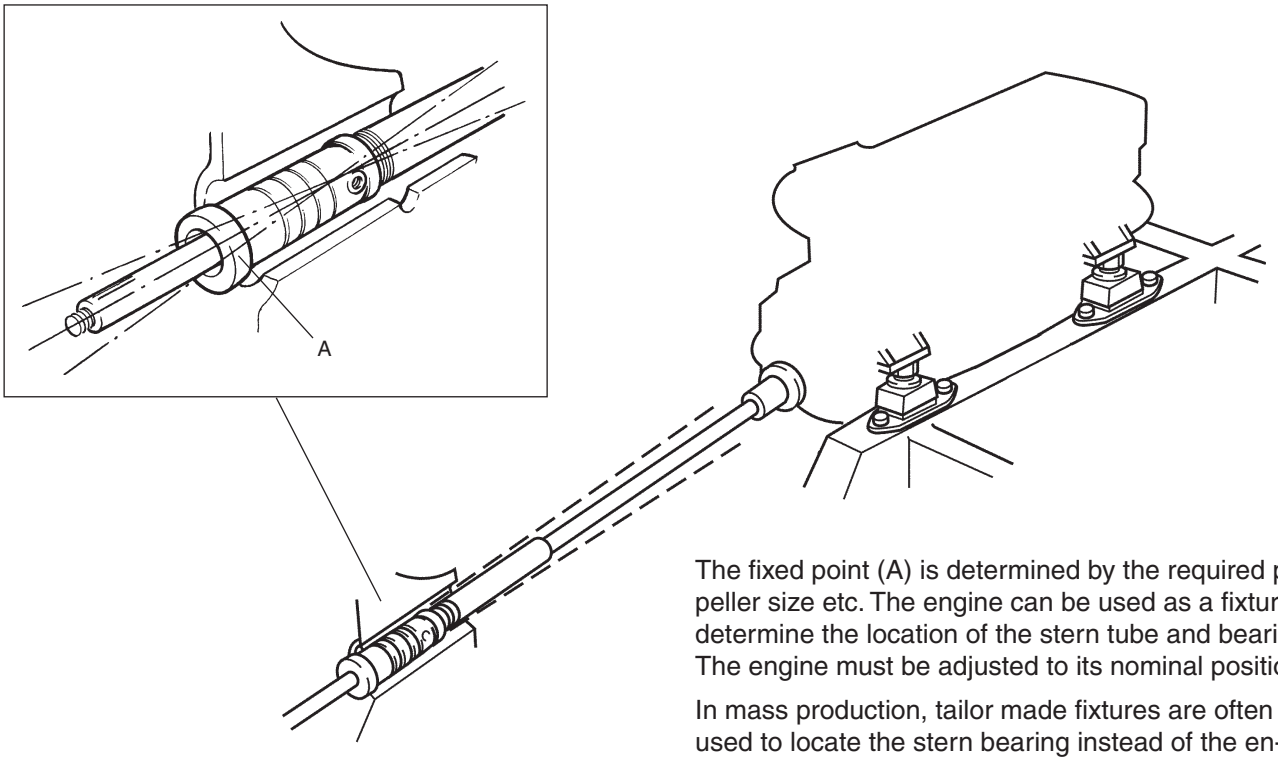
It is important to check that the water lubrication is also adequate at full speed, when testing a new installation.

Grease lubricated shaft seal



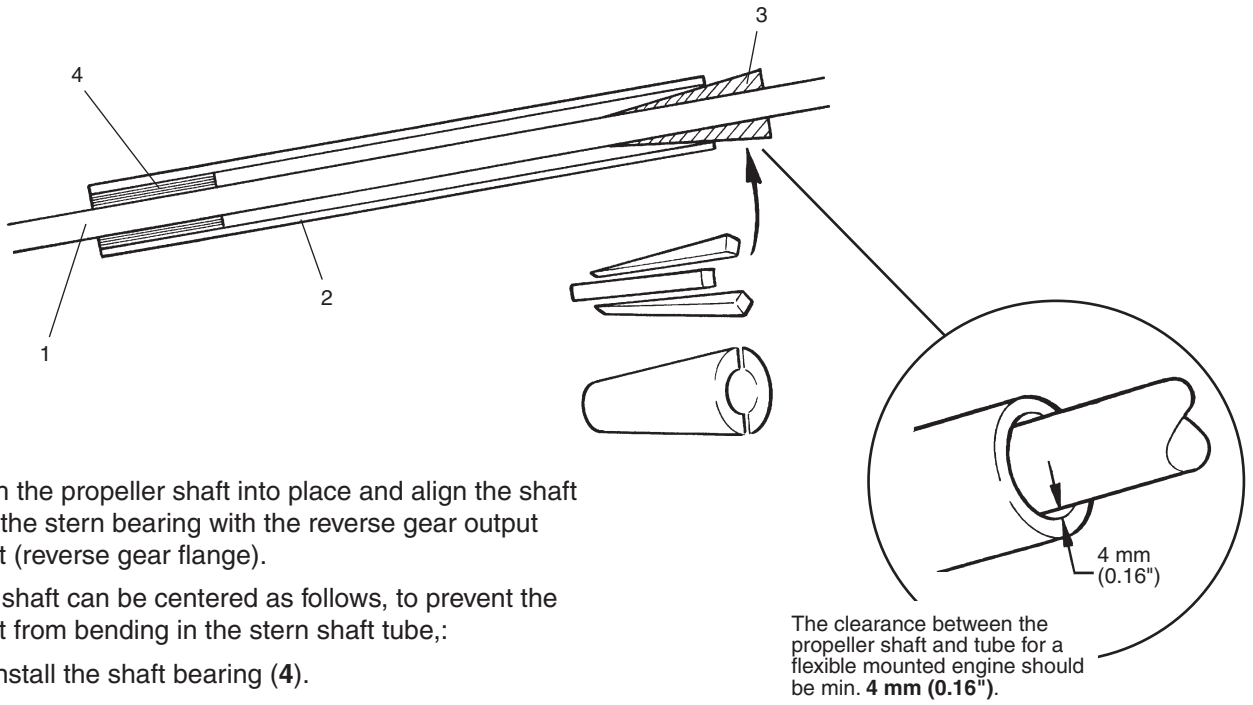
Grease is either injected either with a grease cup fitted to the seal assembly or from a remote greaser. The bolt holding the seal should not be overtightened as this may cause overheating and excessive wear on the propeller shaft.

Installation of stern tube and shaft bearing



The fixed point (A) is determined by the required propeller size etc. The engine can be used as a fixture to determine the location of the stern tube and bearing. The engine must be adjusted to its nominal position.

In mass production, tailor made fixtures are often used to locate the stern bearing instead of the engine.



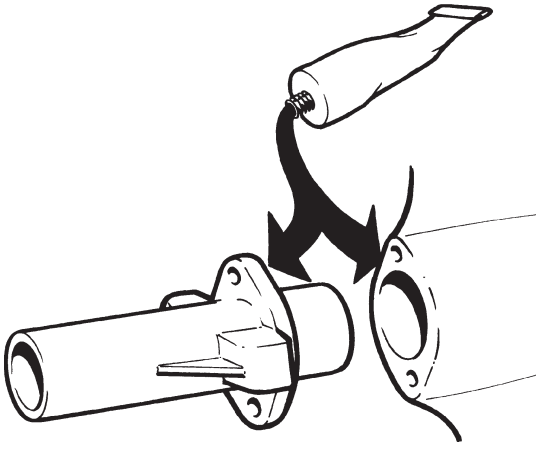
The clearance between the propeller shaft and tube for a flexible mounted engine should be min. **4 mm (0.16")**.

Push the propeller shaft into place and align the shaft and the stern bearing with the reverse gear output shaft (reverse gear flange).

The shaft can be centered as follows, to prevent the shaft from bending in the stern shaft tube,:

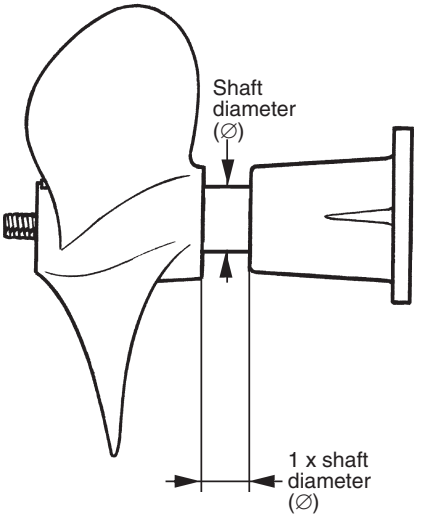
- Install the shaft bearing (**4**).
- Center the shaft (**1**) in the propeller shaft tube (**2**) using wedge-shaped guides (**3**).
- Check that the shaft is not bent in front of the tube; support the shaft if necessary.

After alignment has been done carefully, the stern bearing can be bolted or bonded in place.

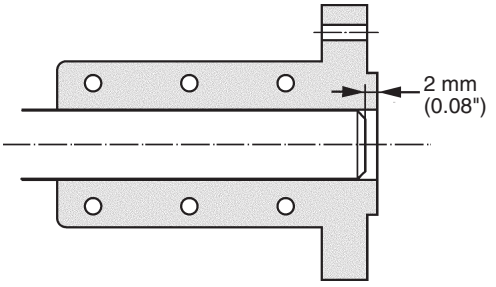


If the stern bearing is to be bolted to the stern, the contact surface for the bearing flange must be sanded flat first. Apply sealing compound, such as silicone rubber, and tighten the bolts holding the bearing.

NOTE! The alignment must be checked after bonding.

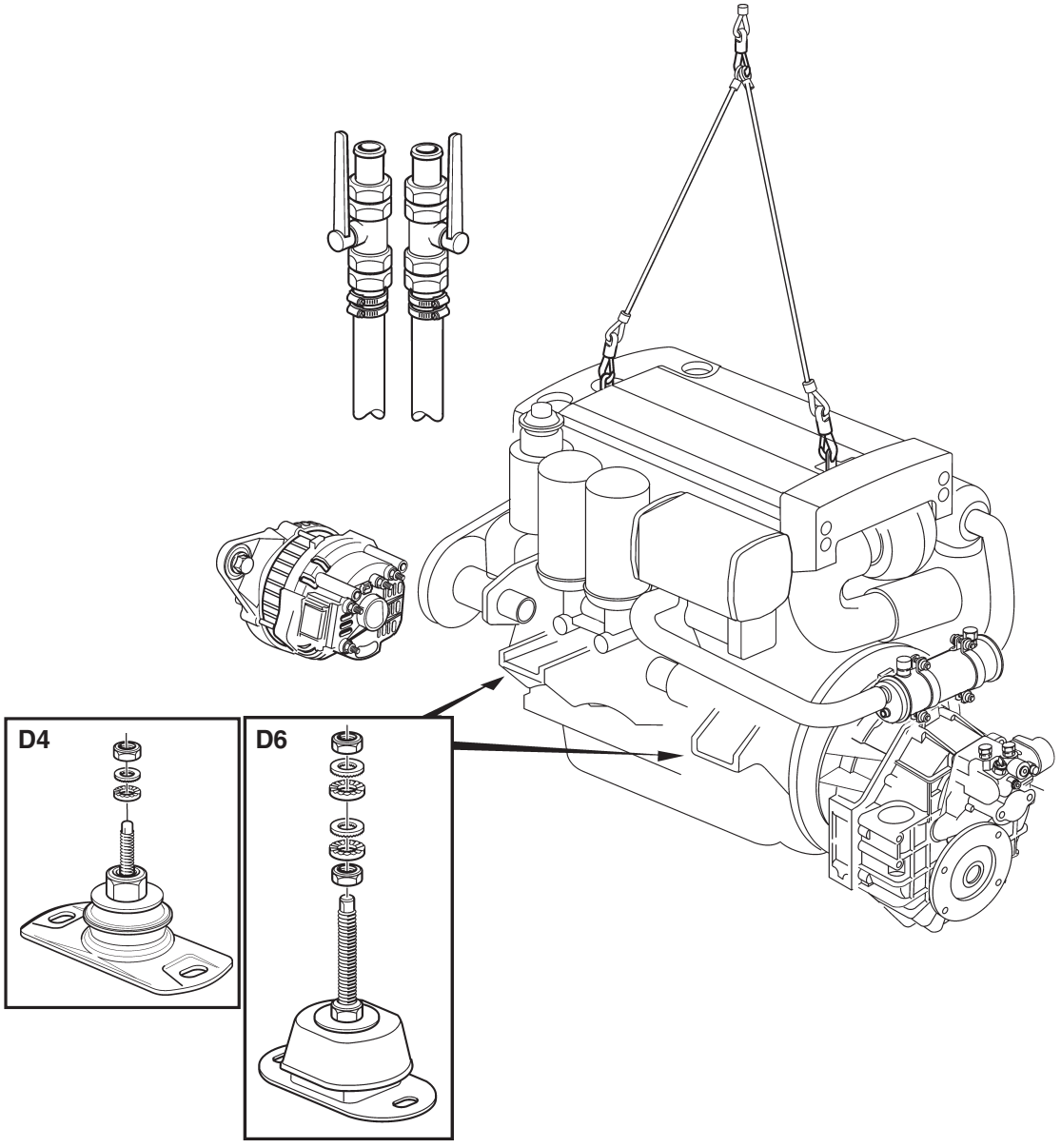


Cut the propeller shaft to the correct length. Remember that the distance between the rear edge of the stern bearing and the propeller must be 1 x the shaft diameter (∅).



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

Inboard applications
Engine installation



Preparing the engine

NOTE! Installations in the engine room for the cooling system, exhaust system, electrical system etc. should be as complete as possible before the engine is installed.

⚠ **WARNING**! Always use both lifting eyes when lifting the engine.

Install extra equipment and accessories on the engine, such as an extra alternator, hot water outlet, power take-off etc. before engine is installed. The figure above shows a flexibly mounted engine.

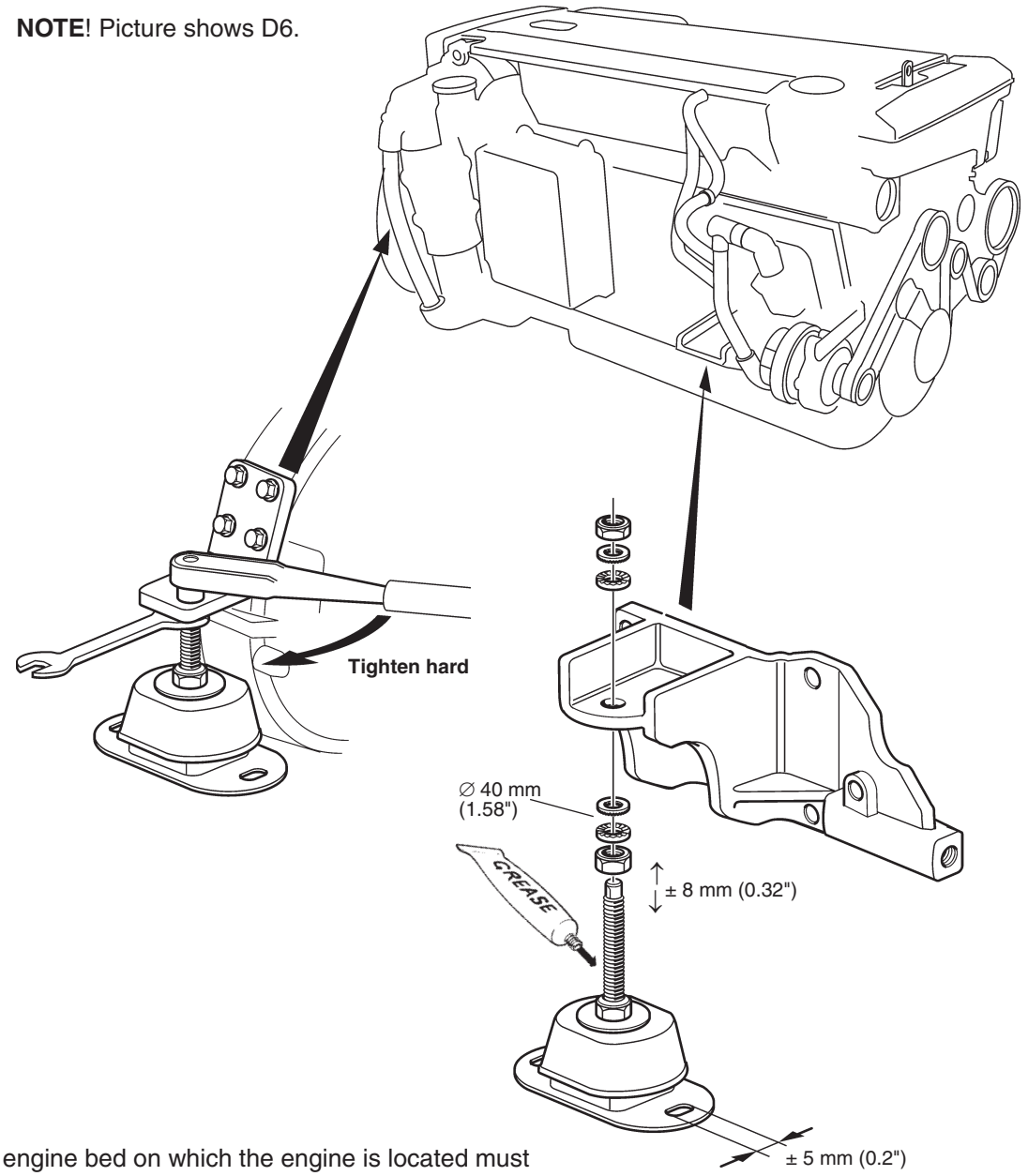
NOTE! All engines and reverse gears are delivered from Volvo Penta without oil and coolant. Check that the oil plug and draining cocks for coolant, hot water cocks etc. are closed.

Fill oil and coolant. Please refer to the chapters ***Coolant /Filling with coolant***.

Check for leakage.

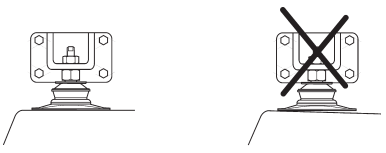
Installing the engine on the engine bed

NOTE! Picture shows D6.

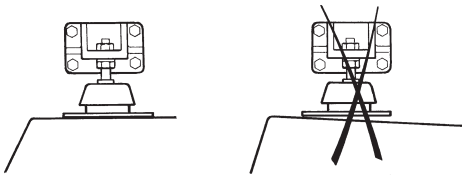


The engine bed on which the engine is located must be on one plane.

D4



D6



Check that the surface of the engine bed where the engine mountings are supported is parallel to the base plates of the engine mountings, and that the bed inclination is correct (use a graded angle spirit level).

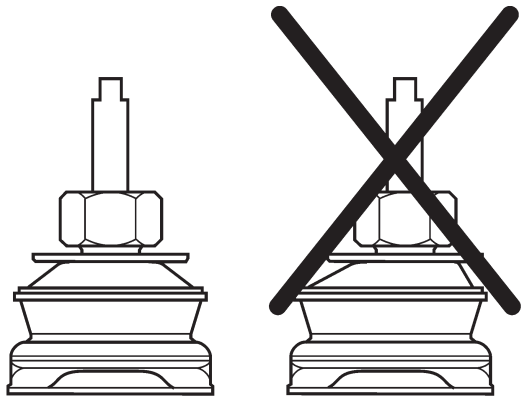
⚠ **WARNING**! Always use both lifting eyes when lifting the engine.

NOTE! Apply grease Volvo Penta part no. **828250** on the threads.

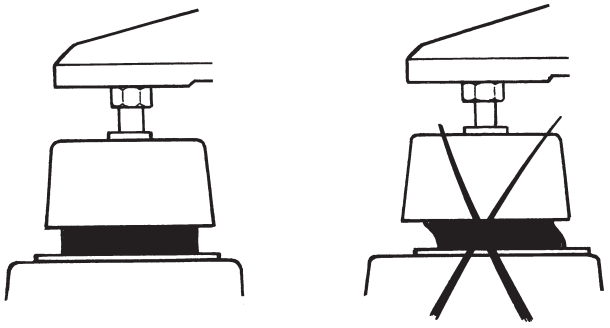
NOTE! Before adjustments can be made to engine mountings for **D6** applications, the engine must rest on the rubber mountings for at least twelve hours.

Never use rubber mounts other than those intended for each particular engine type.

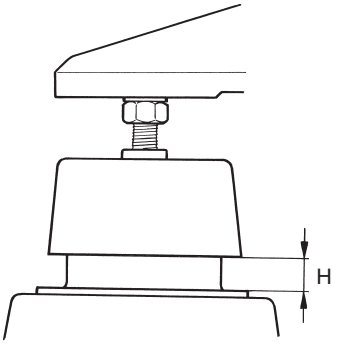
D4



D6



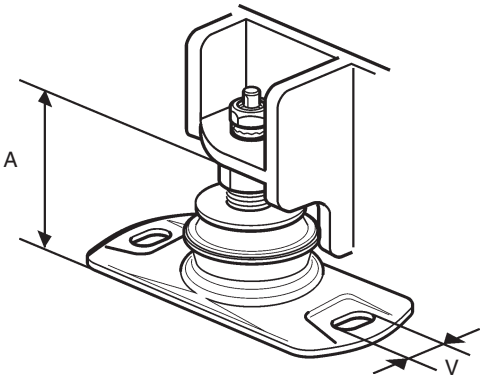
NOTE! Make sure that the rubber mountings are installed so that no pre-load or side forces occur when the engine has been installed and aligned with the propeller shaft.



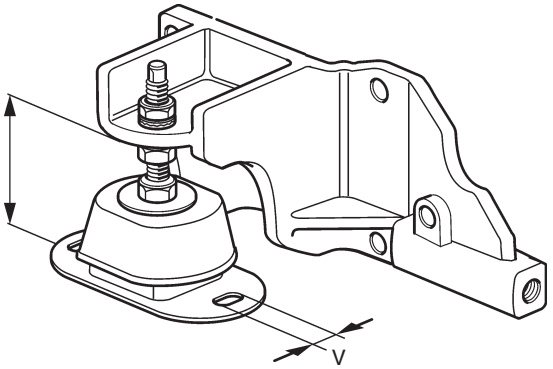
When the engine is installed, the loading on the front mountings must be equal, as is the loading on the rear mountings. Check the loading on the rubber mountings by measuring the distance (**H**) between the attachment plates and the housing.

Adjustable engine mountings should have their basic position mid way along the length of the fastening plate holes. The fastening plates have elongated holes for adjusting. These can be turned facing forward or backwards, whichever allows the best accessibility.

D4



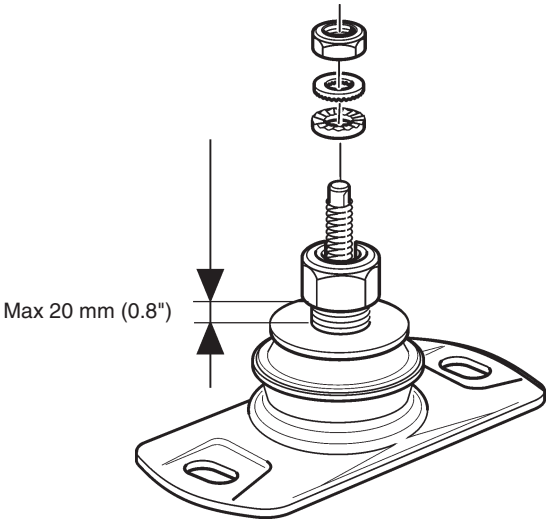
D6



Nominal height, **D4**: 116 mm (4.6"), **D6**: 122 mm (4.8")

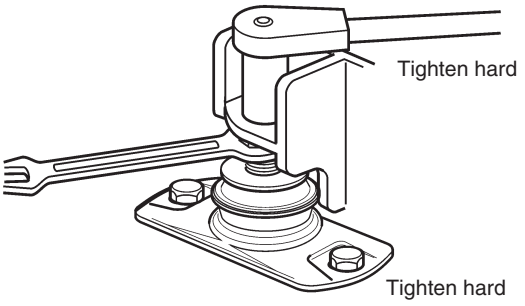
A = Nominal height ± adjustment **D4/D6**: ± 8 mm (0.3")

V = Sideways adjustment **D4**: ± 7 mm (0.3"), **D6**: ± 5 mm (0.2")

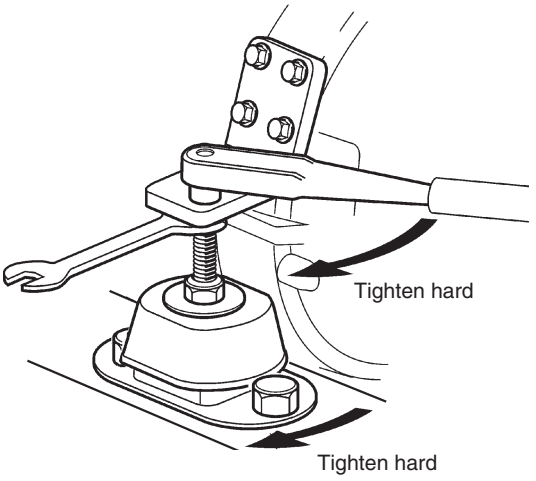


NOTE! The measurement between the washer nut and the lower edge of the middle adjustment nut must never exceed 20 mm (0.8").

D4



D6



After verification of engine bed parallelism, propeller shaft alignment and loading on the mountings – tighten the upper nut on all four engine mountings.

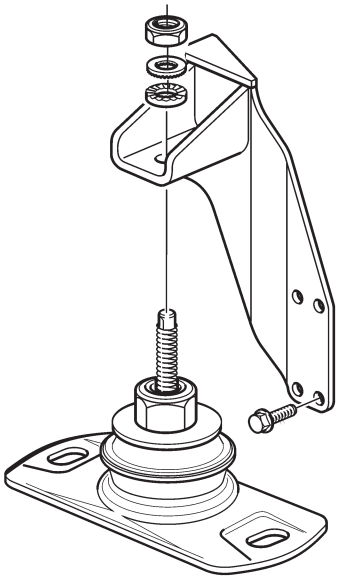
The recommended bolt diameter for Volvo Penta D4 and D6 flexible mountings is **M12** or **1/2" UNC**.

Tightening torque, bolts in engine bed:
Tighten hard

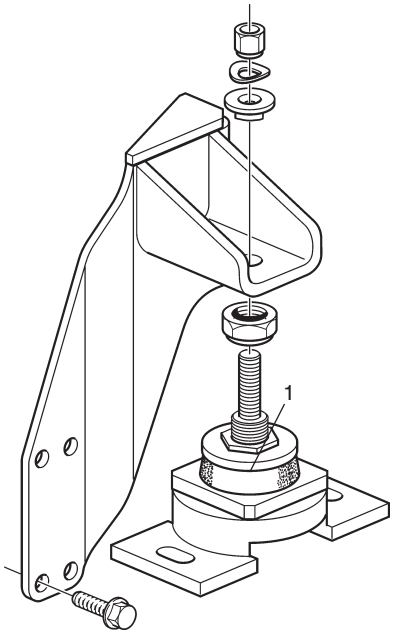
Tightening torque, adjustment nuts:
Tighten hard

V-drive rubber mounts

D4



D6



Install the rubber mountings for V-drive installations according to the figure.

The adjustment sleeve (1) should be tightened against the mounting.

Nominal height for this mounting:
D4: 116 ± 8 mm (4.6 ± 0.3"), **D6**: 115 ± 5 mm (4.5 ± 0.2").

Sideways adjustment:
D4: ± 7 mm (± 0.3"), **D6**: ± 9 mm (± 0.35").

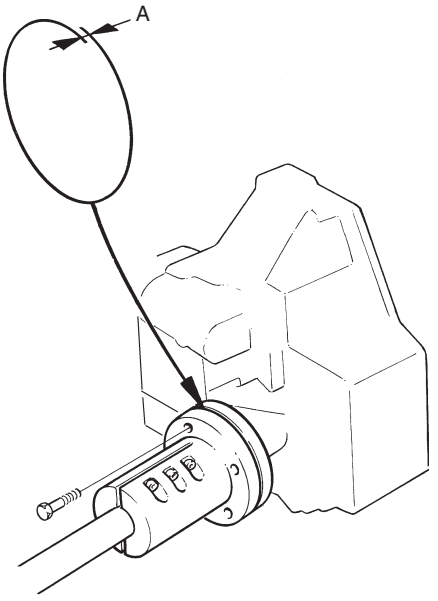
After alignment has been carried out, tighten the nut.

Tightening torque: **Tighten hard**

Make sure the mounting is not adjusted too high. If so, a shim of appropriate thickness must be installed between the mounting and the bed.

Alignment

Before the propeller shaft is connected to the reverse gear flange, check to make sure that the flanges are parallel.

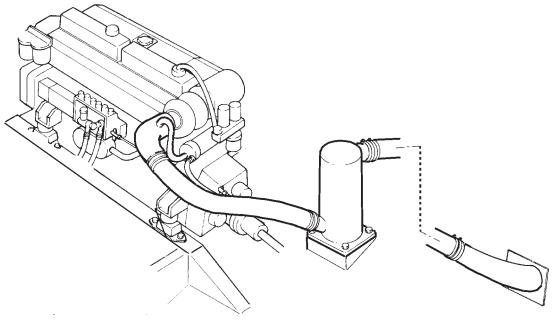


Move the flanges together, so that the guide engages. Then, with the flanges pressed together, check that they are parallel and that a 0.10 mm (0.004") feeler gauge cannot be inserted anywhere in between them (**A**). Then turn the flanges 90°, 180° and 270° and repeat this check at the new positions. Make sure that the flanges are well pressed together during the entire check. If the deviation is greater than **0.10 mm (0.004")**, the alignment must be re-adjusted.

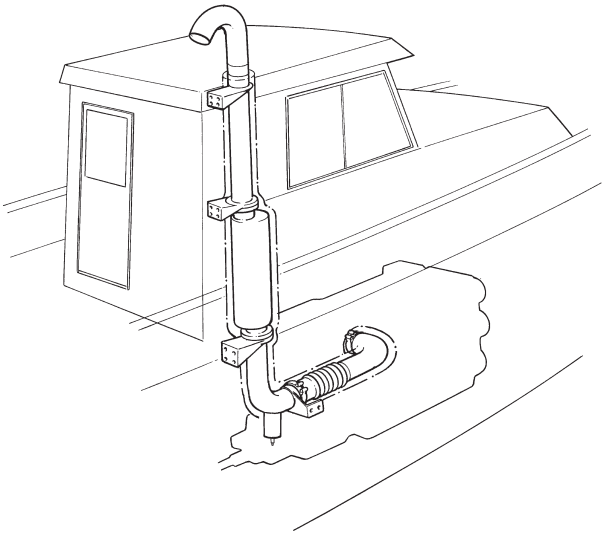
Remove any aids being used and connect the shaft to the reverse gear flange, or flexible coupling.

⚠ **IMPORTANT**! The alignment should be re-checked again a few days after the launch when the boat is completed and rigged (sailboats).

Inboard applications
Exhaust system



Wet exhaust system



Dry exhaust system

General

Exhaust systems for marine engines can be divided in two categories:

- Wet exhaust line
- Dry exhaust line, insulated

Most of the boats/vessels in the Volvo Penta power range with inboard engines are equipped with wet exhaust systems. Water is injected into the system to cool the exhaust gas and the water passes out together with the exhaust.

A wet system has several advantages compared with a dry system. The water lowers the exhaust temperature considerably after the point where the water is fed into the system, enough to permit the use of a flexible rubber hose. A flexible hose is usually easier to install than pipes, is not affected by corrosion or stress and absorbs the vibration from a flexibly mounted engine. A wet exhaust system does not need insulation either and radiates less heat.

It is important, when using a wet exhaust, to design the system correctly and make sure the used coolant cannot enter into the engine backwards.

⚠ **IMPORTANT**! The exhaust system should be designed and installed in such a way that the exhaust emissions are taken out of the boat without any harmful back pressure for the engine and so that there is no risk of overheating any adjacent parts of the boat. The demand for silencing must also be met and the system must be arranged in such a way as to prevent the exhaust fumes from entering the boat. All exhaust systems must be installed in such a way that water cannot force its way back into the engine when the engine has been switched off.
When designing the exhaust system, note that the back pressure must not exceed the values in the table on page 147.

NOTE! Local regulations regarding sound levels may apply. This has to be considered when designing the exhaust system.

Dry exhaust systems for inboard diesel engines are mainly used for slower vessels in commercial operation. A dry system might be necessary to avoid freezing when engines are operated in cold climates with temperatures below 0°C (32°F). A dry system generally requires less maintenance and has a longer service life. Insulation of the system is usually required as temperatures are dangerously high and heat radiation into the engine room is negative for engine operation.

Volvo Penta does not market complete dry exhaust systems but provides some of the key components.

"Station wagon effect"

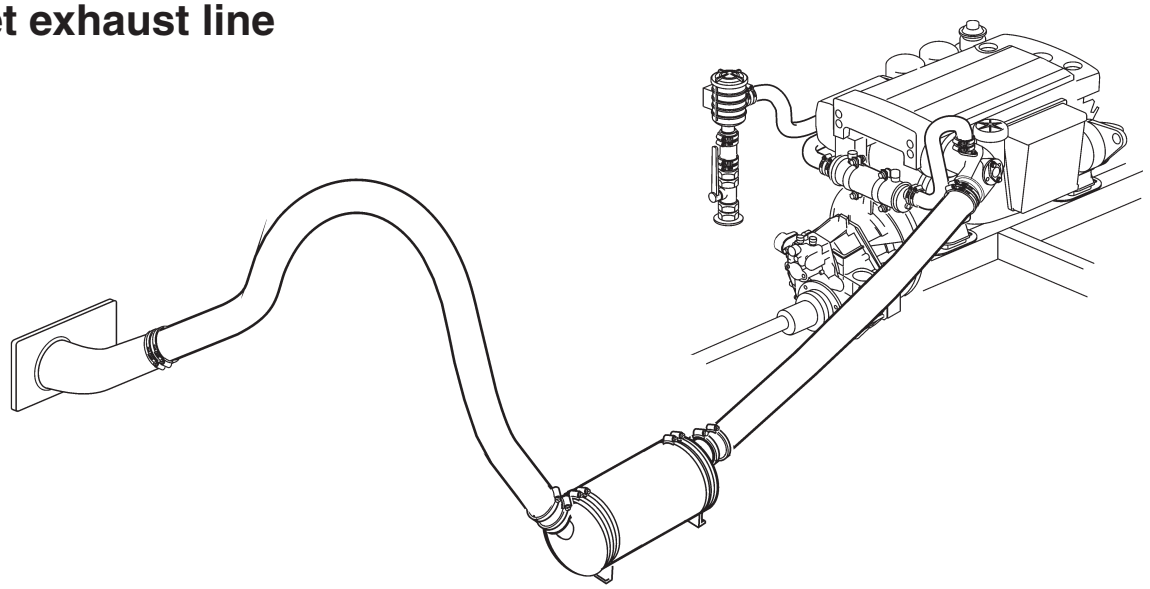
As long as we continue to use combustion engines as sources of power, we will always be faced with the problem of exhaust emissions. Even though the level of exhaust emissions from modern combustion engines has now been minimized, smoke and fumes are still given off when fuel is burnt.

When we also have a sheer body in motion, another problem arises. It is the phenomenon we call the "Station wagon effect".

On a boat with a sheer, broad transom and high superstructure, the result of the "station wagon effect" is that the exhaust fumes are drawn up towards the afterdeck, dirtying the cockpit and making for unpleasant conditions for those on board. The problem originates with what is known as recirculating air. When a boat moves forward and creates a backward current of air, a partial vacuum forms in the boat and the exhaust fumes are drawn into it.

To avoid such a problem, it is of utmost importance to design and locate the exhaust outlet properly.

Wet exhaust line



General

The expression "wet exhaust line" implies that the outgoing coolant is taken into the exhaust line for cooling and silencing purposes.

Volvo Penta offers complete exhaust systems for these engines.

A wet exhaust line can mostly be made of oil and heat-resistant rubber exhaust hose. Thus it would be the best system for easy installation and noise reduction.

The geometry of vessels and engine rooms varies from spacious volumes to very compact and tailor-made systems.

Marine engine manufacturers do not usually market complete wet exhaust systems. The OEM, shipyard, boat manufacturers etc. are the ones who design, chose components and experiment to develop a final exhaust system that complies with all component supplier requirements.

The recommendation in this section should be regarded as an empirical framework and refers to a complete system with a maximum length of **10 meters (33') and maximum 4 x 90° bends**.

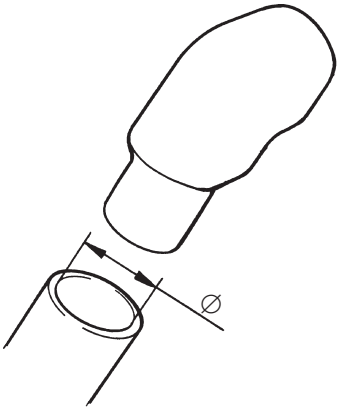
All systems containing silencers, especially the "Aqua-lifts", contribute to the total back pressure in the system. The contribution of each silencer must be carefully estimated and calculated as well as sea-tried and verified by measurement.

Dimensioning the exhaust line

The exhaust line must be dimensioned to avoid harmful back pressure. This is particularly important in the case of turbocharged engines. Excessive back pressure means output power loss and can cause malfunctions such as increased smoke level and shorter service life. For recommendations please refer to diagram on page 147.

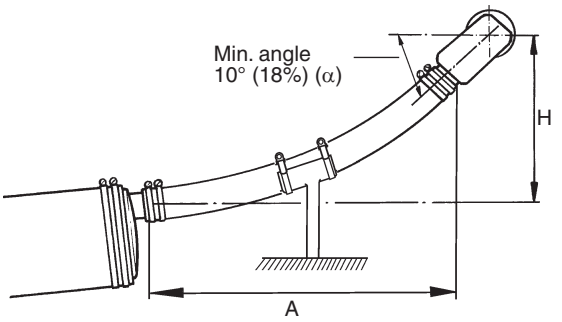
Exhaust hose diameter

The table below indicates standard wet exhaust connection diameters. Note that the complete system might require larger diameters depending on length, silencer and outlet configuration.



Hose diameter, internal diameter (∅) :

D4	100 mm (4")
D6	125 mm (5")



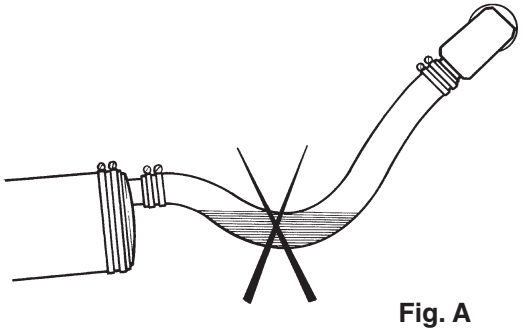


Fig. A

Exhaust elbow angle (α) relative to water line, fig. A should be min 10° (18%).

