YANMAR

INSTALLATION MANUAL
Volume 1

General Information and Formulas

GM, YM, JH, LH, LP, LV, LY, CX, BY, SY Series

California Proposition 65 Warning
Diesel engine exhaust and some of its constituents are known to the state of California to cause cancer, birth defects, and other reproductive harm.

California Proposition 65 Warning
Battery posts, terminals, and related accessories contain lead and lead compounds, chemicals known to the state of California to cause cancer and reproductive harm. Wash hands after handling.

This installation manual has been developed for the exclusive use of service and repair professionals such as YANMAR authorized distributors and YANMAR authorized dealers. It is written with these professionals in mind and may not contain the necessary detail or safety statements that may be required for a non-professional to perform the service or repair properly and/or safely. Please contact an authorized YANMAR repair or service professional before working on your YANMAR product.

Disclaimers:

All information, illustrations and specifications in this manual are based on the latest information available at the time of publishing. The illustrations used in this manual are intended as representative reference views only. Moreover, because of our continuous product improvement policy, we may modify information, illustrations and/or specifications to explain and/or exemplify a product, service or maintenance improvement. We reserve the right to make any change at any time without notice. YANMAR and **YANMAR** are registered trademarks of YANMAR CO., LTD. in Japan, the United States and/or other countries.

INSTALLATION MANUAL	MODEL	General Information and Formulas
	CODE	0FMPE-EN0015

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Section 1

INTRODUCTION

WELCOME TO THE WORLD OF YANMAR MARINE!

Yanmar Marine offers, engines, drive systems and accessories for all types of boats, from runabouts to sailboats, and from cruisers to mega yachts. In marine leisure boating, the worldwide reputation of Yanmar Marine is second to none.

Yanmar designs engines to respect nature. This means quieter engines, with minimal vibrations, cleaner than ever. All of our engines meet applicable regulations, including emissions, at the time of manufacture.

ABOUT THIS MANUAL

This manual provides boat designers, naval architects, installers and builders with the instructions necessary to safely install Yanmar Marine propulsion systems. Optimum boat and engine performance are achieved when the appropriate diesel marine engine, marine gear, propeller and accessories are selected for an application.

Accurate information is required during the engine selection and space planning processes for each pleasure craft application. Numerous calculations are needed in determining vessel performance characteristics. Boat designers, naval architects, installers and builders use the data and formulas in these three volumes to provide systems that satisfactorily answer the operator’s exacting requirements.

The manual is organized into three volumes. Volume 1 contains important formulas and procedures while Volumes 2 and 3 represent a comprehensive collection of critical engine, marine gear and mounting specifications.

Please note that this manual does not include guidance about the safety regulations of each country. Also, the diagrams, figures and information in this manual are subject to change in accordance with technical improvements made to our engines. Engine data and optional accessories are subject to change without notice.

The Yanmar Installation Manual set is intended as a guideline for marine pleasure craft engine installations. It cannot cover every conceivable situation or unique application. If any value, standard, etc. is unclear, or if you intend to deviate from these specifications for any reason, first contact the Yanmar distributor or Yanmar RHQ for guidance and/or approval.

REVISION HISTORY

This manual is a living document. Periodic manual revisions are published to document product improvements and changes. This practice ensures the manual has the most current information.

As manual revisions become necessary, individual pages are prepared and sent to those who need the information. If a page, or number of pages should be replaced, the replacement information is sent along with a revised **Revision Control Table**. Discard the older, obsolete information.

At times the revision involves inserting additional pages in one or more sections. Insert the new information and only the **Revision Control Table** should be replaced.

This method of revision control represents the most cost-effective solution to providing fresh, updated information as needed.

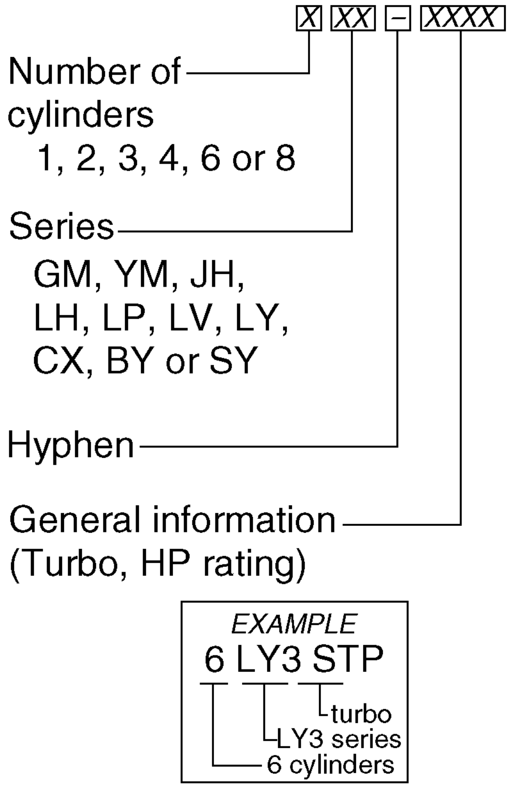
Revision Control Table

Revision date Revision number	New page numbers involved	Remarks	Initiating dept.
June 2006 1st edition	All	Re-release	YMI
December 2008 2nd edition	All	Update template, safety and multiple edits throughout manual	YMU
July 2009 3rd edition	6-11	Removed impeller matching reference	YMU
	7-111	Added gear PTO information	YMI
January 2013 4th edition	7-16	Multiple Battery Systems (Added a diode type battery isolator: VALEO 12 V - 120 A alternator)	Marine Operations Division
	7-48, 49, 50	Added new panel (B20, C30)	
	7-74	Added fuel inlet label (ULSD)	
January 2014 5th edition	3-2	Added Emission-related installation instructions	Marine Operations Division
	7-50	Revised Speed pulse value (YM/JH4/JH5 with VALEO alternator)	
	7-74	Deleted Fuel inlet label	
	7-102	Added Measuring Exhaust Gas Emission	

Revision date Revision number	New page numbers involved	Remarks	Initiating dept.

Model Numbering System

Yanmar Marine engine models are identified by a six- to ten-character numbering system that provides specific information about each model. The first character represents the number of cylinders. The next two or three characters indicate the series. The last group of characters provide some general information about a specific model in the series. If a hyphen separates the last group of characters from the first characters, that model number is describing a turbocharged engine. A graphic explanation of this numbering system follows:



Details for each engine model are found in vol. 2 and 3.

Section 2

SAFETY

Yanmar is concerned for your safety and the condition of your marine engine. Safety statements are one of the primary ways to call your attention to the potential hazards associated with Yanmar Marine engines. Follow the precautions listed throughout the manual before operation, during operation and during periodic maintenance procedures for your safety, the safety of others and to protect the performance of your marine engine. Keep the decals from becoming dirty or torn and replace them if they are lost or damaged. Also, if a part needs to be replaced that has a decal attached to it, make sure to order the new part and decal at the same time.

This safety alert symbol appears with most safety statements. It means attention, become alert, your safety is involved! Please read and abide by the message that follows the safety alert symbol.

DANGER

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

WARNING

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

CAUTION

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

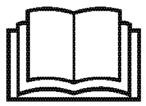
NOTICE

NOTICE indicates a situation which can cause damage to the machine, personal property and/or the environment or cause the equipment to operate improperly.

SAFETY PRECAUTIONS

There is no substitute for common sense and careful practices. Improper practices or carelessness can cause burns, cuts, mutilation, asphyxiation, other bodily injury or death. This information contains general safety precautions and guidelines that must be followed to reduce risk to personal safety. Special safety precautions are listed in specific procedures. Read and understand all of the safety precautions before operating or performing repairs or maintenance.

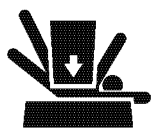
⚠ DANGER



- **Never permit anyone to install or operate the engine without proper training.**

- **Read and understand this *Installation Manual* before operating or servicing the engine to ensure that safe operating practices and maintenance procedures are followed.**
- **Safety signs and decals are additional reminders for safe operating and maintenance techniques.**
- **Contact your Yanmar RHQ for additional training.**

Crush Hazard



- **Never stand under a hoisted engine. If the hoist mechanism fails, the engine will fall on you.**

- **Always secure the engine solidly to prevent the engine from falling during maintenance.**

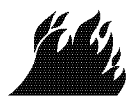
⚠ WARNING

Explosion Hazard

- **While the engine is running or the battery is charging, hydrogen gas is being produced and can be easily ignited. Keep the area around the battery well-ventilated and keep sparks, open flame and any other form of ignition out of the area.**

- **Always turn off the battery switch (if equipped) or disconnect the negative (–) battery cable before servicing the equipment.**

Fire and Explosion Hazard



- **Diesel fuel is flammable and explosive under certain conditions.**

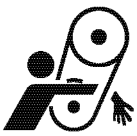
- **Never use a shop rag to catch the fuel. Vapors from the rag are flammable and explosive.**
- **Wipe up all spills immediately.**
- **Never refuel with the engine running.**
- **Store any containers containing fuel in a well-ventilated area, away from any combustibles or sources of ignition.**
- **Always keep sparks, open flames or any other form of ignition (match, cigarette, static electric source, etc.) well away when refueling.**
- **Never overfill the fuel tank.**
- **Never use diesel fuel as a cleaning agent.**
- **Always put diesel fuel container on the ground when transferring the diesel fuel from the pump to the container. Hold the hose nozzle firmly against the side of the container while filling it. This prevents static electricity buildup which could cause sparks and ignite fuel vapors.**

⚠ WARNING

Fire Hazard

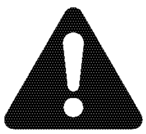
- Have appropriate safety equipment available. Have all fire extinguishers checked periodically for proper operation and/or readiness.
- Always read and follow safety-related precautions found on containers of hazardous substances like parts cleaners, primers, sealants and sealant removers.
- Undersized wiring systems can cause an electrical fire. Be sure to use proper size wiring for the application.

Entanglement Hazard



- Never leave the key in the key switch when servicing the engine. Attach a “Do Not Operate” tag near the key switch while performing maintenance on the equipment.
- Always stop the engine before beginning service.
- If the engine must be serviced while it is operating, remove all jewelry, tie back long hair and keep hands, other body parts and clothing away from moving/rotating parts.

Piercing Hazard



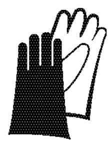
- Avoid skin contact with high-pressure diesel fuel spray caused by a fuel system leak such as a broken fuel injection line. High-pressure fuel can penetrate your skin and result in serious injury. If you are exposed to high-pressure fuel spray, obtain prompt medical treatment.
- Never check for a fuel leak with your hands. Always use a piece of wood or cardboard. Have your authorized Yanmar Marine dealer or distributor repair the damage.

⚠ WARNING

Flying Object Hazard

Always wear eye protection when servicing the engine or when using compressed air or high-pressure water. Dust, flying debris, compressed air, pressurized water or steam may injure your eyes.

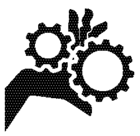
Coolant Hazard



Wear eye protection and rubber gloves when handling Long Life Coolant (LLC). If contact with the eyes or skin should occur, flush eyes and wash immediately with clean water.

⚠ WARNING

Sever Hazard



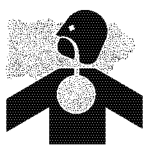
- Never wear jewelry, unbuttoned cuffs, ties or loose-fitting clothing and always tie long hair back when working near moving/rotating parts such as the flywheel or PTO shaft. Keep hands, feet and tools away from all moving parts.
- The propeller may rotate during towing or if the engine is running at idle speed. Never service the engine while being towed or when the engine is running.
- If the vessel has more than one engine, never service an engine if either of the engines is running. In multi-engine configurations the propeller for an engine that is shut down may rotate if any of the other engines are running.
- Never operate the engine without the guards in place.
- Never operate the engine while wearing a headset to listen to music or radio because it will be difficult to hear the warning signals.
- Before you start the engine, make sure that all bystanders are clear of the area.
- Keep children and pets away while the engine is operating.

⚠ WARNING

Electrical Hazard

- Make welding repairs safely.
- Always turn off the battery switch (if equipped) or disconnect the negative (–) battery cable and the leads to the alternator when welding on the equipment.
- Remove the multi-pin connector to the engine control unit. Connect the weld clamp to the component to be welded and as close as possible to the welding point.
- Never connect the weld clamp to the engine or in a manner which would allow current to pass through a mounting bracket.
- When welding is complete, reconnect the leads to the alternator and engine control unit prior to reconnecting the batteries.
- Always keep the electrical connectors and terminals clean. Check the electrical harnesses for cracks, abrasions, and damaged or corroded connectors.
- Never turn off the battery switch (if equipped) or short the battery cables during operation. Damage to the electrical system will result.

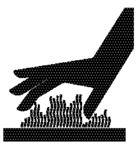
Exhaust Hazard



- All internal combustion engines create carbon monoxide gas during operation and special precautions are required to avoid carbon monoxide poisoning.
- Never block windows, vents or other means of ventilation if the engine is operating in an enclosed area.
- Always ensure that all connections are tightened to specifications after repair is made to the exhaust system.

⚠ WARNING

Burn Hazard



- Some of the engine surfaces become very hot during operation and shortly after shutdown.

- Keep hands and other body parts away from hot engine surfaces.
- Handle hot components with heat-resistant gloves.

Sudden Movement Hazard

- To prevent accidental equipment movement, never start the engine in gear.
- Shift the marine gear into the NEUTRAL position any time the engine is at idle.

Lifting Hazard

- The engine lifting eyes are engineered to lift the weight of the marine engine only. Always use the engine lifting eyes when lifting the engine.
- Additional equipment is necessary to lift the marine engine and marine gear together. Always use lifting equipment with sufficient capacity to lift the marine engine.
- If transport is needed for engine repair, have a helper assist in attaching it to a hoist and loading it onto a truck.

Alcohol and Drug Hazard

Never operate the engine while under the influence of alcohol or drugs, or when ill.

Exposure Hazard

Always wear personal protective equipment including appropriate clothing, gloves, work shoes and eye and hearing protection as required by the task at hand.

⚠ CAUTION

Poor Lighting Hazard

Ensure that the work area is adequately illuminated. Always install wire cages on portable safety lamps.

Tool Hazard

- Always use tools appropriate for the task at hand and use the correct size tool for loosening or tightening machine parts.
- Always remove any tools or shop rags used during maintenance from the area before operation.

NOTICE

Any part which is found defective as a result of inspection or any part whose measured value does not satisfy the standard or limit must be replaced.

Always tighten components to the specified torque. Loose parts can cause equipment damage or cause it to operate improperly.

Only use replacement parts specified. Other replacement parts may affect warranty coverage.

Never attempt to modify the engine design or safety features such as defeating the engine speed limit control or the diesel fuel injection quantity control.

Never attempt to adjust the low or high idle speed limit bolt. This may impair the safety and performance of the engine and shorten its life. Modifications of this type may void the warranty. If adjustment is ever required, contact your authorized Yanmar Marine dealer or distributor.

Modifications may impair the engine's safety and performance characteristics and shorten the engine's life. Any alterations to this engine may void its warranty. Be sure to use Yanmar genuine replacement parts.

NOTICE

- Follow the guidelines of the EPA or other governmental agencies for the proper disposal of hazardous materials such as engine oil, diesel fuel and engine coolant. Consult the local authorities or reclamation facility.

- Never dispose of hazardous materials by dumping them into a sewer, on the ground or into groundwater or waterways.

If any indicator illuminates during engine operation, stop the engine immediately. Determine the cause and repair the problem before continuing to operate the engine.

Make sure the engine is installed on a level surface. If a Yanmar Marine engine is installed at an angle that exceeds the specifications stated in the Yanmar Marine *Installation Manuals*, engine oil may enter the combustion chamber causing excessive engine speed, white exhaust smoke and serious engine damage. This applies to engines that run continuously or those that run for short periods of time.

The anode of the gear or drive is only calculated for the gear or drive. Changing the material of the propeller may require additional anodes to be installed on the gear or drive.

Section 3

EMISSION-RELATED INSTALLATION INSTRUCTIONS

(EPA Requirement for USA and Other Applicable Countries)

Page

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EMISSION-RELATED INSTALLATION INSTRUCTIONS (REQUIREMENTS FOR THE ENGINE THAT MEET EPA REGULATIONS OF §1042.130)

No modification for emission-related parts

You are not allowed to modify the emission-related parts without the permission of YANMAR.

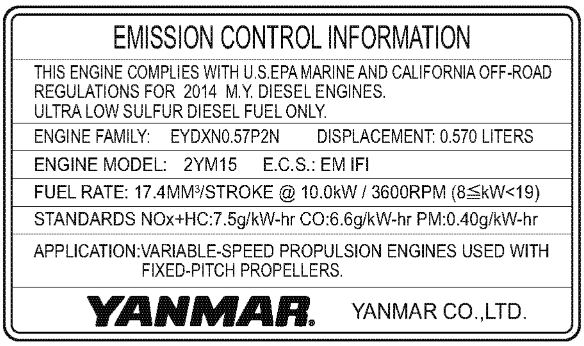
The typical emission-related parts are as follows:
Common rail system (fuel supply pump, rail, fuel injection nozzle), ECU, turbocharger, air cooler, temperature sensor, pressure sensor.
Mechanical fuel injection system (fuel injection pump, fuel injection nozzle)

If you are making modification from the specification confirmed in the installation evaluation, be sure to contact YANMAR in advance to have a re-evaluation.

Failing to follow these instructions when installing a certified engine in a vessel violates federal law (40 CFR 1068.105(b)), subject to fines or other penalties as described in the Clean Air Act.

Emission control information label

As an evidence of receiving the approval for the emission control regulation, Yanmar attached an "EMISSION CONTROL INFORMATION" label on the engine.