The silencer should be fitted as close to the engine as possible. The hose must be arranged with a continuous fall towards the silencer along its entire length, please refer to fig. A.

NOTE! The minimum distance (H) between the engine exhaust centerline and the silencer inlet center should be 150 mm (6").

Length (A)	Height min. (H)
650 mm (25")	150 mm (6")
1000 mm (40")	190 mm (7.5")
1500 mm (59")	220 mm (8.5")

If the hose between elbow and silencer has a length or design as in the illustration, it must be supported to avoid a "sag", please refer to figure A.

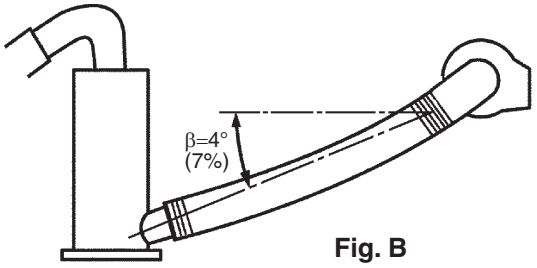


Fig. B

All longitudinal exhaust lines, before and after the silencer, should have an **average** fall of **min 4° (7%)**, angle (β) figs B and C.

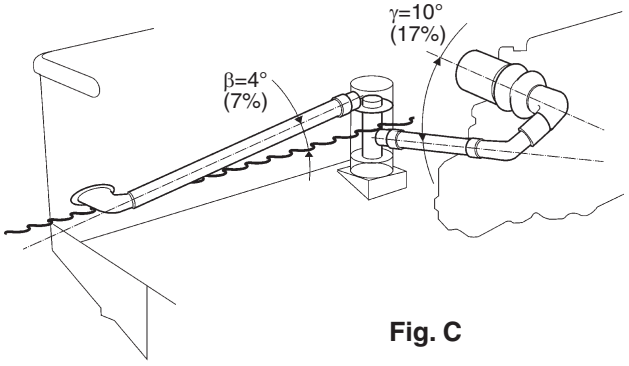
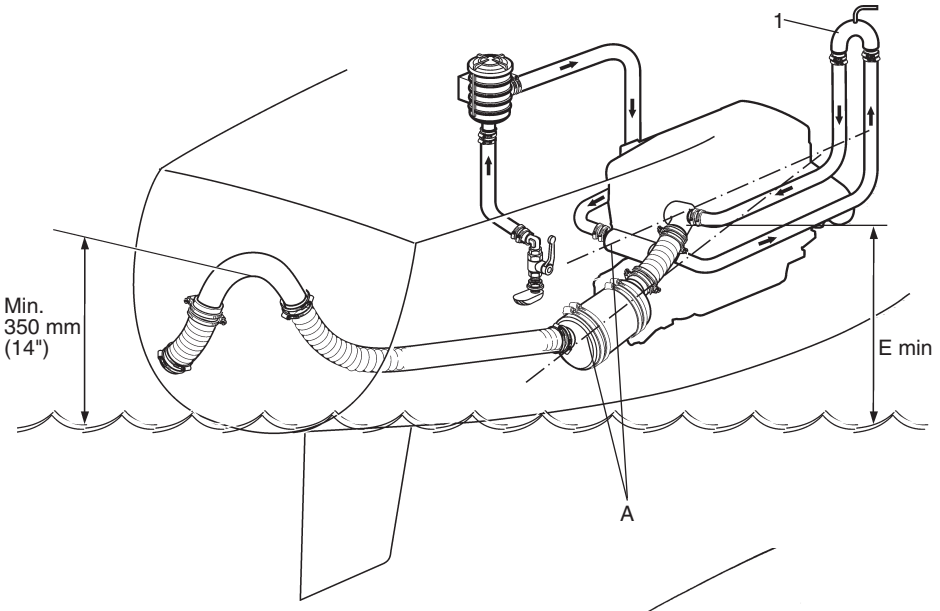


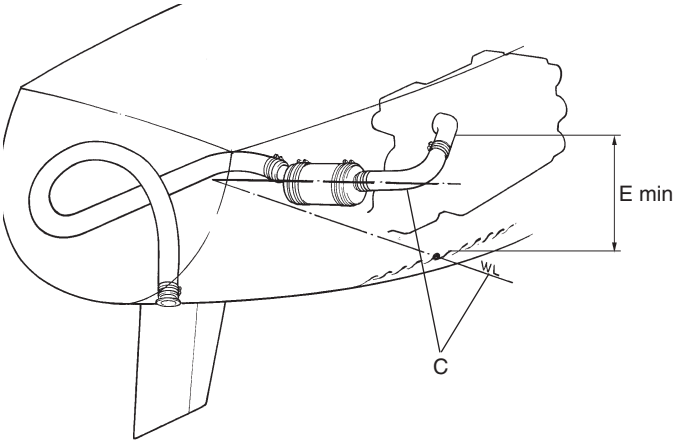
Fig. C

All transverse exhaust lines, before and after the silencer, should have an **average** fall of **min 10° (17%)**, angle (γ) fig C.

For sailing yachts please refer to principle system fig. D on the following page.

Principle system for sailing yachts





Principle system

The last part of the exhaust line should be arranged in a bend (swan neck) to prevent water from entering from the stern, reaching up to at least 350 mm (14") above the water surface when the boat is loaded.

Always use stainless hose clamps. If the hose passes through bulkheads or similar it must be protected against chafing.

The inclination of the Volvo Penta silencer (**A**) should be **5°–7.5°** with the inlet facing upwards.

It is recommended that the exhaust outlet should be positioned at the side of the hull and close to the transom to reduce the "station wagon effect".

NOTE! If the Volvo Penta silencer is installed transversely in the boat, it should be inclined between 25°– 45° (**C**) with the silencer inlet facing upwards. This inclination is important to prevent water ingress in the engine when the boat heels over (particularly with sailing boats).

Anti-siphon valve (vacuum valve)

The height of exhaust elbow above the water line (E min), please refer to figure, should be **at least 200 mm (8")**. If less, an anti-siphon valve (1) is needed in the cooling system to avoid siphon action that could result in water ingress through the exhaust system.

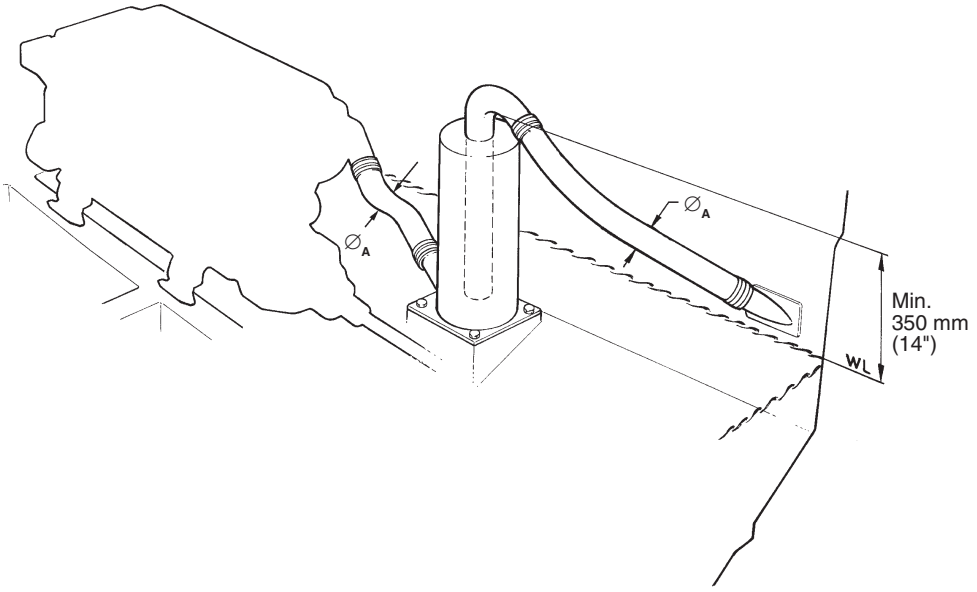
Installation of anti-siphon valve, please refer to page 141.

Silencers

There are various types of silencers depending on the type of installation. Two very common types are:

- Aqua-lift silencers
- In-line silencers

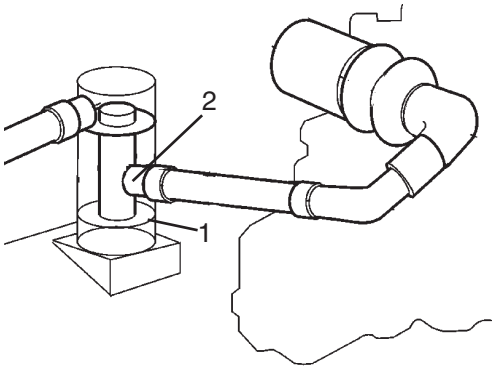
Exhaust system, Aqua-lift silencer. Wet exhaust line in motor boats



The figure shows an example of an engine with the Aqua-lift silencer system.

Make sure the Aqua-lift silencer has a volume that can accommodate the water quantity after the engine is shut down. The water level (1) must be well below the silencer inlet (2).

The **inner diameters** of the exhaust hoses ($Ø_A$) should be chosen to suit the engine power, to give low exhaust back pressure.

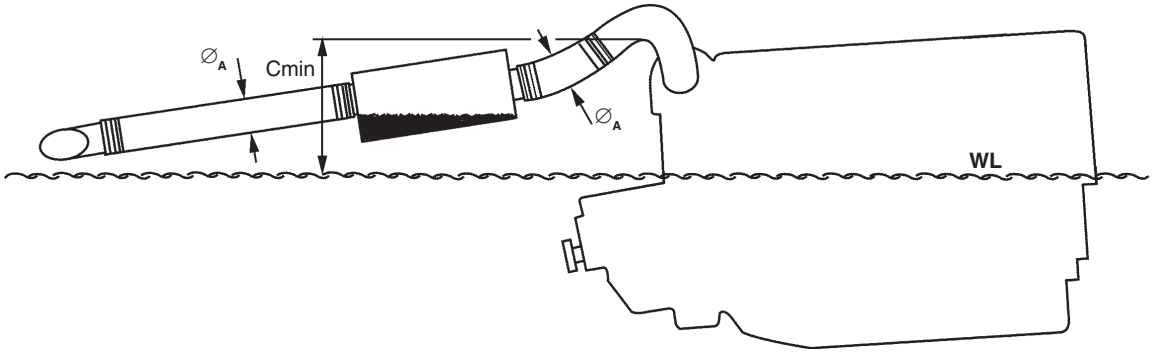


The minimum height between the lower edge of the silencer exhaust outlet and the water line is at least 350 mm (14") unless a swan neck is installed. Please refer to figures above and on previous page.

Recommended hose diameters, elbow – silencer and silencer outlet ($∅_A$) Aqua-lift systems

Engine	Exhaust hose inner diameter ($∅_A$)
D4	100 mm (4")
D6	125 mm (5")

Exhaust system, In-line silencer. Wet exhaust line

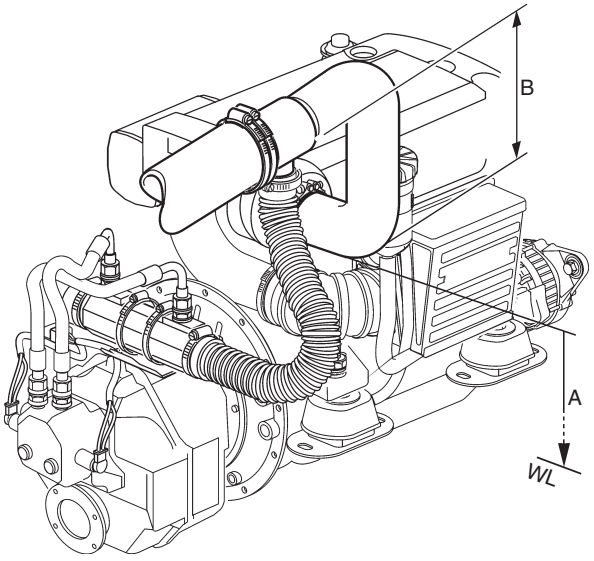


An in-line silencer is most suitable when the exhaust outlet is located high in relation to the water line so an acceptable downward inclination can be achieved. It is important that the system is drained when the engine is shut off.

Recommended hose diameter (inner diameter) **Ø A** please refer to table on previous page.

NOTE! An in-line system is not recommended when height (Cmin) exhaust elbow – waterline is less than **350 mm (13.7")**.

Exhaust riser



350 mm (14"), or the recommended exhaust line fall can not be achieved, an exhaust riser should be fitted.

Minimum inclination of the exhaust riser outlet should be **10**°.

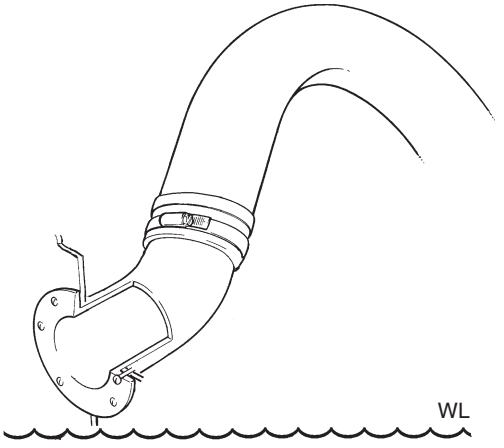
Maximum increase of height (B) at min. inclination 10° compare with the standard exhaust elbow is approximately:

D4 (4"): 175 mm (6.9")
D6 (5"): 180 mm (7.1")

Risers suitable for 4" (100mm) and 5" (125 mm) exhaust elbows are available from Volvo Penta.

Exhaust outlet - through-hull fittings

The through-hull fittings are placed at a suitable point above the waterline when the boat is loaded. If the through-hull fitting opens below the water-line a shut-off valve must be installed at the outlet, or a rigid pipe connected.

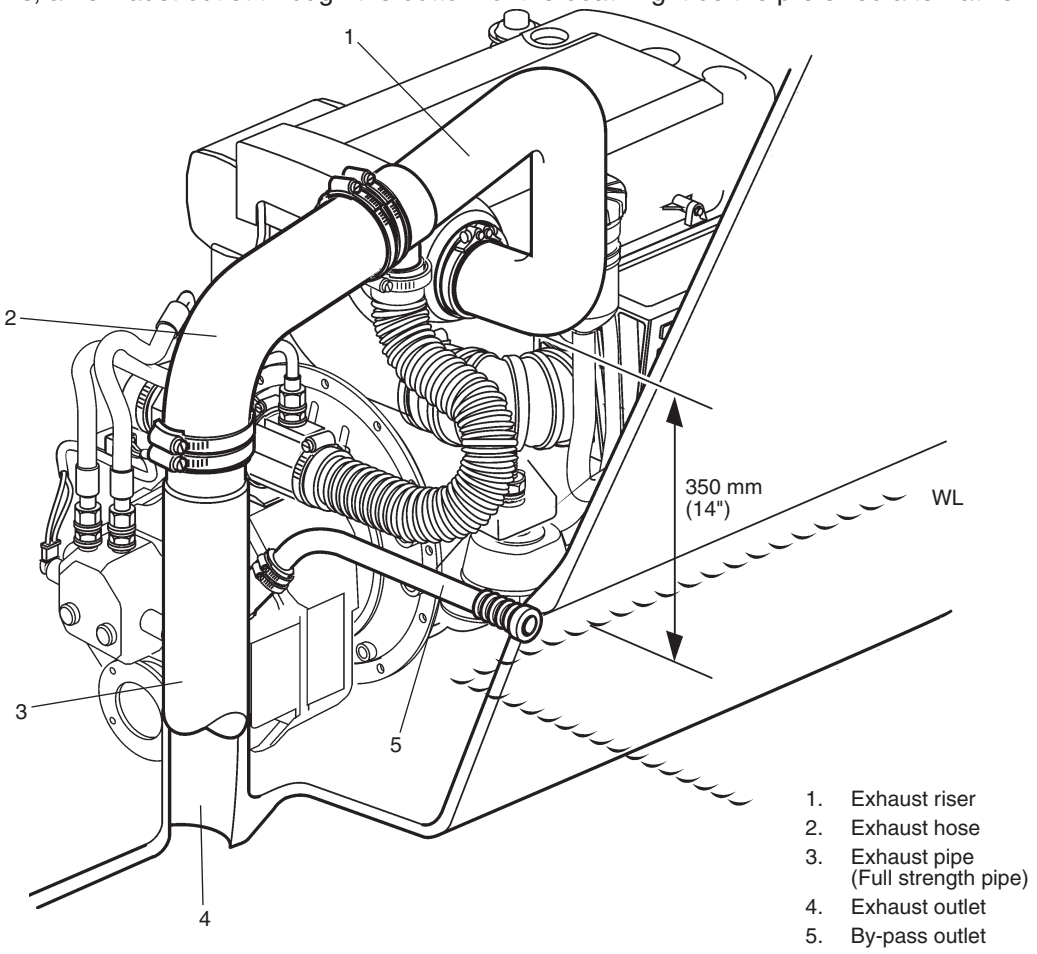


This type of outlet is a type of standard component and should not be located on flat transoms. Please refer to the section ***"Station wagon effect"***.

Exhaust outlet through boat bottom – concept design

Principal sketch, exhaust outlet through bottom

In some installations, an exhaust outlet through the bottom of the boat might be the preferred alternative.



1. Exhaust riser
2. Exhaust hose
3. Exhaust pipe (Full strength pipe)
4. Exhaust outlet
5. By-pass outlet

In such an installation a full strength pipe (metal, GRP, or similar) must go from the hull up to a level above the static water line when the boat is moored in order to avoid the need for a shut-off valve.

Incline the pipe slightly backwards and design the outlet on the bottom so that water is not forced up the pipe if the boat is towed or running on one engine only.

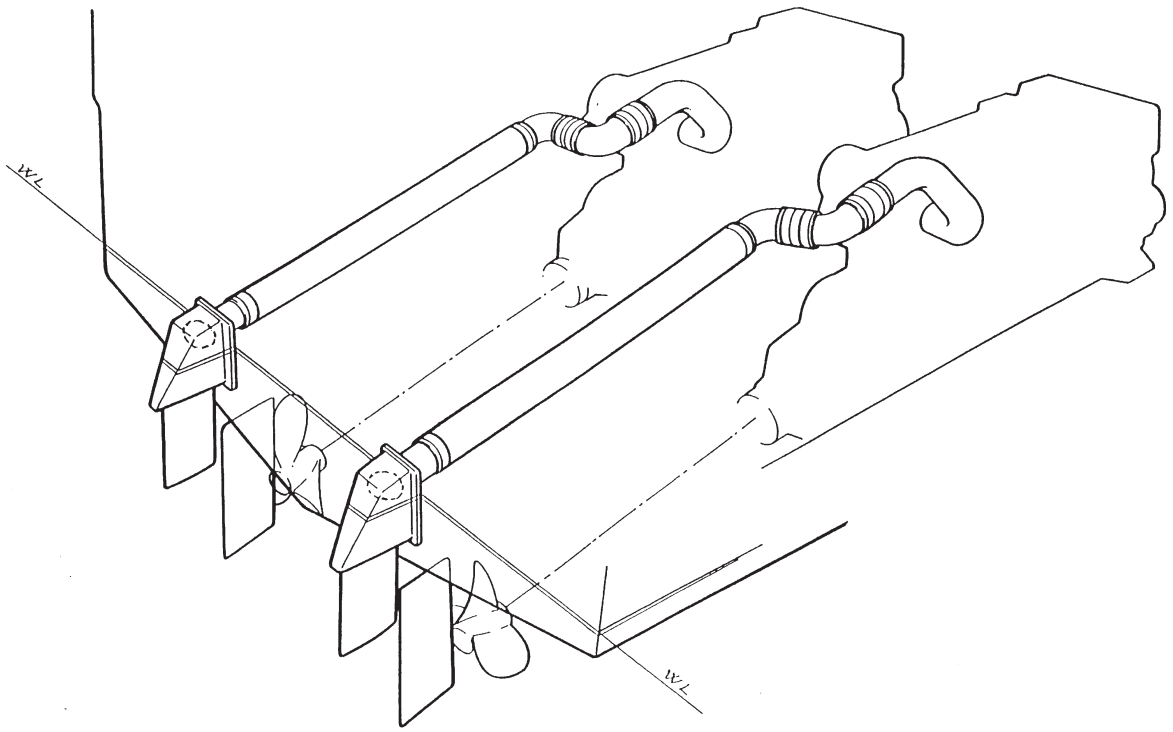
Locate the outlet in the bottom in a position where the exhaust gases will not create negative turbulence in the water flowing into the propeller or trim tabs, not even when the boat is turning, as this will affect the performance of the boat.

A by-pass outlet should be installed from the exhaust pipe above the water line, to an outlet above the water line to avoid high back pressure when starting the engine and reduce the low idling pressure pulses to the hull, which create noise.

A riser is often needed to obtain the correct distance (350 mm / 14") to water line (WL). Please refer to figures above and on previous page.

Air turbulence behind the boat – Exhaust boot

Principle sketch of an exhaust boot system



When a boat moves forward and creates a backward current of air, especially a boat with a sheer, broad transom and high superstructure, a partial vacuum forms in the boat and the exhaust fumes are drawn towards it.

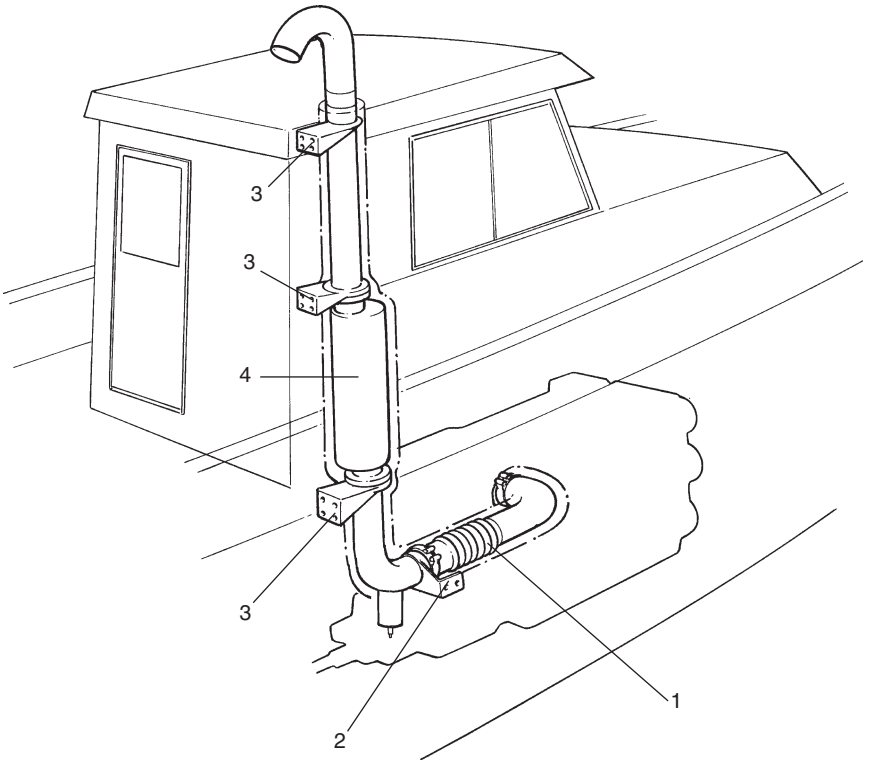
To minimize this problem, the water flowing past the propeller can be utilized to release the exhaust fumes far from the boat transom. The boot outlets should preferably be positioned in line with the propeller shaft just behind the propeller and rudder. In this way, the exhaust emissions are carried into the currents of water aft of the propeller.

Please refer to the section ***"Station wagon effect".***

This slipstream system can be profiled to meet the requirements of individual boat builders.

Volvo Penta has considerable know-how in the application of custom-made exhaust boots, and can provide conceptual design drawings of a hydrodynamically developed boot for local manufacturing in GRP/ FRP.

Dry exhaust line



The figure shows an example of how a dry exhaust line can be installed. The line should preferably be made of acid-resistant stainless steel pipe, but satisfactory service life can also be obtained with other stainless steel pipes. Copper pipes must not be used for diesel engines. Due to the high temperatures, 400°C– 500°C (842°F–932°F) occurring in the dry exhaust line, it must be insulated with insulating material in to avoid the risk of fire and personal injury.

The line must also be provided with a flexible compensator **(1)** to absorb heat expansion and vibration from the engine. The compensator should be fitted to the engine exhaust pipe flange as little stress as possible.

The exhaust line must be insulated throughout its whole length, noting that the movement of the compensator must not be obstructed. After the compensator, the exhaust line, including silencer **(4)**, must be suspended from flexible brackets **(2, 3)** so that the movement caused by heat expansion is not obstructed.

The exhaust fitting must be placed in a suitable position with good margin of clearance above the waterline, with the boat loaded and with insulation against the hull side to prevent heat damage.

An arrangement for draining condensation water should be fitted at the lowest point of the line.

When the exhaust line is dimensioned, note that the back pressure in the complete exhaust system must not exceed the values shown in table on the following page.

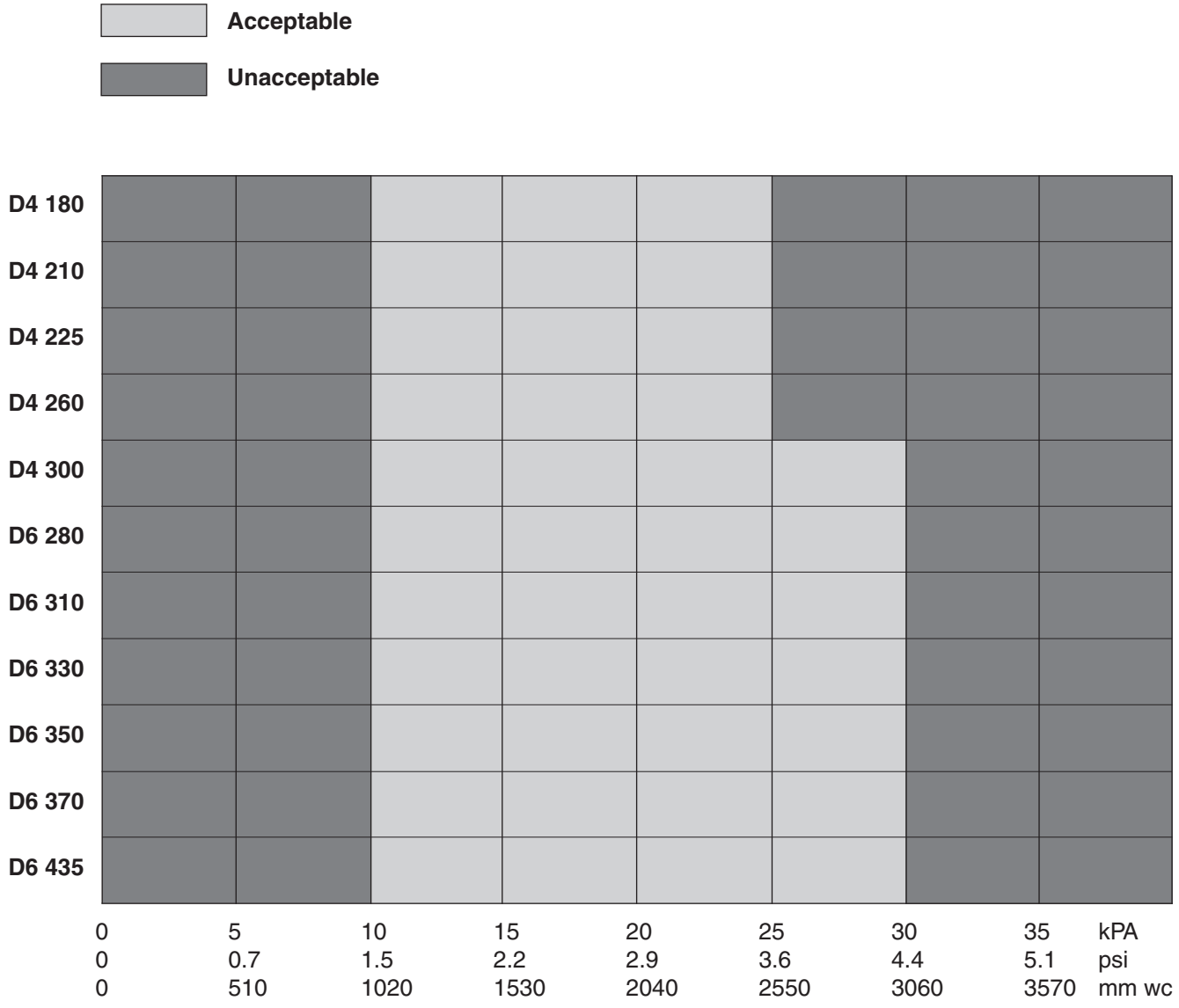
Back pressure

The exhaust system will produce a certain resistance to the exhaust gas flow. This resistance or back pressure must be kept within specified limits. Excessive back pressure can cause damage and will lead to:

- Loss of power output
- Poor fuel economy
- High exhaust temperature

These conditions produce overheating and excessive smoke from the installation, and reduce the service life of the valves and turbocharger.

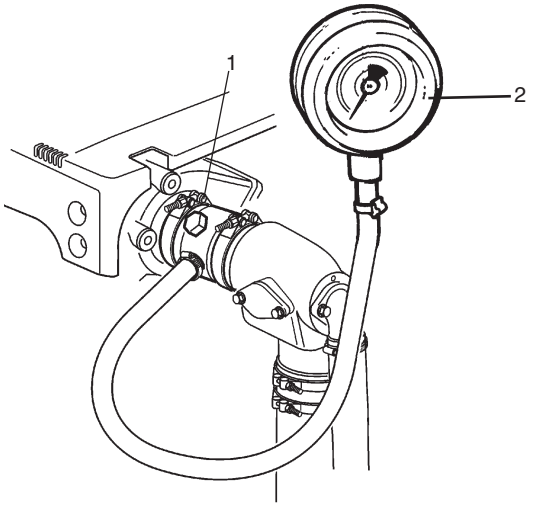
Allowable back pressure in exhaust line at rated rpm



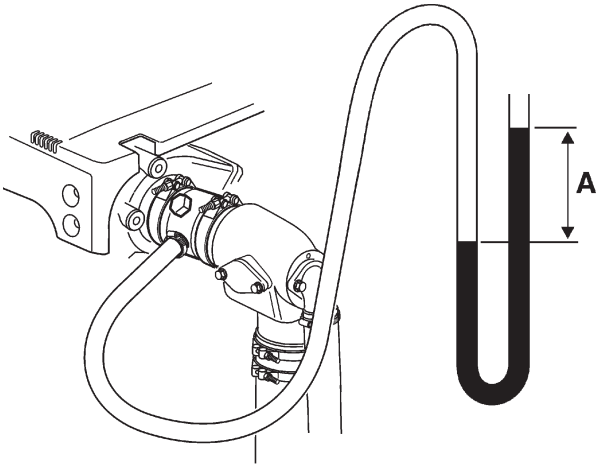
Measuring exhaust back pressure

After the exhaust line has been installed, the back pressure must always be checked.

When testing is carried out, the engine should be run under full loading for a sufficiently long period to obtain a stable value.



1. Measuring flange **885164 (D6) and 885683 (D4).**
2. Pressure gauge 9996065 and nipple 9996666.



Measuring procedure

Remove the exhaust pipe from the turbocharger exhaust output. Clean the mating surface.

Install the measuring flange **885164 (D6) or 885683 (D4)** a with V-clamp to the turbine housing flange. Install the exhaust elbow pipe on the measuring flange.

Connect pressure gauge **9996065** with a pressure hose and a nipple **9996666** for connection to the measuring flange.

Run the engine at full load and max. rpm for several minutes and check that the back pressure is not outside the permitted values.

Allowable exhaust back pressure in exhaust line: Please refer to the table on previous page.

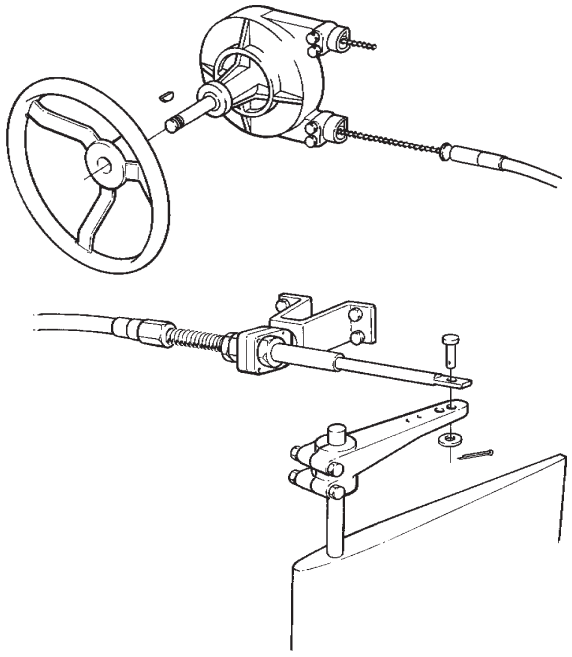
NOTE! Alternatively, a transparent plastic hose can be connected to the measuring flange as illustrated. The difference between the water columns (A) indicates the exhaust system back pressure in mm (") water column (distance A might be up to 4000 mm).

Run the engine at full load and max. rpm for several minutes and check that the back pressure is not outside the permitted values.

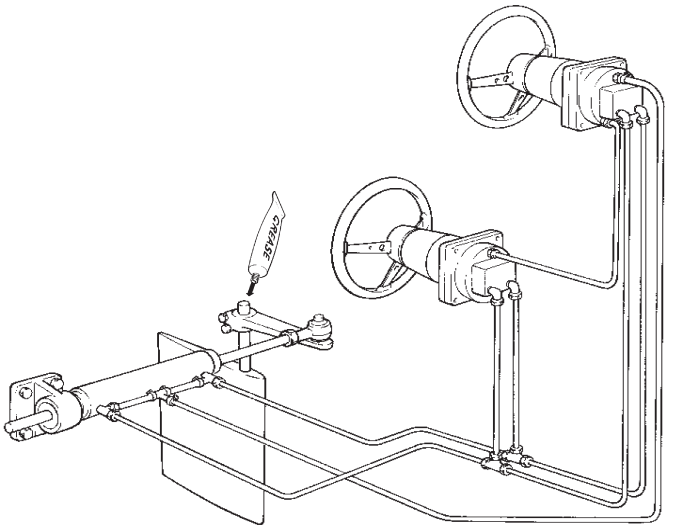
Allowable exhaust back pressure in exhaust line: Please refer to the table on previous page.

Inboard applications
Steering system

Mechanical system



Hydraulic system



General

The following instructions give general information which should be observed for all types of installations.

⚠ **WARNING**! When the steering equipment is installed, it is important that all components are fitted correctly. Incorrect installation can jeopardize the boat's maneuvering ability and, in the worst case, completely make it unable to steer. Please refer to the ***Installation Instructions*** included in the kit.

⚠ **IMPORTANT**! Hydraulic steering systems: Exercise great cleanliness. Make sure that working areas are free from dust and dirt. Keep protective plugs on the connections until the pipes and hoses are to be connected. Make sure that pipes and hoses are clean and free from dirt etc. Use a knife when cutting pipes etc.

Single steering positions

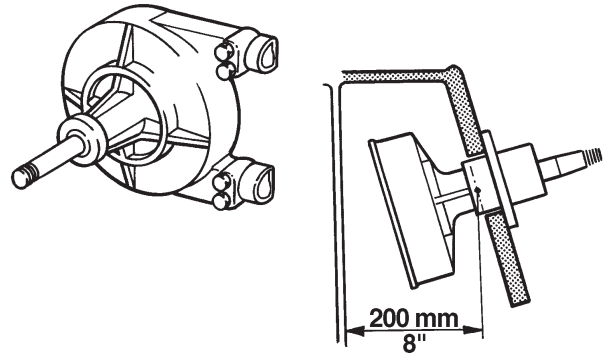
For mechanical steering systems, the length of the steering cable should not exceed 9 m (29.50 ft). This includes an installation with 3 × 90° bends and the cable not clamped. Installations which require cable lengths of 9–12 m (29.50–39.30 ft) must be tried out in each individual case. When using such cable lengths, it is extremely important for the cable to be installed as straight as possible and the cable to be clamped. Hydraulic steering should, however, preferably be installed in these cases.

Twin steering positions

Generally, a hydraulic steering system is preferred in installations with two steering positions. When a mechanical steering system with a DS unit is used, we recommend a maximum steering cable length of 7 m (22.96 ft) for the DS unit. This includes 3 × 90° bends for each cable. The DS unit has a standard 2.25 m (7.38 ft) cable which means that a maximum of 9.25 m (30.33 ft) of cable is permitted between the steering position and the rudder when this DS unit is fitted.

The following instructions give general information which should be observed for all types of installations.

Mechanical steering, location of steering head



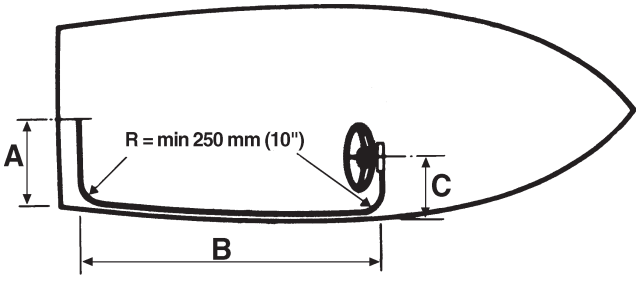
Select a suitable position for the installation of the steering head, to avoid bending the steering cable too much. Avoid using more than one bend if at all possible.

Make sure that sufficient space is provided for the steering wheel and a comfortable driving position.

The steering can be installed either on the starboard or on the port side of the boat.

NOTE! Remember to locate the shift and speed control so that the steering cable can be installed without any bends.

Cable routing



Select a steering cable of correct length.

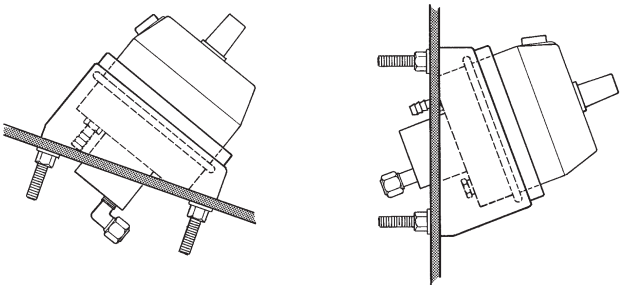
A + B + C = length of the steering cable.

When a DS unit is installled, make sure it is located in a dry and easy accessible place. It should preferably be located close to the steering tiller arm.

Finally, clamp the steering cable all the way. Distance between the clamps approx. 250 mm (10").

NOTE! Bend the steering cable with the most gentle bend possible. Minimum bending radius = **250 mm (10")**.

Hydraulic steering, location of steering pump



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

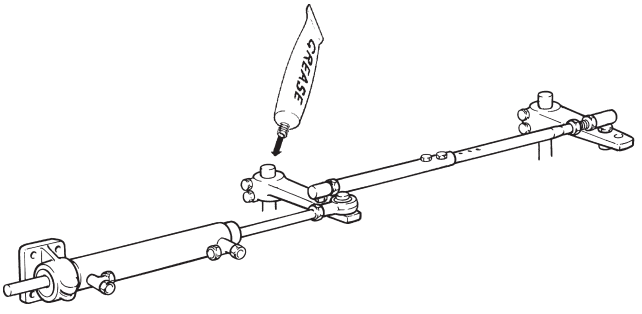
Hydraulic hose routing

Install the hydraulic oil pipes. Minimum bending radius **60 mm (2½")**.

Make sure that the pipes do not come into contact with hot surfaces. Fix the pipes with plastic tie wraps. Distance between tie wraps is approx. 250 mm (10"). Metal clamps must not be used!

Cut the pipes off to the correct lengths. Use a knife to avoid swarf and burrs. Make sure that the pipe ends are at right angles and are completely clean.

Hydraulic steering system with tie bar



Inboard applications
Controls

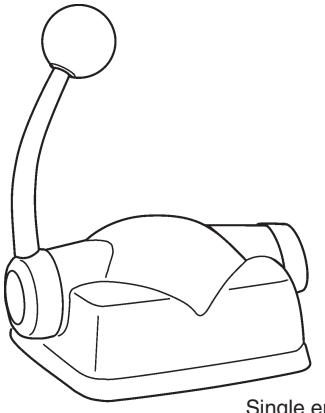
General

If the boat is to be maneuvered and operated in a convenient and safe manner, the operating station should be arranged in such a way that the controls, steering and instruments, navigational equipment and alarm systems are located practically. This applies to each operating station.

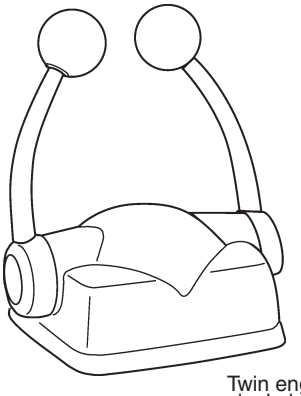
Controls for EVC engines, (Electronic Vessel Control)

Please refer to the manual ***Installation, Electronic Vessel Control EVC D4, D6*** when controls and other components for the EVC system are installed.

Top mounted electronic controls

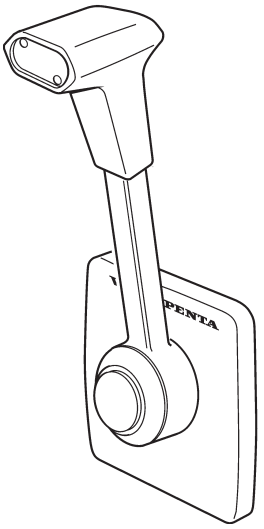


Single engine,
single lever control, EVC



Twin engine,
single lever control, EVC

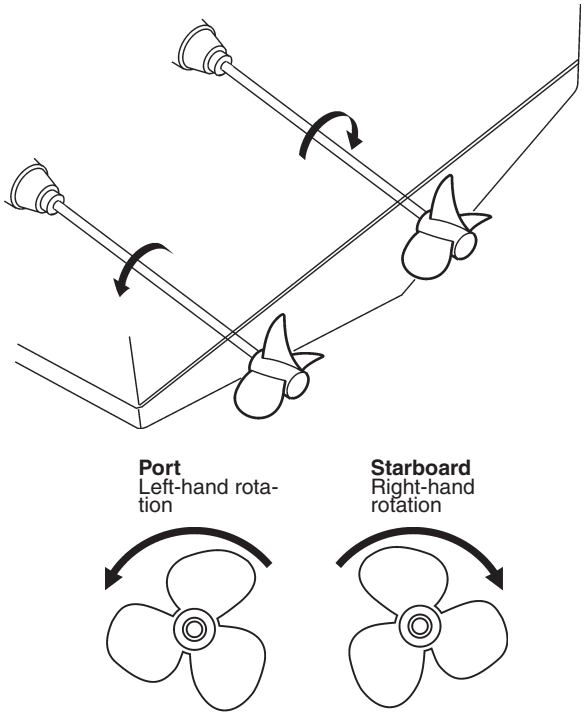
Side mounted electronic control



Single engine,
single lever control.
Reverse gear

Propeller rotation, Inboard applications

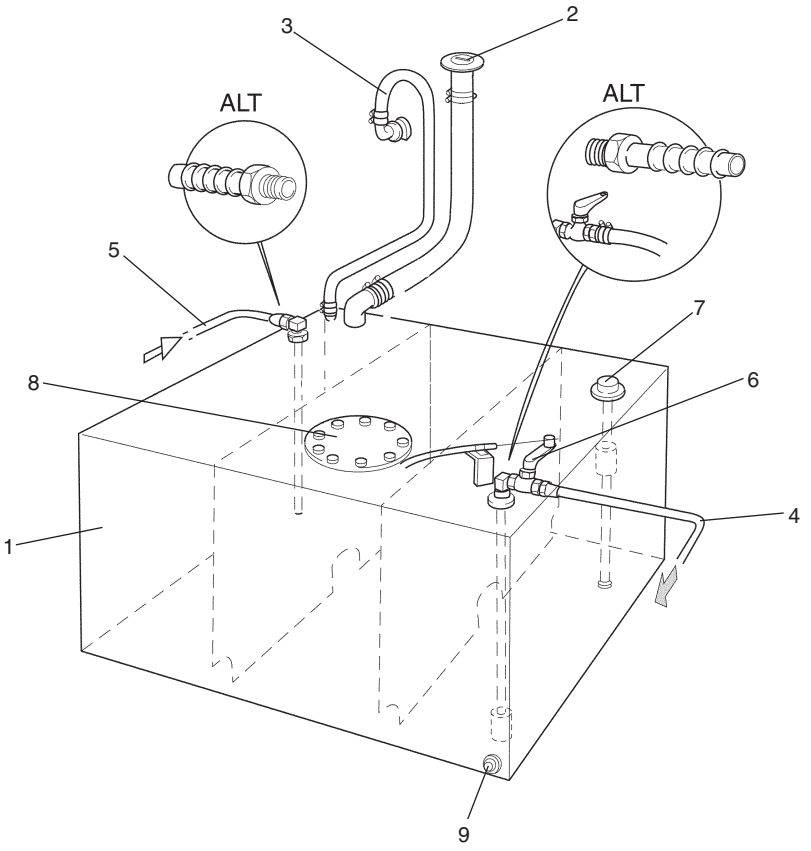
For a single installation, a right-hand rotating propeller is recommended.



In twin installations, the starboard propeller should always rotate clockwise and the port propeller anticlockwise, seen from the aft and looking forward. Otherwise there is a risk that air bubbles will be drawn down into the water between the two propellers, which can cause aeration.

NOTE! Please refer to the manual ***Installation, Electronic Vessel Control EVC D4, D6*** for information about propeller rotation and gear shift solenoids.

Fuel system



1. Fuel tank
2. Fuel filler
3. Venting line
4. Suction line
5. Return line, steel/copper piping, alt. rubber hoses
6. Remote controlled fuel shut-off valve
7. Fuel level gauge
8. Inspection hatch
9. Draining

General

Installation of the fuel system components - fuel tanks, taps, fuel piping and extra fuel filters etc., must be carried out very carefully to ensure the engine has a sufficient supply of fuel and that demands relating to perfect sealing and fire safety are complied with.

Plan the location of the tanks very carefully before starting work. Use good quality taps to avoid fuel leakage. A leaking fuel system always implies a great risk of malfunctions and the danger of fire.

Use high grade material and high quality components.

The taps should preferably be fitted outside the engine room or be remote controlled.

The amount of fuel can be subdivided between several tanks to keep the center of gravity low and also allow the hull to be trimmed.

If the tanks are built in, the surrounding space should be provided with ventilation.

NOTE! Local legislation may apply, which will always override the engine manufacturer's literature and recommendations.

In Europe, material and installation of fixed fuel systems must comply with ISO 10088. In the USA, the installation must comply with ABYC and USCG requirements.

Be sure not to bend the high pressure pipes between the injection pump and the injectors and do not stand on the engine due to risk of bending the high pressure pipes.

Do not clamp anything to the high pressure pipes, and keep the original clamping intact on the engine. Other-wise there will be a risk of broken pressure line and fire.

When working with the fuel system, it is important to keep it free from dirt.

Fuel tanks

If possible, the tanks should be located so that they are at the same level or somewhat higher than the engine. If they are placed lower, due attention must be paid to the maximum suction height of the feed pump for the engines, which varies between 1.5–2.0 m (60–78"). Note that the suction height must be calculated from the lower end of the suction pipe, i.e. 25 mm (1") above the bottom of the tank.

The return pipe should be installed away from the suction pipe and about 15 mm (0.6") above the tank bottom to prevent air from entering when the engine is switched off.

If the tanks are located lower than the level permitted by the suction height of the common rail pump, then the fuel must be pumped up to a day tank by means of a hand pump or power pump. In this case, return fuel from the engine is routed to the day tank.

The fuel tanks must not be positioned higher than 1.0 m (3 ft) above the top cover of the engine.

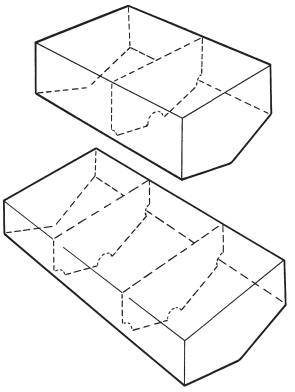
Double tanks should be connected at the bottom by means of pipelines fitted with shut-off cocks. The lower connecting pipe should have an internal diameter of at least 1" so that the tanks can be filled from either side of the boat and to even out fuel consumption. Other fuel tank shapes that are adapted to the installation geometry are of course acceptable. Whatever shape is chosen, it is important to design the tank to provide a low part where water and sludge can be drained.

NOTE! An extra fuel filter with water separator must be installed for all Volvo Penta engines.

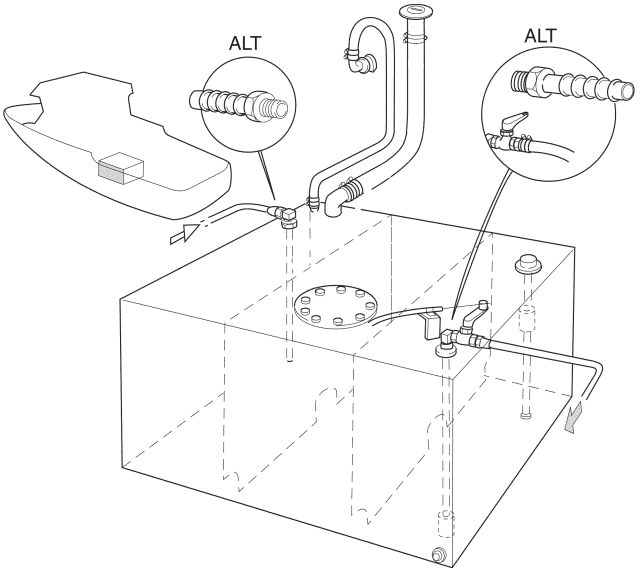
If a day tank is installed, then it is advisable to connect the return line to this tank.

A shut-off valve must be installed in the supply pipe, between the tank and the filter. It should be possible to operate this valve from a location outside the engine room.

Stainless steel or aluminum sheet metal are a suitable materials for fuel tanks.



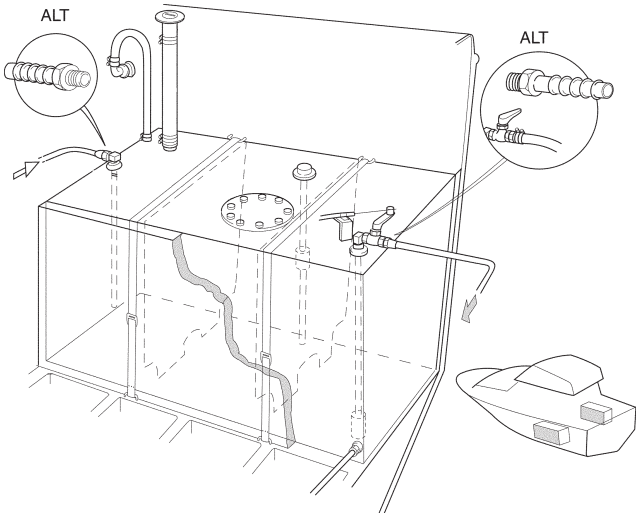
NOTE! All tanks must be provided with at least one baffle plate for each 150 liters (37 US gal) of volume. Check whether there are special restrictions about volumes and baffle plates.



Filling and venting connections must not be positioned on the side of the tank.

The fuel tank has connections for filling, venting, suction line, return line, sender for tank gauge and an inspection hatch with cover. The suction line and the return line should be separated as shown in the figure.

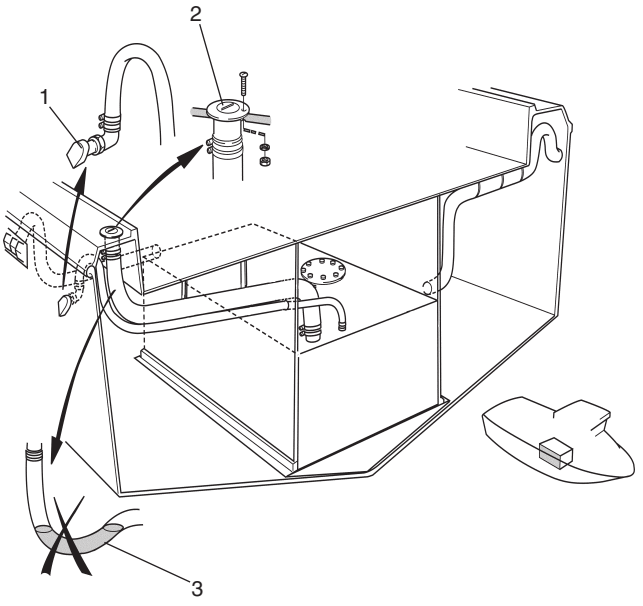
The fuel return line on diesel engines must be routed to the bottom of the tank in order to prevent air from entering the fuel system when engine is stopped.



Position the tank on some kind of soft bedding. Do not position the tank on wooden blocks or on other types of uneven bedding. This might cause abnormal stresses with subsequent risks of cracking in the tank.

Install the fuel tank in the boat. Secure the tank by clamping, to prevent it from moving in rough seas. The tank should be located in a cold compartment by itself, in order to avoid heating of the fuel or spreading of the fuel to other parts of the boat in case of leakage.

In boats where space is at a premium, the tank can be tailored to suit the space underneath the gunwale or some other similar space.



The tank must be properly vented. The tank venting line (1) should have an inner diameter of min. 12 mm (1/2"). Make an upwards pointing bend inside the boat to create a water lock.

The filler fitting (2) should be designed to accept hose connections for at least 50 mm (2.0") diameter. The hose between the deck fitting and the tank must overlap the tubing at either end by at least 75 mm (3.0") and be locked with two hose clamps at each end. The hose clamps must be made of a corrosion-resistant material.

A common ground for the fuel tank, filling etc. is not generally required for diesel installations. Local authorities, however, could demand this on boats in general.

NOTE! Install the filler and venting hoses, to prevent traps (3) from being formed.

NOTE! The fuel filler fitting and the tank vent must be installed in a way that prevents overfilling and prevents fuel from entering the air intakes.

Piping

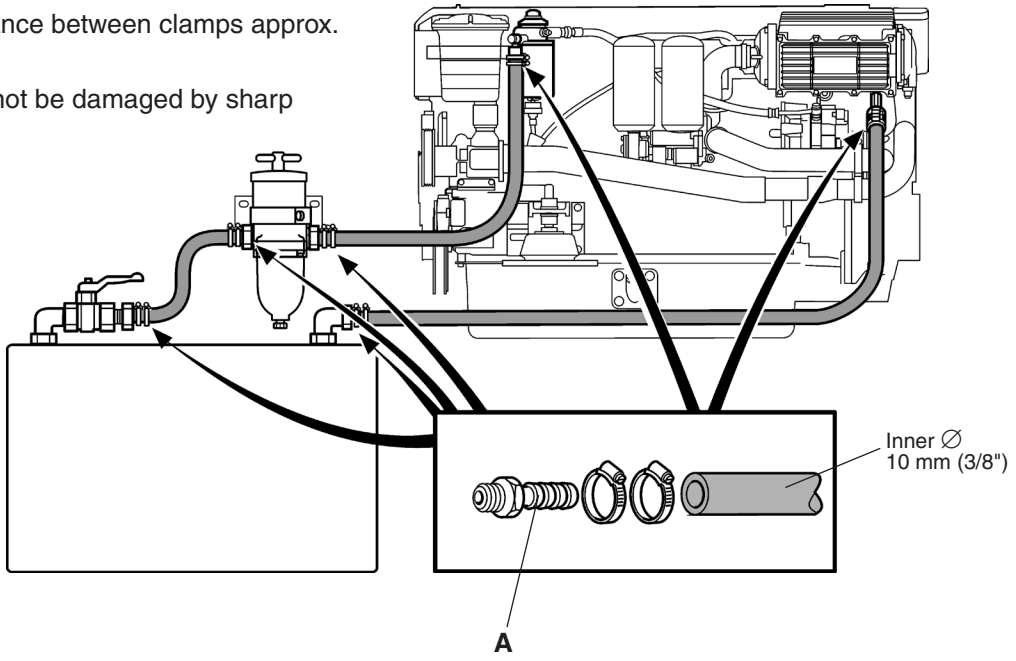
All fuel lines should be installed and properly clamped near the bottom of the boat to avoid heat absorption. The air temperature is lower at the bottom of the engine room.

Rubber hoses

NOTE! Classification Societies and some registration bodies (i.e. river authorities) do not permit rubber hoses for fuel lines, or require hoses to conform to certain specifications. Check if the boat is to be used in these areas.

Clamp the fuel line. Distance between clamps approx. **300 mm (12").**

Make sure the hose cannot be damaged by sharp edges.



D4 engines

Inner diameter

Required minimum inner diameter for
- feed line hose: **10 mm (3/8")**
- return hose: **10 mm (3/8")**

NOTE! Only use approved flexible hose.

Length and suction height

Maximum length: **8.0 m (26.3 ft)**
Maximum suction height: **2.0 m (6.5')**

D6 engines

Inner diameter

Required minimum inner diameter for
- feed line hose: **10 mm (3/8")**
- return hose: **10 mm (3/8")**

NOTE! Only use approved flexible hose.

Length and suction height

Maximum length: **6.0 m (19.5 ft)**
Maximum suction heght: **1.5 m (5.0 ft)**

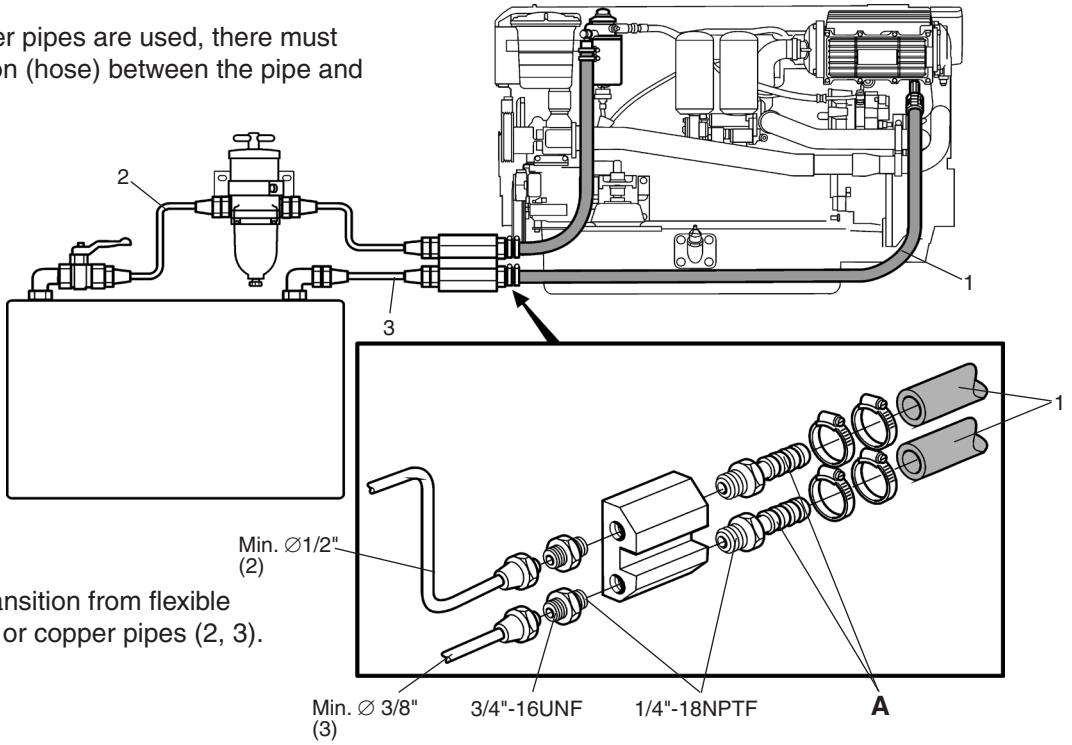
Nipples (A)

Min. inner diameter: **7.0 mm (0.28")**
Male thread : **1/4" NPTF**
Volvo Penta part no.: **3825000**

Steel and copper piping

Clamp the fuel line. Distance between clamps 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 figure shows a transition from flexible fuel hoses (1) to steel or copper pipes (2, 3).

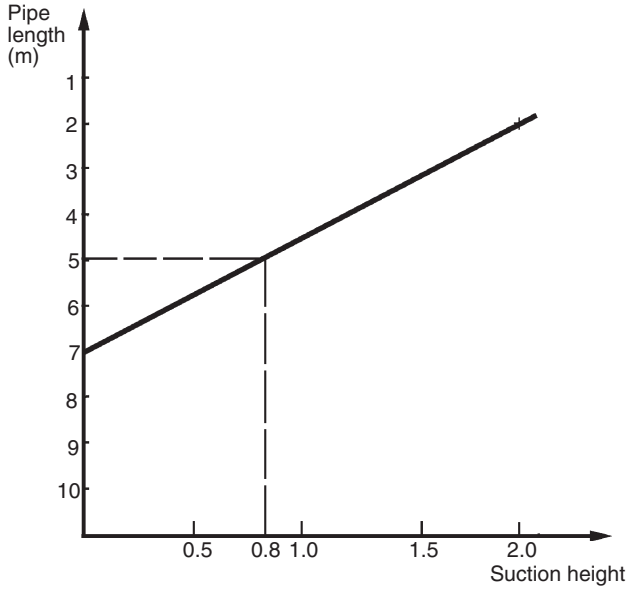
D4 engines

Outer diameter

Required minimum outer diameter for
- feed line pipe: **3/8" (10 mm), see diagram alt. 1/2" (12 mm)**
- return pipe: **3/8" (10 mm)**

Length and suction height 3/8" feed line

Please refer to figure/graph below.



Length and suction height 1/2" feed line

Maximum length: **8.0 m (26.3 ft)**
Maximum suction heght: **2.0 m (6.5 ft)**

D6 engines

Outer diameter

Required minimum outer diameter for
-feed line pipe: **1/2" (12 mm)**
-return pipe: **3/8" (10 mm)**

Length and suction height

Maximum length: **6.0 m (19.5 ft)**
Maximum suction heght: **1.5 m (5.0 ft)**

Nipples (A)

Min. inner diameter: **7.0 mm (0.28")**
Male thread : **1/4" NPTF**
Volvo Penta part no.: **3825000**

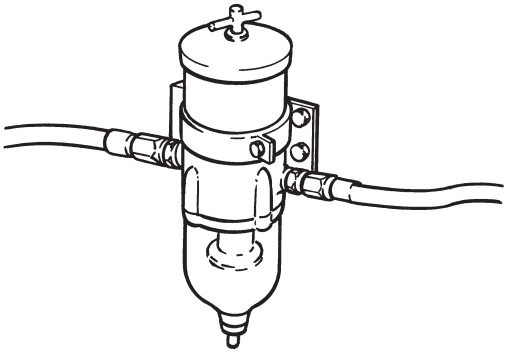
Fuel flow

The fuel flow is the quantity of fuel passing the fuel line from tank to engine, including both fuel consumption and fuel return. This should be considered when selecting the primary fuel filter.

The table below shows the fuel flow at rated speed.

	l/h	USgal/h
D4 180	95	25.1
D4 210	100	26.4
D4 225	105	27.7
D4 260	115	30.4
D4 300	120	31.7
D6 280	120	31.7
D6 310	125	33.0
D6 330	130	34.3
D6 350	140	37.0
D6 370	140	37.0
D6 435	150	39.6

Fuel filter



Use a fuel pre-filter of correct size to avoid excessive resistance across the filter. The recommended filtration is 10 micron (10µ) .

NOTE! Fuel pre-filters with a glass bowl may not be installed in boats intended to be CE-marked.

Fuel line, checking negative pressure

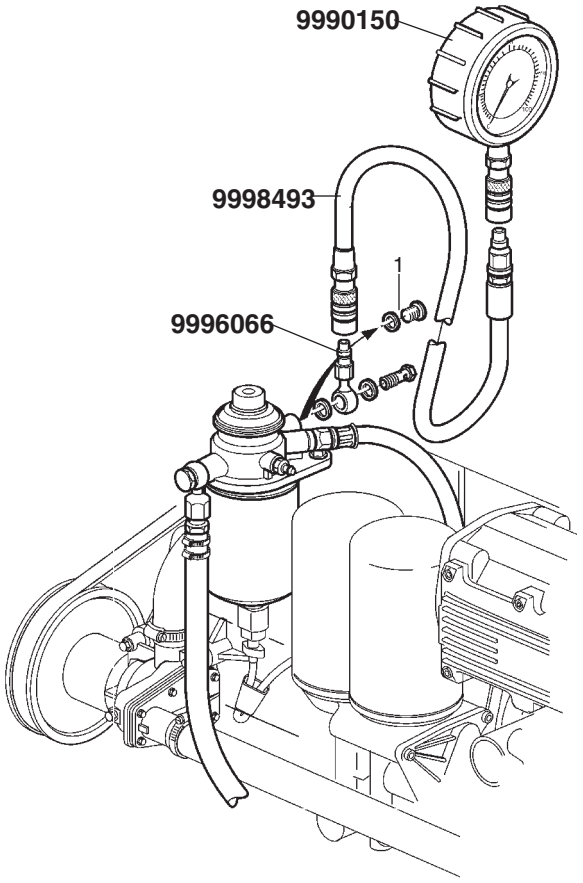
NOTE! You do not normally need to check the fuel feed pressure. This should only be done when excess resistance in the system is suspected. If necessary, follow the procedures below.

Normal measurement of the fuel feed pressure cannot be done since the feed pump is integrated in the high pressure pump.

But, on the other hand, it is of great importance that the **negative pressure** in the fuel lines, fuel filter and water separators does not exceed the max. value. Since the vacuum gauge is connected after the engine fuel filter, you can measure a total value from fuel tank to the high pressure pump.

Two consequences of an incorrect value are that the high pressure pump will have difficulty in controlling the rail pressure and that cavitation damage may occur in the pump.

NOTE! Measuring is done with a new filter insert. Both fuel filter (on engine) and primary filter should be new.



1. Remove the plug and gasket **(1).**

Attach the nipple **9996066** and connect hose **9998493** and vacuum gauge **9990150**.

2. Start the engine.

3. Run the engine under loaded conditions at an increased engine speed throughout the entire rpm range.

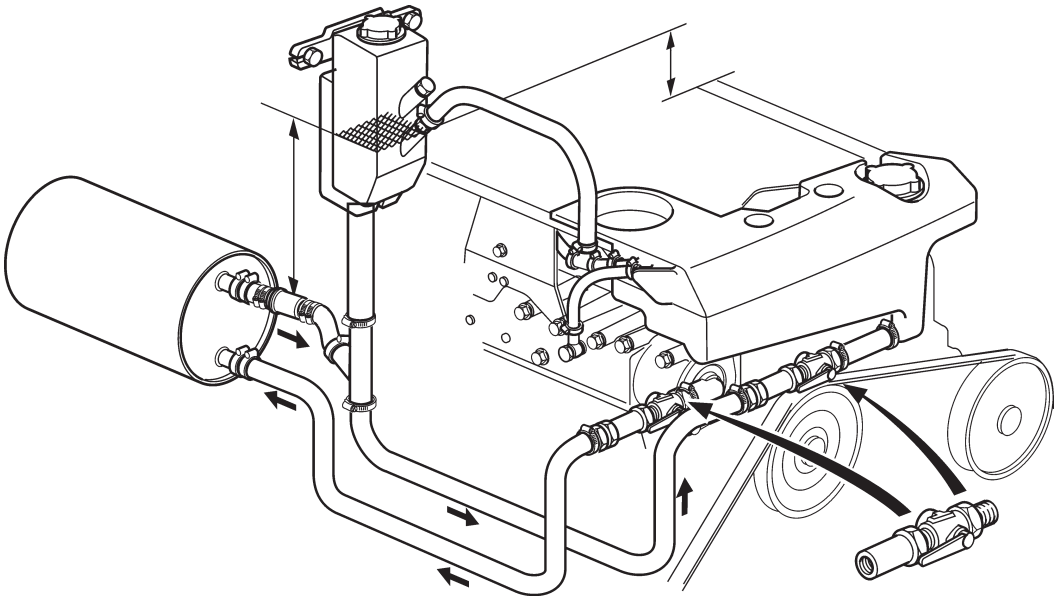
The feed pressure (negative pressure) should be:

0 – -37 kPa (0 – -5.4 psi) measured with a new filter insert. **0 – -50 kPa (7.3 psi)** is mentioned in workshop literature as a max negative value. This value is related to dirty filter inserts.

4. If pressure is too low (negative pressure): Check filter inserts and fuel lines. Check pipe or hose dimensions. Check the primary filter.

5. Remove the measuring equipment and fit the plug **(1)**. Use a new gasket.

Cooling system



The engines are fresh water cooled and have a seawater cooled heat exchanger. In the fresh water system, coolant is circulated by a gear driven circulation pump. The sea water from the heat exchanger goes out through the exhaust system (wet exhaust line).

The installer of the cooling system is responsible for ensuring that the cooling system operates in accordance with these installation instructions.

The cooling system must be dimensioned generously enough to ensure that fouling and repainting do not adversely affect its cooling performance even after a long period of service.

The pipe and hose diameters stated in these installation instructions are to be treated as recommendations. The only way to tell whether an installation is correct is to check pressures, temperatures and flows with the engine running. In case of doubt, contact the Volvo Penta organization.

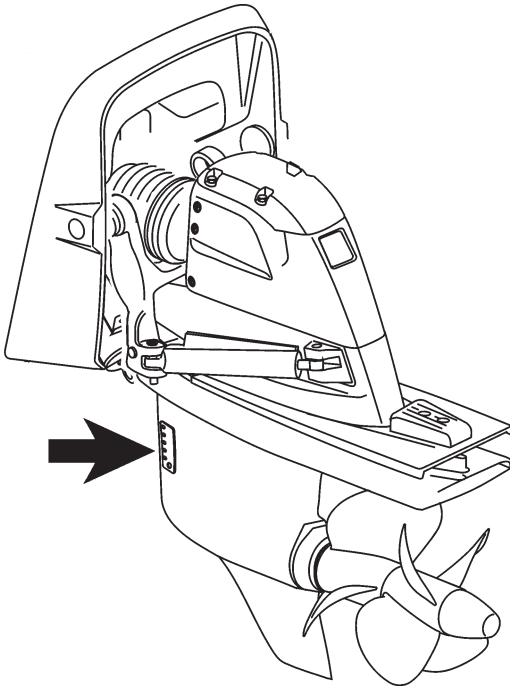
Carefully plan where the fittings are to be placed so that they are accessible. The lines should be arranged so that they are as short as possible.

To reduce corrosion to a minimum, use the correct combinations of materials in pipes, valves etc. plus a correctly sized and pressurized expansion tank. Electrolytic corrosion may occur when two different materials are in contact with each other and placed in an electrolyte such as moisture or seawater.

Use genuine Volvo Penta accessories and spare parts wherever possible. Accessories are described in ***Volvo Penta Accessories & Maintenance Parts***. Make sure that components not supplied by Volvo Penta do not restrict or reduce pressures and flow in the engine. Lines with an excessively small bore, unsuitable routing, incorrect connections etc. will cause restrictions and lead to abnormal engine temperatures.

Use Volvo Penta coolant. The coolant used affects the cooling performance and corrosion protection of the engine.

Seawater system, Aquamatic



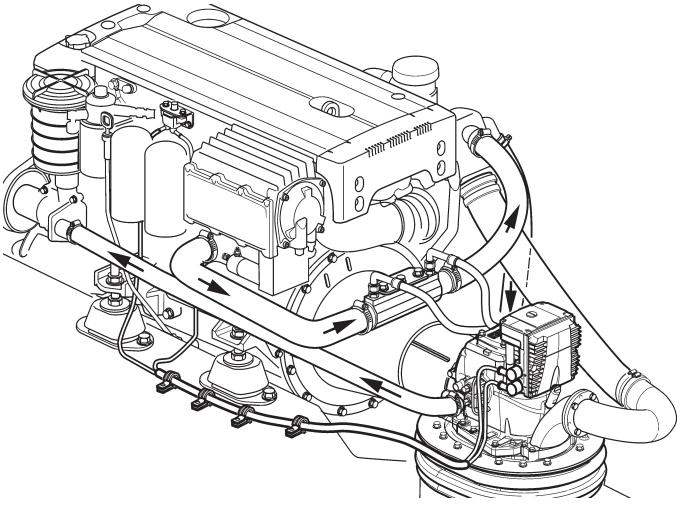
The complete seawater system, including seawater filter is delivered by Volvo Penta.

The water pick-up is located in the drive. The Volvo Penta cooling system is designed for seawater temperatures of max. **32°C (90°F)**.

The water circulating in the seawater system cools:

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

Seawater system, Volvo Penta IPS



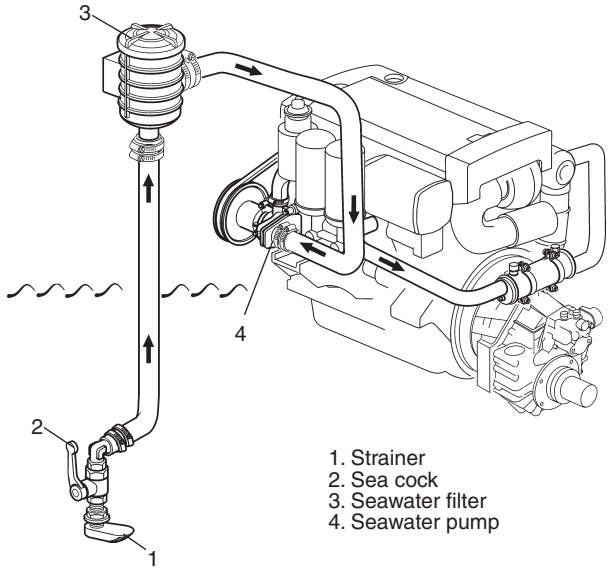
The complete seawater system, including seawater filter is delivered by Volvo Penta.

The water pick-up is located in the Volvo Penta IPS unit. The Volvo Penta cooling system is designed for seawater temperatures of max. **32°C (90°F)**.

The water circulating in the seawater system cools:

- engine coolant
- engine oil
- charge air
- Volvo Penta IPS unit oil
- exhaust gases.

Seawater system, Inboard applications



1. Strainer
2. Sea cock
3. Seawater filter
4. Seawater pump

The water circulating in the seawater system cools the:

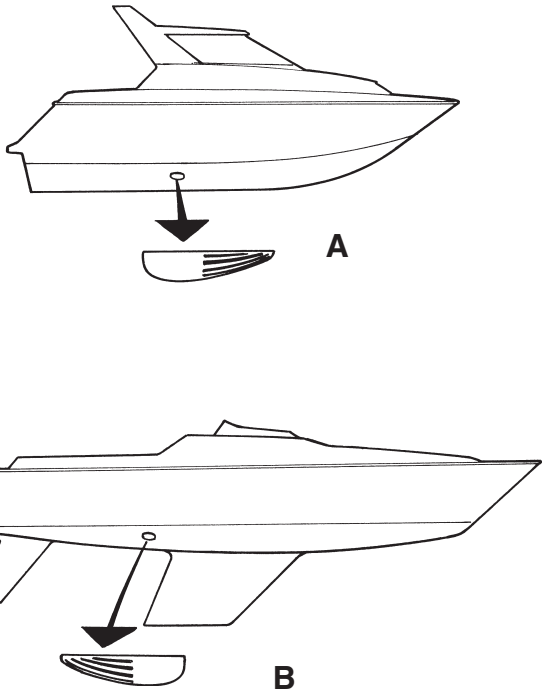
- engine coolant
- engine oil
- charge air
- reverse gear oil

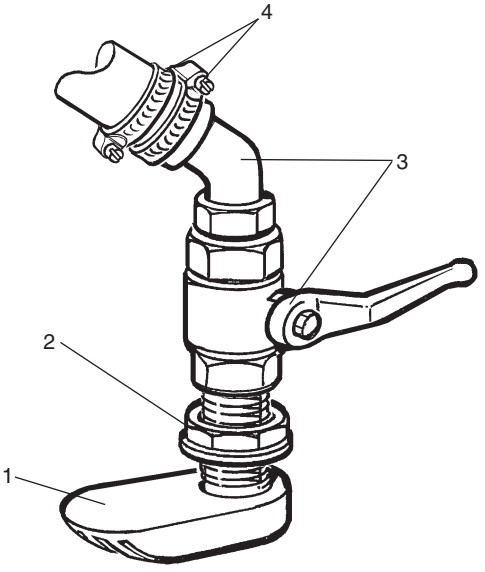
In an installation with a wet exhaust system, this water is also used to cool the exhaust gases. The engines should be equipped with a seawater filter in most cases.

The Volvo Penta cooling system is designed for seawa**ter temperatu**res of max. 32°C (90°F).

Seawater intake

The seawater intake should preferably be made of bronze alloy (brass is unsuitable since it corrodes due to its high zinc content). In the case of boats made of steel, however, the same material as that in the boat hull must be used. If the hull and seawater intake materials differ, then it may be necessary to insulate the intake electrically from the hull to avoid galvanic corrosion.