EMISSION CONTROL INFORMATION
THIS ENGINE COMPLIES WITH U.S.EPA MARINE AND CALIFORNIA OFF-ROAD REGULATIONS FOR 2014 M.Y. DIESEL ENGINES.
ULTRA LOW SULFUR DIESEL FUEL ONLY.
ENGINE FAMILY: EYDXN0.57P2N DISPLACEMENT: 0.570 LITERS
ENGINE MODEL: 2YM15 E.C.S.: EM IFI
FUEL RATE: 17.4MM³/STROKE @ 10.0kW / 3600RPM (8≦kW<19)
STANDARDS NOx+HC:7.5g/kW-hr CO:6.6g/kW-hr PM:0.40g/kW-hr
APPLICATION:VARIABLE-SPEED PROPULSION ENGINES USED WITH FIXED-PITCH PROPELLERS.
YANMAR YANMAR CO.,LTD.

128790-07712-E

Figure 3-1

If you install the engine in a way that makes the engine's emission control information label hard to read during normal engine maintenance, you must place a duplicate label on the vessel, as described in 40 CFR 1068.105.

Contact Yanmar Customer Support below:
Yanmar Customer Support
EMAIL: cs_support@yanmar.com
PHONE: +1-855-416-7091

Installation of recreational engine

Installing a recreational marine engine in a non-recreational vessel is a violation of 40 CFR 1068.101(a)(1).

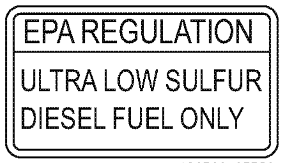
For the engine certified as a recreational engine, Yanmar attached a label stating as below:

"INSTALLING THIS RECREATIONAL ENGINE IN A COMMERCIAL VESSEL OR USING THE VESSEL FOR COMMERCIAL PURPOSES MAY VIOLATE FEDERAL LAW SUBJECT TO CIVIL PENALTY (40 CFR 1042.601)"

Fuel inlet label

In accordance with the EPA emission control regulations 40CFR1042.135, it is a requirement to attach a fuel inlet label near the fuel inlet of the boat.

The EPA Tier 3 (40CFR1042) certified models are attached with the labels **(Figure 3-2)**. If they are lost or damaged, please contact your Yanmar dealer or distributor.


EPA REGULATION
ULTRA LOW SULFUR
DIESEL FUEL ONLY

128790-07750

Figure 3-2

Note: It is also described "ULTRA LOW SULFUR DIESEL FUEL ONLY" on the EMISSION CONTROL INFORMATION label attached on the EPA Tier 3 (40 CFR 1042) certified engine.

Installation of exhaust system

Installation method of the exhaust system is described in this installation manual (Volume 1). *See Exhaust System on page 7-94*.

Measuring Exhaust Gas Emission

Measuring exhaust gas emission method is described in this installation manual (Volume 1). *See Measuring Exhaust Gas Emission on page 7-102*.

Section 4

ENGINE SELECTION GUIDE

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MAIN CONSIDERATIONS

Selecting the ideal propulsion system for a vessel is a process that requires special analysis. Boat manufacturers generally specify a range of propulsion requirements for specific vessels. Selecting a propulsion system within the manufacturer's parameters involves meeting specific manufacturer's requirements while addressing the desired performance characteristics of those individuals who use the vessel.

Overview

One user's performance requirements for a particular vessel might differ from those of another user's expectations for a vessel of the same dimensions. Because of the differences in requirements by the users, re-power projects do not automatically imply replacing an existing engine, marine gear and propeller with similar equipment. Each project (re-power or original equipment) is unique.

Operating range and economy are often the first items explored. These factors are used to determine the initial investment costs and an acceptable operating budget.

After identifying the desired operating range, available initial costs and fuel economy requirements, the primary considerations are vessel purpose, hull design, hull size and weight, and desired performance characteristics. Understanding these factors is necessary when selecting the propulsion system.

Vessels larger than approximately 6.7 m (22 ft) might be powered with a twin-screw configuration. Twin-screw applications have advantages and disadvantages, as do single-screw applications. Consideration must be given to these advantages and disadvantages as part of the engine selection process.

Speed and acceleration performance characteristics are driven by the user's needs in that area. Ski boats, for example, might require favorable acceleration curves, while cruising boats might best be served with the best fuel efficiency. Power output requirements are driven by the vessel's mass and need for speed.

Specifying the marine gear and propeller requires attention to the desired performance characteristics.

Re-Power Projects

Manufacturers generally specify propulsion equipment in terms of minimum and maximum weight and horsepower. These parameters often represent a wide range of possibilities. Because a vessel's purpose might change, re-power projects can involve increasing or decreasing engine horsepower.

Range

Range is a function of drivetrain efficiency and fuel capacity. It can be defined as the distance the vessel can be expected to travel with the maximum amount of fuel available on board. Generally, the larger the fuel tank capacity, the greater the range.

Economy

Fuel economy is a function of engine efficiency. It can be defined as the cost of exhausting the vessel's fuel capacity and full range.

The most efficient engines move a vessel further on a unit of fuel than less efficient engines. Slower vessels are generally more economical to operate.

Vessel Purpose

The purpose for which a vessel is used must be determined as part of the selection process. This three-volume manual addresses pleasure vessel applications.

■ Pleasure vessels

NOTICE

All information within this manual is relevant only to pleasure vessel applications.

Pleasure vessels range in size from runabouts as small as 5 m (16.5 ft) to larger crafts in excess of 15 m (50 ft). Because these vessels are classified as pleasure craft, they generally are burdened with relatively light workloads. Pleasure craft either have short-duty cycles, small power requirements or both of these elements.

Pleasure vessel engines are designed for pleasure vessel applications. These engines are designed to be operated at: maximum throttle for less than 5 % of its total operation time (30 minutes out of every 10 hours). Pleasure vessel engines should be operated at a cruising speed of (maximum min^{-1} (rpm) minus 200 - 400 min^{-1} (rpm)).

Pleasure vessels require a variety of different propulsion systems, depending on the operating environment and performance needs. Ski boats, fishing boats, cabin cruisers and sailboats might be operated in lakes, rivers or oceans. Like their work vessel counterparts, pleasure vessels may be operated in a variety of sea conditions.

For addition information, refer to the Yanmar Marine warranty “Limited warranty handbook” for recreational and light duty commercial applications.

■ Definition of a light duty commercial application

NOTICE

All information within this manual is relevant only to pleasure vessel applications.

Work vessels range in size from fishing charter boats as small as 5 m (16.5 ft) to large fishing trawlers larger than 15 m (50 ft). Because these vessels are classified as work vessels, they generally are burdened with heavy workloads. Work vessels either have long-duty cycles, high-power requirements or both of these elements.

Any engine used in a revenue producing, government service or rental use is considered a non-recreational craft application and is not covered by the Yanmar recreational limited warranty policy. Rental use is defined as a vessel used for pleasure charter, typically sailboats, sailing catamarans, power catamarans and trawlers. For an engine to be considered for a light duty commercial application it must fall within the following guidelines:

- Engine is operated at maximum output for less than 5 % of total operation hours.
- Standard operation is at less than 90 % of the maximum output RPM.
- Wide open throttle RPM’s, under load, must reach rated speed in any operating condition.
- Load factor must not exceed 35 %.
- Annual operation hours must not exceed 1000 hours.
- An approved application must be on file with the Yanmar regional headquarters before any commitments are made and before the project begins.

For addition information, refer to the Yanmar Marine warranty “Limited warranty handbook” for recreational and light duty commercial applications.

Work vessels require vastly different propulsion systems, depending on the type of commercial or government activity for which the watercraft is used. Water taxis, rescue vessels, tow boats and others might be operated in lakes, rivers or oceans.

Attention must be given to sea conditions (rough, oceanic vs. calm, inland waterways).

Hull Types

Watercraft are generally built in one of three basic design categories:

- Planing
- Displacement
- Semi-displacement

Each hull type exhibits performance characteristics with distinctive properties, each different from the others.

■ Planing hulls

Planing hulls are driven up on top of the water rather than being driven through the water **(Figure 4-1)**.

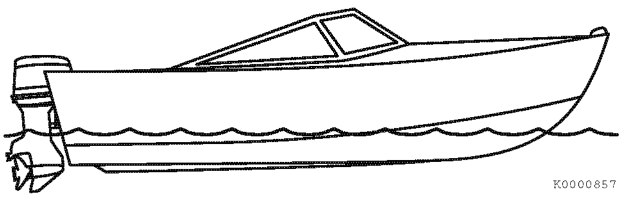

Figure 4-1

They are relatively fast hulls and typically have flat bottoms near the stern. These hulls are typically less seaworthy in high seas than displacement or semi-displacement hulls. When equipped with high power, high rpm propulsion systems, planing hulls offer extremely high speed capabilities.

■ Displacement hulls

Displacement hulls are driven through the water, rather than being pushed up on top of the water **(Figure 4-2)**.

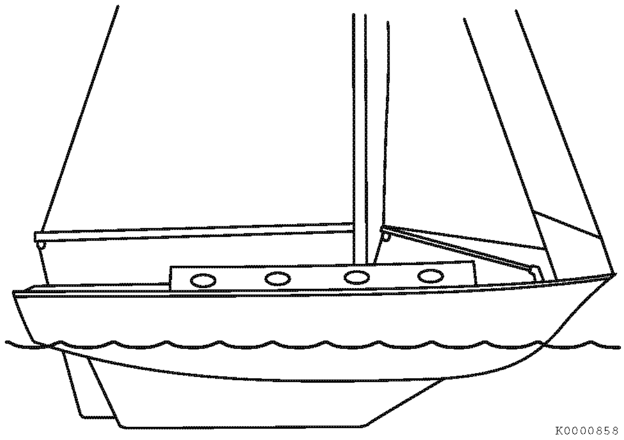

Figure 4-2

They are relatively slow hulls but can accommodate highly powerful propulsion systems and have useful cargo and towing capacity, compared to planing designs. The approximate maximum hull speed is defined as:

$$(1.34)\sqrt[2]{LWL} = V$$

Where:

LWL = Vessel length in feet (at waterline)

V = Maximum hull speed in knots

While additional horsepower can help maintain hull speed in adverse weather conditions, it cannot improve the maximum hull speed of displacement hulls. These hulls are typically very stable in high seas. When equipped with high power propulsion systems, displacement hulls offer favorable towing ability.

■ Semi-displacement

Semi-displacement hull designs represent a compromise between planing and displacement hull designs **(Figure 4-3)**.

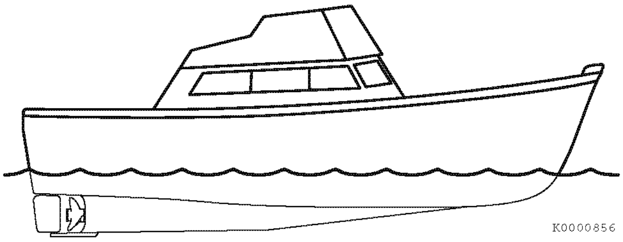

Figure 4-3

These hulls are slightly faster than displacement designs but more stable than planing hulls. While additional horsepower can help maintain hull speed in adverse weather conditions, it cannot improve the maximum hull speed of semi-displacement hulls. This hull design offers favorable cargo and towing capacity compared to planing designs.

Hull Displacement

Hull displacement is defined as the weight of water displaced by the total mass of a vessel. The greater the vessel hull displacement, the greater the horsepower required to move the vessel.

Displacement and semi-displacement hulls are most often driven by inboard engines. The engine power, marine gear, propeller and the number of engines are all a function of the hull displacement and the total power requirements.

Total maximum hull displacement is the sum total of all material and personnel mass onboard:

- Vessel displacement (empty weight)
- Engine
- Marine gear
- Ancillary equipment
- Cargo and provisions
- Fuel storage
- Passengers

When determining the horsepower requirements, consider the total hull displacement of the vessel. Determining the horsepower required to achieve maximum hull speed, given a specific hull displacement, involves calculating the speed-to-length ratio (SL). The horsepower requirement is typically calculated by the vessel manufacturer. The power and weight of the re-power propulsion system should not exceed the specification of the original design without consulting a naval architect.

■ Performance characteristics

Desired speed and acceleration are the determining factors when selecting the engine, marine gear and the propeller. *Refer to General on page 6-3 in Propeller Selection.*

Twin-Screw Applications

Most pleasure craft of modest dimensions and displacement or semi-displacement hull design, are candidates for single-screw applications. Larger vessels and fast planing vessels might best serve their users with twin-screw applications. The following table illustrates the advantages and disadvantages of twin-screw and single-screw applications.

	Twin-screw applications	**Single-screw applications**
Advantages	• Greater maneuverability • Greater speed and power • Safety after one engine loss	• Greater fuel economy • Greater range
Disadvantages	• Greater fuel consumption • Shorter range	• Less maneuverable • Slower and less powerful • No redundancy for engine loss

Marine Gear

Selection of a marine gear requires consideration of torque limits, rpm requirements and propeller selection. Horsepower loss inside the transmission is assumed to be 3 % (shaft hp - hp × 0.97). Some Yanmar Marine engines are equipped with marine gears and drives. Others can be matched with that equipment separately. In any case, the selection of this equipment is dependent upon gear reduction requirements, rpm and the propeller. For more details on propeller requirements, *refer to Propeller Selection on page 6-1.*

Inboard marine gears are installed in three different drive configurations:

- Parallel **(Figure 4-4)**
- Angle **(Figure 4-5)**
- V-drive **(Figure 4-6)**

Also within these configurations are mechanical and hydraulic clutch, mechanical or electric shift, and trolling.

Note: *Some mechanical gears need power capacity corrections when used with two or three cylinder engines.*

■ Parallel drive

The output shaft of the marine gear is parallel to the crankshaft **(Figure 4-4)**. The engine is installed at an angle. This configuration offers the greatest engine efficiency but might not provide the best possible hull efficiency.

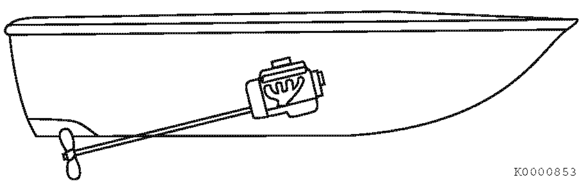

Figure 4-4

■ Angle drive

This configuration is sometimes called the down-angle drive system. The output shaft of the marine gear is inclined at 7 to 10° to the crankshaft **(Figure 4-5)**. The gentle inclination of the engine/marine gear package reduces space requirements in the engine room.

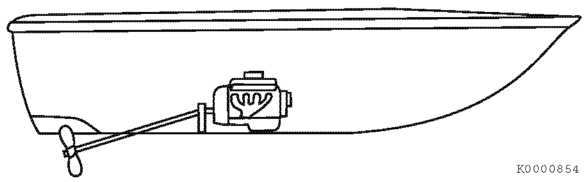

Figure 4-5

■ V-drive

In this configuration, the output shaft of the marine gear forms a V-shape with the input shaft. The propeller shaft leads aft compared with propeller angle drive and the engine is installed with the driveshaft facing forward **(Figure 4-6)**. The advantage of this type of marine gear is that a stern engine installation leaves more room for living space.

Refer to section 4 for more information on drives and gears.

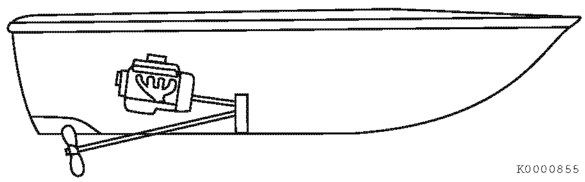

Figure 4-6

Power Rating Standard

The output of Yanmar's main propulsion engines for pleasure boat use is rated according to the Yanmar Industrial Standard (YIS).

The output testing conditions of the YIS are as follows:

■ Standard atmospheric condition (ambient condition)

	Unit	YIS
Atmospheric pressure	kPa (mmHg)	100 (750)
Temperature	°K (°C)	298 (25)
Relative humidity	%	30
Inlet seawater temperature	°K (°C)	303 (30)

■ Diesel fuel, Japanese Industrial Standard (JIS), K2204 No. 2

Note: For biodiesel information, refer to the latest service advisories or contact a Yanmar distributor.

Flash point	Above 50 °C (122 °F)
Distillation temperature (90 point)	350 °C (662 °F) maximum
Flow point	Below -7.5 °C (18.5 °F)
Carbon residue on 10 % residuum	Mass below 0.10 %
Cetane number	Above 45
Kinematic viscosity 30 °C	2.5 cSt minimum
Sulfur content	Below 0.05 %

■ Equipment attached to the engine when testing output

In the YIS, the engine output is measured with the following equipment installed. There is no need to consider any loss of output due to these engine attachments.

- Fuel feed pump
- Cooling water pump
- Alternator
- Intake air silencer

■ Output indication

Shown in kW and hp metric.

Yanmar conversion: 0.7355 kW = 1 hp metric

■ Rated output

Continuous rating output: The maximum output that the engine can produce continuously at a fixed engine speed under the standard atmospheric condition. Refer to Engine Specifications in vol. 2 and 3.

Maximum rating output: This value is determined by using international standards and is listed in each Engine Specification Chart of vol. 2 and 3.

Adjusting Output (De-Rating)

The engine output rating for Yanmar pleasure boat series engines is specified at the following standard atmospheric conditions:

Atmospheric pressure (P_r): 100 kPa (750 mmHg)

Ambient temperature (T_r): 298 °K (25 °C)

Relative humidity (Φ_x): 30 %

If the operating conditions are different from the standard atmospheric conditions, use the following formulas to adjust the engine output.

Formula 1: Formula for adjusting output (P)

$$P = kP_o$$

P :	Adjusted output (Output under standard atmospheric conditions)	kW
P_o :	Actually measured output	kW
k :	Coefficient of adjustment	

Formula 2: Calculating the coefficient of adjustment (k)

$$k = (f_a)^{f_m}$$

k :	Coefficient of adjustment
f_a :	Coefficient of atmospheric environment
f_m :	Coefficient of adjustment for air-fuel ratio

Formula 3: Calculating the coefficient of atmospheric environment (f_a)

The coefficient of atmospheric environment (f_a) varies with conditions (atmospheric pressure, ambient temperature and relative humidity) of the air taken in by the engine.