The seawater intake, the sea cock and the strainer must have a sufficiently large through-flow area to avoid constriction losses and the subsequent reduced water supply to the pump. The negative pressure difference at the inlet of the seawater pump must not exceed **30 kPa (4.35 psi)**.

The seawater intake should have a diameter that fits a hose with an internal **diameter o**f:

D4 38 mm (1½")
D6 50 mm (2")

Minimum flow area of the water pick-up strainer **:**
1.5 x hose inner cross section area.

The seawater intake must be located so deep that the strainer is under water even when the boat heels over or moves in heavy seas. Do not locate the seawater intake too far forward in the boat.

Fit the bottom strainer (**1**) with opening (strainer) facing forwards (**A**), except on sailing boats where the opening (strainer) should face astern (**B**) to prevent water from being forced up into the coolant line when sailing. When a motor boat is being towed, the sea cock must be closed.

Coat the sealing surfaces with a suitable compound, such as silicone rubber. Secure the bottom strainer with the nut (**2**).

Fit the seawater shut off valve and hose connection (**3**). Use non-hardening sealing compound.

NOTE! Always use two hose clamps on each hose connection in the seawater system. Position the hose clamp screws (**4**) as in the figure.

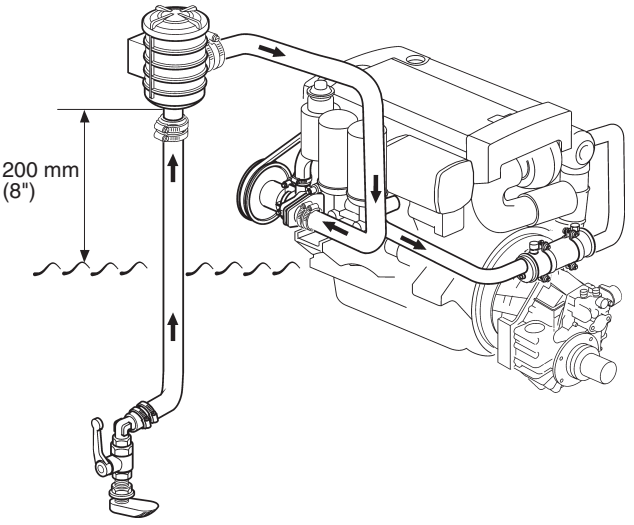
The pipeline must be made up in smooth curves to avoid unnecessary stresses and restriction losses. Use reinforced rubber hose in order to withstand the suction pressure.

NOTE! The hose between the seawater intake (seawater filter) and engine must not be under tension, it must allow flexibility. If the hose has to be taken through bulkheads or similar, it must be protected against chafing.

Seawater filter

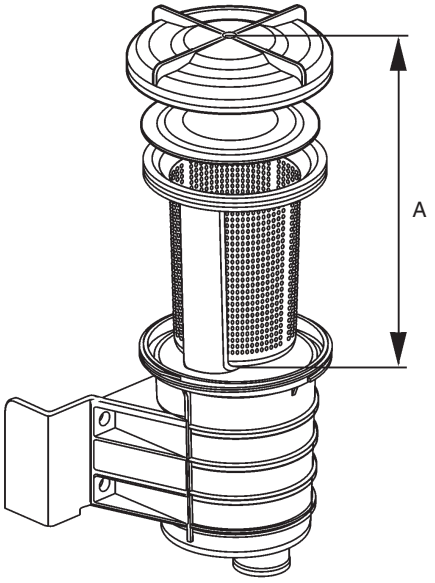
When operating in coastal waters, dock areas, etc., it is not possible to prevent small particles, sludge, sand from entering the seawater inlet. These impurities can be trapped by installing a filter in the suction line. A seawater filter contributes to longer pump lifetime and also prevents engine damage which can result from unsatisfactory cooling in the intercooler or in the heat exchanger.

On **Aquamatic engines**, the seawater filter is standard equipment and mounted on engine.



Inboard engines

The **seawater filter** should be fitted in an accessible position, min. **200 mm (8")**, above the seawater line with the boat loaded, such as on an easy accessible bulkhead. When installed in a sailing boat, this dimension must still apply at full heel.



Intake from sea cock, diameters:

D4 38 mm (1½")

D6 50 mm (2")

Outlet to seawater pump, diameters:

D4 38 mm (1½")

D6 50 mm (2")

Free space for removal of filter cage (A):

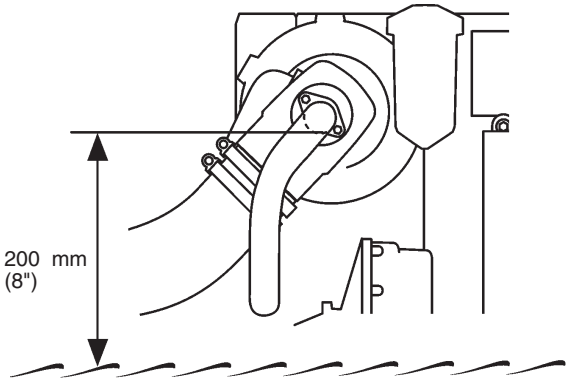
120 mm (5")

If the water is heavily contaminated, it may be necessary to fit a filter with extra large capacity of the type shown in figure above.

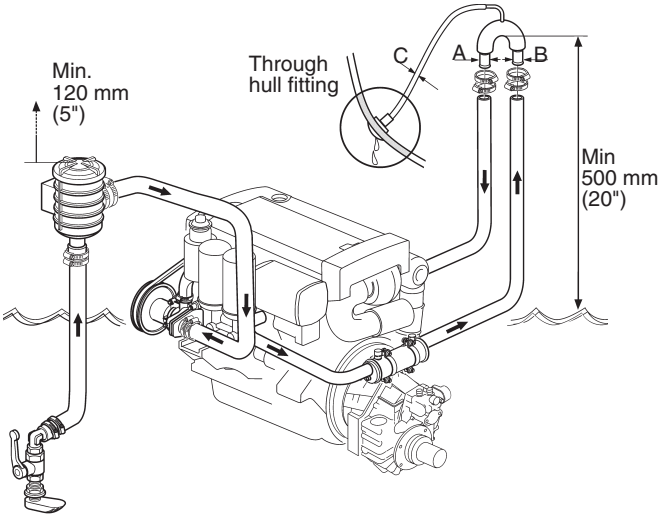
The hose connection on the **seawater pump** has a diameter of:

D4 38 mm (1½")
D6 50 mm (2")

Anti-siphoning valve, inboard engines



The anti-siphoning valve (vacuum valve) should be fitted in cases where the engine is installed so deep in the boat that the distance between the exhaust pipe flange (lower part) and water-line is less than **200 mm (8")**. When correctly fitted the valve prevents siphoning, which causes water entry into the engine.



NOTE! The anti-siphoning valve (vacuum valve) should be fitted min. **500 mm (20")** above sea-waterline with the boat loaded.

The valve is not supplied by Volvo Penta. It has to be tailor made.

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

Hose dimensions

Inner diameter, hose (A) = 45 mm (1 3/4")
Inner diameter, hose (B) = 50 mm (2")
Inner diameter, hose (C) = 6–10 mm (1/4"–3/8")

Freshwater system

Fresh water is circulated via the cooling ducts and heat exchanger of the engine by a centrifugal pump.

As long as the coolant is cold, the thermostat(s) remain closed, preventing the coolant from passing to the heat exchanger. Instead the coolant flows through a by-pass duct directly back to the suction side of the pump. This ensures that the engine rapidly reaches its working temperature. The thermostats also maintain the correct temperature at low power/load.

Coolant

We recommend that you use "Volvo Penta Coolant, Ready Mixed", or "Volvo Penta Coolant" (concentrated) mixed with pure water according to spec, please refer to Water quality. Only coolant of this quality is suited too and approved by Volvo Penta.

The coolant should contain ethylene glycol of good quality with a suitable chemical formulation, for adequate protection of the engine. Using anti-corrosion additive exclusively is not permitted in Volvo Penta's engines. Never use water by itself as coolant.

⚠ **IMPORTANT**! Coolant must be used all year round. This applies even if there is never any risk for frost, to ensure that the engine has adequate protection against corrosion. Future warranty claims on the engine and additional equipment may be rejected if an unsuitable coolant has been used or if the instructions concerning coolant mixing have not been followed.

"Volvo Penta Coolant" is a concentrated coolant that is to be mixed with water. It has been developed to function optimally with Volvo Penta's engines and provides excellent protection against corrosion, cavitation and frost damage.

"Volvo Penta Coolant, Ready Mixed" is a ready-mixed coolant, 40 % "Volvo Penta Coolant" and 60 % water. This concentration protects the engine against corrosion, cavitation damage and freezing conditions down to -28°C (18°F).

Coolant mixture

⚠ **WARNING**! All glycol is hazardous and harmful to the environment. Do not consume!
Glycol is flammable.

⚠ **IMPORTANT**! Ethylene glycol must not be mixed with other types of glycol.

Mix:

40 % "Volvo Penta Coolant" (conc. coolant) with 60 % water.

This mixture protects the engine against internal corrosion, cavitation and frost damage down to -28°C (18°F). (Using 60 % glycol lowers the freezing point to -54°C (65°F)). Never mix more than 60 % concentrate (Volvo Penta Coolant) in the cooling liquid, this will give reduced cooling effect and increase the risk of overheating, and will give reduced freezing protection.

⚠ **IMPORTANT**! Coolant must be mixed with **pure** water, use **distilled – de-ionized water**. The water must comply with the requirements specified by Volvo Penta, please refer to "Water quality".

⚠ **IMPORTANT**! It is extremely important that the correct concentration of coolant is added to the system. Mix in a separate, clean vessel before adding into the cooling system. Ensure that the liquids mix properly.

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

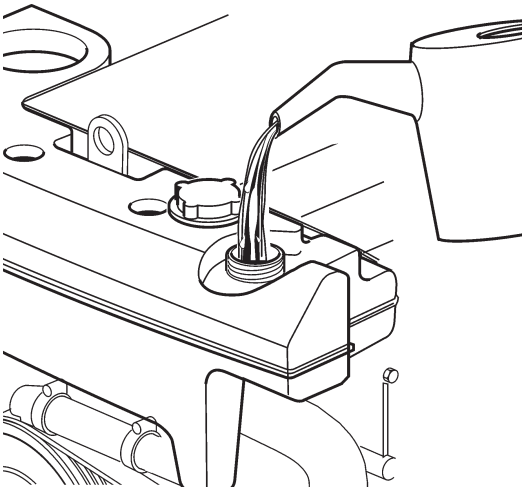
Manganese (acc. ASTM D858) .....< 0.05 ppm

Conductivity (acc. ASTM D1125).....< 500 µS/cm

Organic content, COD_{Mn}
(acc. ISO8467).....< 15mg $kMnO_4$/l

Filling with coolant

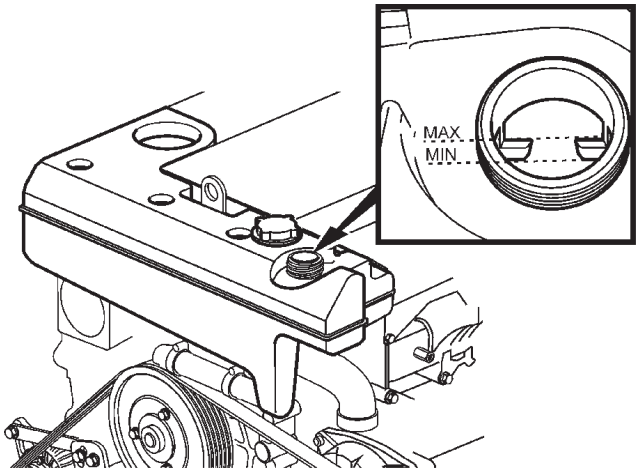
NOTE! Coolant should be filled with the engine stopped and cold.



Fill the system carefully through the expansion tank opening, approximately 10 – 15 l/min (2.5 – 4.0 US gal/min) so the system will be vented during filling.

Cooling system volume excluding extra circuits:

D4 12.5 liters (3.3 US gal)
D6 15.7 liters (4.2 US gal)



Fill until the system is completely filled up, including the expansion tank. The coolant level should be between the MIN and MAX levels.

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

NOTE! If it is difficult to check the water level in the expansion tank, Volvo Penta can supply a water level sender to install in the tank.

External systems:

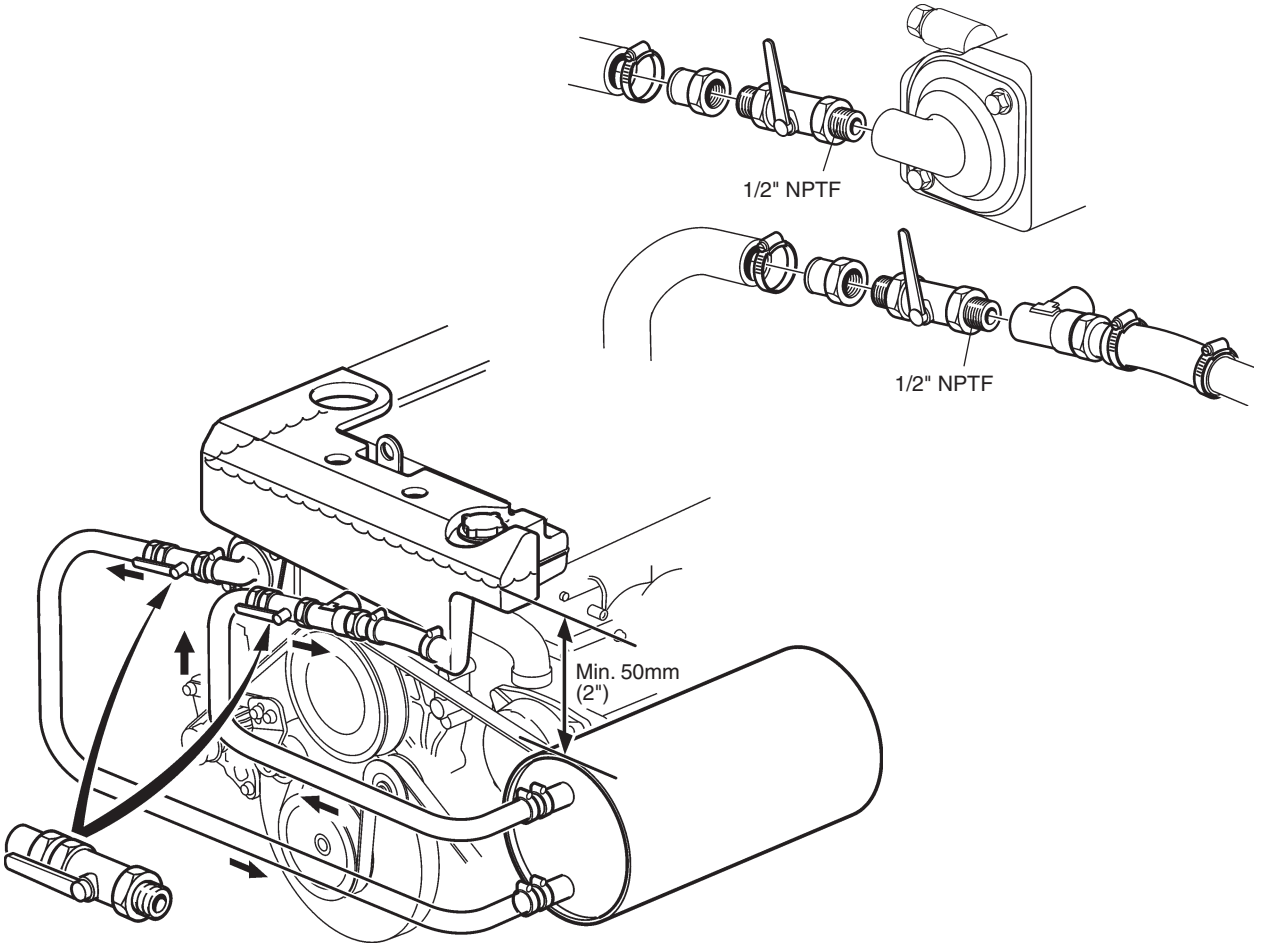
When external systems are connected to the engine cooling system, the valves in the systems should be opened and the units vented during filling.

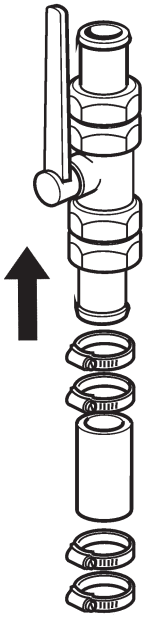
Special venting nipples may be fitted in external circuits, especially systems located above the engine.

⚠ **IMPORTANT**! The engine must not be started until the system has been completely filled with coolant.

⚠ **WARNING**! Do not open the pressure cap on a hot engine. Steam or hot water can spray out and release system pressure. Low system pressure will cause insufficient cooling!

Hot water connections





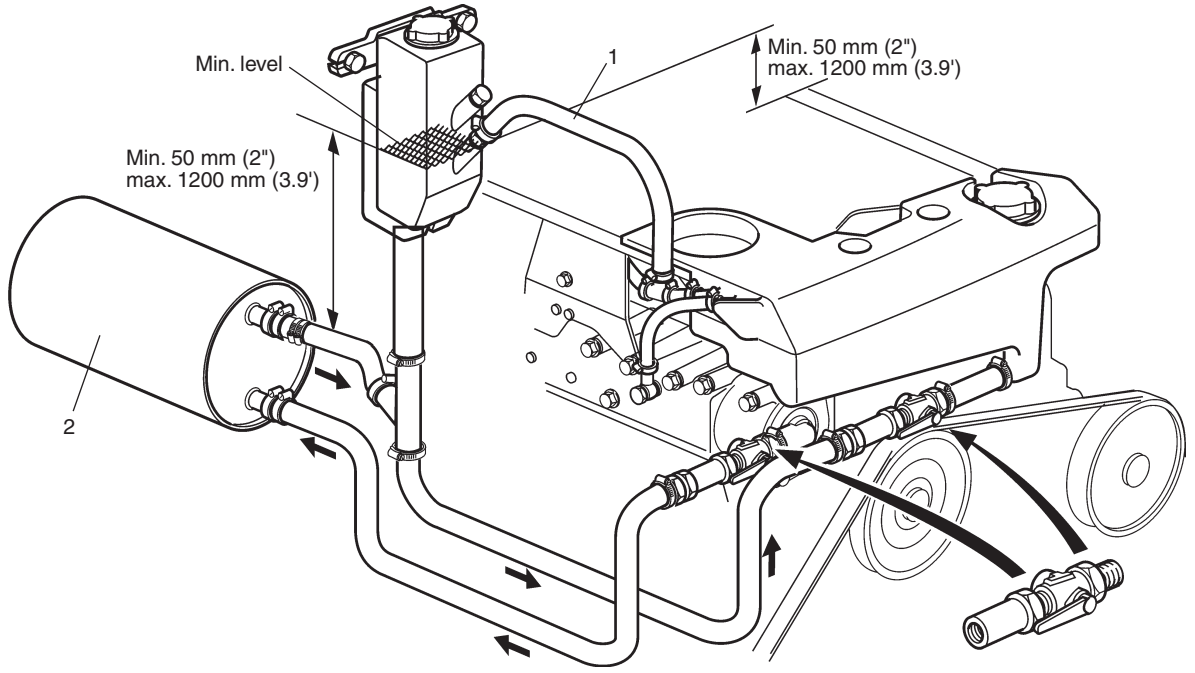
Connections for hot water outlets may be fitted to the thermostat housing (outlet) and circulation pump (inlet). The nipples supplied by Volvo Penta are intended for a hose with an inner diameter of 16 mm (5/8").

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 should be installed in the extra circuit on both the supply and return sides. Locate the valves as close to the engine as possible.

Extra expansion tank



Capacity of the freshwater standard system and extra circuits

The volume of the engine's freshwater system can be increased by an extra circuit without adding an extra expansion tank to the system.

Max. additional volume, D4 and D6 with standard engine mounted expansion tank: **5.0 lit (1.3 US gal.)**.

When the volume is **further** increased or when the extra circuit is placed **above** the top of the engine, the cooling system has to be equipped with a larger expansion tank.

Hot water circuits and cabin heaters are examples of extra circuits.

An extra expansion tank shall be installed with its minimum level mark at min. **50 mm (2")** and max. **1200 mm (3.9')** above the highest point of the engine, or the highest point of the external circuit (the point that has the highest position, please refer to figure above).

The extra expansion tank should be located for easy access when checking and filling.

The venting hoses (1) must not be routed below their connection points on the engine. Pos. (2) in figure is a calorifier.

	Volume in engine including heat exchanger lit (US gal.)	Max. additional volume in extra circuit with standard, engine mounted expansion tank lit (US gal.)
D4	12.5 (3.3)	5.0 (1.3)
D6	15.7 (4.2)	5.0 (1.3)

The expansion tank volume in the extra tank should be 15 % of the **total capacity** of the cooling system. Of this volume:

5 % is meant for coolant expansion when hot (expansion volume),

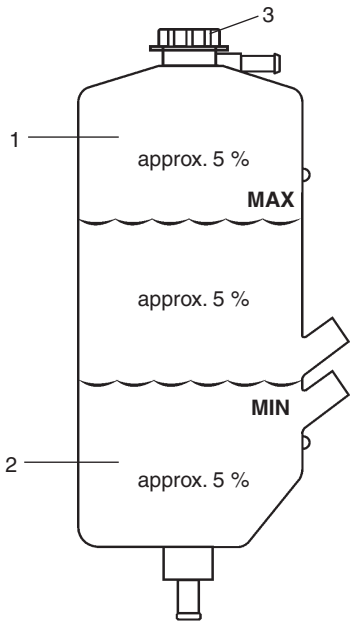
5 % is meant for the difference between **MAX** and **MIN** levels

5 % is reserve volume.

The expansion tank for the engine must have a separate vent to the extra tank connected below MIN level.

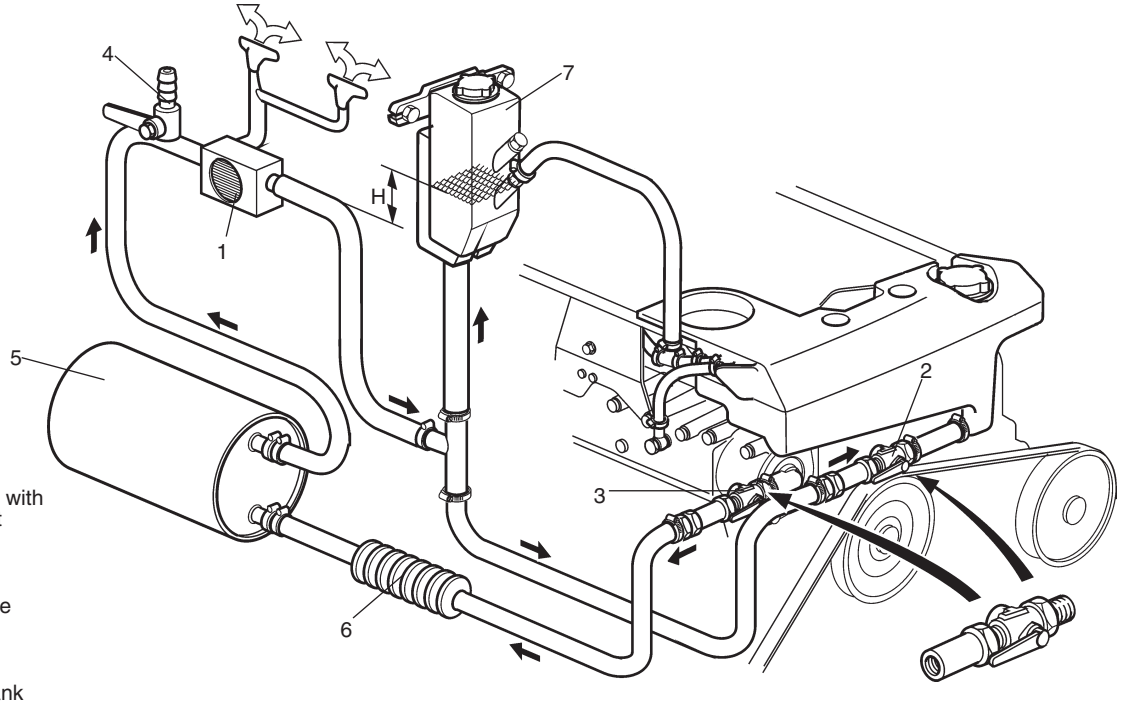
The hoses must be able to withstand temperatures of up to **115°C (240°F)**.

The engine's pressure cap is replaced with a sealed cap. The standard engine venting hose from the thermostat housing can be connected to the extra expansion tank below the **MIN** level to facilitate venting when topping up with coolant.



1. Expansion volume, approx. 5 %
2. Reserve volume, approx. 5 %
3. Pressure cap

Venting the system



1. Cabin heater with defroster unit
2. Outlet valve
3. Inlet valve
4. Venting nipple
5. Calorifier
6. Heater
7. Expansion tank

H. Min. 50 mm (2")

In most cases, such as in the system shown in the figure on the previous page, the system is self venting to the expansion tank.

In an external system not automatically vented to the expansion tank, a separate venting nipple **(4)** must be added.

Electrical system

General

The electrical installation has to be planned very carefully and installed with the greatest of care. Seek simplicity when designing the electrical system.

The wires and connectors used in the installation have to be of a type approved for marine use. The wires should be routed in a protective sheath and clamped properly.

Make sure that the leads are not installed too close to heated parts of the engine or close to another source of heat. The leads must not be subject to mechanical wear. If necessary, draw the leads through protective tubing.

Attempt to design the system with a minimum number of joints. Make sure that cables, and joints in particular, are accessible for inspection and repair.

A wiring diagram of the complete electrical system should be supplied with the boat. This will simplify fault tracing and installation of additional equipment considerably.

NOTE! Make sure that all components used are suitable for a marine environment. Make sure that no joints in the engine room are installed deep down. All cable joints should be located higher up than the alternator.

⚠ **IMPORTANT!** Power supply cables – batteries, alternators, distributors, starters and heavy loads shall be installed separately from the EVC bus cable and from the steering unit cables in an Volvo Penta IPS installation.

Positive (+) and negative (–) cables should be clamped close to each other and not separated.

2-pole electrical system

D4 and D6 engines have a 2-pole electrical system with insulated return. In a 2-pole system, each electrical component on the engine has an insulated DC negative return.

NOTE! The D4 and D6 engines are delivered in two different versions:

1. With a braid mounted between the starter and the engine block. The engine block is connected to the battery negative (–) terminal.

   In this case the engine has a 2-pole system with a grounded engine block.

2. Without any braid mounted between the starter and the engine block. The engine block is not connected to the battery negative (–) terminal.

Both types of engines are 2-pole and shall be installed as such.

⚠ **IMPORTANT**! Do not ground (earth) any conductors on the engine block.

Power supply

⚠ **IMPORTANT**! Accessories which are heavy electrical loads, such as bow thrusters, anchor winches or similar must be connected to a separate accessory battery and **not to the starting batteries**.

Batteries

Battery terminology

Capacity

Capacity is measured in Ampère-hours (Ah). The starter battery capacity (Ah) is usually stated as the 20 hour capacity of the battery, i.e. the battery can be discharged at a constant current for 20 hours to a final voltage of 1.75 V/cell. For example: If a battery can produce 3 A for 20 hours, its capacity is 60 Ah.

The cold cranking amperage (CCA) measures the starting performance of the battery. The society of Automotive Engineers (SAE) has specified the following test: A battery at a temperature of –18°C (0°F) must be able to deliver a current equal to the cold cranking amps for 30 seconds with the voltage remaining above 1.2 V/cell or 7.2 V for a 12 V battery. There are other CCA tests defined by DIN, JIS, ETN etc. These tests will give different CCA values compared with the SAE test.

Battery capacity is affected by temperature. Battery capacity is specified at +20°C (68°F). Cold considerably reduces a battery's ability to release its energy. The following table shows the difference in capacity between +20°C (68°F) and -18°C (0°F).

Temperature	+20°C (68°F)	-18°C (0°F)
Capacity	100 %	50 %
	70 %	35 %
	40 %	25 %

Connecting batteries

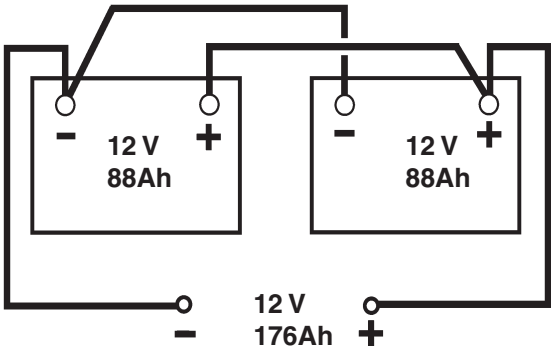
If a boat has more than one battery, please observe the following for each connection method:

Parallel connection:

Two (or more) 12 V batteries are connected in parallel so that the capacity is increased. The boat's system voltage is the same as the rated voltage of the battery.

- The batteries must have the same nominal voltage.
- The batteries may have different capacities.
- The batteries do not need to be of the same age.

When two batteries are connected in parallel, the voltage remains the same but the capacity is the sum of the capacities. When charged, each battery receives a charge lower than that stated on the charger. To find out the charge current supplied to each battery, measure the charging current to each battery with an ammeter.



Example: For two 12 V batteries, each with a capacity of 88 Ah, connected in parallel the voltage will be 12 V and the total capacity will be 176 Ah.

If one of two batteries connected in parallel has a short-circuited cell, the nominal system voltage will be approx. 10 V.

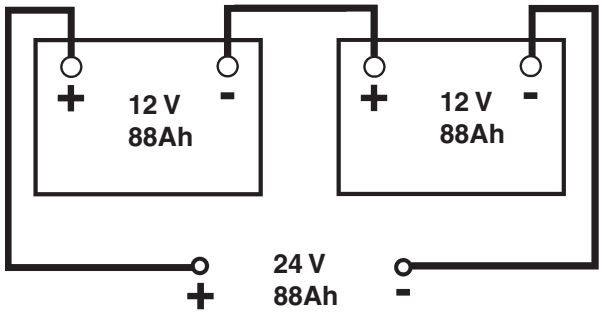
Series connection:

Two 12 V batteries are connected in series so that the system voltage in the boat is 24 V.

⚠ **WARNING!** Always check the boat's system voltage before connecting. A particular engine type may be available for 12 V and 24 V configurations.

- The batteries must be similar (same capacity and voltage).
- The batteries must be the same age since the charge current required to produce a certain voltage changes with the age of the battery.
- There must not be unequal loading (equipment should load both batteries - not just one). A small load such as a radio connected across only one battery can quickly destroy the batteries.

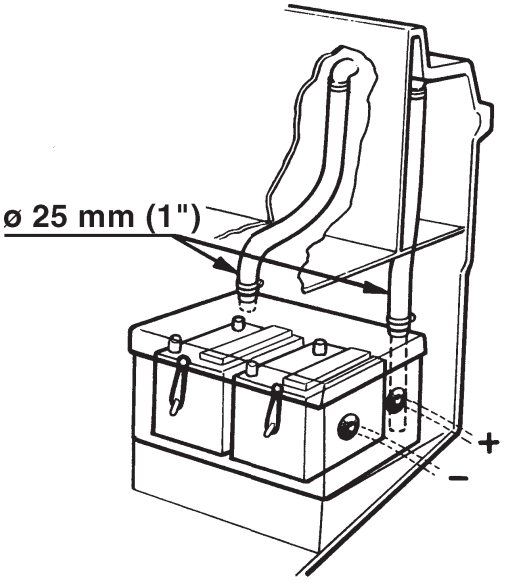
Two batteries connected in series retain the capacity but double the voltage. During charging, each battery receives the current supplied by the charger. The total battery voltage must not exceed the battery voltage marked on the charger.



Example: For two 12 V batteries, each with a capacity of 88 Ah, connected in series the voltage will be 24 V and the total capacity will be 88 Ah.

When two 12 V batteries are connected in series and one battery has a short-circuited cell, the resting voltage across the two batteries will be approx. 23 V.

Battery installation



Install the batteries in a box with tight-fitting lid. Vent the box with 25 mm (1") hoses. The ventilation hose must end up outside the boat to allow the flammable gas produced by batteries to escape.

The batteries should be fastened and only allowed to move max 10 mm (3/8").

⚠ **WARNING!** The batteries, if they are not the sealed type, may only be installed in the engine compartment if they are installed in a separate, sealed and well ventilated battery box. Battery gas is easily ignited and highly volatile. Sparks or open flames can cause explosion or fire.

Starting group battery capacity

The battery sizes listed below are recommended to start the engines at specified temperatures. The list applies for both 12 V / 24 V applications.

NOTE! The battery capacity will fall by approx. 1% / degree, from +20°C (68°F), which must be considered at extreme conditions in temperature.

Aquamatic / Inboard

Engine:	**Min.battery capacity (SAE) Lowest temp: +5°C (41°F)**	**Min.battery capacity (SAE) Lowest temp: -5°C (23°F)**
D4 (One battery / engine)	**750CCA** and 75Ah	**800CCA** and 75Ah
D4 (Common starting group)	**750CCA** and 88Ah	**800CCA** and 88Ah
D6 (One battery / engine)	**750CCA** and 75Ah	**1150CCA** and 120Ah
D6 (Common starting group)	**750CCA** and 88Ah	**1150CCA** and 120Ah

Instead of using one 1150CCA and 120Ah battery, two 680CCA and 75Ah can be used.

Common starting group: One battery is used to feed both engines (twin installation)

Volvo Penta IPS

⚠ **IMPORTANT!** Common starting battery group is not permitted in an IPS installation

Engine:	**Min.battery capacity (SAE) Lowest temp: +5°C (41°F)**	**Min.battery capacity (SAE) Lowest temp: -5°C (23°F)**
Volvo Penta IPS 350	**750CCA** and 88Ah	**800CCA** and 88Ah
Volvo Penta IPS 400/450/500/600 (One battery / engine)	**750CCA** and 88Ah	**1150CCA** and 120Ah

Instead of using one 1150CCA and 120Ah battery, two 680CCA and 75Ah can be used.

NOTE! Separate starting battery groups are required in IPS installations to provide full redundancy and single-failure tolerance.

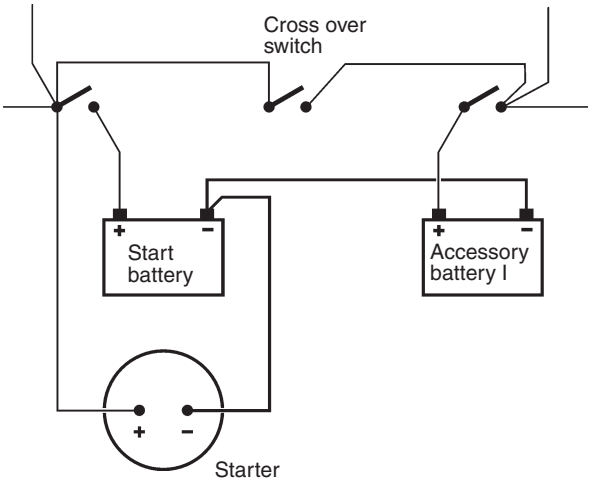
Accessory battery

The use of a separate battery group for accessories is mandatory.

Volvo Penta recommends using a charge distributor to feed the accessory batteries.

Cross-over switch

The use of a cross-over switch between the accessory battery and the starter battery is recommended.



Mixed voltage systems

Note that extra alternators can only be fitted on engines not equipped with a power steering pump. Please refer to the chapter ***Power Take-off, Universal Bracket***.

		Power steering pump
Single inst. D4/D6 AQ		Yes
Twin inst. D4/D6 AQ	stb.	Yes
	port	No
All inboard inst. D4/D6		No
All Volvo Penta IPS		No

Single engine

Engine 12 V Extra alternator 24 V*

Engine 24 V Extra alternator 12 V*

*)These arrangements are not that common and need a power take-off solution. Please refer to chapter ***Power take-off***.

Twin engines

Engine 12 V Extra alternator 24 V (80 A)

Engine 24 V Extra alternator 12 V (115 A)

⚠ **IMPORTANT!** In a mixed voltage system, the two drivelines should have the same voltage.

That is, a boat can have two 12 V engines with 24 V electrical systems for accessories. Or a boat can have two 24 V engines with 12 V electrical systems for accessories. **You can not** have a boat with one 12 V engine and one 24 V engine, regardless of what the electrical systems look like otherwise.

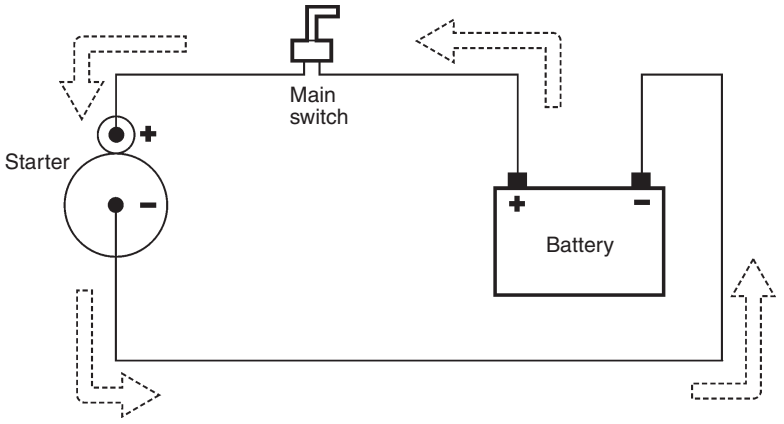
The alternator voltages for both engines must be the same, to assure correct operation of the EVC/Volvo Penta IPS system.

For information about extra alternators, please refer to the chapter ***Power Take-off***.

Starting battery cable area

Volvo Penta recommends cable areas as below, to provide sufficient power from the battery to the starter motor.

NOTE! The table applies to both 12 V and 24 V systems.



Measure the **total cable length** from the battery positive (+) terminal via the main switch to the starter motor positive (+) terminal and from the starter motor negative (–) terminal back to the battery negative (–) terminal .

Thereafter select the recommended cable area according to the table below for **both** the negative (–) cable and the positve (+) cable.

Since the cable has to absorb generated heat, the cross section area should not be less than 50 mm².

Total start battery cable length and cable area

Total length of positive (+) and negative (–) cables, max. lengths m (ft)	5.2 (17)	7.3 (24)	9.7 (31.8)	12.4 (40.6)
Cable area, mm²	50	70	95	120

Comparison cable area (mm²) – diameter (mm) according to Volvo standard

Area, mm²	**50**	**70**	**95**	**120**
Core diameter approx, mm	12	14	16	18
Cable diameter approx., mm	15	17	19	21

Comparison cable area – SS IEC 228, Volvo standard

Area, mm²	**10**	**16**	**25**	**35**	**50**	**70**	**95**	**120**
Core diameter approx., mm	6	7	9	11	12	14	16	18
Cable diameter approx., mm	8	9	11	13	15	17	19	21

Alternator

Rating

The alternators for the D4 and D6-engines are rated as follows:

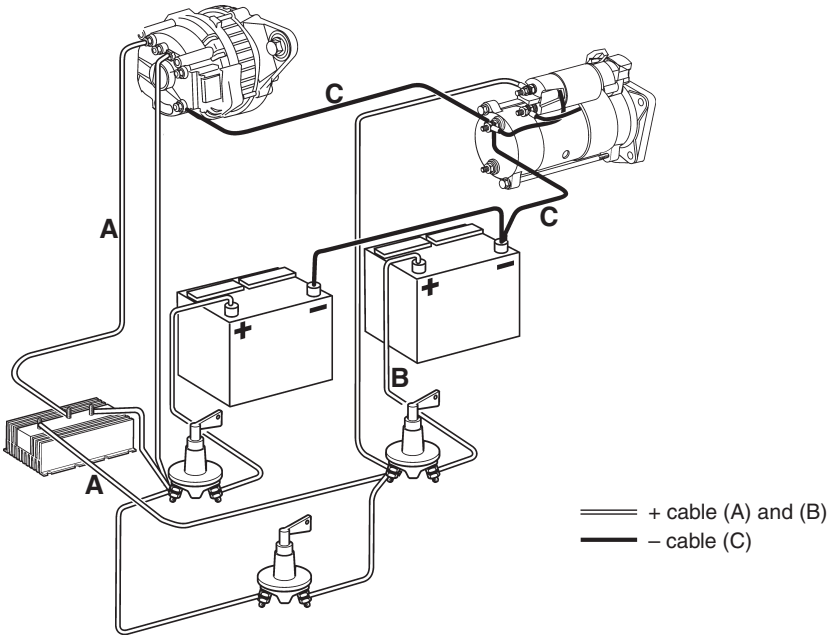
12 V for D4, D6: 115 A
24 V for D6: 80 A

Sensor and power cable from alternator

⚠ **IMPORTANT!** For systems without a separate accessory battery, the factory-mounted sensor cable from the alternator to the positive terminal of the starter motor must be left in place. Similarly, the power cable from alternator to starter motor must be left in place.

For systems with a separate accessory battery, do as follows:

1. Find the yellow 0.75 mm² sensor cable between the alternator and the starter motor. Disconnect and cut the cable at both ends.
2. Find the red 16 mm² power cable between the alternator and the starter motor. Disconnect and cut the cable at each end.
3. Install a new 0.75 mm² (preferably yellow) cable from the main switch for the accessory battery to the alternator sensor terminal.
4. Install a new (preferably red) power cable from the alternator to the charging distributor. Also make a new (preferably red) power cable from the charging distributor to the main switches (starter and accessories).
5. Add the length of the two cables A and B. The areas of the negative (–) cables should be at least the same area as the positive (+) cable.
6. Find the required cable area in table below.

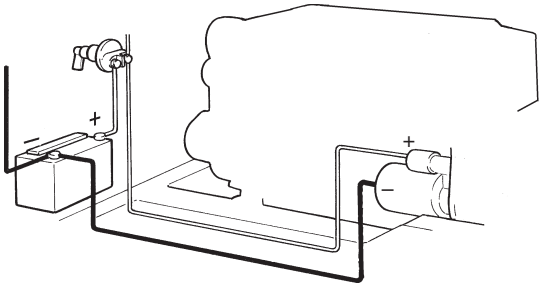


Total power cable length and cable area from alternator to battery

Total length of cable A and B, max. lengths, m (ft)	**12 V alternator**	1.0 (3.3)	1.5 (4.9)	2.5 (8.2)	3.5 (11.5)	5.0 (16.4)	7.0 (23)	10.0 (32.8)	12.0 (39.4)
	24 V alternator	2.0 (6.6)	3.2 (10.5)	5.0 (16.4)	7.0 (23)	10.0 (32.8)	14.0 (45.9)	19.0 (62.3)	24.0 (78.7)
Cable area, mm²		10	16	25	35	50	70	95	120

Main switch

A main battery switch should be installed on the positive side. The bulkhead transitions for both the positive and negative cables must be provided with grommets. Position the main switch outside the engine room but as close to the engine as possible, to reduce cable length.

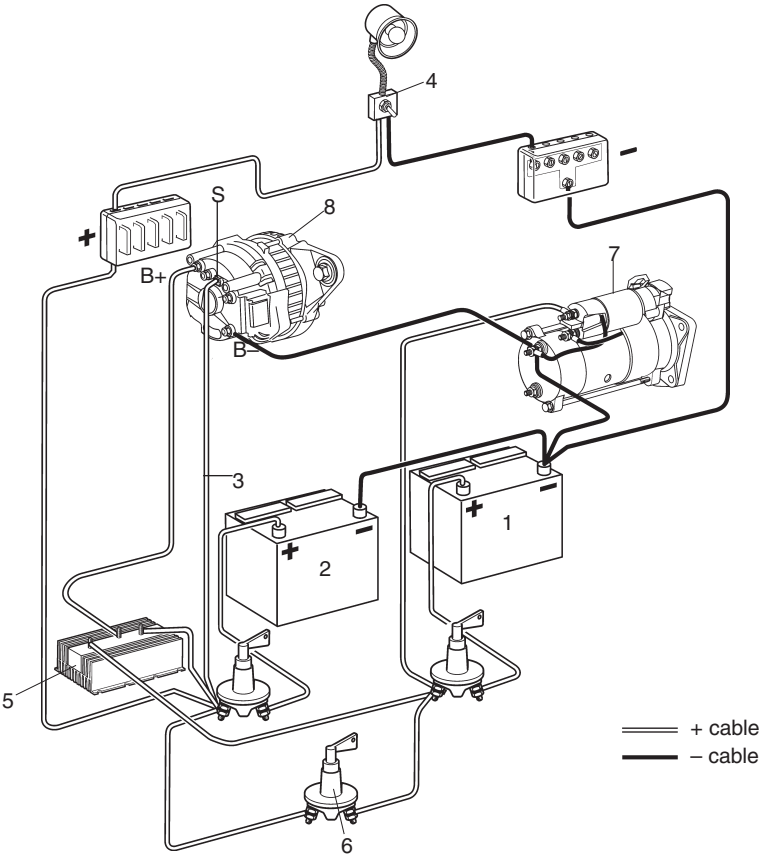


Main switch requirements

Normal voltage	Nominal capacity			Working temp. Max.	Standard	Protection degree
	Continuous	During 5 sec.	During 5.5 min.			
≤48 V	150 A	1000 A	450 A	+85°C +185°F	SAE Marine J1171	IP 66

Charge distributor 12 V and 24 V, engine and boat

Example

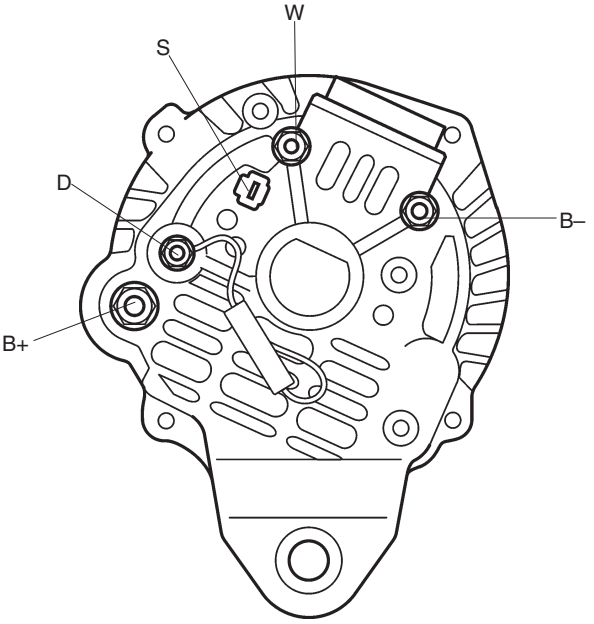


1. Starting battery
2. Accessory battery
3. Sensor cable
4. Accessories
5. Charge distributor
6. Cross over switch
7. Starter
8. Alternator

The charge distributor automatically charges two battery circuits, independently of each other. One circuit is used for starting the engine and the other circuit is used for other electrical equipment. This means that if you discharge the accessory battery, you will still be able to start the engine with the start battery.

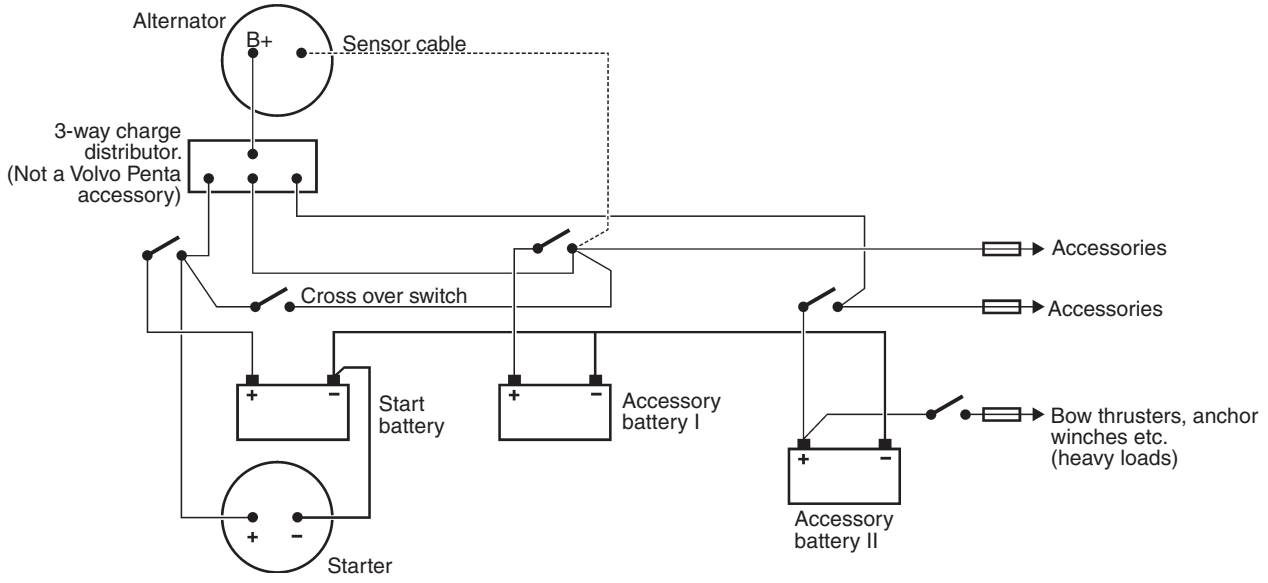
Alternator connnections

B+	Battery plus (+)
B–	Battery minus (–)
S	Sensor cable
D	Excitation
W	Rpm (not used)



Single installation, D4/D6 12 V or 24 V, Aquamatic and Inboard

Recommended installation:



- **NOTE**! No equipment is connected to the starting battery group.
- Two separate accessory battery groups.

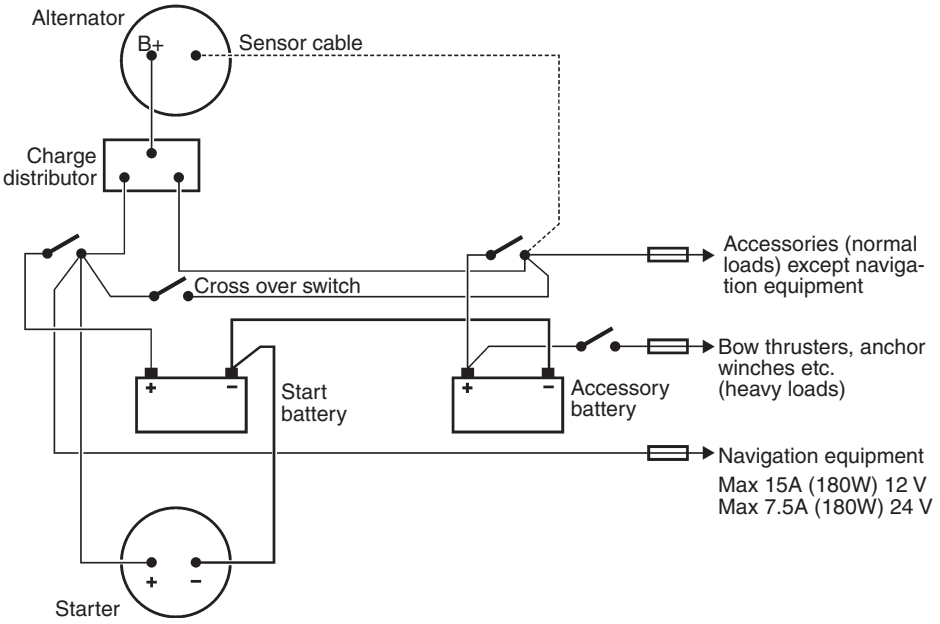
  Navigation equipment is connected to accessory battery I.
- Bow and stern thrusters, anchor winches and other heavy electrical loads are connected to accessory battery II. This to prevent voltage drop in equipment connected to accessory battery I, such as navigation instruments.

NOTE! Heavy electrical loads should have a separate switch connected directly to the accessory battery positive (+) terminal.

- All other equipment, lamps, fans, refrigerators etc. (navigation instruments excepted) can be connected either to accessory battery I or II.

Single installation, D4/D6 12 V or 24 V, Aquamatic and Inboard

Alternative installation:



- Navigation equipment of max. 15 A/180 W (12 V), 7.5 A/180 W (24 V) can be connected to the starting battery group. This to prevent interference (voltage drop) when using heavy electrical loads such as bow thrusters, anchor winches etc. If bow thrusters are not used, navigation equipment should not be connected to the starting battery group.

  NOTE! Referring to figure above. Using navigation instruments when engines are not running may discharge the battery and cause problems when starting.

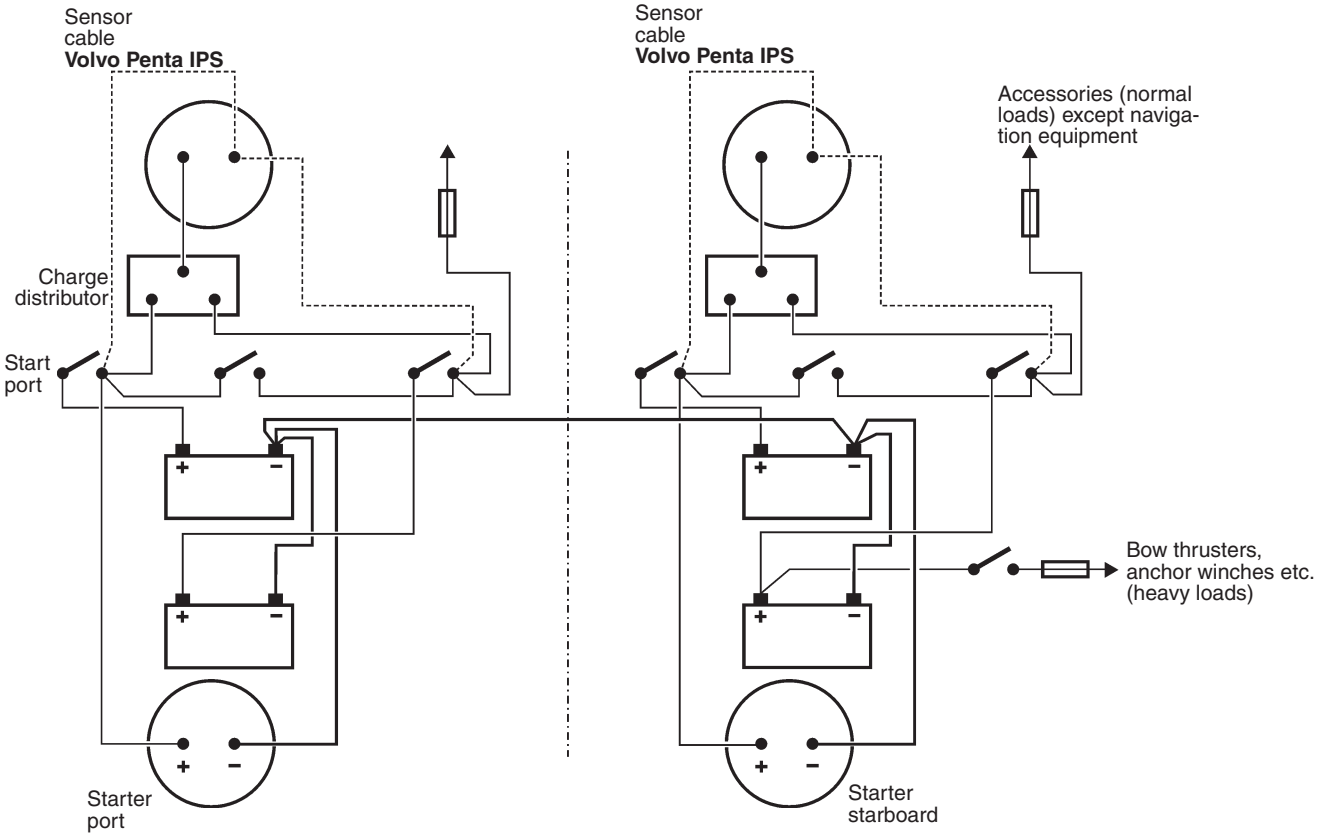
- All other equipment, including heavy current loads, are connected to the accessory battery.

  NOTE! Heavy electrical loads should have a separate switch connected directly to the accessory battery positive (+) terminal.

Twin installation, D4/D6 12 V or 24 V, two accessory battery groups, Aquamatic, Inboard and Volvo Penta IPS

(single failure tolerant system)

Recommended installation:



- Separate starting battery group for each engine (driveline).
- **NOTE**! No equipment connected to the starting battery group.
- Two separate accessory battery groups.

  Navigation equipment is connected to the port accessory battery.

  NOTE! Navigation equipment should not be connected to the starting battery group.
- Volvo Penta IPS: Sensor cables from the alternators must always be connected to the starting battery groups.
- **Aquamatic and inboard**: Connect the sensor cables from the alternators to the accessory battery groups.
- Bow and stern thrusters, anchor winches and other heavy electrical loads are connected to the starboard accessory battery (II). This to prevent voltage drop in equipment connected to the port accessory battery, such as navigation instruments.

  NOTE! Heavy electrical loads should have a separate switch connected directly to the accessory battery positive (+) terminal.
- All other equipment, lamps, fans, refrigerators etc. (except navigation instruments) can be connected either to the port or starboard accessory battery .

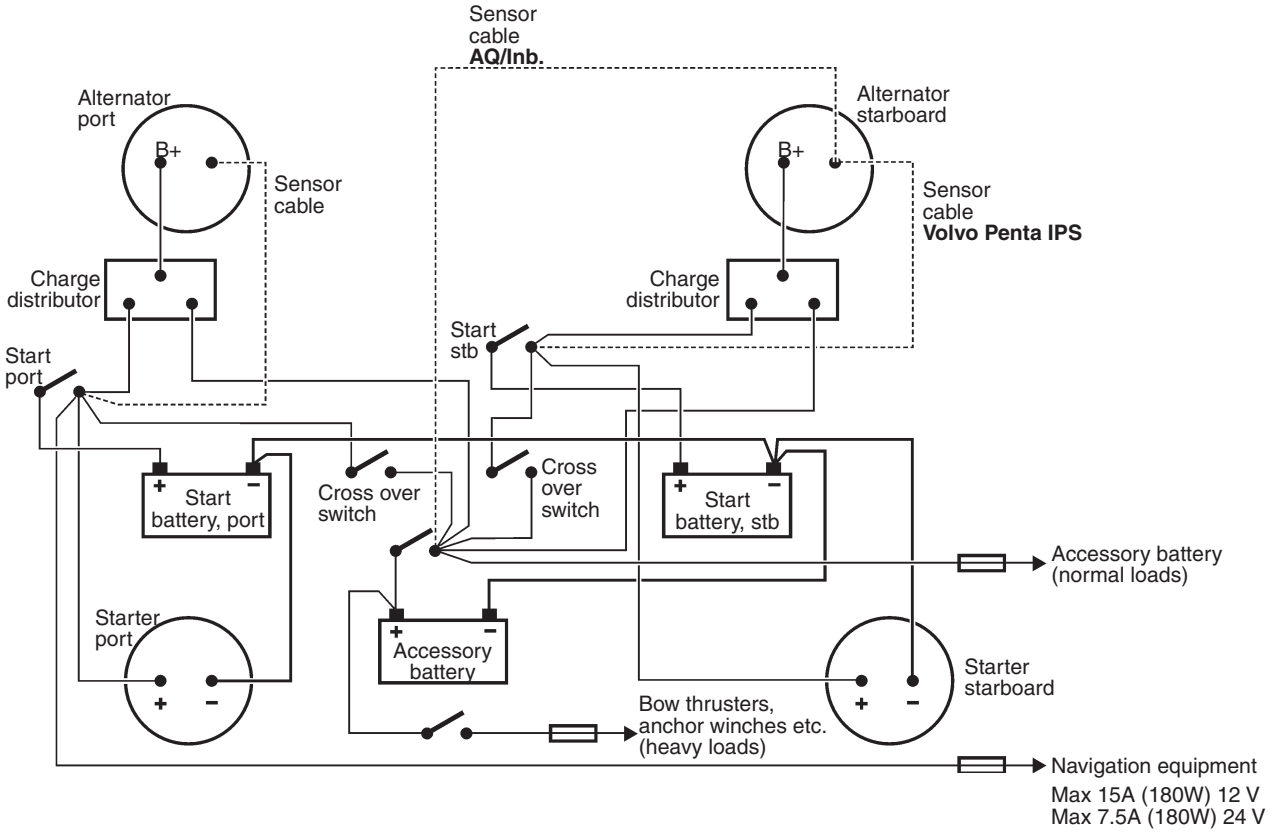
Single failure tolerant system

If a short circuit appears in one of the drivelines, this will not affect the other driveline.

Twin installation, D4/D6 12 V or 24 V, one common accessory battery group, Aquamatic, Inboard and Volvo Penta IPS

(single failure tolerant system)

Alternative installation:



- Separate starting battery group for each engine (driveline).
- **Volvo Penta IPS**: Sensor cables from the alternators must always be connected to the starting battery groups.
- **Aquamatic and inboard**: Connect the sensor cable from starboard alternator to accessory battery group.
- Navigation equipment of max. 15 A/180 W (12 V), 7.5 A/180 W (24 V) is connected to one of the starting battery groups. This to prevent voltage drop when using heavy electrical loads such as bow thrusters, anchor winches etc. If bow thrusters are not used, navigation equipment should not be connected to the starting battery group.

  NOTE! Referring to figure above. Using navigation instruments when engines are not running may discharge the battery and cause starting problems.
- One accessory battery group.
- All equipment, heavy loads such as bow thrusters and anchor winches, lamps, fans, refrigerators etc. are connected to the accessory battery group.

  NOTE! Heavy electrical loads should have a separate switch connected directly to the accessory battery positive (+) terminal.

  Some sensitive navigation instruments may occasionally stop working when connected to the same battery group as a bow thruster.

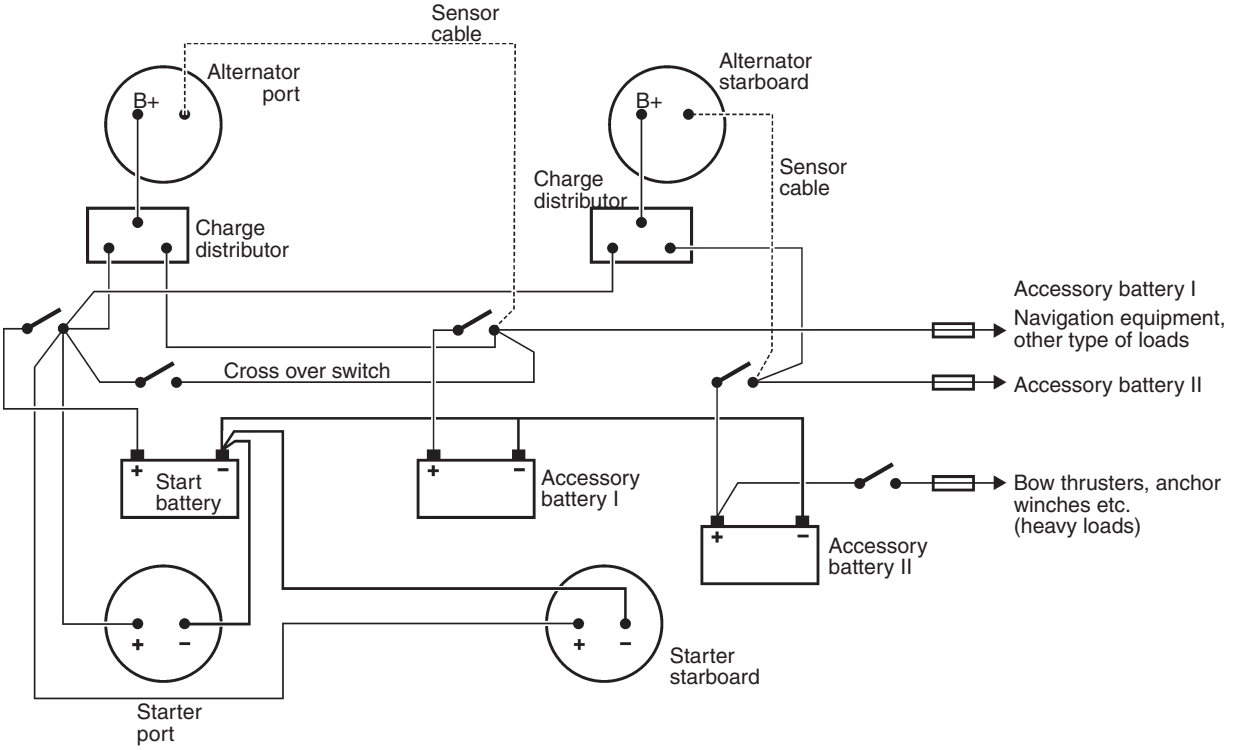
Single failure tolerant system

If a short circuit appears in one of the drivelines, this will not affect the other driveline.

Twin installation, D4/D6 12 V or 24 V, Aquamatic and Inboard

(non-single failure tolerant system)

Alternative installation:



- No equipment connected to the starting battery group

  NOTE! A common battery start group is permitted for both engines. Please refer to the chapter ***Start group battery capacity***.
- Navigation equipment is connected to accessory battery I.
- Bow and stern thrusters, anchor winches and other heavy electrical loads are connected to accessory battery II. This to prevent voltage drop in equipment connected to accessory battery 1, such as navigation instruments.

  NOTE! Heavy electrical loads should have a separate switch connected directly to the accessory battery positive (+) terminal.
- All other equipment, lamps, fans, refrigerators etc. (except navigation instruments) can be connected either to accessory battery 1 or 2.

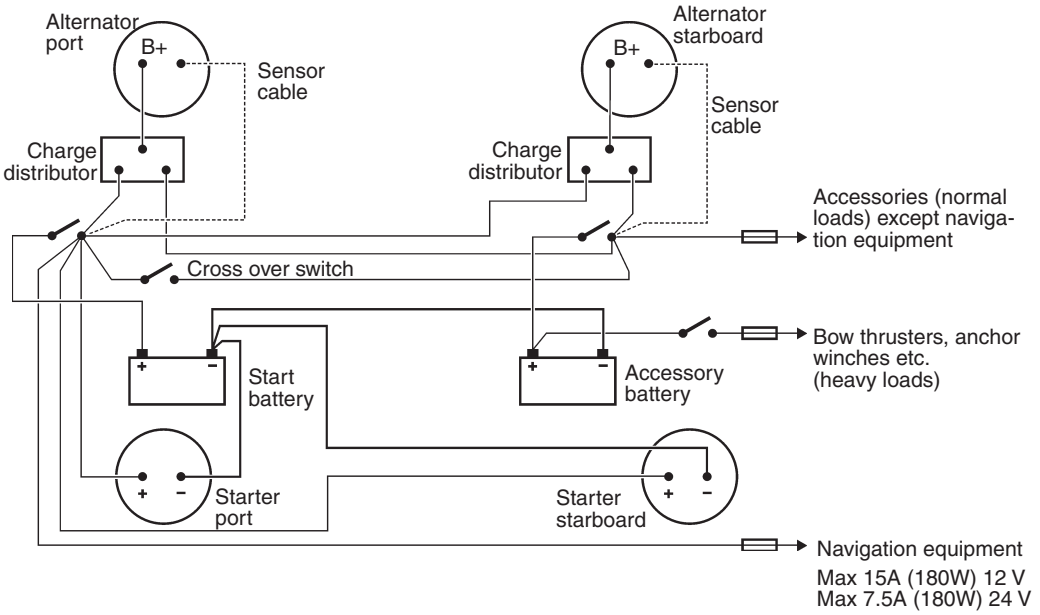
Non-single failure tolerant system

If a short circuit appears in one of the drivelines, this could affect the other driveline.

Twin installation, D4/D6 12 V or 24 V, Aquamatic and Inboard

(non-single failure tolerant system)

Alternative installation:



- Navigation equipment of max. 15 A/180 W (12 V), 7.5 A/180 W (24 V) is connected to the starting battery group. This to prevent voltage drop when using heavy electrical loads such as bow thrusters, anchor winches etc. If bow thrusters are not used, navigation equipment should not be connected to the starting battery group.

  NOTE! Referring to figure above. Using navigation instruments when engines are not running may discharge the battery and cause starting problems.

  NOTE! Heavy electrical loads should have a separate switch connected directly to the accessory battery positive (+) terminal.

  NOTE! A common battery start group is permitted for both engines. Please refer to the chapter ***Start Group Battery Capacity***.

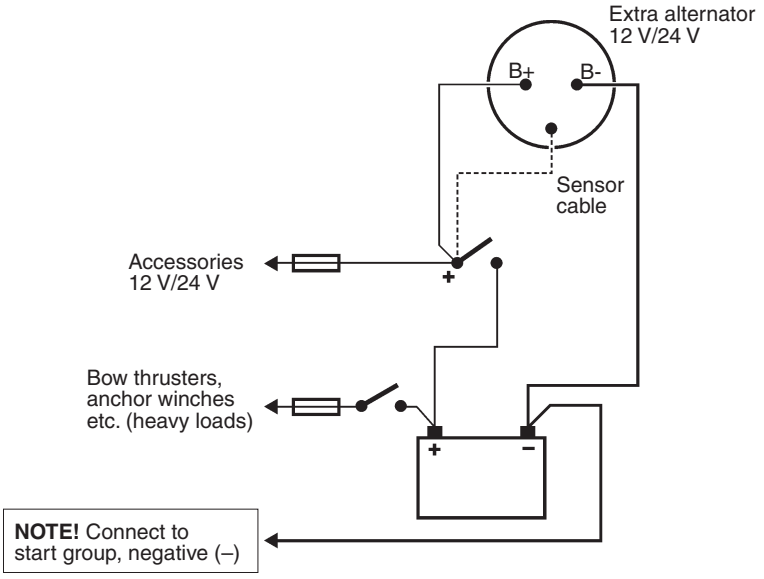
- All other equipment, including heavy current loads, are connected to the accessory battery.

Non-single failure tolerant system

If a short circuit appears in one of the drivelines, this could affect the other driveline.

Extra alternator, single and twin installations, D4/D6 12 V or 24 V, Aquamatic, Inboard and Volvo Penta IPS

Example:



- Keep 12 V systems and 24 V systems separate.
- Connect sensor cables to appropriate voltage group, 12 V or 24 V.

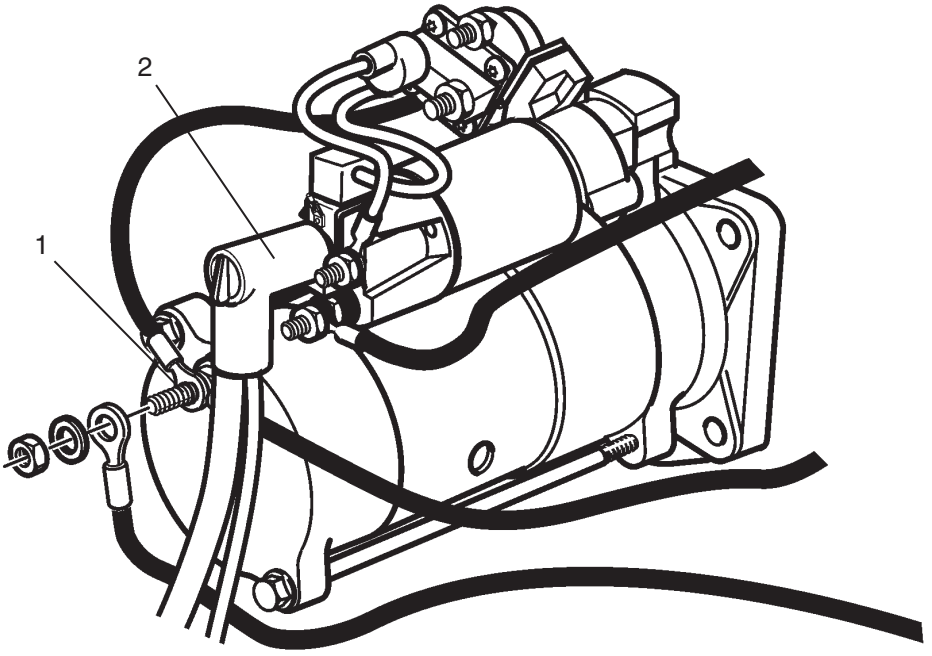
NOTE! Heavy electrical loads such as bow thrusters, should have a separate switch connected directly to the accessory battery positive (+) terminal.

Connections to starter motor

Connecting the battery cables, 2–pole system

NOTE! Engines may have one of two different versions of starters and starter connections.

Starter

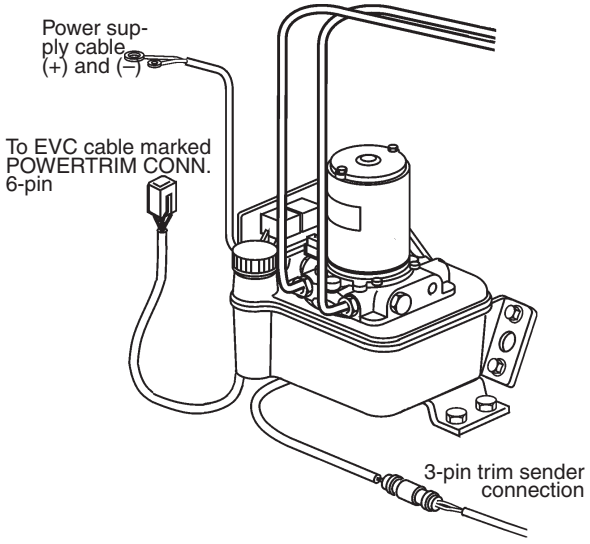


Terminal 1 (-)	**Terminal 2 (+)**
Battery	Battery
Alternator (factory fitted)	Alternator (factory fitted)
Engine power supply (factory fitted)	Engine power supply (factory fitted)
PowerTrim (factory fitted)	Sensor cable (factory fitted)
	PowerTrim (factory fitted)

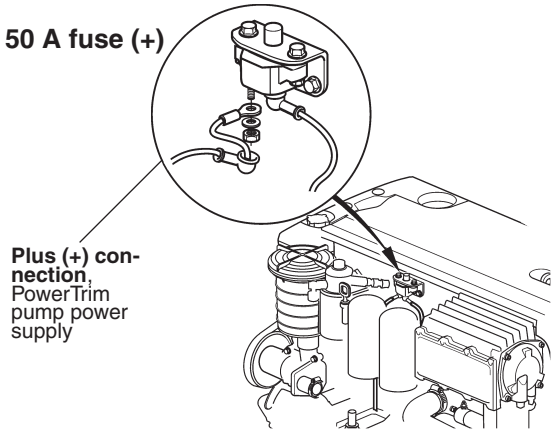
The negative (–) cable from the battery is connected to the negative (–) pole on the starter motor.
The positive (+) cable from the battery is connected to the positive (+) pole on the starter motor.

Dimensions of starting battery and cable size, please refer to the chapter ***Starting battery cable area***.

Power supply, PowerTrim pump, Aquamatic



The 6-pin connector from the PowerTrim pump harness and the cable from the trim sender to the trim pump 3-pin connector are connected.

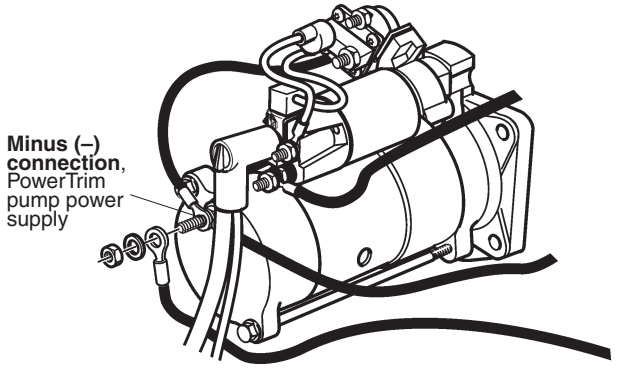


Connect the power supply cable, ring terminals, positive (+) to the 50A fuse on the port side of the engine.

Tightening torque: **10–12 Nm (7.4–9.0 lbf.ft)**.

Clamp all cables correctly.

Starter (–)

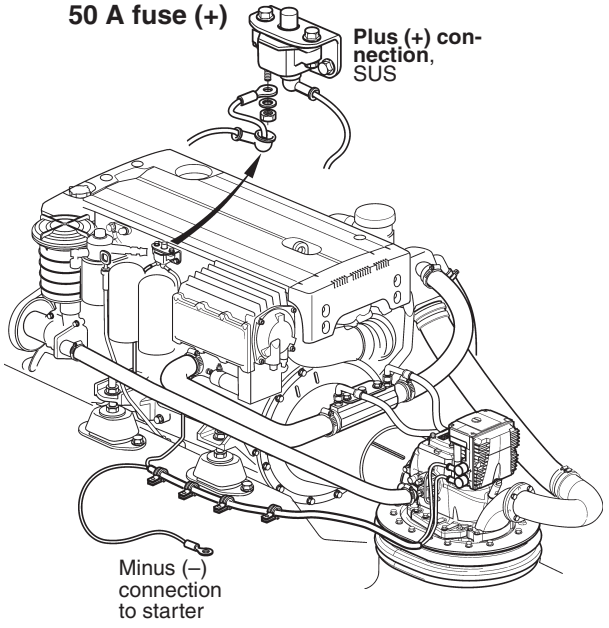


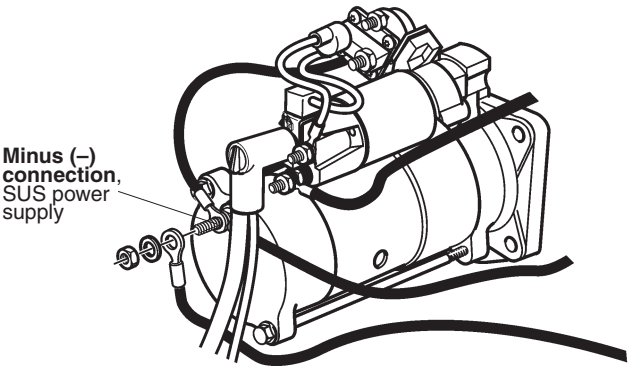
Connect the power supply cable ring terminals, negative (–) to the starter. Two versions of starters, please refer to illustrations.