- Natural aspirated engine

$$f_a = \left(\frac{P_r - \Phi_r \times P_{sr}}{P_x - \Phi_x \times P_{sx}}\right)\left(\frac{T_x}{T_r}\right)^{0.7}$$

- Turbocharged engine

$$f_a = \left(\frac{P_r - \Phi_r \times P_{sr}}{P_x - \Phi_x \times P_{sx}}\right)^{0.7}\left(\frac{T_x}{T_r}\right)^{1.5}$$

f_a :	Coefficient of atmospheric environment	
P_r :	Standard atmospheric pressure	kPa (mmHg)
Φ_r :	Relative humidity under standard atmospheric condition	
P_{sr} :	Saturated vapor pressure under standard atmospheric condition	kPa (mmHg)
P_x :	Atmospheric pressure in operating environment	kPa (mmHg)
Φ_x :	Relative humidity in operating environment	%
P_{sx} :	Saturated vapor pressure in operating environment	kPa (mmHg)
T_x :	Intake air temperature in operating environment	°K (°C)
T_r :	Intake air temperature under standard atmospheric condition	°K (°C)

Saturated vapor pressure in relation to atmospheric temperature chart

Ambient temperature			Saturated vapor pressure		
°K	°C	°F	kPa	mmHg	in.Hg
293	20	68	2.337	17.53	0.6902
295	22	72	2.642	19.82	0.7803
297	24	75	2.983	22.38	0.8811
298	25	77	3.172	23.80	0.9370
299	26	79	3.360	25.21	0.9925
300	27	81	3.560	26.74	1.0528
301	28	82	3.779	28.35	1.1161
303	30	86	4.243	31.83	1.2531
305	32	90	4.755	35.67	1.4043
307	34	93	5.319	39.90	1.5709
309	36	97	5.941	44.57	1.7547
311	38	100	6.625	49.70	1.9567
313	40	104	7.377	55.34	2.1787
315	42	108	8.201	61.52	2.4220
317	44	111	9.103	68.29	2.6886
319	46	115	10.088	75.68	2.9795
321	48	118	11.164	83.75	3.2972
323	50	122	12.338	92.56	3.6441

Formula 4: Calculating the coefficient of adjustment for air-fuel ratio (f_m)

Note: Air-fuel ratio is the mass ratio of air and fuel supplied to the engine cylinder.

$$f_m = 0.036q_c - 1.14$$

$$q_c = \frac{q}{r}$$

r : Ratio of turbocharger outlet pressure to inlet pressure
- Naturally aspirated engine: 1
- Turbocharged engine: 1.2 - 2.0 (varies according to revolution speed and output)

q_c : Air-fuel ratio (mg/L-cycle)

q : Fuel supply quantity per cycle for engine displacement volume of one liter (mg/L-cycle)

$$q = \frac{\text{Specific fuel consumption} \times \text{Output (kW)} \times 1000}{60 \times \frac{\text{Engine speed}}{2} \times \text{Displacement}}$$

Specific fuel consumption: g/kW

Displacement: liter

Note: The coefficient of air-fuel ratio (f_m) is 0.3 when the air-fuel ratio (q_c) is less than 40 mg/L-cycle, and constant at 1.2 if the air-fuel ratio (f_m) exceeds 65 mg/L-cycle ***(Figure 4-7)****.*

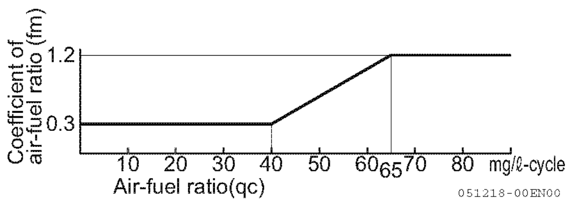

Figure 4-7

Calculating Engine Output Adjustment

The 6LY-STE engine is used for this example. Under standard atmospheric conditions the engine has the following characteristics:

Maximum output (at 3300 min^{-1}): 257.4 kW

Specific fuel consumption (at 3300 min^{-1}): 252 g/kW-h

The following values are from the standard atmospheric conditions presented in the *Saturated vapor pressure in relation to atmospheric temperature chart on page 4-10* and will be used in this example.

Atmospheric pressure (P_r): 100 kPa (750 mmHg)

Intake air temperature (T_r): 298 °K (25 °C)

Relative humidity (Φ_r): 30 % = 0.3

Saturated vapor pressure (P_{sr}): 3.172 kPa (23.80 mmHg)

In this exercise we need to calculate the maximum output for the 6LY-STE under these operating atmospheric conditions:

Atmospheric pressure (P_x): 96 kPa (720 mmHg)

Intake air temperature (T_x): 323 °K (50 °C)

Relative humidity (Φ_x): 60 % = 0.6

Saturated vapor pressure (P_{sx}): 12.338 kPa (92.56 mmHg)

Calculation of engine output adjustment:

In Formula 1 we substitute 257.4 kW for “P”. Note that we need to determine the value of “k”.

$$P = kP_o \Rightarrow P_o = \frac{257.4}{k}$$

To determine the value of “k” we will use Formula 2 and 3. Recall that Formula 2 is:

$$k = (f_a)^{f_m}$$

In Formula 3, we will substitute the values for standard atmospheric conditions and operating atmospheric conditions presented in the assumptions.

$$f_a = \left(\frac{P_r - \Phi_r \times P_{sr}}{P_x - \Phi_x \times P_{sx}}\right)^{0.7}\left(\frac{T_x}{T_r}\right)^{1.5}$$

$$f_a = \left(\frac{100 - 0.3 \times 3.172}{96 - 0.6 \times 12.338}\right)^{0.7} \times \left(\frac{323}{298}\right)^{1.5} = 1.218$$

Recall that Formula 4 is:

$$fm = 0.036q_c - 1.14$$

For turbocharged engine:

$$q_c = \frac{q}{r}$$

$$r = 1.2 \sim 2.0$$

$$q_c = \frac{q}{1.8}$$

$$q = \frac{\text{Specific fuel consumption} \times \text{Output (kW)} \times 1000}{60 \times \frac{\text{Engine speed}}{2} \times \text{Displacement}}$$

$$= \frac{252 \times 257.4 \times 1000}{60 \times \frac{3300}{2} \times 5.184} = 126.39\text{mg/L-cycle}$$

$$q_c = \frac{126.39}{1.8} = 70.22$$

Substituting value for q_c back into Formula 4:

$$f_m = 0.036 \times 70.22 - 1.14 = 1.39$$

Substituting f_a and f_m back into Formula 2:

$$k = fa^{fm}$$

$$= 1.218^{1.39}$$

$$k = 1.32$$

Substituting value “k” back into Formula 1:

$$P_o = \frac{P}{k}$$

$$= \frac{257.4}{1.32}$$

$$P_o = 195\text{kW}$$

Altitude Correction for Atmospheric Pressure (P_x)

Formula:

$$P_x = P_r(1 - 0.00002257h)$$

P_x :	Atmospheric pressure at altitude, h (m)	kPa (mmHg)
P_r :	Standard atmospheric pressure at 0 (zero meters above seal level)	100 kPa (750 mmHg)
h :	Altitude	m

Calculation of Altitude Correction for Atmospheric Temperature (T_x)

Formula:

$$T_x = T_r - (1 - 0.0065h)$$

T_x :	Atmospheric temperature at altitude, h	C°
T_r :	Standard atmospheric temperature at 0 (zero meters above sea level)	25 °C
h :	Altitude	m

Relationship Between Atmospheric Pressure and Temperature

Altitude (m)	Atmospheric pressure kPa (mmHg)	Atmospheric temperature °K (°C)	Altitude (m)	Atmospheric pressure kPa (mmHg)	Atmospheric temperature °K (°C)
0	100.0 (750)	298.0 (25.0)	1400	84.5 (634)	288.9 (15.9)
100	98.8 (741)	297.4 (24.4)	1600	82.5 (619)	287.6 (14.6)
200	97.7 (732)	296.7 (23.7)	1800	80.5 (604)	286.3 (13.3)
400	95.4 (716)	295.4 (22.4)	2000	78.5 (589)	285.0 (12.0)
600	93.1 (698)	294.1 (21.1)	2500	73.7 (553)	281.8 (8.8)
800	90.9 (682)	292.8 (19.8)	3000	69.3 (520)	278.5 (5.5)
1000	88.7 (665)	291.5 (18.5)	3500	65.0 (488)	275.3 (2.3)
1200	86.6 (650)	290.2 (17.2)	4000	60.9 (457)	272.0 (-1)

Obtaining Relative Humidity by Dry and Wet Bulb Hydrometer

Note: Relative humidity is obtained from the following table when the wet bulb is not frozen.

Dry bulb K (t)	Difference between dry bulb and wet bulb K-K' (t-t')										
	273.0 (0.0)	273.5 (0.5)	274.0 (1.0)	274.5 (1.5)	275.0 (2.0)	275.5 (2.5)	276.0 (3.0)	276.5 (3.5)	277.0 (4.0)	277.5 (4.5)	278.0 (5.0)
313 (40)	100	97	94	91	88	85	82	79	76	73	71
308 (35)	100	97	93	90	87	83	80	77	74	71	68
303 (30)	100	96	92	89	85	82	78	75	72	68	65
298 (25)	100	96	92	88	84	80	76	72	68	65	61
293 (20)	100	95	91	86	81	77	73	68	64	60	56
288 (15)	100	95	89	84	78	73	68	63	58	53	48
283 (10)	100	93	87	81	74	68	62	56	50	44	38
278 (5)	100	92	84	76	68	60	53	46	38	31	24
273 (0)	100	90	80	70	60	50	40	31	21	12	3
268 (-5)	100	87	74	61	48	35	22	9			
263 (-10)	100	82	64	47	29	12					

Dry bulb K (t)	Difference between dry bulb and wet bulb K-K' (t-t')									
	278.5 (5.5)	279.0 (6.0)	279.5 (6.5)	280.0 (7.0)	280.5 (7.5)	281.0 (8.0)	281.5 (8.5)	282.0 (9.0)	282.5 (9.5)	283.0 (10.0)
313 (40)	68	66	63	61	58	56	53	51	49	47
308 (35)	65	63	60	57	55	52	49	47	44	42
303 (30)	62	59	56	53	50	47	44	41	39	36
289 (25)	57	54	51	47	44	41	38	34	31	28
293 (20)	52	48	44	40	36	32	29	25	21	18
288 (15)	44	39	34	30	25	21	16	12	8	4
283 (10)	32	27	21	16	10	5				
278 (5)	16	9	2							
273 (0)										
268 (-5)										
263 (-10)										

Air Volume Necessary for Engine Combustion

The minimum theoretical air volume necessary for the complete combustion of one kilogram of fuel is about 14.6 kg ≈ 12.5 m^3. In practice more air is needed. The ratio of auxiliary air volume to the theoretical minimum is called the excess air ratio.

In diesel engines, the excess air ratio is 1.5 - 2.0 at full load, i.e., the air volume needed is 1.5 - 2.0 times more than the theoretical minimum air volume.

The simple calculation to obtain the required air volume from the engine's total displacement is as follows.

Formula of required air volume:

$$Q_1 = K_t \times V_s \times N \times C \times 10^{-3}$$

Q_1 :	Required intake air volume	m^3/min.
K_t :	Volumetric efficiency	
	• Naturally aspirated engine	0.85 - 0.9
	• Turbocharged engine	1.3
V_s :	Engine displacement	L
N :	Engine speed	min^{-1}
C :	Constant, 4-cycle engine	1/2

Example: Engine model 4JH4-TE

- Type: 4-cycle, vertical water-cooled diesel engine
- Aspiration: Turbocharged with intercooler
- Displacement: 1.995 L
- Maximum rating output: 55.2 kW (75 hp)/3200 min^{-1}

$$= \frac{1.3 \times 1.995 \times 3200 \times 0.5}{1000}$$

$$= 4.15 \ m^3/min$$

Section 5

ENGINE MOUNTING

Page

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ENGINE AND DRIVE CONFIGURATIONS

Engine alignment and mounting is a critical operation that requires a high level of accuracy and attention to detail. Engines need to be aligned and matched properly with shafts and marine gears while maintaining the appropriate positional relationship between the propeller and the vessel. The entire propulsion system (engine, shafts, marine gear and propeller) must engage the water in the most efficient way possible, answering the operator's performance requirements. For large vessels driven by high-power propulsion systems, a qualified naval architect must verify the application's structural integrity.

Each engine has inclination angle limits. Exceeding these limits causes engine cooling or lubrication problems. Refer to the engine specifications for appropriate data.

Engine and propeller selection are critical to successful installation and mounting. Engine selection precedes propeller selection. Refer to the *Propeller Selection* and *Engine Selection Guide* sections for more information.

Inboard Applications for Displacement and Semi-Displacement Hulls

■ Trim tabs

Since inboard propulsion systems have propellers that are generally fixed, trim adjustments are not possible on such systems. Separate trim systems can be installed. A hydraulically controlled trim system contributes to vessel stability while underway **(Figure 5-1)**.

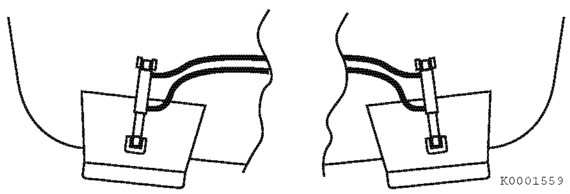


Figure 5-1

Adjusting the trim tabs brings the vessel to level roll, compensating for changes in weight distribution as passengers move about the deck or cabin.

Marine Gear Systems

The marine gear is installed to transfer and control power from the crankshaft to the propeller driveshaft. Through a system of gears and reducers, engine power can be transferred to one of three positions:

- FORWARD
- AFT
- NEUTRAL

■ Type of marine gear

The basic types of marine gear are the mechanical and the hydraulic mechanisms. These are operated by the remote control handle.

Mechanical

Mechanical gear systems are usually used with pleasure craft engines under 100 hp. More force is needed to shift gears when using the mechanical gear.

Hydraulic

The hydraulic gear is usually used for boats with high output engines, especially powerboats. Hydraulic gear systems make shifting easier and are often used for dual station control systems.

Engine Configurations

Inboard or sterndrive engine configurations are installed in single- or multi-screw arrangements.

■ Single-screw configuration

The most basic configuration is the simple single engine application **(Figure 5-2)**.

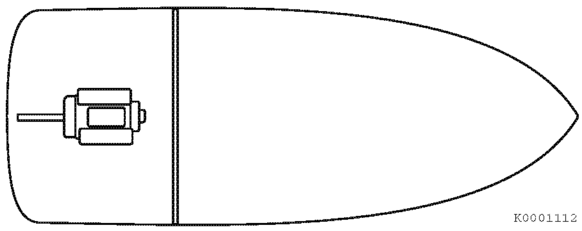


Figure 5-2

The ideal installation is one in which the propeller shaft is aligned with the vessel's center line. In small vessels, when right-hand propeller rotation is used, the helm is best situated on the starboard side. Propeller force tends to torque the vessel, sinking the port side of the vessel lower in the water. The helmsman's weight tends to counter that force. When left-hand propeller rotation is used, the helm is best situated on the port side.

■ Twin-screw configuration

Two-screw applications allow for greater power and maneuverability than single-screw applications. The power of both engines contribute to added thrust **(Figure 5-3)**. In congested harbors, marine gears can be shifted counter to one another. For example, if the port gear is shifted forward and starboard gear is shifted aft, the vessel can come to port far more sharply then a single-screw vessel.

Since the port propeller rotates counter to the starboard propeller, the propeller wash is equal on both sides with no measurable tracking.

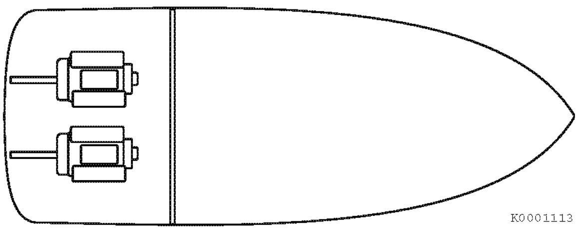


Figure 5-3

The ideal installation is one in which the propeller shafts are aligned with equal distance to the center line, maintaining perfect symmetry.

■ Triple-screw configuration

Three-engine applications allow for greater power and maneuverability than two-engine applications. The power of all engines contribute to added thrust **(Figure 5-4)**.

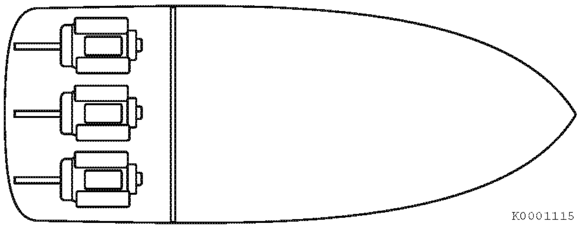


Figure 5-4

The ideal installation is one in which the port and starboard propeller shafts are aligned with equal distance to the center line. The center engine is aligned with the center line, maintaining perfect symmetry between all propellers.

Staggered triple-screw

Staggered triple-screw applications allow for closer propeller shaft positions than traditional side-by-side systems. With the propeller shafts closer together, a more stable cruise is achieved, especially at top speed **(Figure 5-5)**. Some power losses are associated with longer shafts and additional hardware.

The center propeller rotation is best when it rotates counter to the helm position.

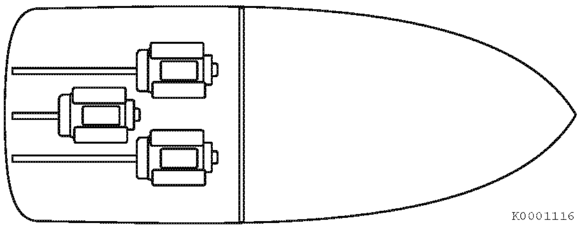


Figure 5-5

Stern Drive Applications for Planing Hulls

Engines matched with sterndrives are nearly always level-mounted with no forward-to-aft inclination when the vessel is at rest in the water. Multi-engine sterndrive applications are installed in standard or staggered configurations. The same principles of geometric symmetry and weight distribution that apply to inboard installations also apply to sterndrive applications.

ENGINE ROOM PREPARATION

⚠ DANGER

Crush Hazard

Never stand under a hoisted engine. If the hoist mechanism fails, the engine will fall causing serious injury or death.

⚠ WARNING

Exhaust Hazards

- **Never operate the engine in an enclosed area, such as a garage, tunnel, underground room, manhole or ship's hold, without proper ventilation.**
- **Never block windows, vents or other means of ventilation if the engine is operating in an enclosed area. All internal combustion engines create carbon monoxide gas during operation. Accumulation of this gas within an enclosure could cause illness or even death.**
- **Make sure that all connections are tightened to specifications after repair is made to the exhaust system.**

⚠ WARNING

Fire and Explosion Hazard

The starter motor, alternator and other electrical components are not classified as "ignition protected" components. Be sure to use caution to prevent accidental ignition within the engine room.

The single most important area in the engine room is the space occupied by the engine. It is the engine position that is established first. All other equipment must be arranged around the engine in its ideal position. The angular position of the engine relative to the vessel is critical to overall performance.

Plan and install critical engine and support equipment before the actual engine installation. Special devices and fittings for the engine are often best installed before securing the engine onto the mounting system. The seacock cover location and related hull drilling are best addressed at this point in the process.

Preparing the engine room for engine installation is an exercise in space planning. The main considerations are:

- Seawater pickup and cooling water requirements
- Engine angular position relative to the vessel (yaw, roll and pitch)
- Propeller shaft surface depth relative to the waterline
- Space requirements for engine systems in the engine room
- Serviceability (service space around the engine)
- Symmetry and weight distribution (affects roll)
- Engine room ventilation and combustion air requirements.

Hull at Rest in Water

NOTICE

Make sure the engine is installed on a level surface. If a Yanmar Marine engine is installed at an angle that exceeds the specifications stated in the Yanmar Marine Installation Manuals, the engine lubrication system and cooling system may fail causing serious engine damage. This applies to engines that run continuously and those that run for short periods of time.

The propeller shaft angle varies depending upon the hull shape and the engine installation arrangement.

The maximum allowable engine angle is up to 20°.

The maximum permissible engine angle is measured between the crankshaft center line and the waterline. The peak angle is the maximum engine angle that continues for under ten seconds during pitching (β & λ) or rolling (α) (4, **Figure 5-6**). These angles differ depending upon the engine model. The propeller shaft angle (1 and 2, **Figure 5-6**) relative to the waterline (3, **Figure 5-6**) influences the engine inclination.

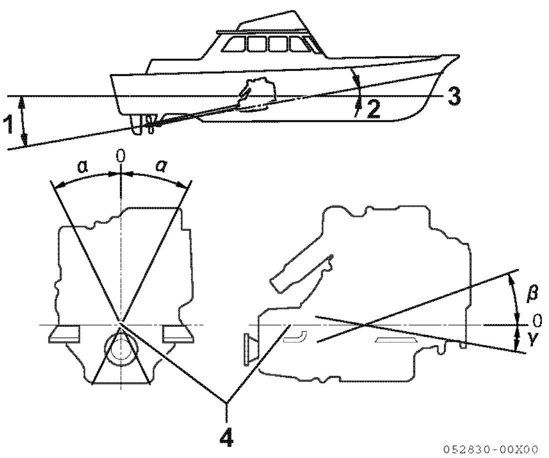


Figure 5-6

	Installation	Constant	Peak
α (left/right)	0°	0° to 20°	0° to 30°
β/λ (up/down)	0° to 8°	-2° to 20°	-10° to 25°

Engine inclination angles that exceed the engine's allowable limits can cause engine seizure, overheating or decreased propulsion efficiency due to hampered cooling and lubrication capacity.

Yaw Angle

Consider the propulsion system symmetry relative to the vessel's center line before engine installation and mounting. In both single-screw and multi-screw applications, driveshaft yaw angle relative to the center line must be held to a minimum.

The center line (1, **Figure 5-7**) is defined as a theoretical line constructed parallel to the sea surface (3, **Figure 5-7**) from the forward-most portion of the bow to a point on a vertical line constructed at the aft-most portion of the stern (2, **Figure 5-7**). The center line is aligned with the vessel's true course line (ignoring current and wind influence) when underway.

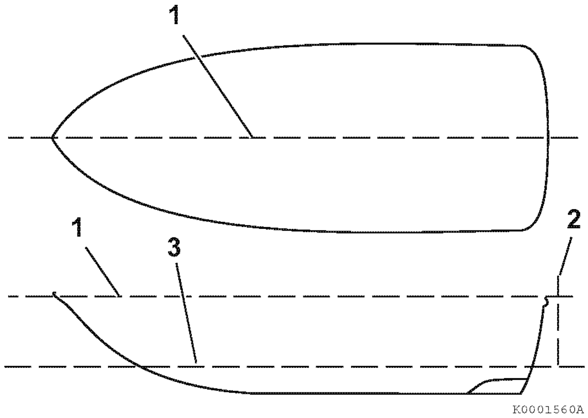


Figure 5-7

Driveshaft yaw angle is defined as the angle between two theoretical planes:

- **Propeller shaft plane** - A theoretical plane constructed perpendicular to the sea surface and parallel to the propeller shaft.
- **Vessel center plane** - A plane constructed perpendicular to the sea surface and parallel to the center line.

In a theoretically perfect single-screw installation, these two planes are one in the same. In practice, a margin of error is present for which correction is required **(Figure 5-8)**.

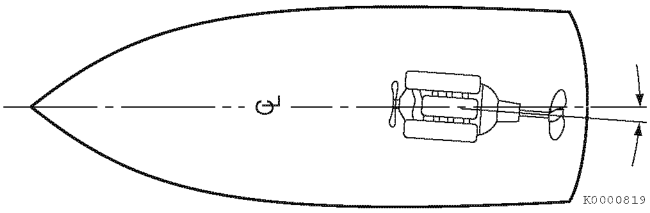


Figure 5-8

The stringers might not be parallel to the center line. They might not be level with the sea surface. If the stringer system is asymmetrical, alteration to the stringer system is needed. The angle between the stringer edge and a line constructed that is parallel to and adjacent to one end of that stringer, represents the stringer yaw angle.

Measuring Stringer Symmetry

1. Locate a point at the center line on the aft-most portion of the vessel.
2. Locate a point on the center line at least 5 cm (2.0 in.) forward of the forward-most portion of the stringers (1, **Figure 5-9**).

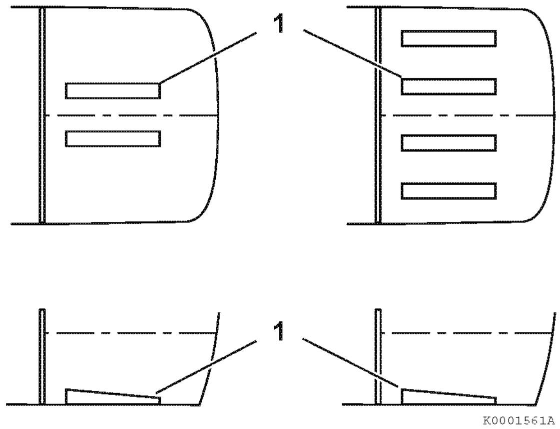


Figure 5-9

3. String a reference line between these two points.
4. Measure the distance between the center stringers to the aft center on both the port and starboard (1 and 2, **Figure 5-10**) sides.

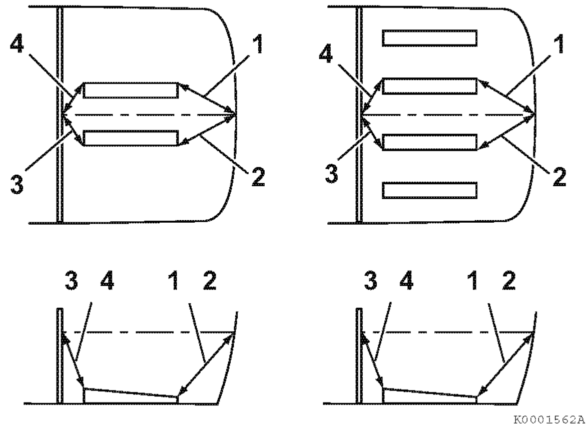


Figure 5-10

5. Measure the distance between the center stringers to the forward center on both the port and starboard (3 and 4, **Figure 5-10**) sides.

   If measurements from the port stringer to the center line are equal to the measurements from the starboard stringer to the center line, the stringers are properly centered. If not, modify as needed.
6. Identify the mounting hole locations for each stringer set based on installation drawings or templates.
7. Measure the cross-dimensions between the stringers in each stringer set (3, **Figure 5-11**). These measurements should be equal. If not, modify the stringer system as needed.

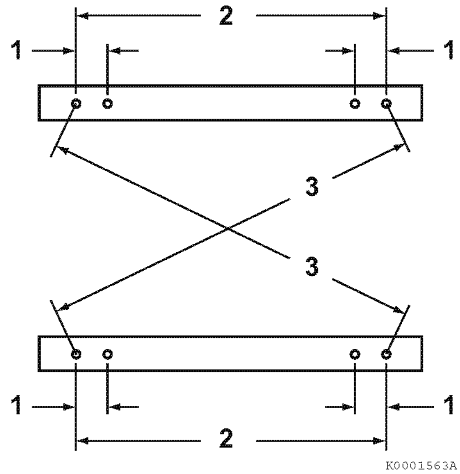


Figure 5-11

8. Measure the stringer length mounting hole dimensions center-to-center for each stringer set (2, **Figure 5-11**). These measurements should be equal. If not, modify the stringer system as needed.
9. Measure the individual mounting hole dimensions center-to-center for each stringer set (1, **Figure 5-11**). These measurements should be equal. If not, modify the stringer system as needed.
10. String a reference line (2, **Figure 5-12**) between points as shown (1 and 3, **Figure 5-12**).

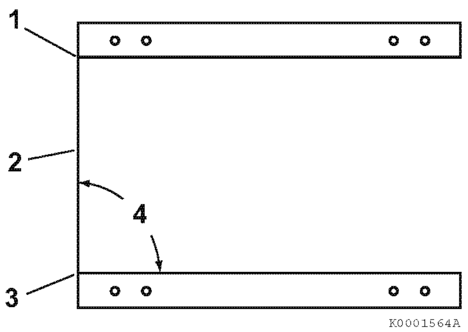


Figure 5-12

11. Measure the angle between the line and the stringer.
12. A measure of 90° (4, **Figure 5-12**) indicates symmetry in the stringer system. Modify as needed.
13. Use a straightedge to ensure that the engine bed or stringer system is even, both forward-to-aft and port-to-starboard (1, **Figure 5-13**). Levels can be used if the vessel is moved, bringing the mounting system to a level position. The engine mounting hardware receives uneven stress if the engine mounting surfaces are uneven. This can loosen the mounting hardware during engine operation **(Figure 5-14)**.

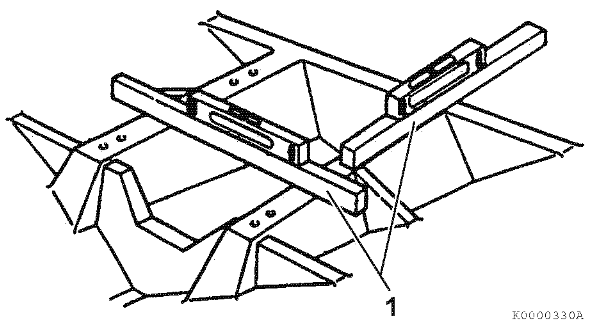
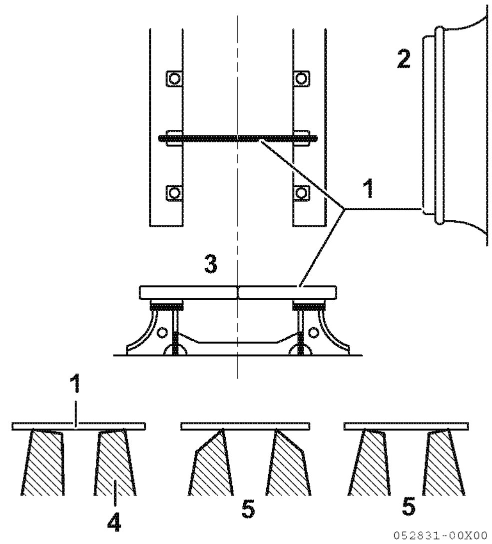


Figure 5-13



1 – Straightedge
2 – Stringer
3 – Port-to-starboard check
4 – Acceptable mounting
5 – Unacceptable mounting

Figure 5-14

Note: The purpose of this exercise is to assure a firm platform for mounting the engine mounts (rubber isolators) on a parallel plane to the engine center line.

Propeller Shaft Centering

The following steps represent the traditional process by which the propeller shaft is properly centered and aligned. Drilling for shaft clearances is critical. Jigs can be designed for this purpose but the geometry is critical and must be verified before using such a jig.

Note: There are many other procedures in use today including laser beam technology.

1. Determine the forward-to-aft positions “o” and “y” of the propeller shaft center line as shown **(Figure 5-15)**.

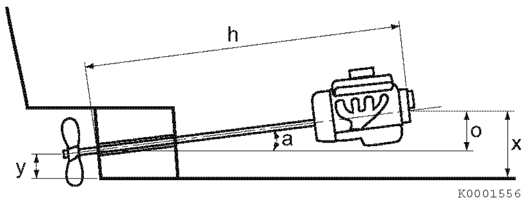


Figure 5-15

Apply the following formula when determining the forward-to-aft positions:

$$\sin\alpha = \frac{o}{h}$$

$$x = o + y$$

Where:

$\sin\alpha$ = Propeller shaft angle

o = Side opposite length

h = Hypotenuse length

y = Propeller height

x = Forward engine height

2. Drill a pilot hole smaller than the stern tube diameter(1, **Figure 5-16**), (7, **Figure 5-17**).

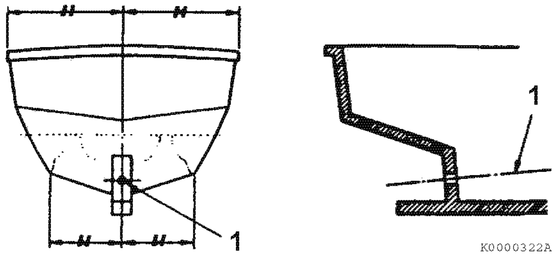


Figure 5-16

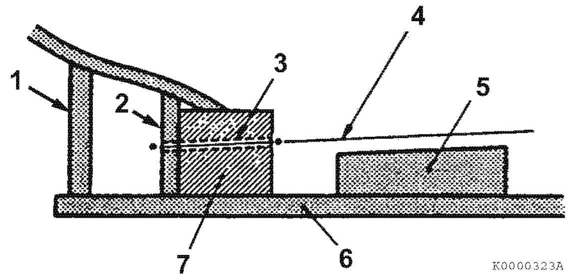


Figure 5-17

3. Pass a centering line (4, **Figure 5-17**) through the pilot hole (3, **Figure 5-17**) and fasten one end to the steering post (1, **Figure 5-17**) and the other end to the forward engine room bulkhead. Observe the positional relationship between the stringer system (5, **Figure 5-17**) and the centering line. Measurements must indicate symmetry. If not, modify as needed.
4. Measure the shaft angle between the hull floor and the centering line (6, **Figure 5-17**) and ensure that the angle is consistent with the specification.
5. Ensure that the propeller dimensions are compatible with the space between the steering post (1, **Figure 5-17**) and shaft penetration point (2, **Figure 5-17**).

6. Construct a parallel cross-frame jig and attach it to the aft bulkhead **(Figure 5-18)**.

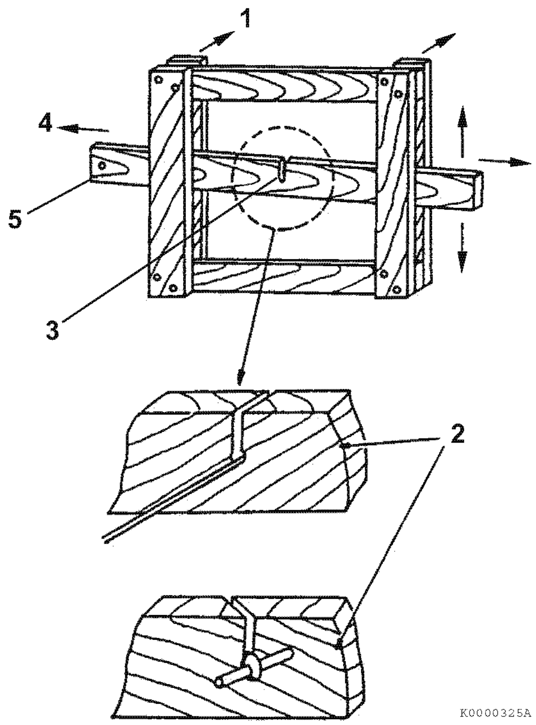
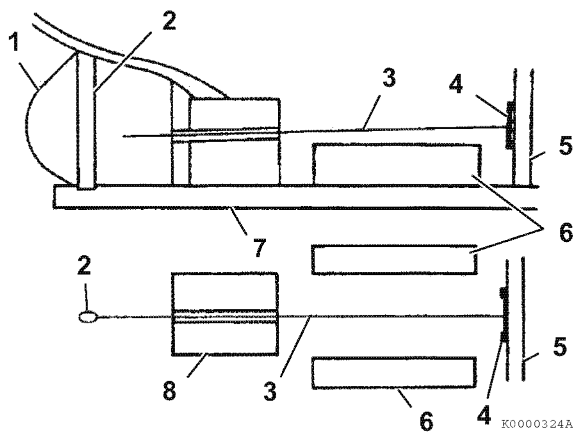


Figure 5-18

7. Insert plate "A", (5, **Figure 5-18**) which carries the centering line. Plate A should be moveable in all directions so that the line position can be corrected.
8. Fasten the line as illustrated in (2, **Figure 5-18**) for easy removal. The hole in this plate permits pencil marking or inspection after line removal.
9. The jig (1, **Figure 5-18**) allows for fine adjustments to the center (3, **Figure 5-18**) line by moving the centering bar (4, **Figure 5-18**).
10. Refer to the installation drawings to determine a mounting arrangement on the stringer system that is consistent with the propeller shaft angle and engine inclination requirements. Build onto the stringer system as needed **(Figure 5-19)**.