Tightening torque: **10–12 Nm (7.4–9.0 lbf.ft)**.

Clamp all cables correctly.

Power supply, Volvo Penta IPS Servo Unit Steering (SUS)





Connect negative (–) to starter. Two versions of starters, please refer to the illustrations.

Tightening torque: **10–12 Nm (7.4–9.0 lbf.ft)**.

Connect positive (+) to the 50 A circuit breaker mounted on the engine.

Tightening torque: **10–12 Nm (7.4–9.0 lbf.ft)**.

Clamp all cables correctly.

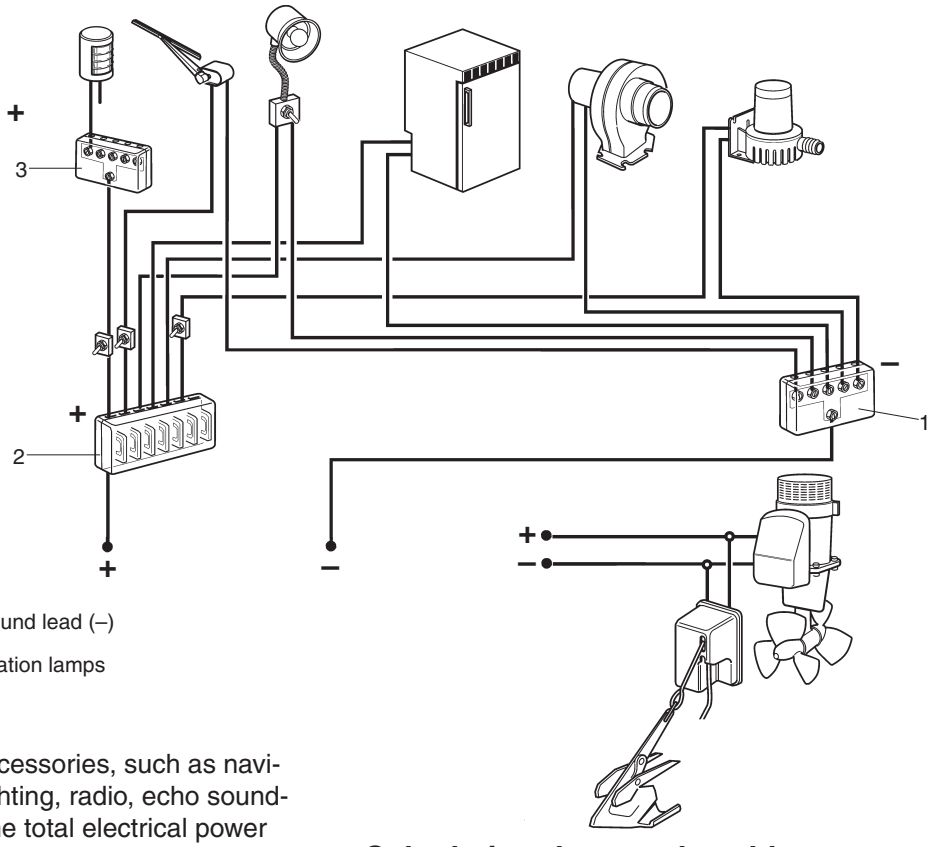
⚠ **IMPORTANT!** Apply corrosion protection part no. 1381065 on all connections.

EVC–Electronic Vessel Control

Installation instructions for EVC system Aquamatic and Inboard, please refer to the manual ***Installation, Electronic Vessel Control EVC D4, D6***.

Installation instructions for EVC system Volvo Penta IPS, please refer to the manual ***Installation, Electronic Vessel Control EVC Volvo Penta IPS***.

Accessories



1. Junction box for ground lead (–)
2. Fuse box (+)
3. Junction box, navigation lamps

Before installing optional accessories, such as navigation instruments, extra lighting, radio, echo sounder etc., carefully calculate the total electrical power consumption of these extras in order to be sure that the charging capacity in the boat is sufficient.

For installation of navigation instruments and heavy current consuming equipment, please refer to the section ***Electrical installation schematics*** in this chapter.

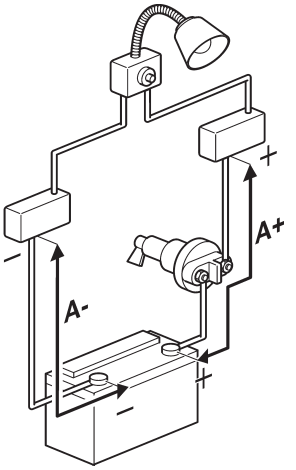
The above diagram indicates how this extra equipment can be installed in the boat. Clamp the leads at close intervals and preferably mark the leads at the fuse and junction boxes (1–3) with the purpose of each lead, i.e. communication radio, refrigerator, navigation lamps etc.

Position the electrical system control panel in a place free from moisture with easy access and close to the instrument panel.

If a 220 V system is installed, this area of the control panel must be clearly identified.

NOTE! Make sure all components used are suitable for a marine environment. Spray all electrical equipment with a moisture-repellent spray.

Calculating the supply cable area

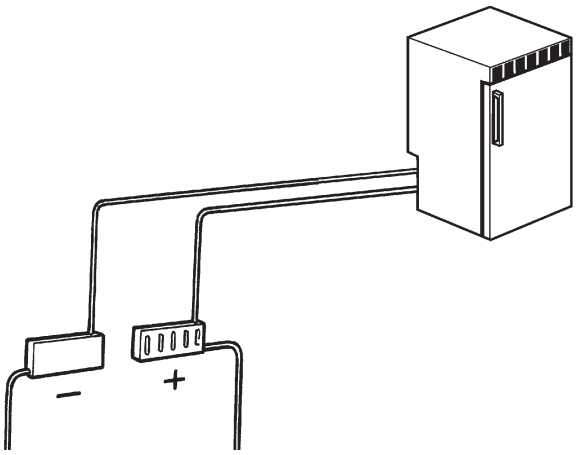


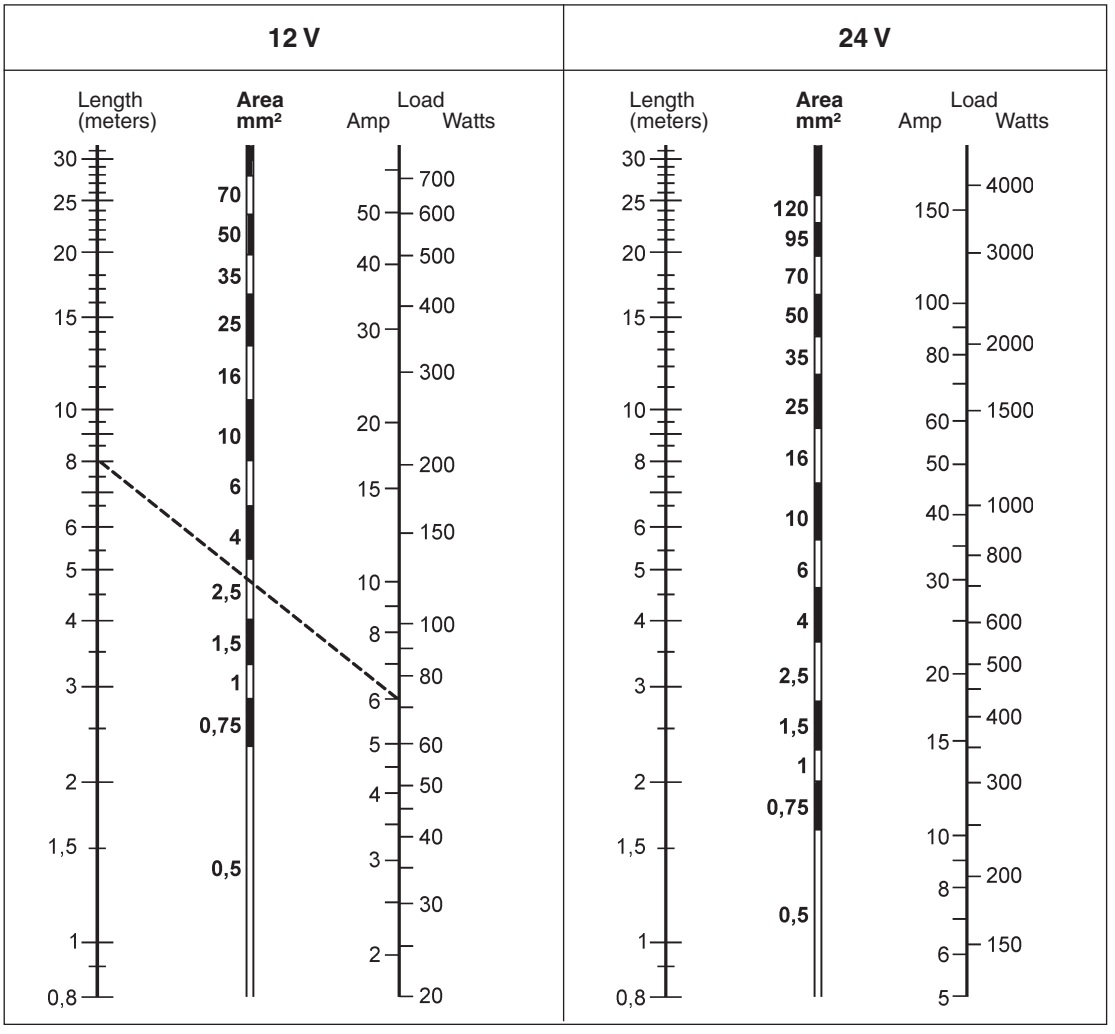
Please note that the length and the area of the supply cables (**A+, A–**) dependends on the number of accessories connected to it.

- Add up all accessories (loads).
- Measure the **total length** on the positive (+) and negative (–) sides of the supply cable (**A+, A–**).
- Please refer to the table on the next page. The table will give you the area of the supply cables.

Calculating the cable area for power loads

- Measure the distance from the terminal block to the accessory.
- Multiply the distance by two.
- Calculate the area in accordance with the nomogram below.





Example: If a 12 V refrigerator consumes 70 W and the distance between the terminal block and the refrigerator is 4 meters, a straight line should be drawn between the figure 8 (4 x 2) on the meter scale and figure 70 on the load scale.

The line passes the area scale in the 2.5 space. 2.5 is equal to the needed area (2.5 mm^2).

The calculation is based on the max. permissible total voltage drop in all cables between the positive terminal to the load and the load back to the negative terminal.

Total voltage drop when using the table above:

12 V system 0.4 V

24 V system 0.6 V

Relationship between mm² (sq in) and AWG

AWG	mm² (std.)	sq. in
18	0.823	0.0013
16	1.309	0.0020
14	2.082	0.0032
12	3.310	0.0051
10	5.260	0.0082
8	8.367	0.0130
6	13.30	0.0206
5	16.77	0.0260
4	21.15	0.0328
3	26.67	0.0413
2	33.63	0.0521
1	42.41	0.0657
0	53.47	0.0829

Extra alternators

Please refer to the chapter ***Power take-off*** for information about extra alternators.

Volvo Penta also offers extra alternators to supply 220V. Please contact Volvo Penta for further information.

Battery charging

⚠ **IMPORTANT**! Always connect the battery charger directly to the battery positive (+) and negative (–) poles.

When a battery charger is used in a 12 V system, the battery voltage rises quickly to around 12.9 V, and then rises slowly to 13.8–14.4 V when gas starts to form. The charge current should be reduced by the charger when gas starts to appear. Charging at a high rate and intensive gassing results in the following:

- The life of the battery is reduced
- The capacity is reduced
- There is a risk of a short circuit in the battery
- There is a risk of explosion

The following parameters determine the duration of the charge period:

- The state of discharge when charging is commenced.
- The capacity of the charger (how much current can be supplied from the charger).
- The size of the battery (capacity in Ah).
- The temperature of the battery. Longer charging is required if the battery is cold. The battery cannot absorb a high charge current at low temperature.

It is better to charge at 10 A for 5 hours than 50 A for 1 hour even if the total charge is 50 Ah in both cases. The battery has difficulty in absorbing a high current.

NOTE! A moderate amount of gas is normal. Towards the end of charging, the voltage rises quickly to 15–16 V. This value is not exceeded even if charging is continued.

Risk of explosion

Gas is formed in the battery during charging. A short circuit, naked flames or sparks in the vicinity of the battery can cause a powerful explosion. Ensure proper ventilation, especially if the battery is charged in a closed area.

⚠ **WARNING**! Always disconnect the charge current before removing the cable clamps.

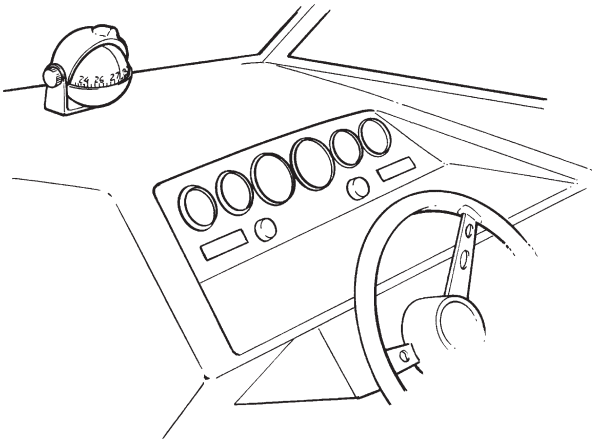
Charge state

The charge state is the level to which the battery is charged. This state can be measured either by measuring the specific gravity of the battery acid in each cell or by measuring the off-load voltage of the cell. The latter cannot be done on modern batteries since the cells' electrical connections are enclosed and therefore not accessible for measurement.

Measuring the off-load voltage across the poles gives entirely wrong information if any cell(s) should be defective. The specific gravity of the battery acid should be measured with a hydrometer instead. Specific gravity varies with temperature. The lower the temperature the higher the specific gravity.

The battery is fully charged when the acid density is 1.28 g/cm3 at +25°C (77°F). A battery filled with tropical acid is fully charged when the acid specific gravity is 1.24 g/cm3 at +25°C (77°F).

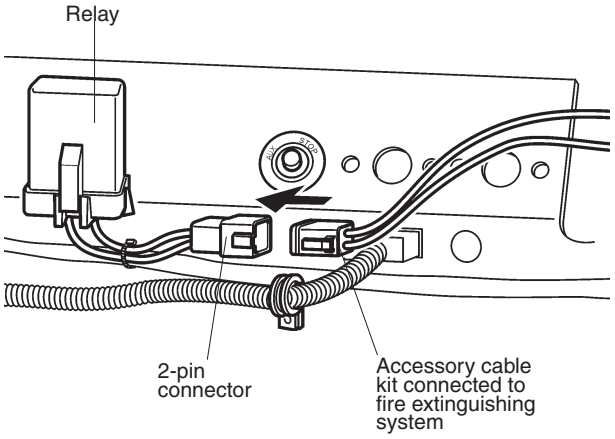
Instruments



Installation instructions for instruments, please refer to the manual ***Installation, Electronic Vessel Control EVC D4, D6*** or the manual ***Installation, Electronic Vessel Control EVC Volvo Penta IPS***.

Fire extinguishing system

Fire shut down system, separate relay and connection



Fault codes presented when fire shut down input is activated:

Red alarm/Buzzer

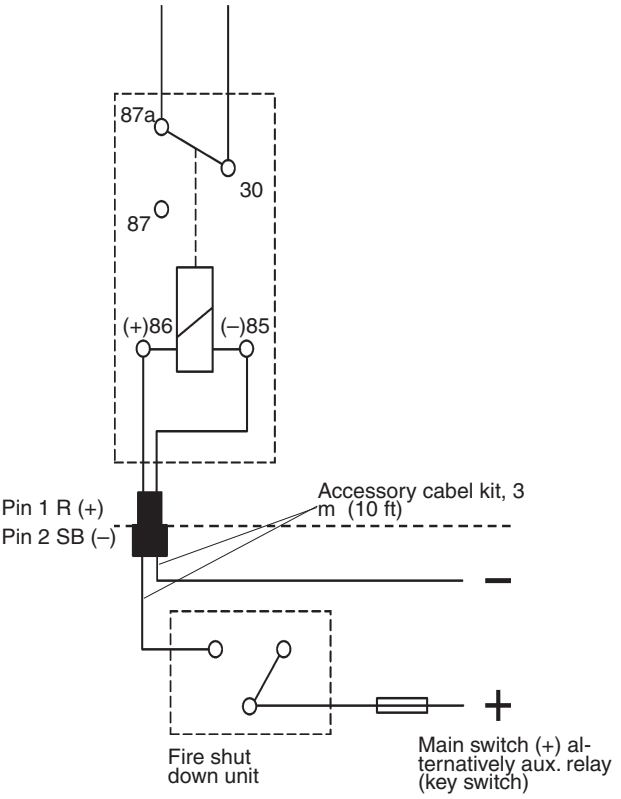
- Flash code 299
  (Internal fault in EVC system)

VODIA/EVC display faults

- Serious communication failure, PCU
  PSID: 200, FMI: 8
- Serious communication failure, PCU
  PSID: 200, FMI: 9
- Internal ECU failure, PCU
  SID: 231, FMI: 2

Recommended installation

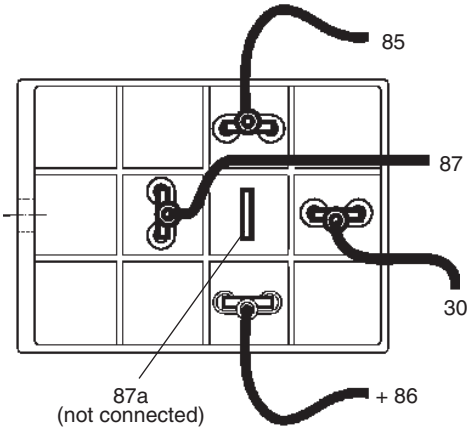
Active (+) when shut down (energize to stop) Default connection



Alternative installation

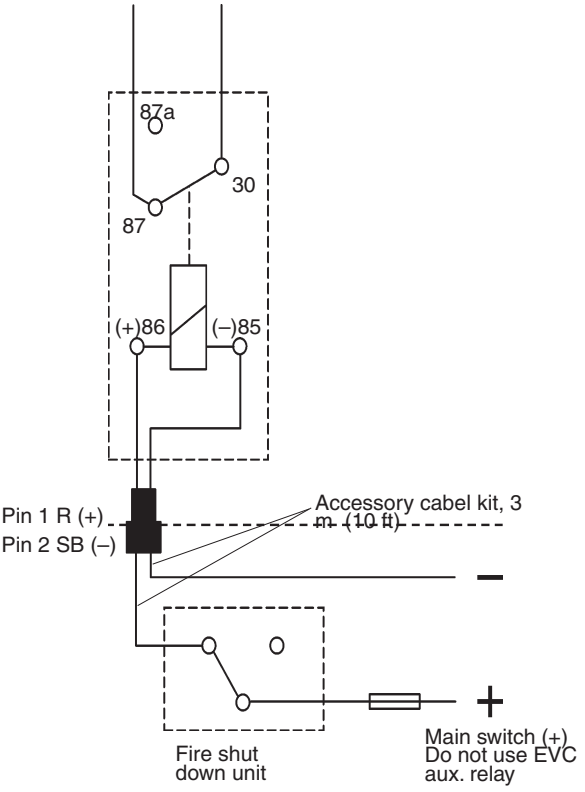
Not active (+) when shut down (energize to run)

NOTE! When there is a need for a hold function of the relay with active plus (+) from the fire shut down system when engine is running and **no** active plus (+) to shut down the system, cables have to be connected in the relay socket according to figure.



Terminal 85 is connected to battery (–) and terminal +86 to the fire alarm unit.

Figure shows a "live state circuit diagram".



Electrochemical corrosion

General

NOTE! Please refer to the ***Marine Electrical Systems Part 1*** manual, chapter ***Electrochemical corrossion*** for more detailed information.

Electrochemical corrosion

Electrochemical corrosion of metals can cause very serious and expensive damage to propellers, propeller shafts, rudders, keels and other equipment fitted to the boat.

The types of corrosion that are particularly significant for boats are:

- Galvanic corrosion
- Crevice and deposit corrosion
- Stray current corrosion

Galvanic and stray current corrosion are of major importance when doing the installation work. It may be caused by mistakes in the electrical installation or choice of wrong materials in submerged components.

The damaging effects of electrochemical corrosion start as soon as the boat is launched. Since corrosion takes place "out of sight" below the surface of the water, damage can be severe and is often not detected until the boat is brought up on land.

Consequently, drives and propellers should be protected against corrosion by the use of sacrificial anodes made of zinc, aluminum, magnesium or iron. This protection may not be sufficient if electrical equipment is connected incorrectly or incorrect material is used in external boat equipment.

Galvanic corrosion

A boat that lies in the water constitutes a galvanic element, since different metals (or metal alloys) such as steel and bronze are in electrical contact with each other while in the same electrolyte, namely salt water. This produces galvanic corrosion.

In popular terms, this can be compared with the similar electrochemical process that goes on in a battery, called a galvanic element. In a non-battery context the result of this process is called galvanic corrosion.

There must be be certain conditions for galvanic currents to occur: The metals need to be in an electrolyte and galvanically connected to each other. A corrosion current will then flow from the metal with the lower potential (the anode) to the metal with the higher potential (the cathode). Two chemical reactions are needed for this; oxidation and reduction. Oxidation (release of electrons) takes place at the anode and reduction (absorption of electrons) takes place at the cathode.

Metals susceptible to corrosion

All metals can be physically listed in a galvanic potential series. This indicates the metal's normal potential (voltage) in relation to a reference electrode when each material is immersed in a particular electrolyte.

The following is a voltage series for metals. The electrolyte is seawater at a temperature range of +10°C to +26.7°C (50°F – 80°F). The water flow rate is 2.4 – 4.0 m/s (7.8-13.1 ft/s).

The reference electrode is silver-silver chloride (Ag-AgCl).

Graphite	+0.19 to +0.25 V
Stainless steel 18-8, Mo, in a passive state *	±0.00 to -0.10 V
Stainless steel 18-8 in a passive state *	-0.05 to -0.10 V
Nickel	-0.10 to -0.20 V
Nickel aluminum bronze	-0.13 to -0.22 V
Lead	-0.19 to -0.25 V
Silicon bronze (Cu, Zn, Si, Mn, Sn)	-0.26 to -0.29 V
Manganese bronze (Cu, Zn, Sn, Fe, Mn)	-0.27 to -0.34 V
Aluminum brass (Cu, Zn, Al)	-0.28 to -0.36 V
Soft solder (Pb, Sn)	-0.28 to -0.37 V
Copper	-0.30 to -0.57 V
Tin	-0.31 to -0.33 V
Red brass (Cu, Zn)	-0.30 to -0.40 V
Yellow brass (Cu, Zn)	-0.30 to -0.40 V
Aluminum bronze	-0.31 to -0.42 V
Stainless steel 18-8, Mo, in an active state **	-0.43 to -0.54 V
Stainless steel 18-8 in an active state **	-0.46 to -0.58 V
Cast iron	-0.60 to -0.71 V
Steel	-0.60 to -0.71 V
Aluminum alloys	-0.76 to -1.00 V
Galvanized iron and steel	-0.98 to -1.03 V
Zinc	-0.98 to -1.03 V
Magnesium and magnesium alloys consumed	-1.60 to -1.63 V

* Metals are in a passive state when the metal has a thin, reaction-inhibiting coating. This coating is not present in an active state.

** Still water.

From the table, we can see that steel has about -0.65 V and aluminum around -0.85 V in the voltage series. The higher up in the voltage series (the greater potential), the more noble the metal. If these metals are connected together in a galvanic element, the less noble metal will be consumed by the more noble metal-galvanic corrosion arises.

In our case, the aluminum will corrode.

The further the metals are apart in the galvanic voltage series, the greater the (corrosive) effect will be on the less noble metal if they are connected together in a galvanic element.

Definitions

One-pole system

In a 1-pole system the engine block itself is used as a negative return for all electrical components on the engine block.

Two-pole system

In a 2-pole system each electrical component on the engine has a insulated DC negative return. The alternator, starter motor and all sensors are electrically isolated from the engine block.

NOTE! The D4 and D6 engines are delivered in two different versions:

1. With braid mounted between the starter and the engine block. The engine block is connected to the battery negative (–) terminal.
2. Without braid mounted between the starter and the engine block. The engine block is not connected to the battery negative (–) terminal.

Both type of engines are 2-pole systems and shall be installed as such.

Isolation Transformer

A transformer with galvanically separated input and output windings.

Galvanic isolator

A device installed in series with the AC grounding conductor of the shore power cable to prevent low voltage DC galvanic current flow, but permit the passage of alternating current normally associated with the AC grounding conductor.

Ground fault circuit interrupter (GFCI)

A device for the protection of personnel. The GFCI de-energize a circuit, when a current to ground exceeds a predetermined value.

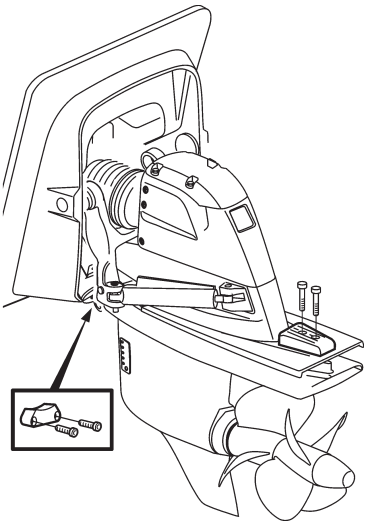
Protection against electrochemical corrosion

It is important that components submerged in the water such as through-hull fittings, swim ladders etc. are protected from galvanic corrosion. Our recommendation is to bond all of them to a transom mounted, protective anode, normally made of zinc. Trim tabs may have their own protection.

NOTE! This bonding system with its individual components should normally have no contact with the negative circuit of the boat's electrical system.

Local recommendations, e.g. ABYC, may state that the battery negative terminal should be connected to the bonding galvanic circuit. If you decide to connect the bonding galvanic circuit to the battery negative (–) terminal, you must also connect the engine block with a cable large enough to carry the engine cranking current, as described in ABYC chapter E-11.

⚠ **IMPORTANT!** Volvo Penta recommends the use of isolation transformer if battery negative is bonded according to ABYC recommendations.

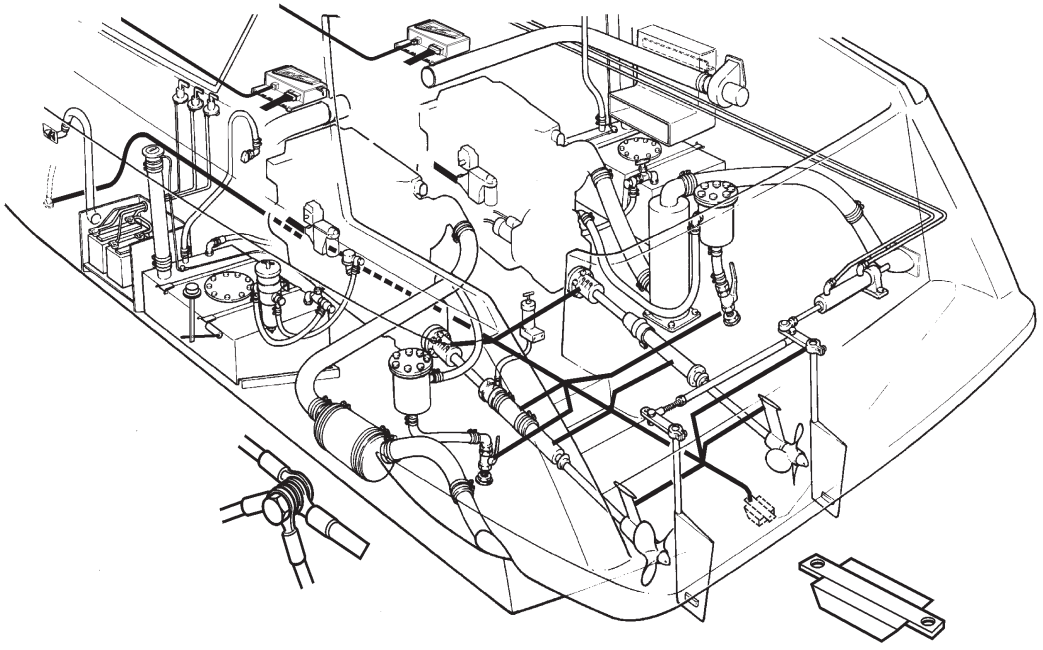


Drive DPH/DPR

The DPH/DPR drive is made of aluminum and is protected against galvanic corrosion by its own sacrificial anodes. The DPH/DPR drive sacrificial anode only protects the drive itself and must not be connected to other components submerged in water.

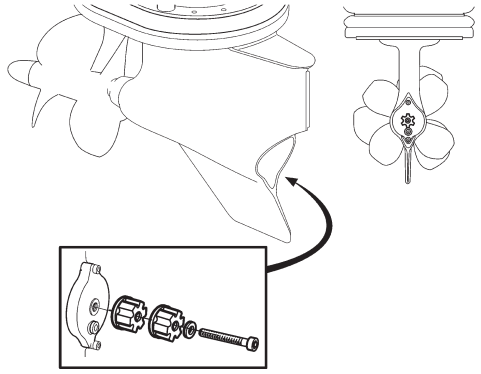
If the engine has a braid mounted between the starter motor and the engine block, any other metallic object connected to the DC negative terminal must have its own cathodic protection system.

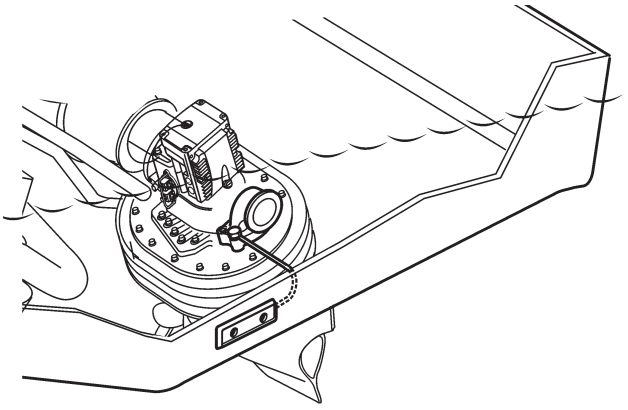
Inboard



Inboard installations shall comply with the paragraph above.

Volvo Penta IPS





The Volvo Penta IPS drive unit is made of a Nickel-Aluminum-Bronze alloy and is protected against galvanic corrosion by two anodes, one mounted in the exhaust tube (iron) and one mounted on the transom (aluminum). The drive unit has a submerged area of more than 1 m^2.

⚠ **IMPORTANT!** Anodes must not be painted.

⚠ **IMPORTANT!** Do not bond Volvo Penta IPS units together.

⚠ **IMPORTANT!** Do not bond Volvo Penta IPS to engine or any other item onboard.

⚠ **IMPORTANT!** Do not bond any other equipment to Volvo Penta IPS transom mounted anode.

NOTE! Above bondeing recommendations are not in conflict with ABYC E-11, in particular paragraph 11.18.1 and 11.17.2.3.

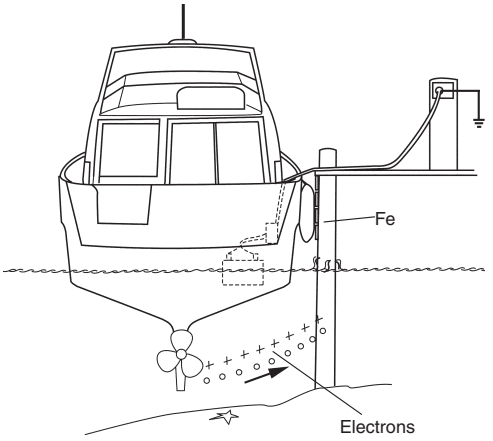
⚠ **IMPORTANT!** In steel and aluminum installations, it is important to ensure a good insulation between Volvo Penta IPS propulsion unit and the hull.
Volvo Penta can not be held liable for corrosion of the hull.

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.

Stray current and shore power corrosion



Stray current corrosion is similar to galvanic corrosion in the way it acts but differs in the way it is caused. In galvanic corrosion, it is the potential differences on the metal that initiates corrosion. As the name implies, stray current corrosion is caused by stray currents.

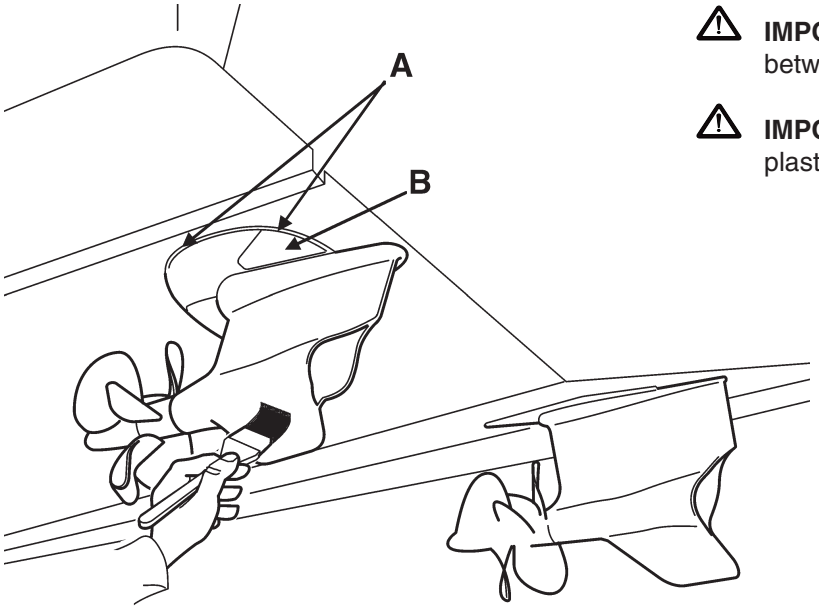
Stray currents can arise as a result of faults in the boat's electrical system, such as connections and splices that are exposed to moisture or bilge water, equipment that is faulty as a result of damage or wear, or an electrical system that is incorrectly connected.

Stray current corrosion can also be caused by stray currents from neighboring boats or equipment for connecting to a shore based power supply at quays.

Painting the IPS propulsion unit

In case the boat is used in waters where the anode consumption is higher than accepted, Volvo Penta recommends painting the IPS. This will reduce the anode consumption as the IPS bronze area exposed to water is reduced significantly by painting the exterior. To get the paint to stay on the IPS, it is recommended that a suitable primer is used before antifouling is applied. Painting the IPS will also help in areas with excessive marine growth.

⚠ **IMPORTANT!** Do not use copper based paint for the IPS propulsion unit.



⚠ **IMPORTANT!** Do not paint in the grove between the IPS and the hull (A).

⚠ **IMPORTANT!** Do not paint the white plastic part (B).

Shore power and generator installation

Recommended installations

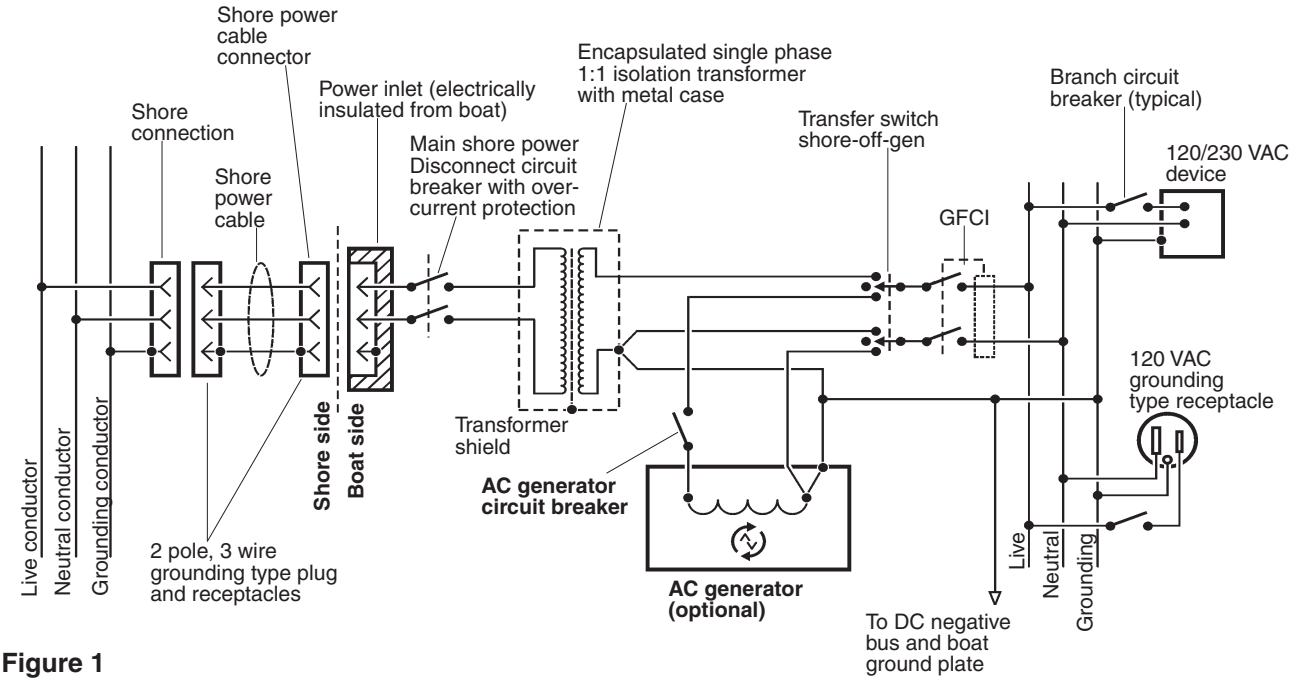


Figure 1
Single-phase, 120/230 VAC system

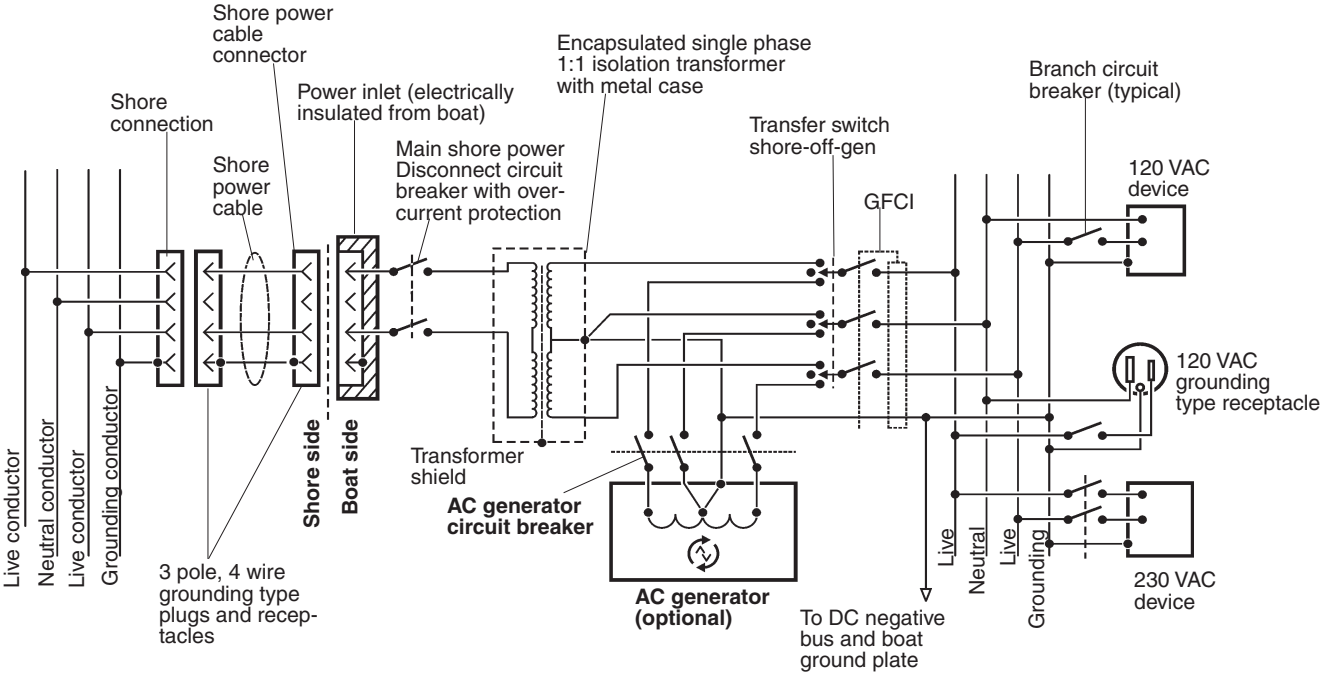


Figure 2
Single-phase, 230 VAC input, 120/230 VAC output

Taking into account considerations of personnel safety and care of the equipment, Volvo Penta gives the following recommendations regarding shore power alternating current (AC) installations:

Installations should be made according to ***figure 1*** or ***figure 2***. Figure 1 shows a single-phase installation for either 230VAC or 120VAC. Figure 2 shows a 230VAC input, 120/230VAC output installation.