1 – Rudder
2 – Steering post
3 – Centering line
4 – Jig
5 – Transom
6 – Stringer system
7 – Hull floor
8 – Shaft drilling

Figure 5-19

Final Drilling and Stern Tube Installation

1. Observe the centering line. This is the reference for the final drilling (1, **Figure 5-20**).

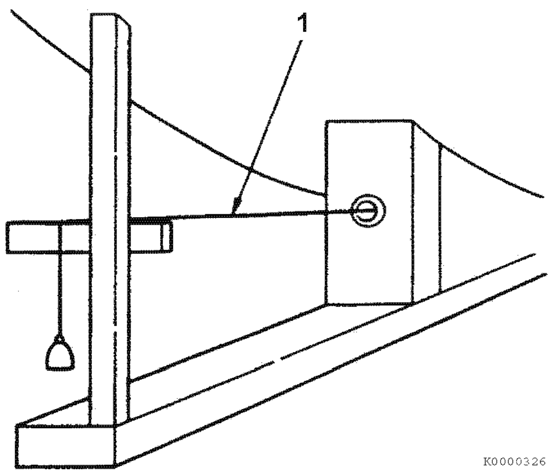
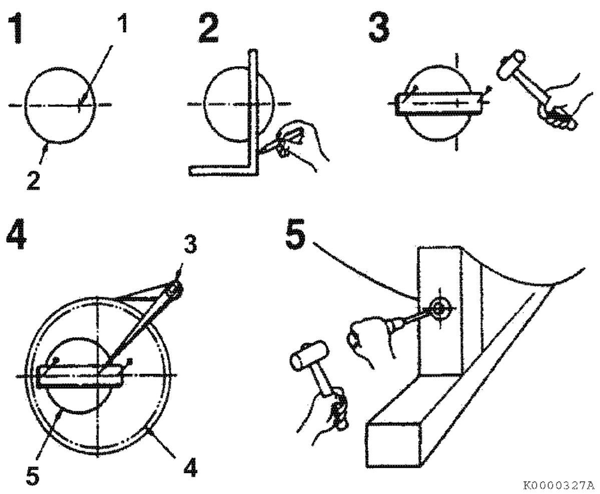


Figure 5-20

2. Using the centering line as a reference, scribe a precise cutting mark on each side of the stern box for the stern tube hole **(Figure 5-21)**.



1 – Pilot hole
2 – Squaring
3 – Temporary drill centering block
4 – Scribing mark
5 – Final hole location

Figure 5-21

3. Drill the final hole while maintaining the proper drill angle.

■ Fitting to stern tube tightening surface

There are different types of stern tubes:

- Attached to the stern port
- Attached with bolts
- Dripless shaft seal

1. When the stern tube attaches with bolts, apply sealing agent and secure with bolts (1, **Figure 5-22**).

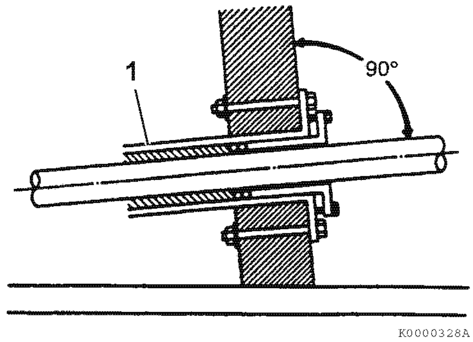


Figure 5-22

Note: Shaft stern tube shown is with bearing. Refer to accepted engineering standards (such as ABYC) to determine if bearing is necessary.

2. Apply an appropriate sealing agent on the stern tube exterior and press it into place.
3. Ensure that the stern tube is clear of sealing agent or any other foreign material.

Note: The dripless shaft seal system requires seawater lubrication. Refer to individual engine sections (vol. 2 and 3) for location of seawater supply.

Installing the Propeller Shaft

1. Apply an appropriate sealing agent, insert the propeller shaft and secure with bolts **(Figure 5-23)**. Avoid damaging the rubber or metal with the threaded parts.

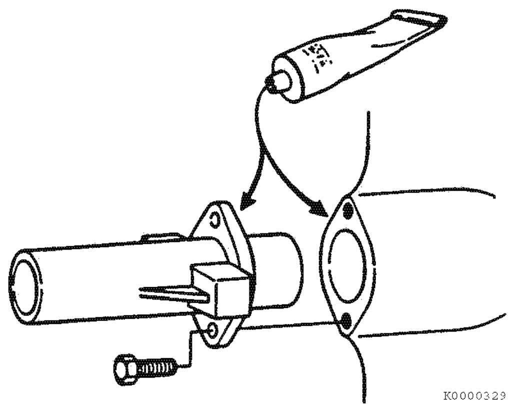


Figure 5-23

2. Temporarily attach the propeller shaft joint to the engine side and ensure that it rotates freely.

Engine Alignment

1. Attach the alignment device (2, **Figure 5-24**) to the propeller shaft flange (1, **Figure 5-24**) and prepare a centering line as shown.

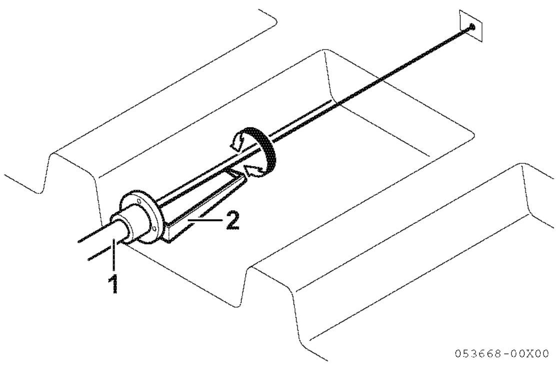


Figure 5-24

2. Slowly turn the propeller shaft. The alignment device (3, **Figure 5-25**) rotates around the center line (2, **Figure 5-25**). With the center line centered in the shaft (1, **Figure 5-25**), the amount of eccentricity is indicated by observing the end of the alignment tool relative to the center line.

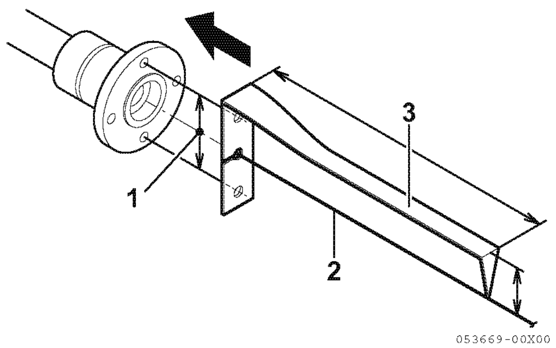


Figure 5-25

3. Adjust the centering line as needed.

Engine Mounts

1. Fabricate an accurate jig based on the installation drawings **(Figure 5-26)**. This jig must have indicating tabs that represent the true shaft location relative to the center line (2, **Figure 5-26**). The jig must also indicate space for the marine gear (1, **Figure 5-26**).

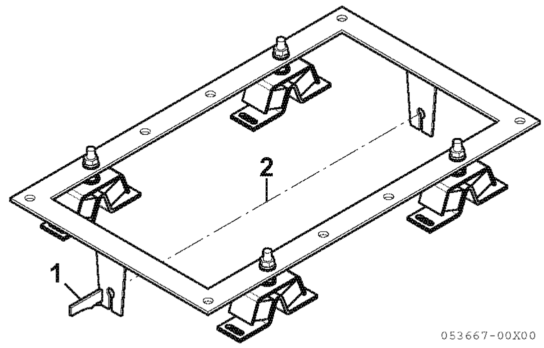
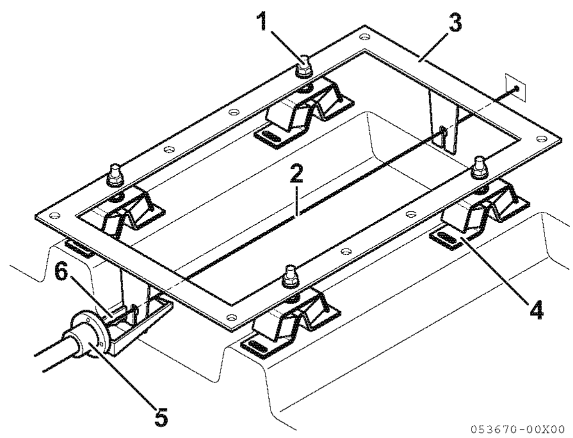


Figure 5-26

2. Temporarily attach the engine mounts to the jig.

3. Place the jig on the stringer system over the centering line **(Figure 5-27)**.



1 – Adjusting nuts
2 – Stringer
3 – Jig
4 – Engine mounts
5 – Propeller shaft flange
6 – Center line

Figure 5-27

*Note: For alternative methods of jig construction, refer to **Figure 5-28**.*

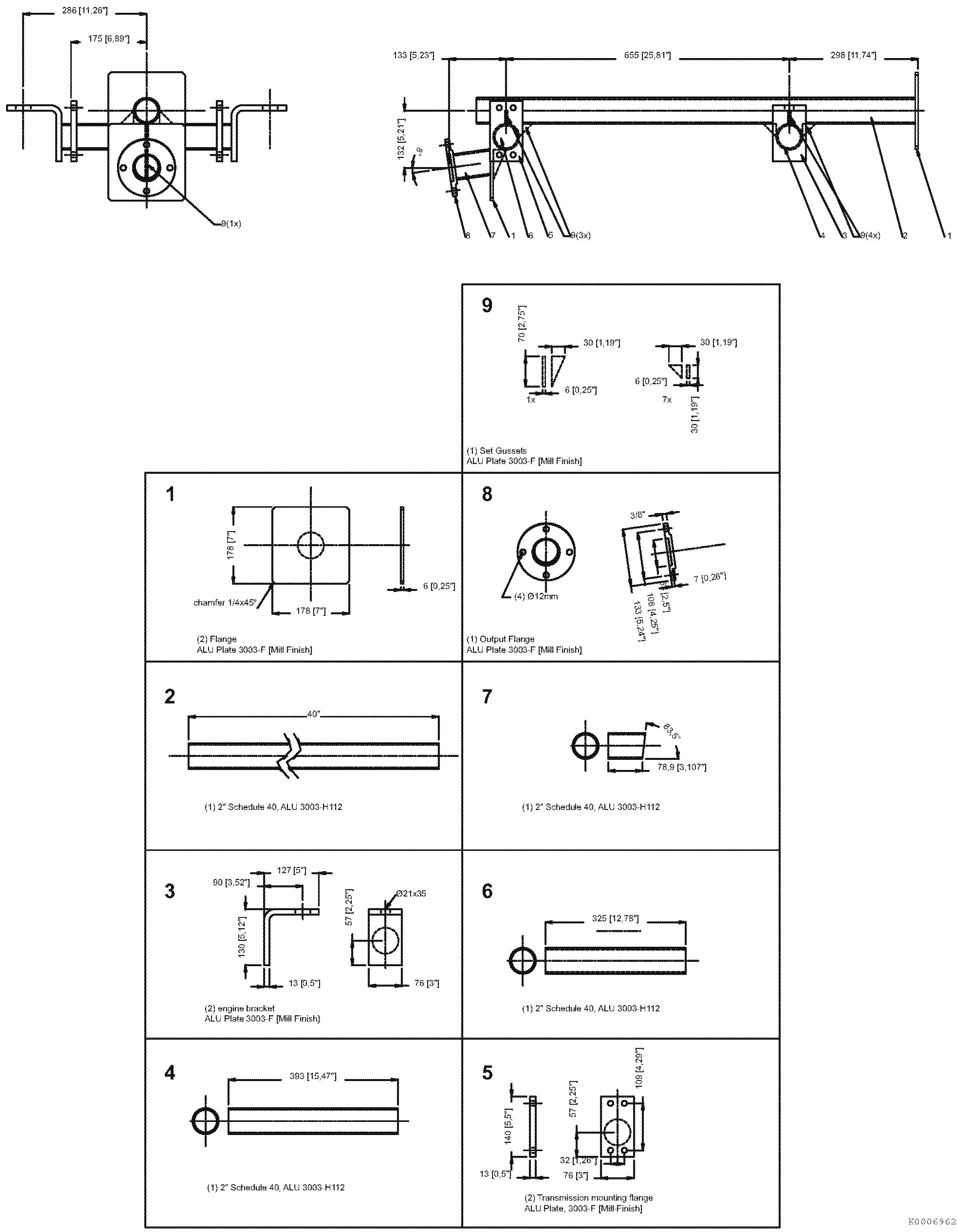

286 [11,26"]
175 [6,89"]
9(1x)
133 [5,23"]
655 [25,81"]
298 [11,74"]
132 [5,21"]
8
7
1
6
5
9(3x)
4
3
9(4x)
2
1
9
70 [2,75"]
30 [1,19"]
6 [0,25"]
1x
7x
(1) Set Gussets
ALU Plate 3003-F [Mill Finish]
1
178 [7"]
6 [0,25"]
chamfer 1/4x45°
(2) Flange
ALU Plate 3003-F [Mill Finish]
8
3/8"
7 [0,26"]
(4) Ø12mm
108 [4,25"]
133 [5,24"]
(1) Output Flange
ALU Plate 3003-F [Mill Finish]
2
40"
(1) 2" Schedule 40, ALU 3003-H112
7
83,5°
78,9 [3,107"]
(1) 2" Schedule 40, ALU 3003-H112
3
127 [5"]
90 [3,52"]
Ø21x35
57 [2,25"]
130 [5,12"]
13 [0,5"]
76 [3"]
(2) engine bracket
ALU Plate 3003-F [Mill Finish]
6
325 [12,78"]
(1) 2" Schedule 40, ALU 3003-H112
4
393 [15,47"]
(1) 2" Schedule 40, ALU 3003-H112
5
109 [4,29"]
57 [2,25"]
140 [5,5"]
32 [1,26"]
13 [0,5"]
76 [3"]
(2) Transmission mounting flange
ALU Plate, 3003-F [Mill-Finish]
K0006962

Figure 5-28

4. Adjust the engine mounts to the approximate position that represents the propeller shaft. When fixing the flexible engine mount (1, **Figure 5-29**) to the jig, ensure that dimension "H" is in the center of the adjusting range.

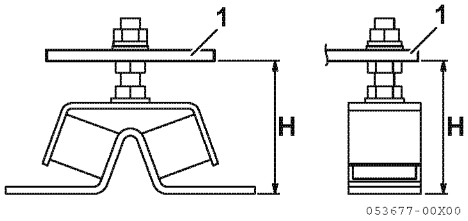


Figure 5-29

5. When the center of the propeller shaft is aligned, and the engine mounts are properly positioned, clearly mark the engine mounting hole locations.
6. Label the mounts "*port forward*," "*port aft*," "*starboard forward*" and "*starboard aft*" accordingly.
7. Remove the jig.
8. Remove the flexible engine mounts from the jig.
9. With the mounting hole locations positively identified and marked, drill the holes.

Precise drilling reduces stresses across the mounts. If no jig is available, the holes can be drilled after the engine is set on the stringers. This method allows the engine with mounts attached to be used as a hole-marking template. If the holes are drilled before the engine is installed, the hole pattern must be accurate to within 1.5 mm (0.06 in.) on all the dimensions.

MARINE ENGINE MOUNTS

⚠ DANGER

Crush Hazard

Never stand under a hoisted engine.

The following information describes basic marine engine mount installation and adjustment. For additional information, refer to Installation vol. 2 and 3.

NOTICE

Always follow the marine mount OEM installation and adjustment procedures, as supplied by the OEM. Contact the marine mount OEM directly for additional information.

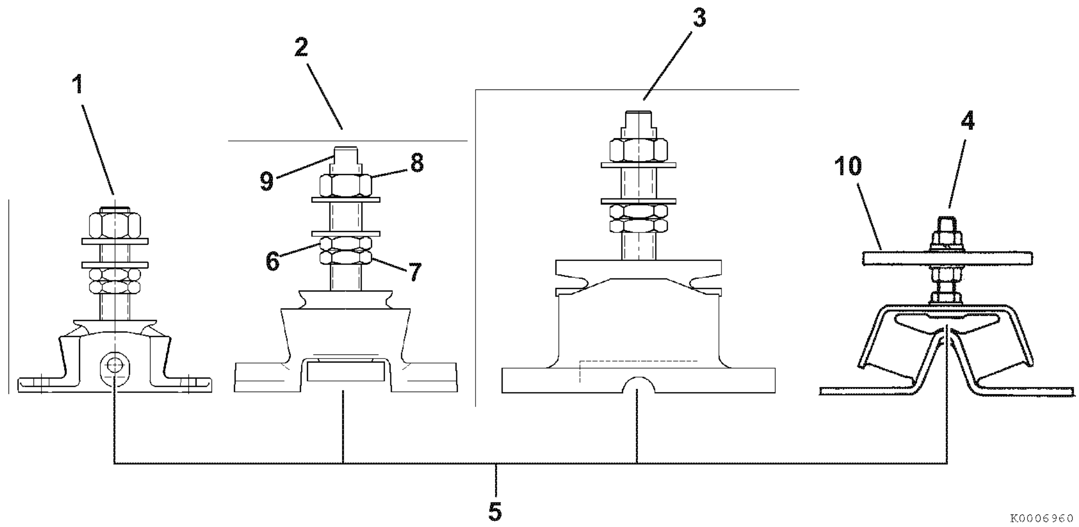
Setup Guidelines

- Engine bed and/or stringers must be level and square with the engine installation.
- Stringers should have tapped metal inserts or nut inserts for fasteners.
- Do not screw lag bolts directly into wood or fiberglass stringers.

Mount Styles

Typical marine mounts are shown in **Figure 5-30**.

Typical marine mounts



1 – Pin style mount
2 – Cushioned snubber style mount
3 – Concealed cushioned snubber style mount
4 – Type 1 mount
5 – Snubber gaps
6 – Adjustment nut
7 – Jam nut
8 – Top nut
9 – Leveling stud
10 – Engine mounting flange (typical)

Figure 5-30

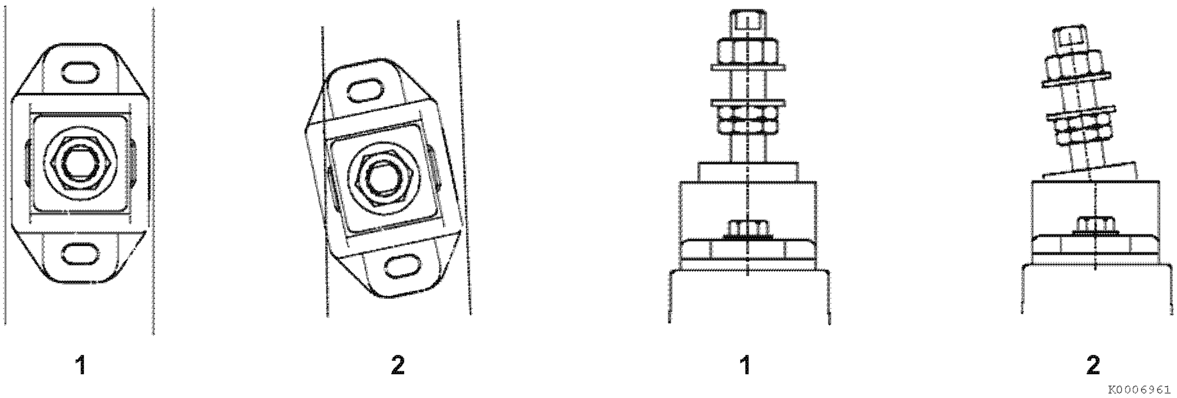
Installation Guidelines

NOTICE

Always follow the marine mount OEM installation and adjustment procedures, as supplied by the OEM. Contact the marine mount OEM directly for additional information.

- Mounts must be installed parallel to the engine support bracket or engine feet **(Figure 5-31)**.

  Mounts must be installed perpendicular to the engine support bracket or engine feet **(Figure 5-31)**.



1 – Correct installation   2 – Incorrect installation

Figure 5-31

- The engine bed or stringers must be parallel to the engine feet. Correct un-level stringers or use shims under the isolators. Shims should only be made of non-compressible material, such as aluminum or steel.
- When assembling the mounts to the engine support brackets, position the nuts to allow thread adjustment in both directions.
- Installed mounts should be upright and parallel to the engine support bracket and stringer to within 4° in all directions.
- When initially lowering the engine, lower the engine slowly and check to ensure the engine is setting in the desired position. Once position is verified, lightly tighten the bolts, keeping the lifting hoist attached and some engine weight supported.
- When aligning the engine and marine drive, keep some engine weight supported by the hoist. Slowly lower the engine while adjusting the mount nuts on all the mounts to the desired position.
- When adjusting the nuts, use the hoist to lift engine weight slightly to avoid damaging the mount threads.

■ Installation procedure (typical)

1. Raise the engine to a working height and attach the mounts and any other equipment as required.
2. Lower the engine into place, bringing the four mount bases to the correct position on the stringers.

NOTICE

Never move the adjustment nuts without using a hoist to take the pressure off the engine mount. Damage to the stud and nut threads may result.

3. Insert the bolts into the stringers and tighten finger-tight. Align the engine and marine gear with the propeller shaft to specification and begin to transfer the weight of the engine from the hoist to the mounts by using the adjusting nuts on all the mounts.

NOTICE

Never move the adjusting nuts without lift assistance from the hoist until the engine weight is nearly evenly distributed. Failure to support the engine could result in damage to the stud and nut threads. Once the weight is evenly distributed, the hoist can be removed.

4. Adjust mount load, *refer to Adjustment Guidelines on page 5-18.*

   Note: *Adjusting the mount snubber gaps could change the shaft flange alignment. Check alignment and repeat the process as needed to ensure that the isolators are properly loaded and the engine is aligned with the shaft. If major adjustments are needed to achieve the proper loading and alignment, shims or stringer modification could be required to center the isolator studs to the engine support bracket. When the nuts are tightened, ensure that the top nut is equal to or less than 2.0 mm (0.08 in.) from the flattened region of the stud. If the nut is too high on the stud, shims must be added under the mount.*

5. Adjust the base flanges in or out as needed and tighten the stringer flange bolts.
6. Tighten the lower and the upper nuts to specification. Hold the adjusting nut and tighten the jam nut against the adjusting nut. Hold the flats on the stud and tighten the top nut.

	Top nut
14 mm diameter stud	140 N·m (105 ft-lb)
16 mm diameter stud	210 N·m (155 ft-lb)
20 mm diameter stud	110 N·m (80 ft-lb)
0.75 in. diameter stud	195 N·m (144 ft-lb)
1.0 in. diameter stud	285 N·m (210 ft-lb)

Note: *On some mounts, it is normal to refer to the rubber portion of the mount bulge out with adjustments (1, **Figure 5-32**).*

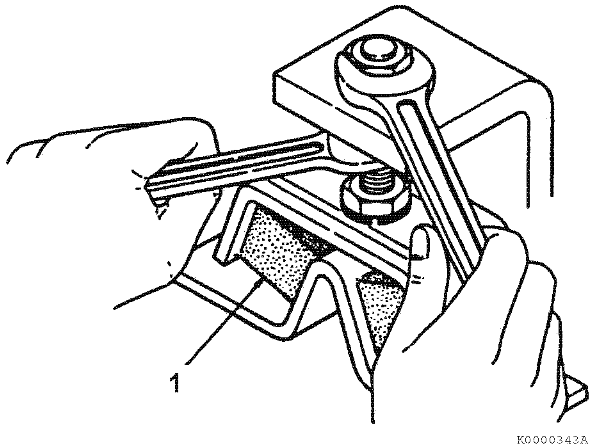


Figure 5-32

Adjustment Guidelines

NOTICE

Always follow the marine mount OEM installation and adjustment procedures, as supplied by the OEM. Contact the marine mount OEM directly for additional information.

- The mounts are fully adjustable to accommodate engine alignment and weight distribution. Any mounting adjustments can influence weight distribution. Ensure uniform weight distribution between mounts by adjusting the mounts to bring the engine's center of gravity as close as possible to the center of the mounting pattern. This equalizes the engine and marine gear weight that each isolator mount bears. In some applications, the forward-to-aft loads cannot be completely equalized. The port-to-starboard load must always be equalized.
- To apply a load to a mount, turn the adjusting nut upward, against the engine, lifting the engine at that corner and compressing the snubber. To reduce the load to a mount, turn the adjusting nut downward, away from the engine, lowering the engine at that corner and decompressing the snubber.
- Always re-check mount adjustment, mount nut torque and engine to drive shaft alignment approximately one week after installation. Mounts will settle slightly three to five days after installation.
- Pin mounts (1, **Figure 5-30**) - A pin is used as the load indicator. Typically, pin mounts are correctly loaded when the pin is approximately 3 mm (0.125 in.) from the edge of the hole in the cast housing. If the pin is touching the top of the hole, the mount is under loaded. If the pin is at the bottom, the mount is overloaded.
- Cushioned snubber mounts (2, **Figure 5-30**) - A rubber snubber, located between the cast housing and the stringer is used as a load indicator. Typically, the isolator is properly loaded if the rubber snubber is not touching the housing or the stringer, with approximately 3 mm (0.125 in.) gaps above and below the snubber. If the snubber is touching the housing, the mount is under loaded. If the snubber is touching the stringer, the mount is overloaded.
- Concealed snubber mounts (3, **Figure 5-30**) - This type of mount is similar to the cushioned snubber mount, however the opening to insert a feeler gauge is restricted. A feeler gauge is inserted through the small opening under the base casting. Typically, if the gap is 8 mm (0.312 in.) or greater the mount is under loaded. If the snubber is touching the stringer, the mount is overloaded.
- Type 1 snubber mounts (4, **Figure 5-30**) - Adjust the mount loads until the port and starboard forward mounts have equal snubber gaps and the port and starboard aft mounts have equal, or near equal, snubber gaps.

MARINE GEAR ALIGNMENT

Before connecting the marine gear driveshaft to the propeller shaft, ensure that the flange surface of both parts are parallel to each other and that their centers are aligned. Adjust the centering of the engine as follows:

1. Attach the shaft to the marine gear finger-tight.
2. With the propeller shaft loose, pull it up as far as it can travel. Then push it as far down as it can travel. Next, move the shaft to the mid-point between these two extremes and tighten the bolts enough to hold the shaft in that position.
3. Insert a feeler gauge between the propeller shaft coupling halves at four equally-spaced points around the circumference **(Figure 5-33)**. Adjust as needed and torque to specification.

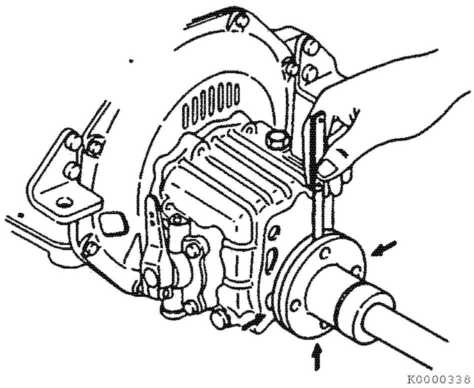


Figure 5-33

4. Using a dial gauge (2, **Figure 5-34**) turn the propeller shaft (4, **Figure 5-34**) and measure the outside run-out. Adjust to minimize run-out as needed **(Figure 5-35)**.

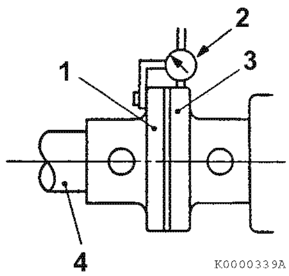
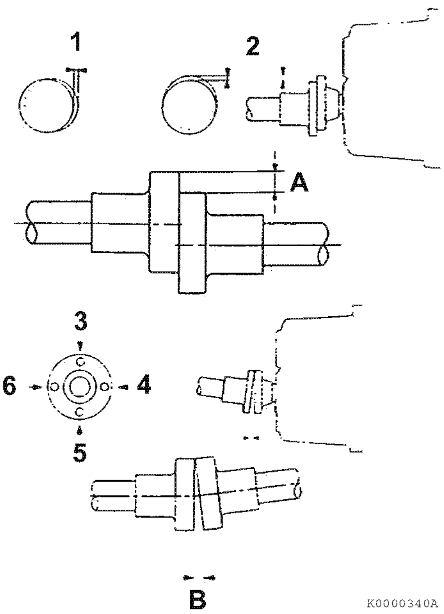


Figure 5-34



1 – Vertical error eccentricity (A)
2 – Horizontal error eccentricity (A)
3 – First bolt axial alignment (B)
4 – Second bolt axial alignment (B)
5 – Third bolt axial alignment (B)
6 – Fourth bolt axial alignment (B)

Figure 5-35

Measuring point	Limit
Coupling alignment, A	0.1 to 0.3 mm (0.004 to 0.012 in.)
Coupling face run-out, B	0.0 to 0.2 mm (0.0 to 0.008 in.)

5. After tightening the bolts, ensure that the shaft coupling face has not slipped. If shaft coupling has slipped, readjust as needed.
6. Recheck shaft centering after launching once the sealing agent is completely cured. If there is any change in the centering, readjust.

7. Tighten the propeller shaft coupling flange with the output flange of the marine gear.

Bolt size	Tightening torque
M10	4.7 to 5.3 kgf·m 46.1 to 52.0 N·m (34.0 to 38.3 ft-lb)
M12	8.5 to 9.5 kgf·m 83.4 to 93.2 N·m (61.5 to 68.7 ft-lb)
M14	12.0 to 13.0 kgf·m 117.7 to 127.5 N·m (86.8 to 94.0 ft-lb)

Note: Any type of shaft misalignment will cause vibration that can potentially lead to component failure.

ENGINE MOUNTS AND VIBRATION

NOTICE

Excessive vibration may cause damage to the engine, marine gear, hull and onboard equipment. In addition, it causes noticeable passenger and crew discomfort. Carefully select engine mounts and propellers when you design Yanmar Marine engine applications.

Vibration produces useless kinetic energy that is expended in areas that do not contribute to vessel propulsion. Mechanical noise and performance deficits are unwanted by-products of excessive vibration.

Damage to the engine, marine gear, hull and onboard equipment all result from excessive vibration. It also causes noticeable passenger and crew discomfort. Minimizing vibration results in smoother, quieter cruising while reducing or eliminating the discomfort and damage it causes.

Accelerometers are used to measure the frequency (Hz) and force (G) associated with vibration. Sound level meters (SLV) are used to measure the frequency (Hz) and amplitude in decibels (dB) of audible noise generated by energy as it radiates from vibrating equipment through the air. These instruments are sometimes used for sea trials.

The two factors that most affect vibration are:

- Engine mounts
- Propeller selection

The flexible engine mounts that are shipped with Yanmar engines reduce vibration. Yanmar flexible engine mounts are designed to reduce vibration through the engine's operating range. At the resonance point the amplitude is at its greatest. This peak vibration is rolling, centered around the propeller shaft (1, **Figure 5-36**).

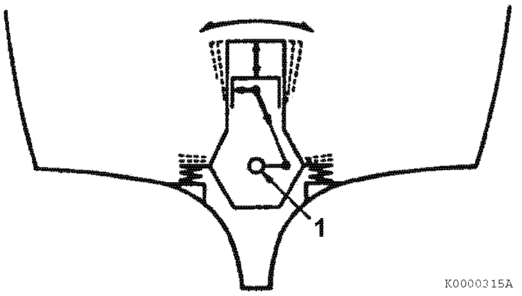
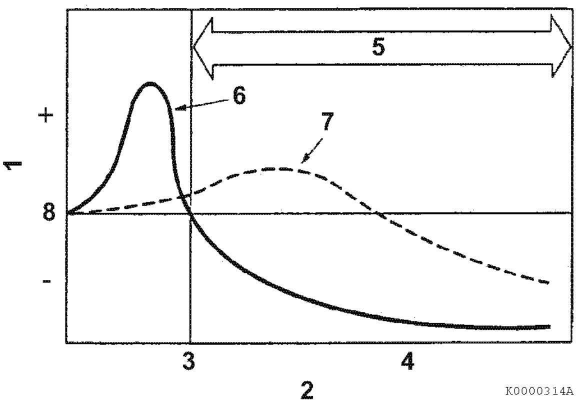


Figure 5-36

Vibration severity changes as a function of hull speed. **Figure 5-37** illustrates the relationship between marine gear and engine vibration at varying speeds. Lowering the spring constant lowers the resonance point.



1 – Anti-vibration characteristics
2 – Vibration transition rate
3 – Idling with marine gear in NEUTRAL
4 – Increasing vessel speed
5 – Operating range
6 – Flexible engine mounts
7 – Rigid engine mounts
8 – Zero point

Figure 5-37

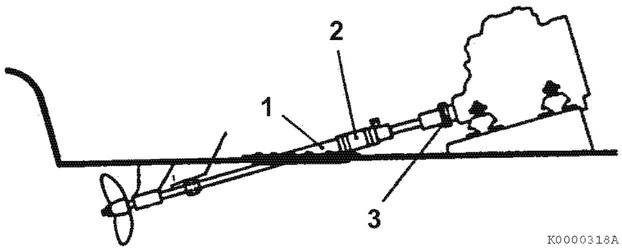
The upper part of the engine vibrates to a larger degree than the propeller. For information on propeller vibration, refer to the *Propeller Selection* section of this manual.

SHAFT CONSIDERATIONS WITH FLEXIBLE ENGINE MOUNTS

Engines mounted on flexible mounts have a measure of mobility relative to the hull. At rest, a non-operating engine could exhibit a measure of static distortion.

Engines that are installed with flexible engine mounting systems may be equipped with a flexible coupling or a flexible tube **(Figure 5-38)**.

Note: Even if the flexible coupling and flexible stem tube are used, they will not be effective if the centering alignment between the marine gear output shaft flange and the propeller shaft is too large.



1 – Shaft tube
2 – Self-aligning shaft seal
3 – Flexible marine gear shaft coupling (refer to **Figure 5-39**)

Figure 5-38

The following illustrations represent examples of flexible couplings **(Figure 5-39)**, **(Figure 5-40)**.

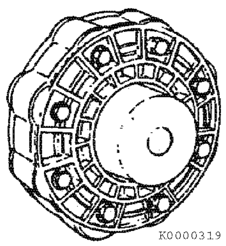


Figure 5-39

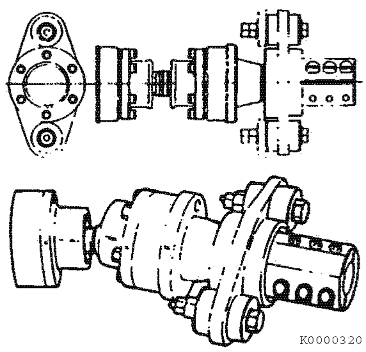


Figure 5-40

VIBRATION

NOTICE

Excessive vibration may cause damage to the engine, marine gear, hull and onboard equipment. In addition, it causes noticeable passenger and crew discomfort. Carefully select engine mounts and propellers when you design Yanmar Marine engine applications.

The effects of vibration and noise are felt in poorly matched propulsion systems through the human senses. Propeller vibration is a rapid propulsion component movement caused chiefly by imbalances in propellers, shafts or engines. This vibration produces useless kinetic energy that is expended in areas that do not contribute to vessel propulsion. Mechanical noise, rattling and lateral vessel tracking are all unwanted by-products of excessive vibration.

Damage to the engine, marine gear, hull and onboard equipment all result from excessive vibration. It also causes noticeable passenger and crew discomfort. Minimizing vibration results in smoother, quieter cruising while reducing or eliminating the discomfort and damage it causes.