Figures 1 and 2 are based on ABYC E-11 diagrams 8 and 11 but require a ground fault circuit interrupter and an isolation transformer. Figures 1 and 2 are considered best practice and are in harmony with recommendations from ABYC and ISO, and provide protection against electrochemical corrosion and electrical shock.

The safety related components are important for the following reasons:

Isolation transformer

The isolation transformer galvanically separates the shore power from the boat. This minimizes the risk of galvanic and stray current corrosion.

Ground Fault Circuit Interrupter (GFCI)

Arcing faults between a live conductor and ground can be sustained at relatively low current levels and does not trigger circuit breakers. Furthermore, even very low current levels represent danger to personnel. A GFCI must be installed on the secondary side of the isolation transformer as a ground fault protection in the boat. The GFCI trip sensitivity and trip time must comply with local standards.

The GFCI placed on the secondary of the isolation transformer ensures ground fault protection on the boat. This is an addition to ABYC E-11, that ensures a higher degree of protection against electrical shock.

Ground plate

To ensure safety of personnel, a common ground plate below the waterline must be connected to the AC and DC electrical system.

Shore power and battery charging

When shore power is connected (120V–230V), the shore safety ground (earth) must not be connected to the engine or any other ground point on the boat. The safety ground must always be connected to the connection cabinet's ground (earth) terminal ashore. The shore safety ground should not be connected to the negative connection on the output side (12V/24V), i.e. it must be galvanically separated.

⚠ **WARNING!** Installation and work using shore connected equipment may only be carried out by an electrician who is qualified to work on mains voltage installations. Incorrect installation can result in danger to life.

Prevention of stray currents during installation

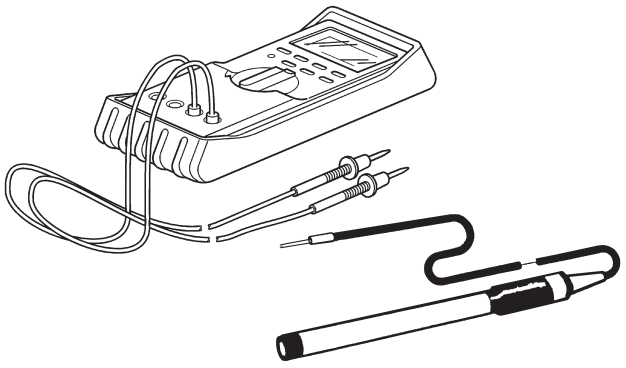
A proper installation will reduce the risk of stray current problems later in the boat's service life.

- All DC circuits must have an insulated return cable. Consequently, a metal keel must not be used as a return conductor.
- All splices in the circuit such as socket housings and terminal blocks shall be installed so that they are not exposed to moisture or bilge water. The same applies to switch panels, fuse holders etc.
- Cables shall be routed as high as possible above the bilge water in a keel. If a cable must be routed where it is exposed to water, it must be housed in a watertight conduit and the connections must also be watertight.
- Cables which can be subject to wear must be installed in self-draining conduits, sleeves, cable channels etc.
- For battery and main switch installation, please refer to the chapter ***Electrical System***.
- Engines and drivelines must not be used as a ground (earth) for radio, navigation or other equipment where separate ground cables are used.
- All separate ground (earth) cables (ground connections for radio, navigation equipment, echo sounder etc.) must be linked to a common ground (earth) point, i.e. a cable that does not normally act as a return for equipment.
- If shore based power is connected (120V/230V), the safety ground (earth) must not be connected to the engine or any other ground point on the boat. The safety ground must always be connected to the connection cabinet's shore ground terminal.
- Transformers connected to a shore base current supply, such as a battery charger, shall have the protection ground (earth) on the input side (120/230V) connected but the negative connection on the output side (12V/24V) not connected, i.e. galvanically separated.

⚠ **WARNING!** Installation and work on shore connected equipment may only be carried out by an electrician who is qualified to work on installations with voltage higher than 50V AC.

Checking electrochemical corrosion

Measuring galvanic currents and stray currents in water



Volvo Penta has produced a method for measuring galvanic currents and stray currents using a calomel electrode.

The calomel electrode (Ag/AgCl), **885156**, is a reference electrode which shall be connected to the multimeter **9812519**. The multimeter is used to measure potential differences.

NOTE! If other multimeters are used, accuracy is required to 1 mV.

Depending on the method used, the measurement result can provide a mean voltage value for the entire measurement object, such as a shaft line or the voltage which an individual component produces.

Examples of such point checks are rudders, water intakes etc.

NOTE! The calomel electrode can be used in water with a varying salt content or in freshwater.

The process measures the potential difference between the measurement object and the calomel electrode. The calomel electrode has a known constant electrode potential. Thus the potential differences recorded must always be related to a particular reference electrode and the same electrolyte, i.e. the same water and water temperature. The water flow rate must also be the same if results from different measurements are to be compared.

Measurement theory

Anodic protection operates by sending out an electric current, the protection current, to oppose the corrosion current. When the protection current rises and the corrosion current falls, the potential of the protected object falls. When a given potential is reached, the corrosion current will have disappeared and the object has complete cathodic protection.

Thus a given electrode potential for the metal provides a guide as to when cathodic protection is in place and whether it is sufficient. The calomel electrode can measure whether this protection potential is provided.

Checking galvanic electricity, calomel electrode (Not for Volvo Penta IPS installations)

Connect the calomel electrode, special tool **885156** to the multimeter, special tool **9812519**.

Connect the multimeter to a good ground (earth) connection. Set the multimeter for DC measurement.

Carefully remove the protective sleeve from the probe tip. The protective sleeve is filled with a saturated salt solution (NaCl). Dry the tip with a clean paper tissue or equivalent after measurement and before putting it back.

Dip the electrode in water approximately 30 cm (12") from the **propeller and propeller shaft**. The measurement result is the mean value for the complete shaft line. The result should lie between (minus) -900 mV and -1100 mV.

To check individual components, move the electrode so that the tip is directed towards the surface, approximate 5 mm (0.2") away from the surface where the component is fitted.

The measurement result here should also lie between –900 and –1100 mV.

If the result exceeds this (i.e. is a more positive value such as –800), the proportion of "noble" metals such as stainless steel, bronze etc., is too great for the zinc anodes to overcome the corrosion current. The number of anodes should be increased.

The result may also be from stray currents caused by incorrect or incorrectly connected (+) cable or (+) cables exposed to bilge water.

There is excess protection if the multimeter gives a result less than –1100 mV. This could also be caused by stray currents from separate ground (earth) cables for VHF radio or other equipment fitted with separate ground (earth) cables which are incorrectly connected.

The reason may also be that the anodes provide too much protection current, such as magnesium anodes in salt water.

Checking galvanic electricity, calomel electrode, Volvo Penta IPS

Connect the calomel electrode, special tool **885156** to the multimeter, special tool **9812519**.

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

Carefully remove the protective sleeve from the probe tip. The protective sleeve is filled with a saturated salt solution (NaCl). Dry the tip with a clean paper tissue or equivalent after measurement and before putting it back.

Dip the electrode in water close to the **propulsion unit**. The measurement result is the mean value for the propulsion unit. The result should not be more negative than –450 mV in sea water or –150 mV in fresh water.

If the result exceeds this (i.e. is a more positive value such as –350 mV resp. –50 mV), the propulsion units does not have enough cathodic protection. Undo the connection between the aluminum anode and the propulsion unit. If the potential only changes slightly, the aluminum anode has been used up or has poor contact. Install a new anode. The iron anode in the exhaust system is less critical. Check next time the boat is taken out of the water.

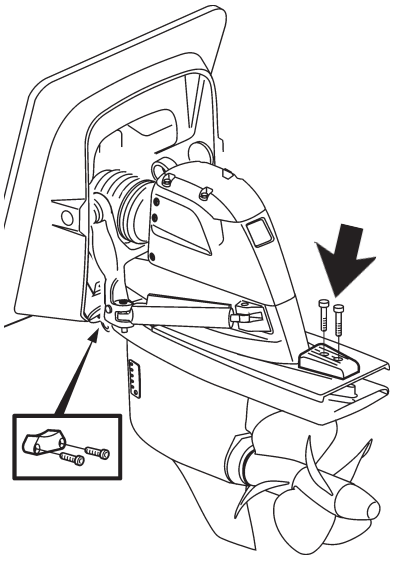
Repeat the measurement for the other drive.

Measuring the propulsion unit insulation
First check that no connections have been made to the propulsion unit, i.e. if the propulsion unit has been connected to the boat's bonding system. If this is the case, remove the connections. Connect the measurement cables to unpainted parts in good contact with the propulsion unit and the engine block. Set the multimeter for DC measurement. Note the value.

Then connect a 9 V battery between the propulsion unit and engine block. Take the battery away after about 10 seconds. Read off the value on the multimeter. If the value is high, >0.2 V, and falls rapidly, the insulation between the propulsion unit and engine block is sufficient.

Repeat the measurement for the other drive.

Checking protective anodes Drive DPH/DPR



Note the position of the protective anodes, one on the cavitation plate and one on the lower part of the shield. Replace the protective anodes if less than 50% remains.

⚠ **IMPORTANT**! Make sure that the anodes have good metallic contact with the sterndrive and shield. Never paint the protective anodes. Never use a steel brush. A steel brush reduces the galvanic protection.

Prior to launching the boat, the anodes must be cleaned (activated) with emery paper in order to remove the oxide layer.

Zinc anodes

The drive and the shield are equipped with zinc protective anodes as a standard, intended for use in salt water.

Magnesium anodes

If the boat is operated in fresh water, magnesium anodes should be used.

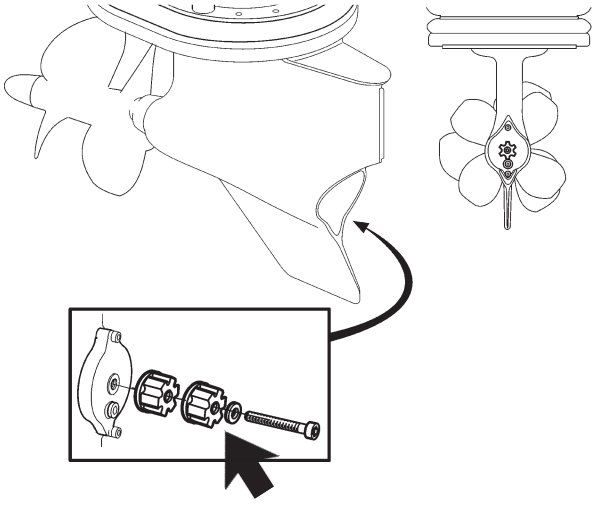
Aluminum anodes

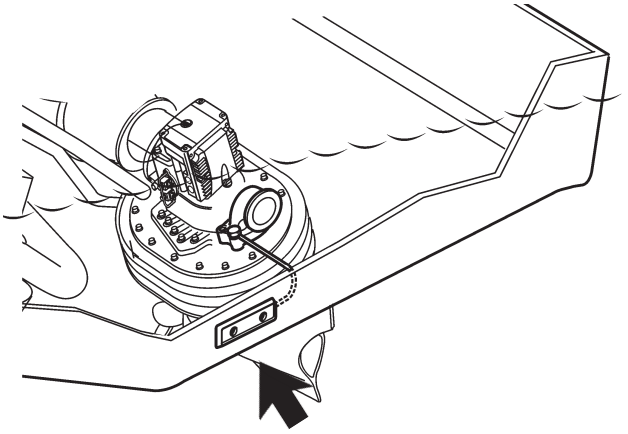
When the boat is operated in brackish water it is advisable to use aluminum protective anodes.

Propellers DPH, DPR

The Volvo Penta propellers fitted on the DPH/DPR drives are electrically insulated from the drive and will therefore not cause any anode consumption.

Checking protective anodes Volvo Penta IPS propulsion unit





The Volvo Penta IPS propulsion unit is protected against galvanic corrosion by two anodes, one mounted in the exhaust tube (iron) and one mounted on the transom (aluminum). Replace the protective anodes if less than 50% remains.

⚠ **IMPORTANT!** Make sure that the anode has good metallic contact with the propulsion unit. Never paint the protective anodes.

⚠ **IMPORTANT!** Do not bond Volvo Penta IPS units together.

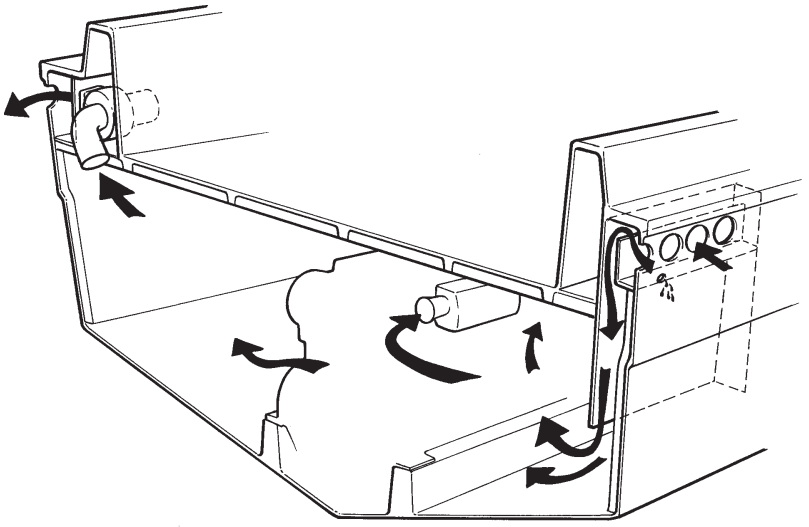
⚠ **IMPORTANT!** Do not bond Volvo Penta IPS to engine or any other item onboard.

⚠ **IMPORTANT!** Do not bond any other equipment to Volvo Penta IPS transom mounted anode.

Propellers Volvo Penta IPS

Propellers are of the same material as the propulsion unit and electrically connected.

Engine room, ventilation and soundproofing



Introduction

Engine performance

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

Diesel engines require excess air. Deviations from the normal values show up first of all as an increase in black smoke. This can be particularly noticeable at the planing threshold when the engine must give its greatest possible torque.

If the deviations from the normal values are great, the diesel engine will lose power. This power loss can be so great that a planing boat cannot pass through the planing threshold.

For the engine to function properly and give full power, it is absolutely necessary that both the inlet and outlet air ducts are sufficiently dimensioned and correctly installed.

Two main conditions must be met:

A. The engine must receive enough air (oxygen) for combustion of the fuel.

B. The engine room must be ventilated, so that the temperature can be kept down to an acceptable level.

Ventilation is also important to keep the engine's electrical equipment and fuel system at a low temperature, and to ensure general cooling of the engine.

If personnel are to be present in the engine room, the ventilation installation must be adapted accordingly.

NOTE! All valid safety regulations and legal requirements for each country must be followed. Each classification society has its own regulations which must be followed when required.

Engine power output at high altitudes above sea level

In most cases, marine engines are run at or near sea level. There are, however, some lakes that are situated at high altitudes above sea level.

There is a loss of power when operating at high altitudes due to the fact that the air density (and therefore oxygen content) decreases as altitude increases. This results in smoky exhaust and the turbocharger operating at abnormally high speeds with increased wear.

The loss of power is, however, not important until approx 500 m (1640 ft) above sea level.

At altitudes exceeding 500 m (1640 ft) above sea level, there is a loss of power of approx 0.1% per 100 m (328 ft).

The D4 and D6 engines are not suitable for running at altitudes exceeding:

D4 180	5500 m (18,000 ft)
D4 210	4500 m (14,800 ft)
D4 225	2000 m (6,600 ft)
D4 260	2000 m (6,600 ft)
D4 300	1500 m (5,000 ft)
D6 280	3000 m (9,900 ft)
D6 310	2000 m (6,600 ft)
D6 330	2000 m (6,600 ft)
D6 350	1500 m (5,000 ft)
D6 370	1500 m (5,000 ft)
D6 435	1500 m (5,000 ft)
Volvo Penta IPS 350	2000 m (6,600 ft)
Volvo Penta IPS 400*	1500 m (5,000 ft)
Volvo Penta IPS 400**	2000 m (6,600 ft)
Volvo Penta IPS 450	2000 m (6,600 ft)
Volvo Penta IPS 500	1500 m (5,000 ft)
Volvo Penta IPS 600	1500 m (5,000 ft)

* D4, Rating 5

** D6, Rating 4

Dimension of air intakes and ducts

When an installation is planned, the following basic facts should be kept in mind:

All internal combustion engines, irrespective of make or type, require a certain minimum amount of oxygen (or air) for the combustion process. Diesel engines, however, work with a somewhat larger air surplus than gasoline engines.

All engines also emit a certain amount of radiant heat to the environment, i.e. to the engine room.

The specific radiant heat is less for modern compact engines than for older and less compact engines. Modern, compact engines have a great advantage in this respect.

Channels or ducts for inlet and outlet air

It is advantageous if the inlet and outlet air ducts can be planned at the construction stage, where they can be placed in the hull or superstructure. This will avoid the need for separate ducts.

In an installation, it is relatively simple to design a system to provide the engine with enough air for the combustion, but it is considerably more difficult to vent the radiant heat away.

The engine sucks in air very effectively and, naturally, will take in air from any direction. Should the inlet or outlet air ducts be too small, the engine will consequently suck air from both ducts and no ventilation air will go out through the outlet air ducts. This causes dangerously high engine room temperatures.

Most of the radiant heat from the engine must be transported out of the engine room. This is a mandatory requirement to keep the engine room temperature below the permissible maximum limit.

Fans

A **suction fan** must normally be installed in the outlet air duct to ventilate the engine room more effectively and thus keep the engine room temperature at a low level.

Fans should not be installed in the inlet air ducts, as this could lead to excess pressure in the engine room with the risk of gas or air leaking out into other parts of the boat.

For diesel engines, the fan can very well be thermostatically controlled and should start at approx. +60°C

(+140°F) engine room temperature, measured at the engine room.

Engine room temperature

Remembering that the engine's performance figures apply at a test temperature of +25°C (77°F), it is important that the inlet air temperature is kept as low as possible.

	Temperature
≤ 25°C (77°F)	**> 25°C (77°F)**
Full power output	Loss of power approx. 1% per 10°C

The temperature of the inlet air at the air filters must not be higher than **+25°C (77°F)** for full power output. During sea trials, the air temperature in the air filter should not exceed **20° C (36° F)** above ambient temperature.

The temperature of the engine itself is rather high in some places. Certain separate electrical components, such as charging regulators and relays, should therefore be fitted on bulkheads or elsewhere where the temperature is relatively low.

The **maximum temperature** for areas where electric components are installed is **70°C (158°F)**. The starter motor and alternator however, have their given locations.

Engine room pressure

Volvo Penta recommends that the negative pressure in the engine room should not exceed 0.5 kPa (0.07 psi) at full speed. A small vacuum in the engine room is not harmful and will prevent gases from being forced out from the engine room into the boat.

Engine air consumption

The engine consumes a certain amount of air in the combustion process. This requires a minimum internal area in the air supply ducting.

The area can be calculated by using the formula:

A = 1.9 × engine power output

A = Area in cm²
Engine output in kW

The value applies to an unrestricted intake and up to 1 m (3.3 ft) duct length, with only one 90 degree bend. The bending radius should be at least twice the diameter.

If longer ducts or more bends are used, the area should be corrected by multiplying by a coefficient from ***Table 1*** below.

Number of bends	Duct length, m (ft)				
	1 (3.3)	2 (6.6)	3 (9.8)	4 (13.1)	5 (16.4)
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

Table 1

Engine room ventilation

A great deal of the radiant heat must be transported out of the engine room to keep the engine room temperature down to the permitted values, in other words the heat must be ventilated away.

The same dimension must be chosen for the inlet and outlet ducts to achieve low flow speeds and low noise levels.

The area of the inlet/outlet air supply is calculated using the formula:

Inlet air = 1.65 × engine power output
Outlet air = 1.65 × engine power output

Areas in cm²
Engine power output in kW

These values must be corrected according to Table 1 with regard to bends and duct length.

The ambient air temperature (outdoor air temperature) is assumed to be +30°C (86°F). Correction factors as per Table 2 shall be used where applicable.

Ambient air temperature °C (°F)	Correction factor
+20 (68)	0.7
+30 (86)	1.0
+40 (104)	1.4

Table 2

Fan selection

The fan must be dimensioned according to air flow volumes as follows:

Air flow = 0.07 × engine power output

Air flow volume in m³ /min
Engine power output in kW

The total pressure increase across the fan should be 10 mm (0.39") water column (100 pa).

These two values, flow and total pressure increase, are sufficient for the selection of a fan. If the fan is fitted directly to the bulkhead, i. e. without a connection pipe, the value of the total pressure increase can be reduced to 7 mm (0.28") water column (70 Pa). This means that a somewhat smaller fan can be used.

Calculation of air ducts

Example 1.

Two diesel engines D6, 228 kW (310 hp)

Calculation of areas for **two** engines at 228 kW with an unrestricted air supply and an ambient air temperature of +30°C (+86°F).

For *each* engine the following is obtained:

Area, engine air consumption:

1. 1.9 × 228 = 434 cm² (67 sq.in).

   No corrections according to tables 1 and 2.
   The area 434 cm² (67 sq.in) gives a duct diameter of 235 mm (9.3") for **one single** engine.

Air ventilation, engine room:

1. **Inlet, engine room:** Area = 1.65 × 228 = 376 cm² (58 sq.in).
   This gives a diameter of 215 mm (8.4") for a single engine.

2. **Outlet, engine room:** Area = 1.65 × 228 = 376 cm² (58 sq.in).
   This gives a diameter of 215 mm (8.4") for a single engine.

3. **Extraction fan capacity:** 0.07 × 228 (kW) = 16.0 m³/min (570 ft³/min).

4. **NOTE!** As this is a twin installtion figures have to be doubled.

Example 2.

One diesel engine D4, 155 kW (210 hp)

Calculation of areas for **one** engine with 2 m (6.6 ft) duct length, 2 bends and an ambient air temperature of +20°C (+68°F).

Area, engine air consumption:

1. 1.9 × 155 = 294 cm² (46 sq.in).

   Correction for air temperature = 0.7 from Table 2, and correction for duct length and bends = 1.41 from Table 1.

   This gives 294 × 0.7 × 1.41 = 290 cm² (45 sq.in).
   The area 290 cm² (46 sq.in) gives a duct diameter of 190 mm (7.5").

Air ventilation, engine room:

1. **Inlet, engine room:** Area = 1.65 × 155 = 255 cm² (40 sq.in).
   This gives a duct diameter of 178 mm (7.0").

2. **Outlet, engine room:** Area = 1.65 × 155 = 255 cm² (40 sq.in).
   This gives a duct diameter of 178 mm (7.0").

3. **Correction, inlet and outlet:** Air temperature = 0.7 from Table 2, and correction for duct length and bends = 1.41 from Table 1.

   This gives 255 × 0.7 × 1.41 = 252 cm² (39 sq.in).
   This gives a duct diameter of
   175 mm (6.9") for each inlet and outlet.

4. **Extraction fan capacity:** 0.07 × 155 (kW) = 11.0 m³/min (388 ft³/min).

Location of ventilators and air intakes

NOTE! Air intakes or outlet holes must never be installed in the transom. The air in this area is mixed with water and exhausts and must therefore never be allowed to enter the boat.

Function of air intakes

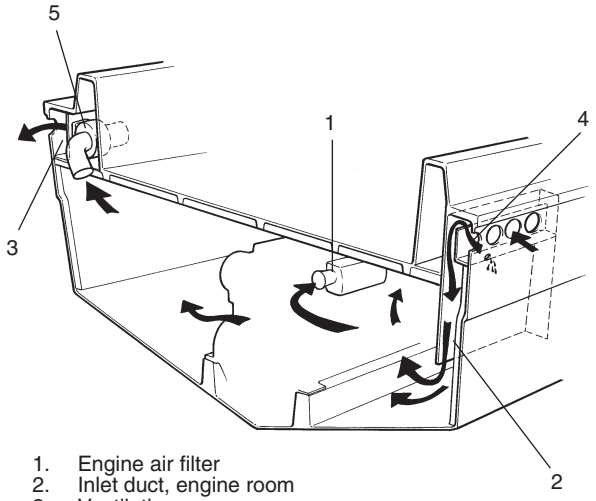
Air intakes and outlets must function well, even in bad weather, and must therefore have efficient water traps. Soundproofing must usually be built in.

The air intake and outlet should be placed as far away from each other as possible, so that a good through-flow is obtained.

If the intake and outlet are too close, the air can recirculate, resulting in poor ventilation.

Location of air ducts

The channels or ducts for the engine air supply should be routed up as close as possible to the air filters, but with a minimum distance of 20–30 cm (8–12"), to definitely prevent water from entering the engine. Please refer to figures.



1. Engine air filter
2. Inlet duct, engine room
3. Ventilation
4. Water trap
5. Suction fan

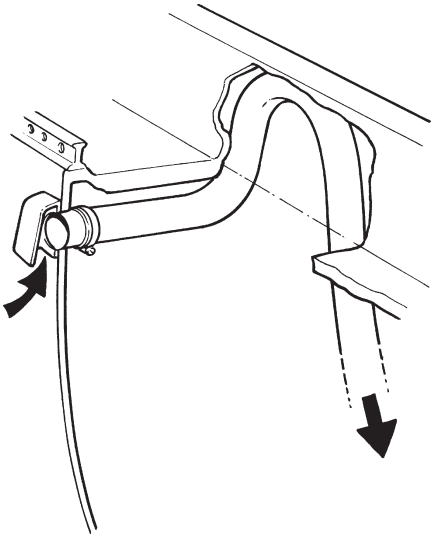
Example of how the inlet and outlet air ducts can be installed in pleasure boats and similar hulls using diesel engines.

For diesel engines, the incoming ventilation air duct should open out low down in the engine room, but not so low that any bilge water can block the air supply. The outlet ducts should be located diagonally across on the other side of the engine.

All channels and ducts must be routed so that the least possible flow resistance is obtained. The bends must not be sharp, they must be softly rounded. The smallest radius is twice the diameter. ***Restrictions must always be avoided***.

The ducts should be cut obliquely at the ends to give the best flow.

There are applicable regulations in certain countries which must be observed.



Should it not be possible to arrange the drainage, the hoses can be bent slightly upwards, as a swan neck, in order to prevent sea water from entering into the engine compartment. Remember to build the engine compartment as roomy as possible to facilitate servicing of the engine.

Soundproofing

The drive package must be installed in such a way as to minimize noise and vibration. The noise that occurs is airborne noise and structural noise (vibration).

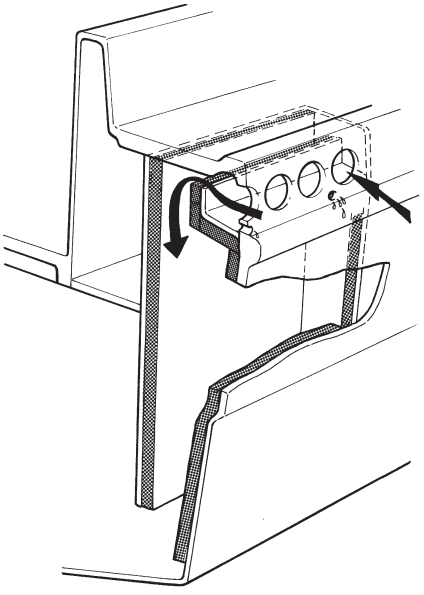
Structural noise

Vibration from the engine is transmitted via the engine mountings and the engine bed to the hull. Other routes are via the transmission and propeller systems, exhaust pipe, coolant pipes, fuel pipes, electrical cables and control cables.

Pressure pulses from the propeller are transmitted through the water and into the hull. Pulsating thrust from the propeller enters the hull via support blocks, bearings and seals.

Airborne noise

This section refers to airborne noise from the engine bay. The most important measure to lower airborne noise from the engine room is to seal the room properly. Further improvements in noise level reduction can be achieved by sound insulation material and by designing sound traps for the air inlets.

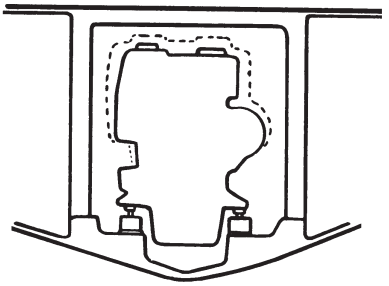


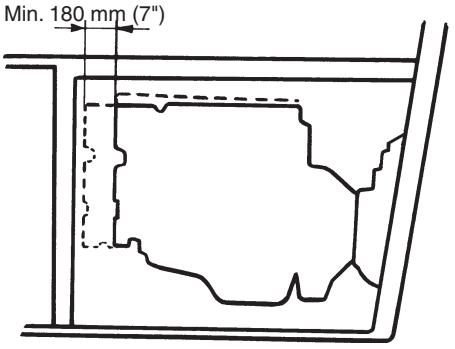
The engine installation should be soundproofed in order to obtain a noise level that is as low as possible. Build the engine compartment with sound traps. Various types of sound traps can be selected. The figure shows a type that is also provided with drainage.

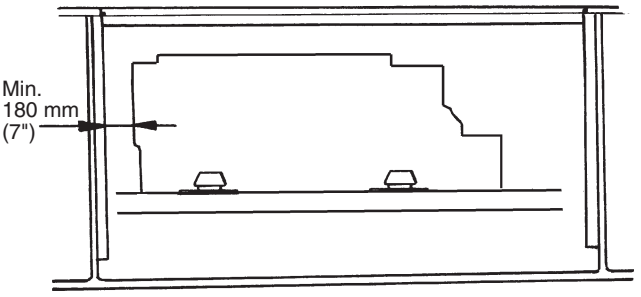
Furthermore, due consideration must be given to the thickness of the insulation material.

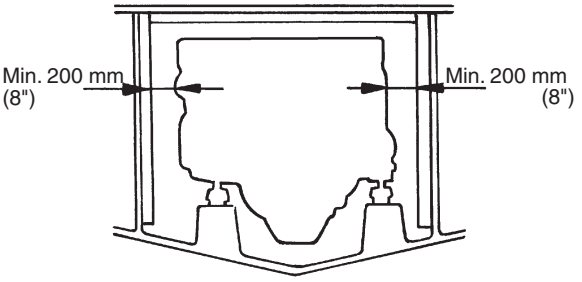
The greatest possible care must be given to the task of screening the sound source as well as possible. Screen all the way down to the hull but leave a small distance to prevent bilge water from penetrating the insulation material.

Cracks, openings etc. must be carefully sealed off with insulation material. In cases where the engine is installed under the floor, line all bulkheads and floorboards.



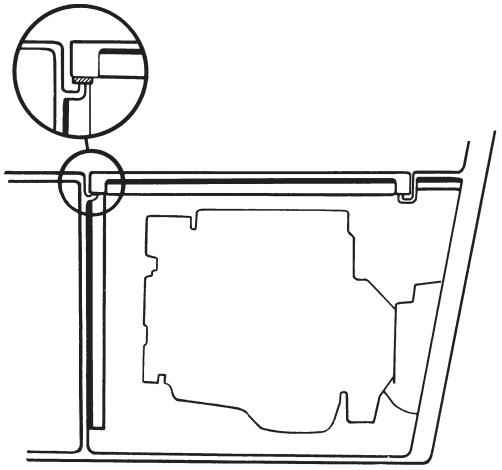


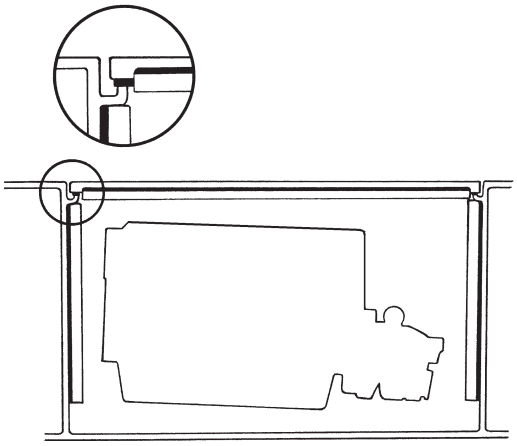




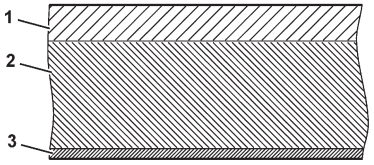
Prior to installing the insulation material, make sure that there is sufficient room for checking, service and repair and for engine movements during operation.

Also make sure that all hatches are properly sealed.





Make sure the necessary room is available for service and repair. Also make sure that all hatches are properly sealed.

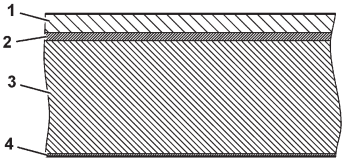


Insulation material installed on wood (plywood):

1. Wood (plywood)
2. Flame-proof absorption sheeting
3. Flame-proof, reflecting soundproofing foil

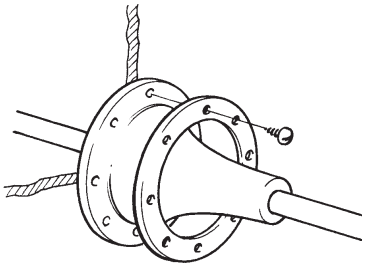
An example of the construction of an insulation material is shown above. This type of insulation material is glued to the frame.

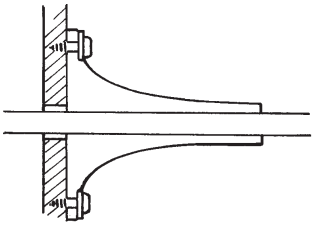
NOTE! The insulation sheeting faces differently, owing to the type of the material in the frame, i.e. GRP or wood.



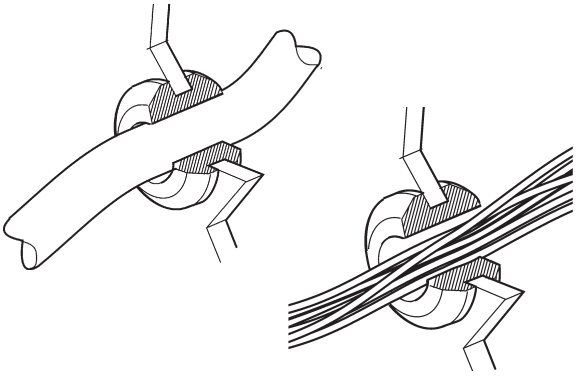
Insulation material installed on GRP:

1. GRP
2. Iron-PVC, thickness 2.5 mm (0.1")
3. Flame-proof absorption sheeting
4. Flame-proof, reflecting soundproofing foil





Shift cables, throttle cables and electrical wires passing through bulkheads can preferably be drawn through a tube or a grommet, sealing off properly. At the same time, the cables are protected against wear.



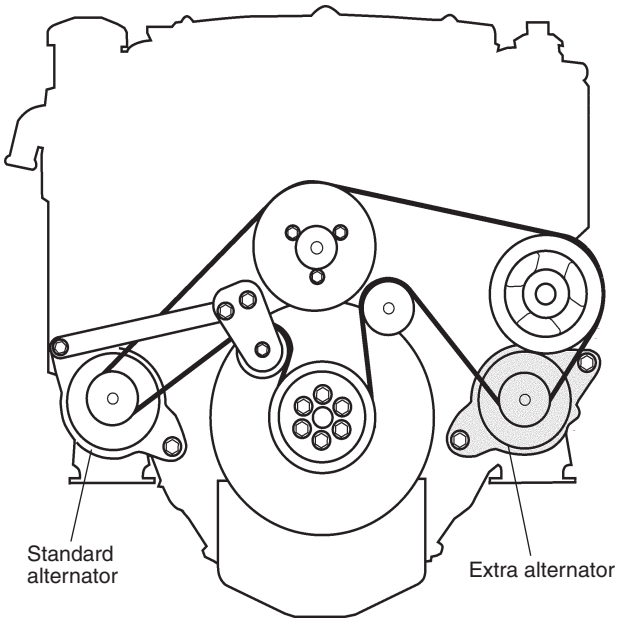
Fuel hoses passing through a bulkhead should be protected by a grommet where they pass through the bulkhead. The grommet seals off and protects the hose against sharp edges, which might cause leakage.