Accelerometers are used to measure the frequency (Hz) and force (G) associated with vibration. Sound level meters (SLV) are used to measure the frequency (Hz) and amplitude in decibels (dB) of audible noise generated by energy as it radiates from vibrating equipment through the air. These instruments are sometimes used during sea trials which help confirm that the proper propeller was selected for the application.

Refer to Torsional Vibration on page 7-108.

Section 6

PROPELLER SELECTION

Page

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GENERAL

The process of matching marine engines to appropriate propellers is a complex one that requires a wide range of special considerations. An analysis of the engine, the hull, the vessel purpose and the required vessel performance characteristics are all integral components of the propeller selection process. It is a process that is best left to engineers and technicians who are specifically trained in this highly specialized area of marine propulsion technology.

Propeller manufacturers are interested in ensuring that the best possible match between the vessel's engine and its propeller is achieved. Seek advice from the manufacturer's application specialists in selecting the best possible propeller type and size.

The degree to which the propulsion system answers the operator's requirements for a particular vessel is the extent to which the project is successful. When the appropriate propeller is selected, the result is a propulsion system that is ideally matched to a vessel. When the process completely meets all of the operator's requirements, the process is successful.

This material is published to aid qualified boat builders, engineers and technicians in selecting the best possible propellers for a wide range of applications. Attention is given to propeller types, performance issues, shaft considerations, multi-engine applications, power rating standards and sea trials. Rarely is the best possible match identified with engineering data alone. Generally, extensive experimentation during sea trials is invaluable in identifying the absolute, best possible propeller.

To allow for increased weight and hull resistance, mechanical engines are generally propped when new to operate at about 100 min^{-1} above the engine's rated wide open throttle rpm. Electronic engines are generally propped when new to operate at 95 % load at rated wide open throttle rpm.

PROPELLER STYLES

Propellers are manufactured in a variety of styles, addressing different power and speed requirements. Propellers are available in two, three, four and five blade configurations. Propeller style is determined by the vessel performance requirements.

Two-Blade Style

A two-bladed propeller is practical for slow speeds as in light trawler or sailboat applications **(Figure 6-1)**.

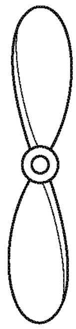

Figure 6-1

Multi-Purpose Style

The most common propeller style is a three-bladed multi-purpose type. It provides adequate performance over the widest range of power and speed applications **(Figure 6-2)**.

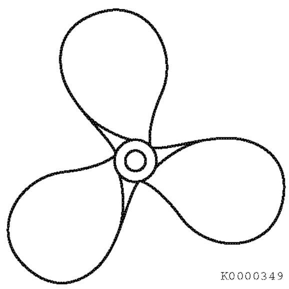

Figure 6-2

Finished, sharp sections tend to maximize performance for faster, planing hull applications. More rounded, sweeping sections tend to provide greater power at slower speeds.

Surface-Piercing Style

Surface-piercing propellers are designed to operate with each blade out of the water half of each revolution while underway **(Figure 6-3)**. This generally requires that the propeller shaft be extended some distance aft of the transom. When the vessel is underway, the effective waterline passes through the propeller's center at the hub.

Fixed-shaft surface-piercing arrangements require a rudder, while articulated arrangements can actually change the propeller attitude achieving steering and trim settings **(Figure 6-3)**. Articulated drive systems for surface-piercing propellers do not need rudders.

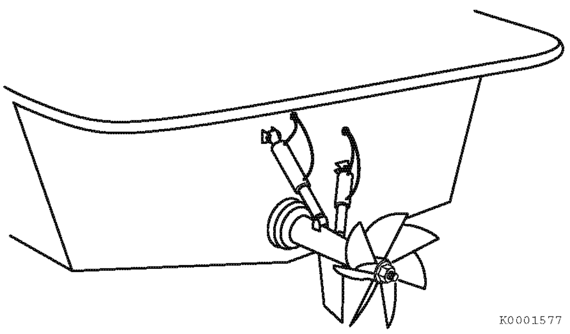

Figure 6-3

Surface-piercing systems are heavily ventilated. This drive arrangement produces the least amount of drag and is seen most often in high-performance applications. The vessel draft is not limited by the propeller to the same extent that traditional inboard or stern drives limit draft.

Adjustable Pitch Style

NOTICE

All Yanmar designated pleasure vessel engines, are designed to conform to worldwide emission standards. Yanmar pleasure vessel engines are designed for use with fixed pitch propellers only. The use of variable, adjustable or other non-fixed types of propellers is prohibited. Use of non-fixed style propellers will void Yanmar Marine engine warranty and will violate emission certification.

Folding Style

Sailboats are also power boats. They have auxiliary power for use in harbors or when the vessel is becalmed. The engine power and speed requirements are relatively small in sail applications.

A folding propeller provides propulsion under power, while folding under the water pressure that results when the vessel is operating under sail **(Figure 6-4)**.

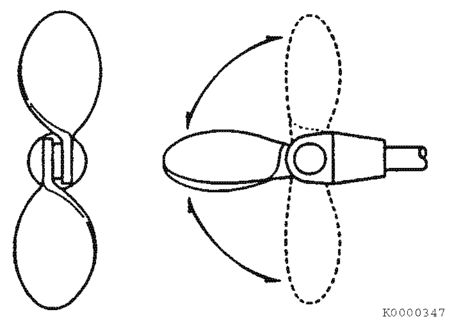

Figure 6-4

As the vessel is driven through the water by sail power, the water pressure folds the propeller blades aft, reducing unnecessary drag. The net result is increased speed under sail.

Folding propellers have four main liabilities:

- Folding propellers are less efficient than fixed propellers.
- Folding propellers have moving parts that are more likely to fail than fixed propellers with no moving parts.
- Folding propellers are less effective in slowing the forward momentum of vessels than fixed propellers. These propellers are sometimes unreliable or ineffective during reverse thrust demand. As a result, safe maneuvering speed in congested harbors and waterways is reduced compared to fixed propeller installations.
- Folding propellers, when unfolding, create potentially damaging shock forces to the drivetrain. Damage to the drivetrain is not covered under Yanmar warranty.

Contact a Yanmar distributor or dealer for specifications on acceptable folding propellers.

PROPELLER PERFORMANCE AND DIMENSION CONSIDERATIONS

The performance characteristics of a propulsion system are influenced by three factors:

- Hull size and shape
- Engine power curves
- Propeller size and type

Performance characteristics are observed in the areas of speed, power and maneuverability. Propeller selection is the process of matching hull and engine characteristics to the operator's performance requirements with the appropriate propeller style, size and material.

Speed

When top speed is achieved, it is at the expense of power at lower speeds and acceleration. The top speed is limited by the hull type and displacement combined with engine power. If these components are treated as constants, propeller variables can be manipulated to achieve top speed.

Power

When peak power is achieved at slower speeds, it is at the expense of top speed. The peak power is limited by engine power. If engine power is treated as a constant, propeller variables can be manipulated to achieve peak power.

Pitch

Pitch is the theoretical distance that a vessel travels for each revolution of the propeller. Propellers are manufactured in constant pitch or progressive pitch configurations. Constant pitch configurations offer a uniform effective pitch over the full range of engine rpm. Progressive (sometimes called variable pitch) configurations have different pitch characteristics at various points on the blade. In both cases, high pitch propellers require greater power to operate at higher speeds.

Rake

Rake is the angle (negative or positive) of the blades relative to the shaft. Positive rake propellers are generally high performance propellers that are slanted aft **(Figure 6-5)**.

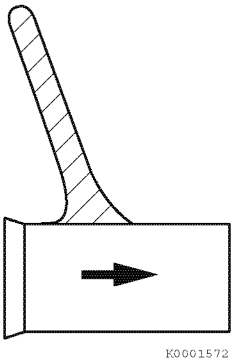

Figure 6-5

Negative rake propellers are propellers that are slanted forward **(Figure 6-6)**.

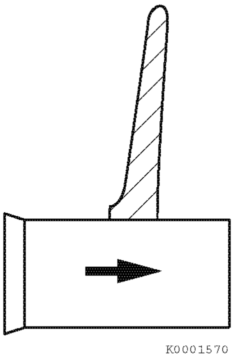

Figure 6-6

If the rake is neither negative or positive, it is zero degree **(Figure 6-7)**. This design represents a compromise between negative and positive rake propellers.

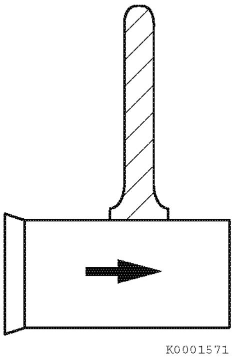

Figure 6-7

Any rake angle can have a parabolic shape, increasing area and cup **(Figure 6-8)**.

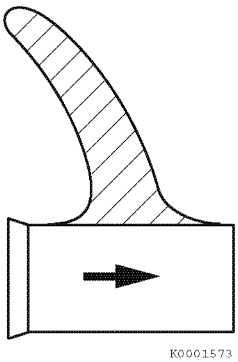

Figure 6-8

Diameter

If an imaginary circle were scribed around the propeller tips, the diameter of that circle would be the propeller's diameter.

Area

Increasing the surface area improves propulsion efficiency. Increasing the number of blades increases total area, resulting in greater efficiency over propellers with fewer blades. An increase in the area and number of blades reduces blade loading and cavitation. Blade area is the surface of the individual propeller blade. The most common two measurements are projected blade area and developed or expanded blade area (DAR or EAR). Projected area is the area of the blades as viewed from directly astern or a shadow cast than the true blade area (DAR or EAR). The expanded or developed area is the true total frequently used in making propeller calculations.*1

**1: David Geer, Propeller Handbook*

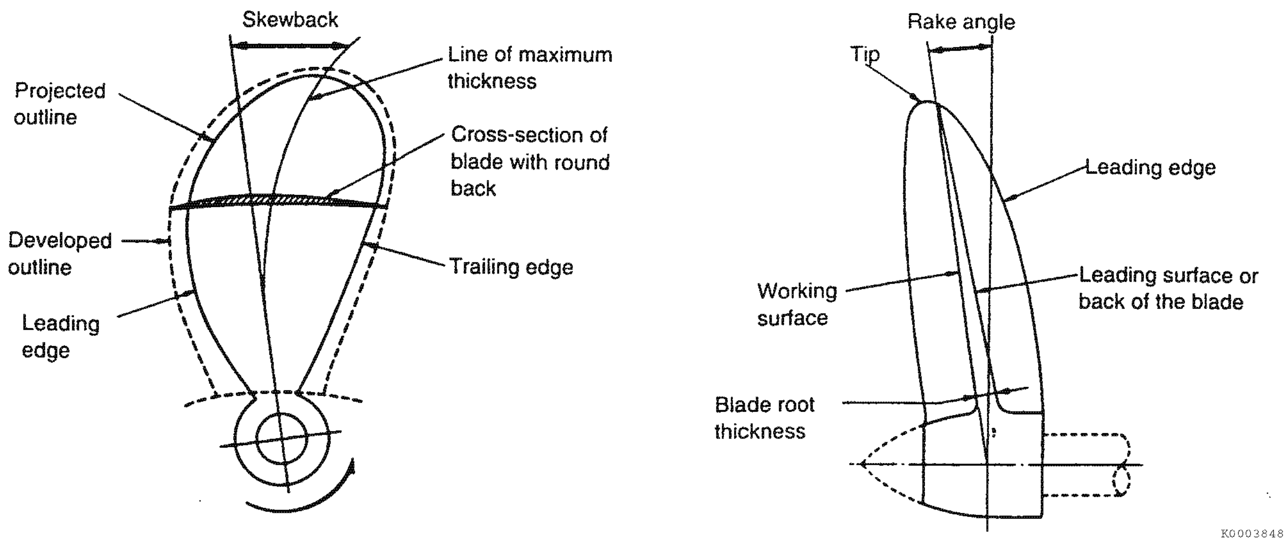

Figure 6-9

PROPELLER SHAFT CONSIDERATIONS

Diameter

This section describes Yanmar recommended propeller shaft diameter calculations. Three methods are described.

■ JCI method

The following method is equivalent to the Japan Craft Inspection Organization (JCI) rule.

Formula

$$d = 154 \times \frac{1}{\sqrt[3]{T}} \times \sqrt[3]{\frac{(1+Y)H}{R}}$$

Where

- d : Propeller shaft diameter (mm)
- T : Allowable torsional stress,
  5.0 kgf/mm = Stainless steel, JIS SUS304
  10.5 kgf/mm = Stainless steel, JIS SUS630
- Y : Torque fluctuation factor (4-cycle diesel engine)
- H : Max. engine output hp
- R : Propeller shaft revolutions min^{-1}

No. of cylinders	Factor
1	0.6
2	0.4
3	0.3
4	0.2
Over 6	0.1

Note: The above formula assumes the use of JIS SUS304 and SUS630 stainless steel for the propeller shaft and the shaft bearing being installed within 1.2 m (3.9 ft) from propeller shaft.

Example:

Engine: 4-cylinder, 4-cycle diesel engine
Maximum output: 40 hp/3600 min^{-1}
Reduction ratio: 2.5
Material of propeller shaft: SUS304 and SUS630

Propeller shaft rpm:

$$R = \frac{3600\ (\text{Max. Eng. speed})}{2.5\ (\text{Reduction ratio})} = 1440\ \text{min}^{-1}$$

1. With stainless steel, SUS304

$$d = 154 \times \frac{1}{\sqrt[3]{5}} \times \sqrt[3]{\frac{(1+0.2) \times 40}{1440}}$$

$$= 154 \times 0.58 \times 0.32$$

$$= 28.58\ \text{mm diameter}$$

2. With stainless steel, SUS630

$$d = 154 \times \frac{1}{\sqrt[3]{10.5}} \times \sqrt[3]{\frac{(1+0.2) \times 40}{1440}}$$

$$= 154 \times 0.46 \times 0.32$$

$$= 22.67\ \text{mm diameter}$$

■ One-fourteenth method*1

The oldest and simplest rule for determining propeller shaft diameter is simply that it should be one-fourteenth of the propeller diameter. In spite of its simplicity, this rule works surprisingly well. A 914 mm (36 in.) diameter propeller would require a 65.3 mm (2.57 in.) diameter shaft, by this method.

The one-fourteenth rule, however, does not take into account many of the variables in selecting the best propeller shaft. It does not reflect differences between shaft materials – tobin bronze has roughly 60 percent of the strength of monel 400, for instance. It also does not take into account that many possible combinations of shaft horsepower and rpm of propeller shaft will dramatically affect torque, though it makes some allowance for this by assuming that the propeller is correctly sized to absorb the engine's power.

**1: Dave Gerr, Propeller Handbook (Maine, International Marine, 2001).*

In spite of its shortcomings, the one-fourteenth rule should be considered in making a shaft selection, if only for the fact that if a selected shaft diameter varies very widely from the rule, the propeller hub may require special machining.

Shaft diameters formulas

The following equations can be used to compute shaft diameters and safety factors.

$$D = \sqrt[3]{\frac{321,000 \times P \times SF}{S_t \times N}}$$

$$SF = \frac{D^3 \times S_t \times N}{321,000 \times P}$$

D = Shaft diameter (inches)
P = Horsepower
SF = Safety factor
S_t = Yield strength, torsional (lbs/in^2)
N = Shaft speed (min^{-1})

The diameter for shafts of any suitable material and any desired safety factor can be calculated by inserting the appropriate value for the yield strength of that material and the desired value for safety factor in the shaft diameter formula.

Table 5-6 Mechanical properties - aquamet 22	
Diameter of shaft	**Strength torsion psi**
3/4” to 1¼”	86,600
Over 1¼” to 2”	70,000
Over 2” to 2½”	63,000
Over 2½” to 3”	50,000
Over 3” to 12”	36,600
Aquamet 22 H.S.	
2½” to 4¾”	70,000
5” to 6”	60,000

SHAFT BEARING

■ Determining shaft-bearing spacing

The propeller shaft must be supported by intermediate shaft bearings, pillow blocks, between the flange coupling at the engine or gearbox and the stern bearing, unless the shaft is relatively short in proportion to its diameter. The shaft diameter formula gives the maximum spacing between shaft bearings for propeller shafts with flexible bearings at both ends. Most small craft have a rigid bearing at the engine and a rigid stern bearing, just ahead of the propeller. Such shafts should have maximum bearing spacings 50 percent greater than that given in the formula. Use the following formula to calculate shaft bearing spacing.

Bearing spacing formula

The formula below is for computing maximum shaft-bearing space.

$$L = \sqrt[2]{\frac{3.21\ D}{N}} \times \sqrt[4]{\frac{E}{W_1}}$$

L = Maximum unsupported length, feet (m)
D = Shaft diameter, inches (mm)
N = Shaft Speed (min^{-1})
E = Modulus of elasticity in tension (lbs/in^2 (MPa))
W_1 = Weight of one cubic inch (cm^3) of material, pounds (gm)

Note: *The minimum required spacing for rigid bearings should exceed 20 shaft diameters when possible to facilitate alignment.*

■ The twenty-times/forty-times*1

Bearing spacing guideline: The simplest rule for determining shaft-bearing spacing is that the bearings should be no closer together than twenty times the shaft diameter, and no further apart than forty times the shaft diameter.

Note: *This is only to be used as a guideline or to double-check the formula. Very frequently, bearing spacing is considerably more than forty times the shaft diameter. Additional bearings simply add expense and unwanted shaft rigidity.*

**1: Dave Gerr, Propeller Handbook (Maine, International Marine, 2001).*

Distance Between Propeller Shafts for Twin-Engine Two Shaft Propulsion

The rough standard minimum distance (A, **Figure 6-10**) between the outside diameters of two propellers should be more than 2.5 times the propeller's outside diameter (A, **Figure 6-10**). If the inter-shaft distance is too small, propeller efficiency, and therefore boat speed, will fall and excessive hull vibrations and other problems will result.