Other cables, electrical wires, battery leads etc. can be drawn through a rubber hose or through a special PVC tube (electrical conduit), built onto the GRP bulkhead. Any gaps between the tubing and the wires can be sealed off with some kind of insulation material or sealing compound.

Power take-off

Extra alternator

Alternators: 12 V / 115 A
24 V / 80 A



Tailor made kits are available from Volvo Penta to facilitate the installation of extra alternators. The alternator is installed on the same place on the engine as the power steering pump.

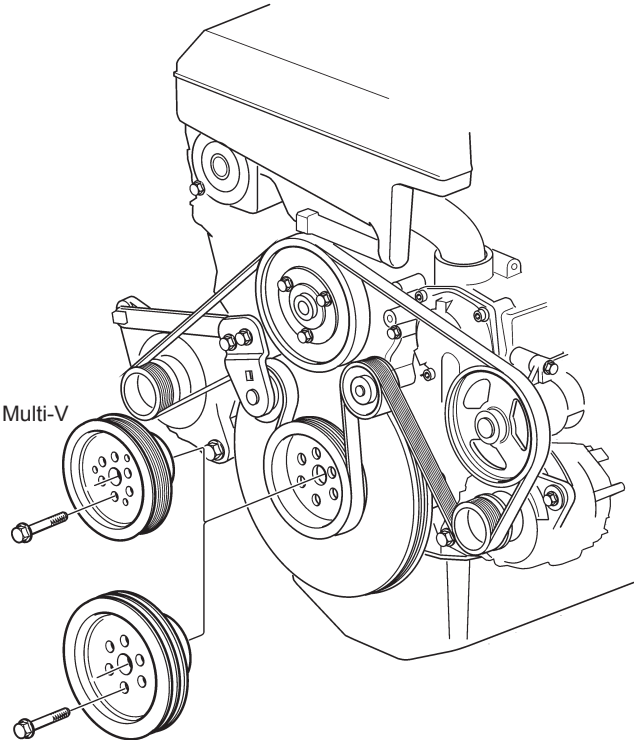
Extra alternators can be mounted on the following engine types:

- All inboard engines.
- Aquamatic engine, port engine only.
  The starboard engine is equipped with a power steering pump and cannot use an extra alternator.

Please refer to the ***Installation instruction*** that is delivered with the alternator kit for detailed installation instructions.

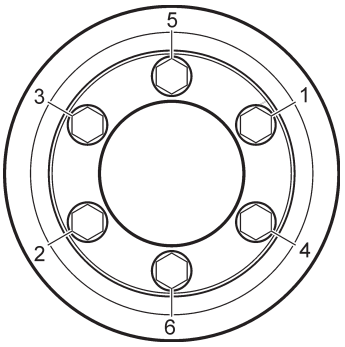
Front end power take-off

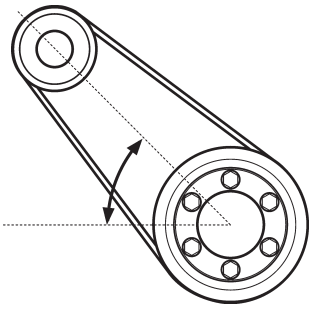
Pulleys: 2 x HC50
Multi-V



2 x HC50

Fitting a pulley





Install the pulley screws and tighten in sequence as per tightening schedule.

Tighten in two stages.

1. Tightening torque: **100 ±10 Nm (74 ±7.4 lbf.ft)**
2. Angle tightening: **45**°

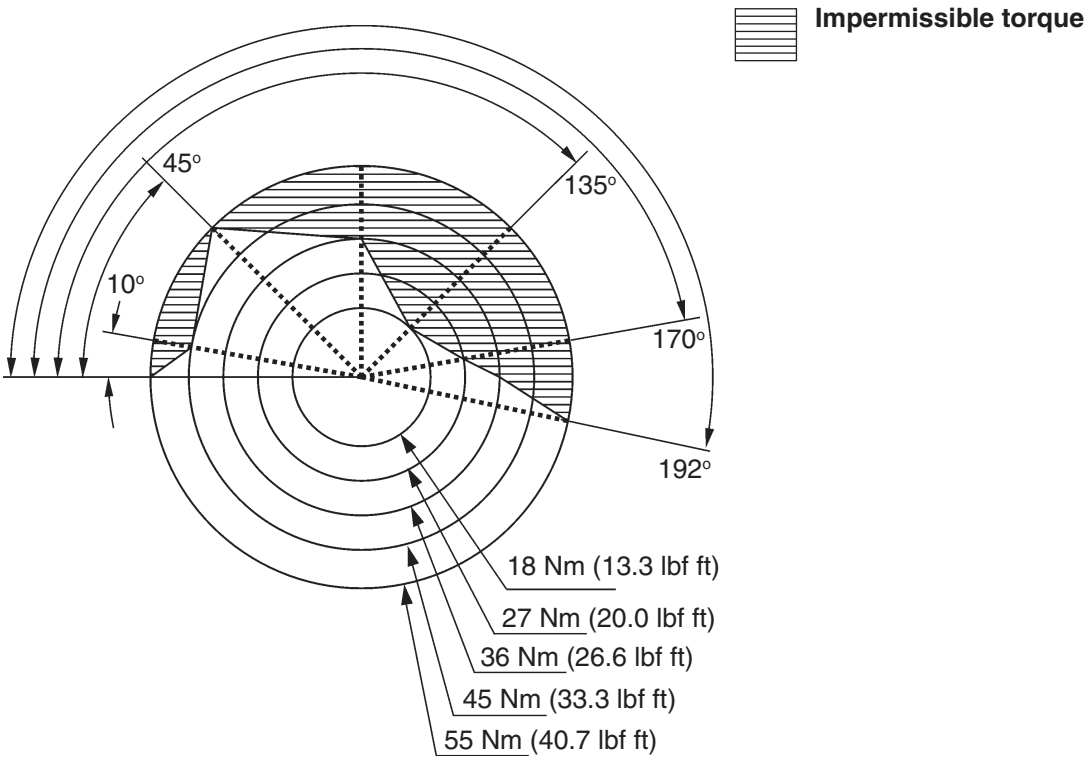
Maximum power take off, Nm (lbf.ft) Torque limitations:

Engine	Pulley Nm (lbf.ft)
D4 180	55 (40.7)
D4 210	55 (40.7)
D4 225	55 (40.7)
D4 260	55 (40.7)
D4 300	55 (40.7)
D6 280	55 (40.7)
D6 310	55 (40.7)
D6 330	55 (40.7)
D6 350	see below 1)
D6 370	see below 1)
D6 435	see below 1)
Volvo Penta IPS 350	55 (40.7)
Volvo Penta IPS 400 (D4)	55 (40.7)
Volvo Penta IPS 400 (D6)	55 (40.7)
Volvo Penta IPS 450	55 (40.7)
Volvo Penta IPS 500	see below 1)
Volvo Penta IPS 600	see below 1)

1)
The maximum permissible torque varies depending on:

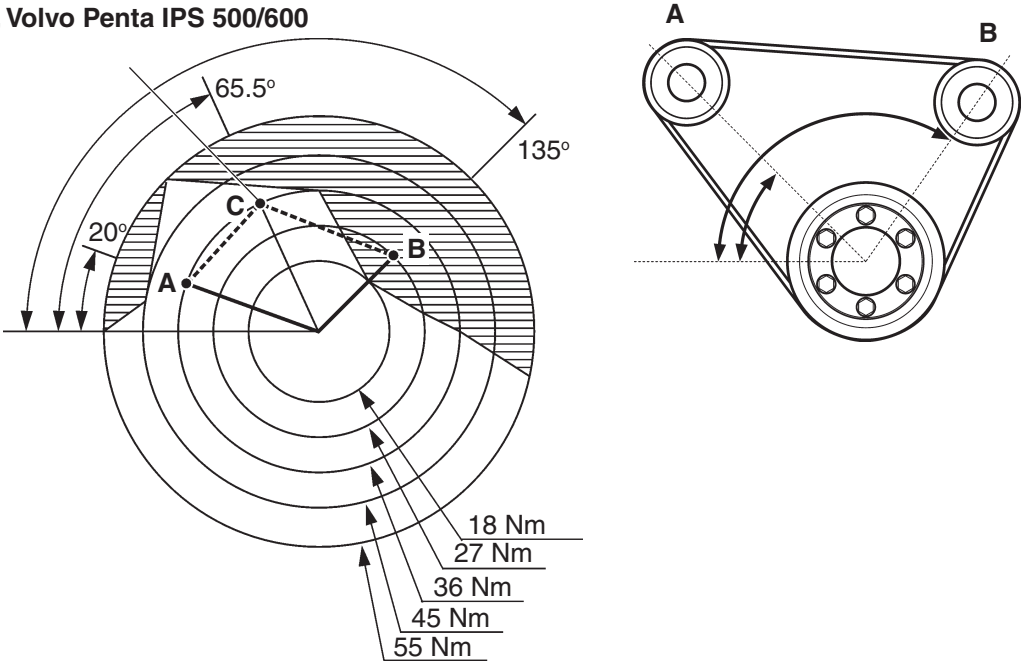
- if the engine is equipped with a compressor or not.
- whether direction of force is for one or several auxiliaries. Please refer to figure.

D6-350, D6-370 DP/DPR, Volvo Penta IPS 500/600



Example 1

D6-350, D6-370 DP/DPR, Volvo Penta IPS 500/600



The engine is a **D6-350, D6-370** or **Volvo Penta IPS 500/600** and the direction of force for two auxiliaries is **A**=20° and **B**=135°.

Maximum permissible torque for auxiliary **A** and **B** depends on the vector sum of their directions of force and their torque. The combination must end up within the permissible torque range.

In this example, the torque for the auxiliary is **A**=36 Nm (26.6 lbf ft) and **B**=27 Nm (20 lbf ft).

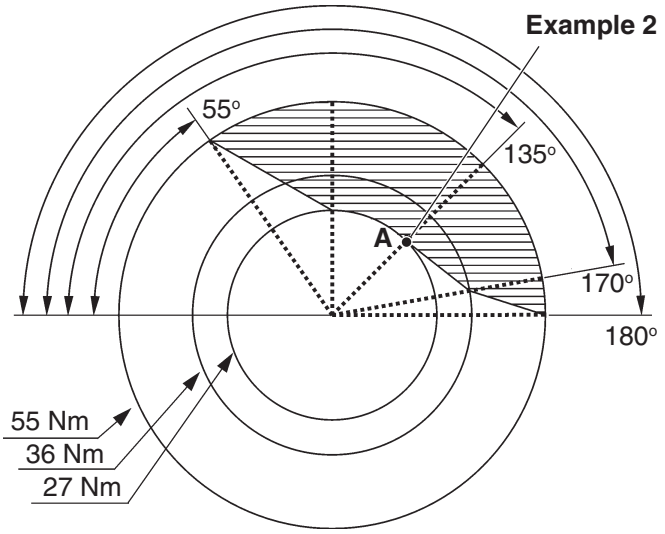
The resultant force gives a torque **C**=34.5 Nm (25.5 lbf ft) with direction of force 65.5°. The resultant ends up within the permissible torque.

In every case:

Read off the resultant of two torques with different directions of forces by drawing a parallelogram in the graph on the same principles as in the example.

Example 2

D6-370 Inboard



Impermissible torque

The engine is a **D6-370** and the direction of force for an auxiliary is **A**=135°.

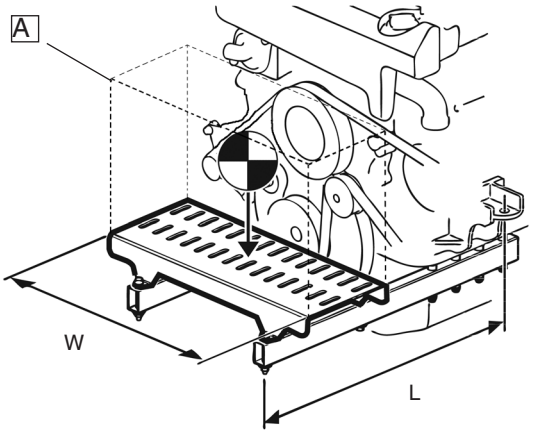
Maximum permissible torque: **27 Nm (20 lbf ft)**

Universal bracket

The front mounted universal bracket enables installation of extra equipment such as alternator, fridge compressor, hydraulic pump etc.

Total width of bracket (W): 564 mm (22.2")
Length from engine bracket center (L): 540 mm (21.3")

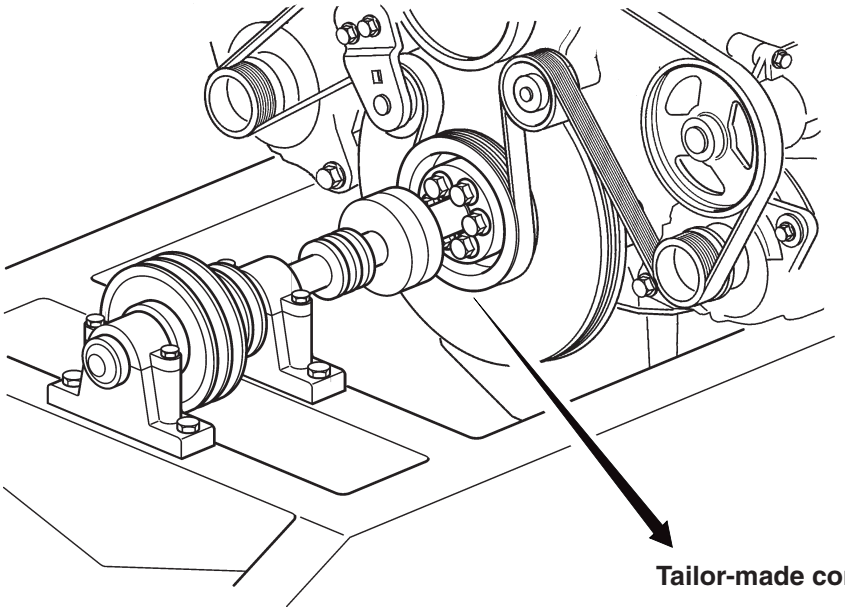
NOTE! The D4/D6 115 A standard alternator cannot be rotated counter-clockvise.



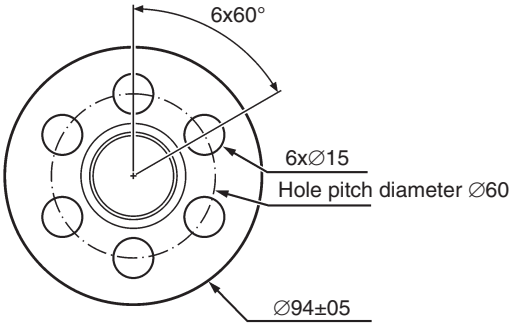
Maximum load is 10 kg.

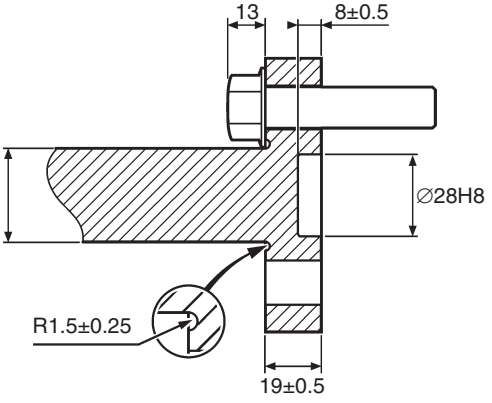
NOTE! The centre of gravity shall be within the highlighted area (A) on the universal bracket.

In-line power take-off



Tailor-made connecting flange



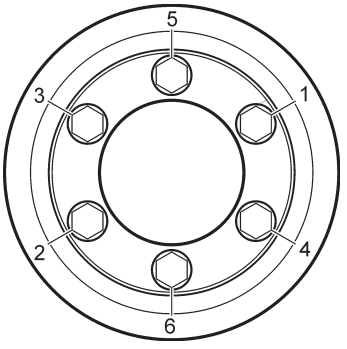


Torque limitation, all D4 and D6 engines:

200 Nm (147.5 lbf.ft)

When using in-line power take-off, a torsional vibration calculation (TVC-calculation) has to be carried out.

⚠ **IMPORTANT!** Special bolts, part no. 465815 (6 pcs) shall be used to fasten the coupling to the crankshaft standard pulley.



Install the coupling screws and tighten in sequence as per tightening schedule.

Tighten in two stages.

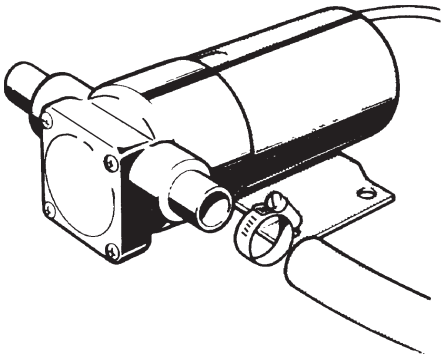
1. Tightening torque: **100 ±10 Nm (74±7.4 lbf.ft)**
2. Angle tightening: **45°**

Draining of oil and coolant

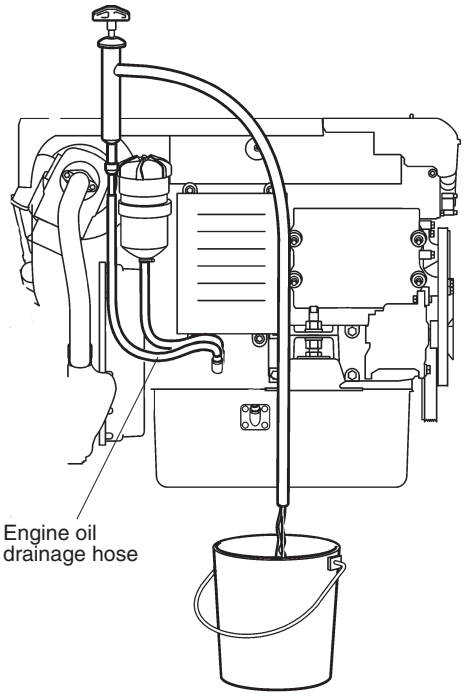
General

Engine installations in boats and vessels, have the potential for negative environmental impact. The fluids involved are harmful to the environment and should be handled in a safe manner.

Oil drain pump

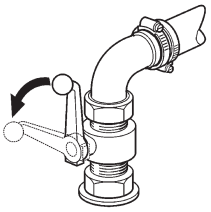


An electrically powered draining pump for oil is available as extra equipment. This pump is installed in a suitable position by using a bracket. The pump can be run in the desired direction by changing the polarity of the cables.



The oil hoses should have a shut off valve or should only be connected when changing oil, to avoid the risk of accidental draining.

Launching and starting

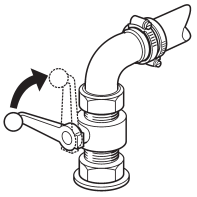


Check before launching

- Check that all valves beside through hull fittings are closed.
- Check that the correct propeller sizes are fitted. Also check that the propeller has the correct rotation (right or left).
- Water lubricated stern bearings. Check that the water pipes are open.
- Check that the anodes on shield and drive are of correct type:

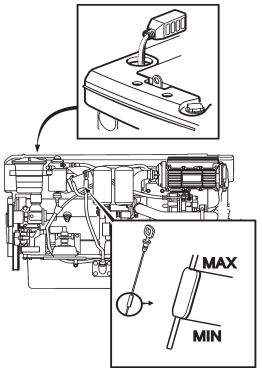
  Zinc anodes are fitted as standard anodes. Magnesium and aluminum anodes are optional.

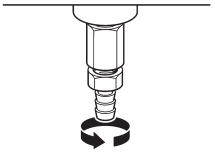
  Please refer to the ***Operator's Manual***.

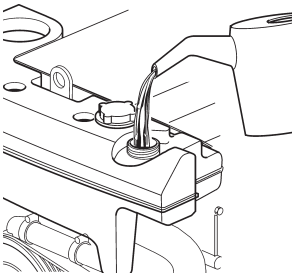


Check after launching but before starting

⚠ **IMPORTANT!** Oil, fluid and grease recommendations, please refer to the ***Operator's Manual***.





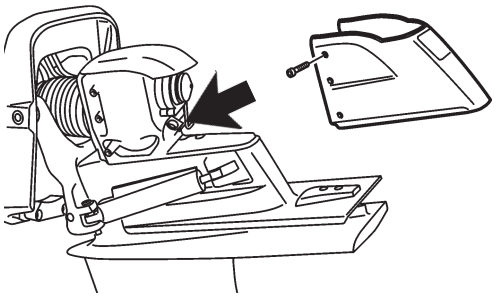


Valves:

- Valves
- Through hull fittings

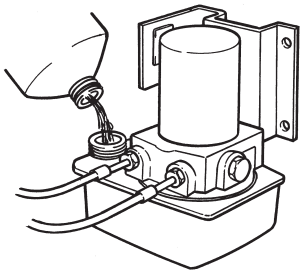
Engine:

- Lubricating oil
- Drain cocks and plugs
- Coolant
  Filling of coolant, please refer to the chapters ***Coolant***, and ***Filling with coolant***.

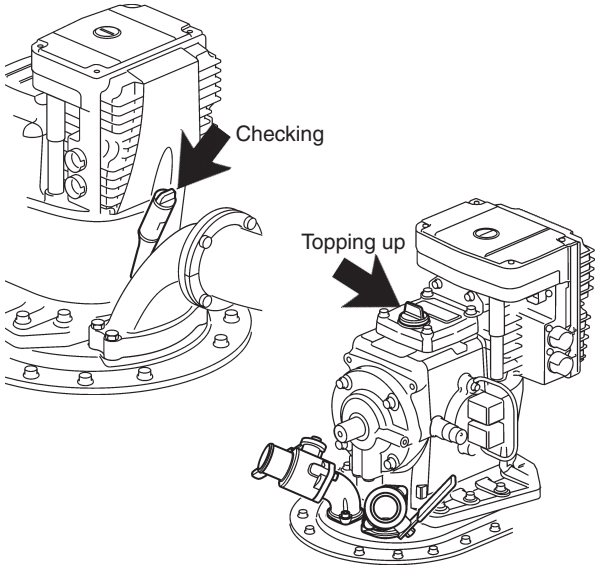


Drive DPH, DPR:

- Transmission oil. Trim the drive to its max. position and top up.



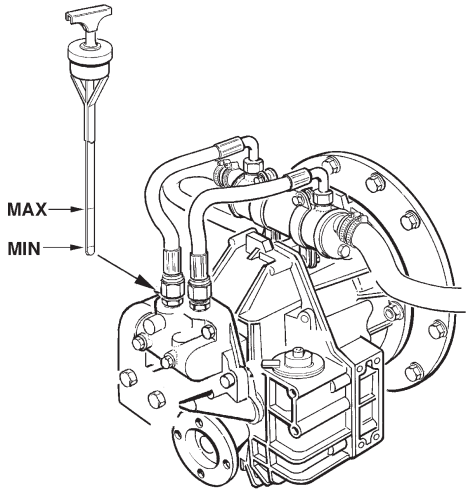
- PowerTrim. Vent the system by trimming the drive up and down. Top up with ATF oil.



Volvo Penta IPS:

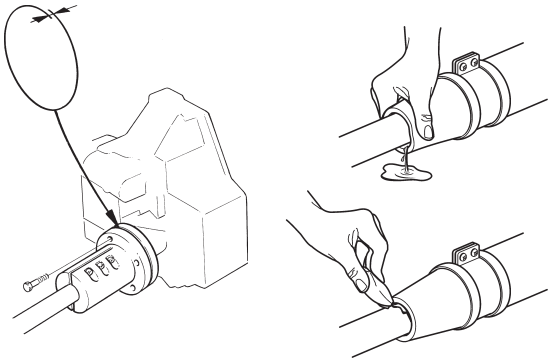
⚠ **IMPORTANT!** The Volvo Penta IPS propulsion unit must been shut down for at least 12 hours before a correct oil level check can be done.

- Transmission oil.
  Check the oil level. Screw the dipstick down as far as it goes. The correct oil level is inside the marked area.
  Top up if necessary.



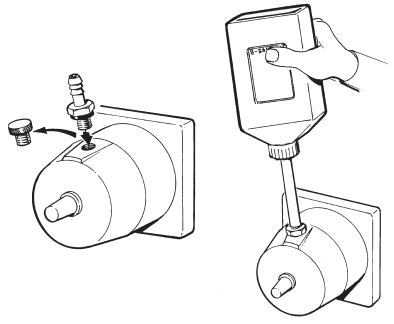
Inboard, reverse gear:

- Oil level, ATF oil



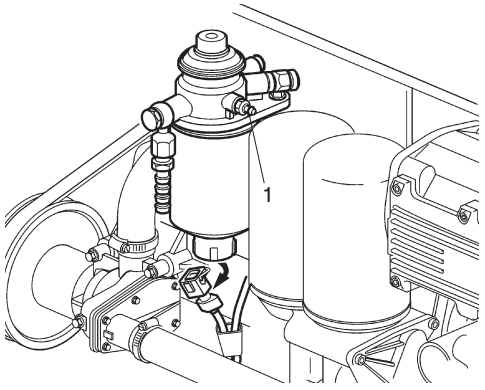
Inboard, propeller shaft:

- Engine–propeller shaft alignment. Preferably after 12 hours in water, boat completed and rigged.
- Water lubricated stern bearing, vent and grease the rubber seal. Pump approximately 1 cm^3 water resistant grease into the rubber seal, Volvo Penta part no. 828250.



Hydraulic steering system:

- Oil level
- Purge the system



Fuel system:

- Fuel level
- Filters and cocks
- Venting. Air vent valve (1)

EVC system:

- Battery terminals
- Auto configuration
- Complete calibration carried out
- Initializing EVC display/s
- Fault messages

Starting the engine

⚠ **WARNING!** Never use start spray or similar products as starting aids. Explosion risk!

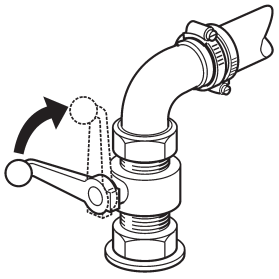
⚠ **IMPORTANT!** Also consult the ***Operator's Manual*** regarding information about starting the engine.

General information about starting

The engine control lever must always be in neutral before starting. The engine management system ensures that the engine receives the correct amount of fuel - even when the engine is cold.

The engine is pre-heated by the engine control unit, which allows the engine to crank several revolutions with the starter motor before fuel is injected. The colder the engine is, the more revolutions the engine makes. This raises the temperature in the combustion chambers, which ensures reliable starting and reduces starting smoke.

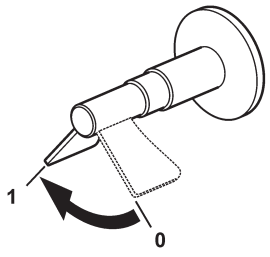
The idling speed is also governed by engine temperature, and is somewhat raised after a cold start.



Check list

The following measures must be carried out before starting up the system:

- Complete calibration
- Initialising of EVC display/s
- Checking of fault messages



Before starting

- Open the fuel tap
- Inboard: Open the sea cock
- Volvo Penta IPS: Open all cocks
- Turn the main switches on

⚠ **IMPORTANT!** Never disconnect the current with the main switches when the engine is running. This can damage the alternator.

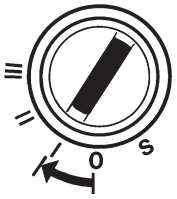
- Start the engine compartment fan, if one is installed, and let it run for at least four minutes.
- Check that the amount of fuel aboard is enough for your planned voyage.

Starting method

Put the reverse gear/stern drive in neutral

Put the reverse gear in neutral by moving the control lever(s) to neutral at all control positions.

Two lever control: Also check that the engine speed lever is in the idling position.



Turn the ignition on

Turn the starter key to position **I** to switch the ignition on.

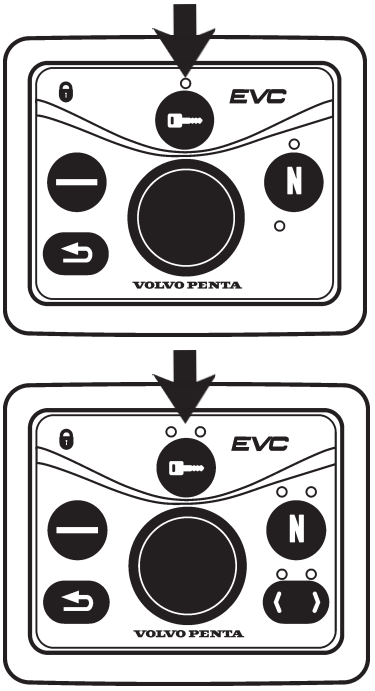
Check the warning lamps and LEDs

Each time the ignition is turned on, all LEDs are illuminated on the main control panel. Check that all LEDs function.

If the boat has more than one helm station, the LEDs on the other panel(s) are not checked until the control panel(s) is(are) activated.

Check the tachometer display

If a fault is registered it will be shown in the tachometer display.



Activate the control panel and lock the system

Press the activation button for at least one second. When the button is released, the indication lights up to confirm that the control position is activated.

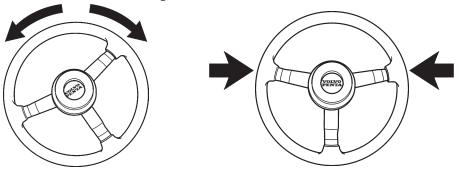
NOTE! If the indicator flashes, the control position has not been activated because the control lever(s) are not in the neutral position or the system has been locked from another control panel.

If the boat has more than one control panel/helm station, the system can be locked, so that the engine can only be controlled from the activated station. Press the activation button for a further second to lock the system. The padlock sign lights up in confirmation.

Unlock the system by pressing the activation button for one second. This can only be done from an activated control panel.

Start the engine

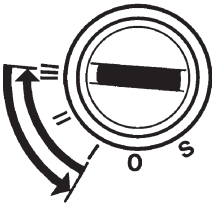
Volvo Penta IPS only



NOTE! Volvo Penta IPS only: Before starting the engine, position the steering wheel in desired position.

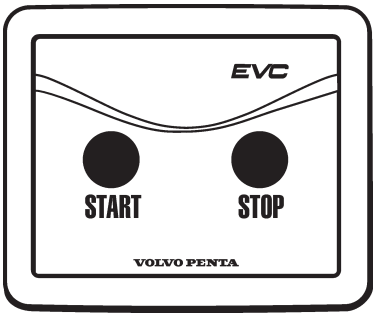
Start using the ignition switch

Turn the key to position **III**. Release the key and let it spring back to position **I** as soon as the engine has started. Stop cranking if the engine does not start within 20 seconds.



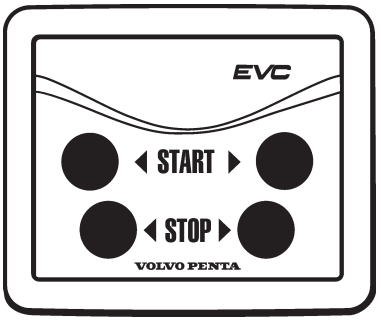
NOTE! If repeated start attempts are needed, the key must be turned back to position 0 first.

Starting with the starter button



Press the starter button. Release the button as soon as the engine has started. Please note that if you start from an alternative control station, the starter key at the main control station must be in position **I**. Stop cranking if the engine does not start within 20 seconds.

Overheating protection



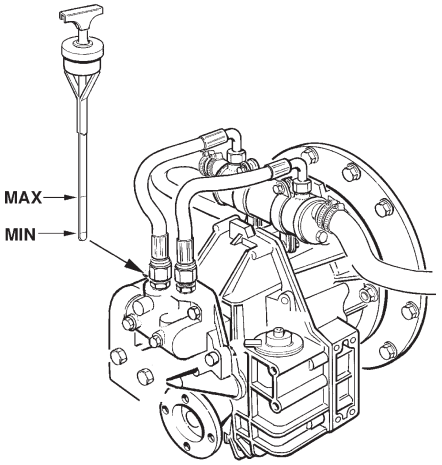
If the starter motor is engaged for its maximum activation time, the starter motor circuit is cut automatically to protect the starter motor from overheating. Leave the starter motor to cool for at least five minutes (if possible) before making a new start attempt.

Read the instruments and warm up the engine

Allow the engine to idle for the first ten seconds, and check that instruments and displays show normal values. Check that no alarms are displayed and that no warning lamps (optional) are flashing.

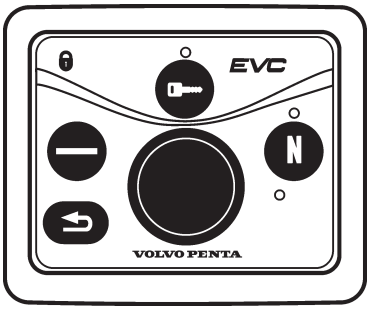
Then warm the engine up at low speed and low load, so that it reaches normal operating temperature before full power is used.

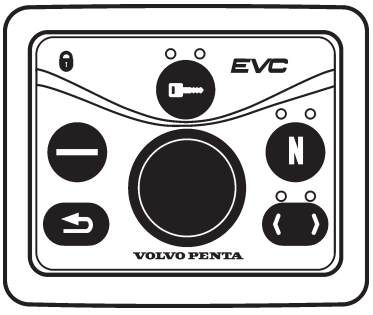
⚠ **IMPORTANT!** Never race the engine when it is cold.



Check the oil level in the reverse gear

Check the oil level when the reverse gear has reached operating temperature.





Disengaging the shift function

The shift function can be disengaged so that the control lever only affects the engine speed. Max engine speed is 1500 rpm.

1. Move the lever to the **NEUTRAL** position.
2. Press the neutral button (N) in and hold it down while moving the control lever forward to the shift position **FORWARD**.
3. Release the neutral button (N). The green indicator begins to flash to acknowledge that the shift function is disengaged.

The lever now only controls engine speed.

When the lever is moved back to the neutral position, it will automatically re-engage. This is confirmed by the green indication which gives constant light.

⚠ **WARNING**! Be careful not to engage the reverse gear/stern drive unintentionally.

Check while the engine is running at idling:

- For leakage in fuel system and cooling system: Check pipes and hoses.

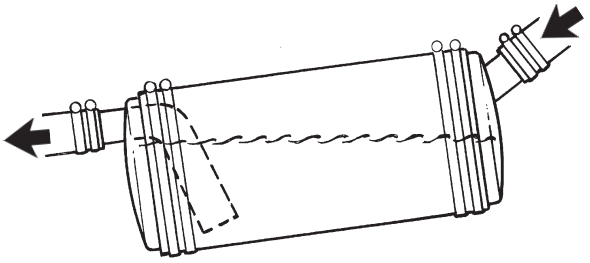
- Instruments and gauges are working and showing correct values.
- Oil level in the reverse gear when the engine has reached operating temperature.
- Equipment such as navigation lamps, instruments etc. are working correctly.

Check idle rpm

Idling rpm depends on engine type.

If needed adjust the rpm, please refer to the ***Operator's Manual*** and the manuals ***Installation, Electronic Vessel Control EVC D4, D6*** and ***Installation, Electronic Vessel Control EVC Volvo Penta IPS***.

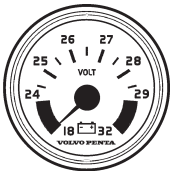
Stop the engine. Check:



- Engine oil level
- Coolant level
- Water level in wet exhaust system

  The level must be **well below** the lower edge of the silencer inlet so that there will be no risk of water entering into the engine exhaust system. Observe the design limit specified by the silencer manufacturer.

Sea trial



Check when test running the boat:

- Instruments.
  Check engine rpm, oil pressure, coolant temperature and charge voltage.

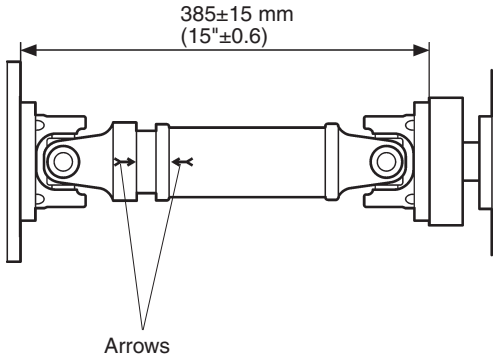
- Check the engine installation for water, coolant, oil and fuel leaks.
- Check if the maximum engine speed can be obtained, please refer to the ***Operator's Manual***.
  Should the maximum engine speed not be obtained, the wrong size propeller might be installed. Also, the boat might be loaded in a way that results in a bad running attitude position in the water.
- **Inboard engines:** Exhaust back pressure. Please refer to the chapter ***Exhaust system, Back pressure***.
- **Inboard engines:** Propeller shaft bearings and seals: These should be at a low temperature and without leaks.

Check over the whole speed range:

- That the engine room temperature is kept at an acceptable level.

- Abnormal noise and vibration.

  Aquamatic: Check that the sterndrive does not cavitate abnormally, when making sharp turns for instance.
  Should the sterndrive cavitate, it could be that the toe-in-angle needs adjustment in a twin installation, please refer to the chapter ***Tie bar installation***.
  It could also be that an extension must be installed on the drive, please refer to the chapter ***Water level at maximum load***.



Volvo Penta IPS: Check that the system does not cavitate abnormally, for instance when making sharp turns. Should the system cavitate, it could be that the propulsion unit toe-in needs to be adjusted. Please refer to chapter ***Drive leg calibration***.

If vibration occurs, check the drive shaft alignment (alignment of arrows). Check the shaft length, 385±15 mm (15"±0.6).

NOTE! The first time a new boat type is tested, the boat builder need to select the appropriate steering angle setting for this boat type. Please refer to the chapter ***Steering angle setting***.

Inboard engines: Check that the water lubrication to the propeller shaft seal is adequate while test running. Also check for good water lubrication at planing speeds and higher.

- Verify that the steering and controls are correctly connected and correspond to the boat's movement.

Check after sea trial:

- Oil level in PowerSteering and PowerTrim systems.

References to Service Bulletins

Group	No.	Date	Concerns

Notes

Report form

Do you have any complaints or other comments about this manual? Please make a copy of this page, write your comments down and post it to us. The address is at the bottom of the page. We would prefer you to write in English or Swedish.

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Refers to publication: .....

Publication no.: ..... Issued: .....

Suggestion/reasons: .....

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AB Volvo Penta
Technical Information
SE-405 08 Göteborg
Sweden

7746265 English 08-2007