Note: *Also very important is the serviceability space between engines. Refer to individual engine sections for specifications or contact a Yanmar distributor for guidance.*

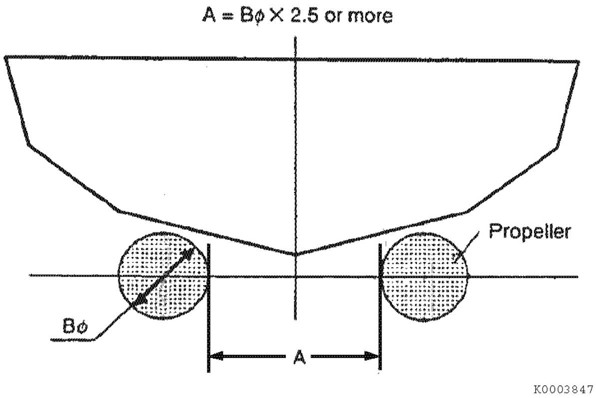

Figure 6-10

■ Engine revolutions of twin-engine installation

When building a boat for twin engine installation, it is difficult to distribute a strictly equal load balance between the port and starboard engines. It is also almost impossible to set the port and starboard engines with identical revolutions in a completed boat, for the following reasons:

1. Variations in engine performance.
2. Variations in tachometer performance.
3. Variations in propeller performance.
4. Possible variation in hull construction.
5. Possible variation in hull shape and weight when all inboard equipment, including fuel and water tanks and engines, is installed.

■ Tip clearance*1

In general, it is important to use the largest diameter propeller possible. For single-screw vessels, diameter is limited by the size or height of the propeller aperture. On twin-screw craft, the diameter is limited by the shortest distance from the center line of the shaft-strut bearing up to the underside of the hull. For a new design, this distance can be found by measuring from the buttock lines at the half-breadth of the propeller shaft, and cross-checking on the sections or body plane at the location of the strut and propeller. On an existing vessel, the distance can be measured directly. (Remember that the shortest distance may not be straight up. When measuring, swing your ruler through an arc centered at the shaft center line. The shortest distance will often be found with the ruler angled slightly up and inboard.)

Once the maximum distance from the shaft center line to the hull (and down to the skeg below, in an aperture) is known, the largest acceptable propeller diameter can be determined. Generally, there should be a *tip clearance* of approximately 15 % of the overall propeller diameter between the blade tips and the hull. However, additional tip clearance is usually found at the cost of the overall propeller diameter. Since smaller diameters mean lower efficiency, you are faced with a trade-off between the increase in efficiency from larger diameter and the increase in efficiency from improved water flow to the propeller and reduced vibration from greater tip clearance.

Note: *Modern CNC machined propellers can accept less tip clearance.*

Actually, the slower the shaft rpm and the lower the boat speed, the lower the minimum tip clearance may be.

**1: Dave Gerr, Propeller Handbook (Maine, International Marine, 2001).*

PROPELLER MATCHING

The selection of a main engine for a boat is decided by the type of boat, hull size, hull weight and loading weight. The selection of an appropriate propeller that matches the output of the main engine is very important for the economical operation and durability of the engine.

When the propeller is too small for the engine output, there will be a loss in both engine output efficiency and boat speed. When the propeller is too large for the output, the engine will be overloaded at full throttle. Prolonged engine use at full throttle will cause engine damage.

The size of the propeller is determined at the design stage of the boat in consideration of the boat's speed and size, the shape and weight of the hull, main engine output, the reduction ratio of the marine gear and the maximum number of the crew (maximum loading weight). However, it is extremely difficult for a boat to be built strictly according to the design drawings. Accordingly, the final checks of the boat speed, propeller matching and other aspects of boat performance must be made by sea trials. If the boat's performance is unsatisfactory, it can be improved by changing the propeller specifications such as the number of blades, diameter, pitch and extended area ratio of blades.

It is easier to change the propeller than the engine or the shape of the hull.

There are various ways to calculate the proper propeller size for pleasure boats, but there is no perfect formula.

Note: It is wise to contact the propeller manufacturer to determine estimated propeller size or to confirm your calculations.

Checking Results of Propeller Matching Against Target Value

Electronically controlled engines generally provide a digital reading of the calculated engine load. Electronically controlled engines should be loaded (by propeller matching) to 95 % load at maximum output rpm. This is the target value.

For mechanically controlled engines, the calculated load can be estimated by measuring exhaust gas temperature, boost air pressure and fuel consumption. The match point for mechanically controlled engines is 100 min^{-1} above maximum output rpm at wide open throttle. This is the target value.

Tip: Recommended propeller matching point; Continuous rating output at propeller shaft: 95 - 100 %

Note: To ensure appropriate propeller matching, consider the following factors, (keeping some output in reserve):

- *Increase of boat resistance due to contamination of hull.*
- *Increase of displacement due to increase of ship's fitting and crew.*
- *Horsepower required to drive auxiliary equipment such as generator set or pump set powered by the main engine (excluding auxiliary equipment not driven while the propeller is operated).*
- *Engine de-rating factors (factors that reduce engine output):*
  - ◆ *Lack of air intake volume*
  - ◆ *Excessive temperature (over 30 °C [86 °F])*
  - ◆ *Excessive exhaust back pressure*
  - ◆ *High temperature fuel*

Simple Propeller Matching Testing

⚠ WARNING

This test must be performed in open waters where it is safe to run at full speed and ensure that the boat is clear of all obstacles forward and aft before performing this test.

It is possible to find if the propeller is too large for the engine output (i.e., the engine is overloaded) or too small (i.e., a loss of engine output) by the following simple procedure during the sea trial.

⚠ CAUTION

Tachometer and rpm readings must be confirmed by using an optical tachometer.

1. Check the engine's maximum speed (high idle) with no load.
   1- Move the shift lever of the marine gear to NEUTRAL.
   2- Raise the engine speed gradually with the engine speed control handle, moving the lever to the full throttle position.
   3- Check whether the engine speed at the full throttle position is within the no load maximum speed range.

   Note:

   - *Tachometer and rpm readings must be checked and confirmed with an optical tachometer.*
   - *Refer to the no load maximum engine speed in the applicable specification table in Vol. 2 or 3.*
   - *If the engine speed is below the no load maximum engine speed range, the problem may be due to the absence of remote control stroke or faulty contact of the remote control cable.*

2. Check the engine's maximum speed under load. After establishing that the engine can reach the acceptable no load maximum rpm (high idle). Then proceed with under load test.
   1- Move the marine gear shift lever to FORWARD at the idling speed of the engine.
   2- Raise the engine speed gradually with the engine speed control handle to the full throttle position.
   3- Check the loaded maximum rpm at full throttle. Repeat this test in opposite directions. The results must reach the target value.

   Note: The engine must be able to reach the maximum output rpm under full load at all times. Failure to do so can lead to reduced engine performance, lead to increased smoke levels and cause permanent damage to the engine.

PROPELLER POSITION (PROPELLER APERTURE)

This boat's full speed will not be obtained if the spacing between the propeller and hull is not equal to, or greater than, the value given in **Figure 6-11**. The position of the propeller selection shaft center must be at least one propeller diameter beneath the surface of the water with the boat fully loaded.

Recommended dimension
D = Propeller diameter
(a) = D × 0.12 more than
(b) = D × 0.15 more than
(c) = D × 0.12 more than
(d) = D × 0.08 more than

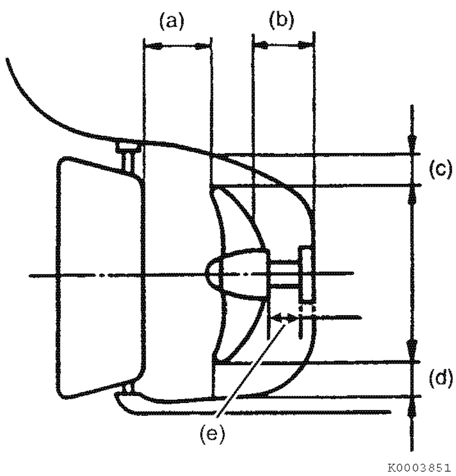

Figure 6-11

Note: Propeller overhang shall be limited to 1X propeller shaft diameter (E).

SEA TRIALS

⚠ WARNING

Improper Operation Hazard

Sea trials can only be performed safely when the vessel is adequately manned. Do not attempt to collect and record performance data while operating a vessel alone.

Sea Trial Test Procedure

⚠ WARNING

This test must be performed in open waters where it is safe to run at full speed and ensure that the boat is clear of all obstacles forward and aft before performing this test.

Check with your Yanmar distributor for current test protocol.

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Section 7

SYSTEMS

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ELECTRICAL SYSTEM

⚠ DANGER

Explosion Hazard

- **Keep the area around the battery well-ventilated. While the engine is running or the battery is charging, hydrogen gas is produced which can be easily ignited.**
- **Keep sparks, open flame and any other form of ignition away while the engine is running or battering is charging.**
- **Never check the remaining battery charge by shorting out the terminals. This will result in a spark and may cause an explosion or fire. Use a hydrometer to check the remaining battery charge.**
- **If the electrolyte is frozen, slowly warm the battery before you recharge it.**

⚠ DANGER

Fire and Explosion Hazard

- **Only use the key switch to start the engine.**
- **Never jump-start the engine. Sparks caused by shorting the battery to the starter terminals may cause a fire or explosion.**

⚠ WARNING

Burn Hazard

- **Batteries contain sulfuric acid. Never allow battery fluid to come in contact with clothing, skin or eyes. Severe burns could result.**
- **Always wear safety goggles and protective clothing when servicing the battery. If battery fluid contacts the eyes and/or skin, immediately flush with a large amount of clean water and obtain prompt medical treatment.**

⚠ WARNING

Shock Hazard

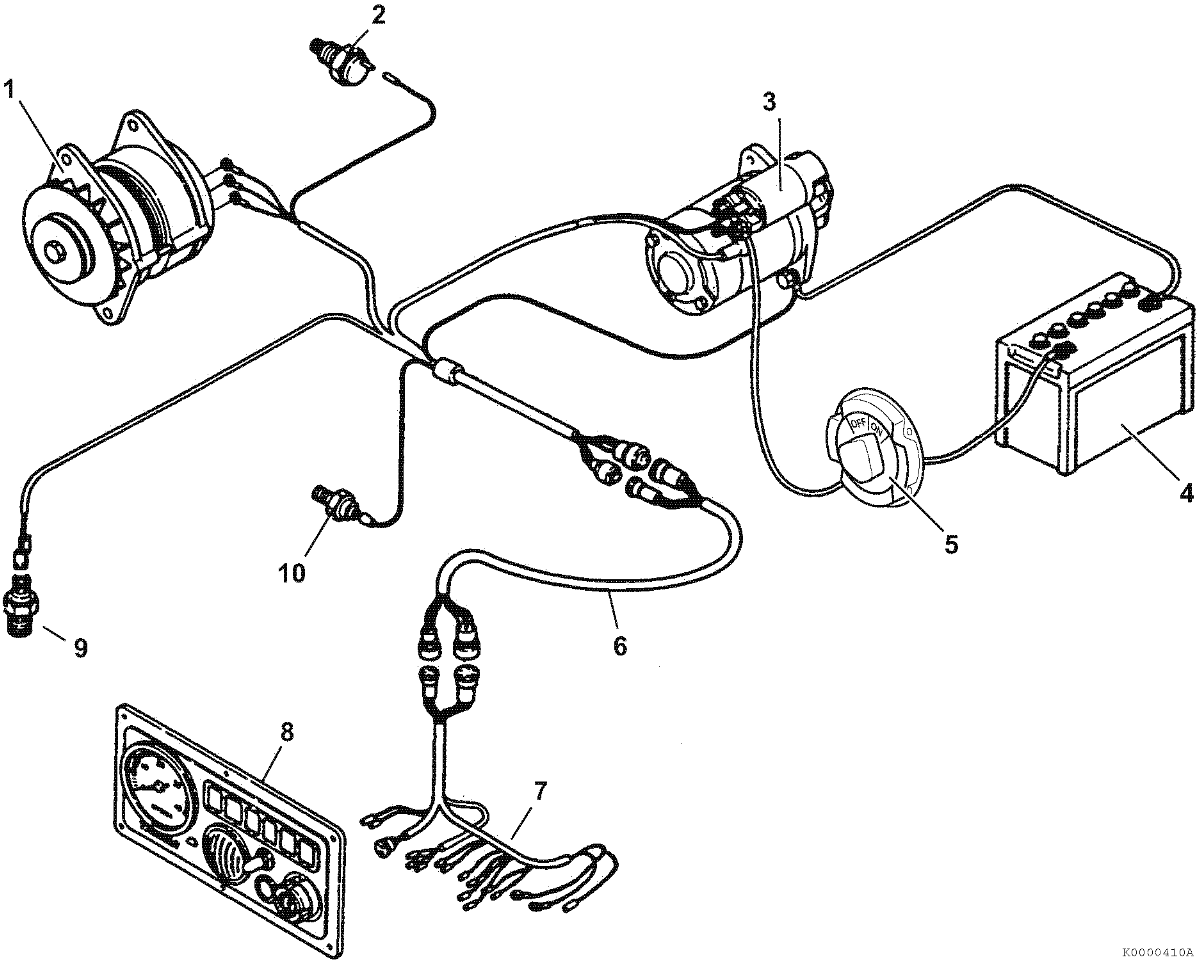
- **Always turn off the battery switch (if equipped) or disconnect the negative (–) battery cable and the leads to the alternator when welding on the equipment.**
- **Always keep the electrical connectors and terminals clean. Check the electrical harnesses for cracks, abrasions, and damaged or corroded connectors.**

NOTICE

- Never turn off the battery switch (if equipped) or short the battery cables during operation. Damage to the electric system will result.
- Always ensure that all connections are tightened to specifications after repair is made to the exhaust system.

TYPICAL ELECTRICAL SYSTEM - MECHANICAL ENGINE

Single Station

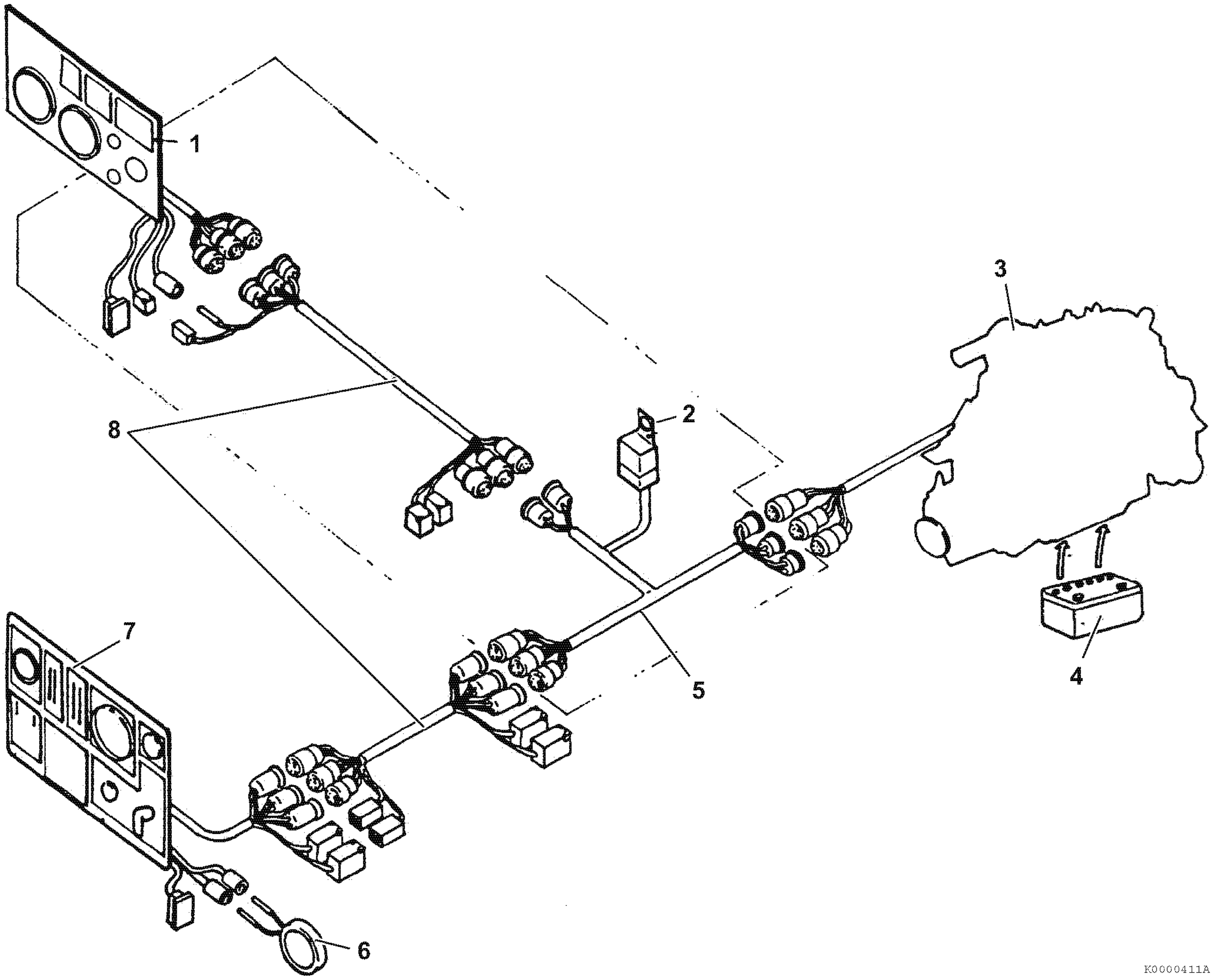


1 – Alternator
2 – Cooling water temperature switch
3 – Starter motor
4 – Battery
5 – Battery switch
6 – Extension wire harness
7 – Wire harness
8 – Instrument panel
9 – Tachometer sender
10 – Lubrication oil pressure switch

Figure 7-1

Note: For details about wiring, refer to the wiring diagrams for the specific engine model in vol. 2 or 3.

Dual Station



1 – Upper bridge instrument panel (option)
2 – Relay
3 – Standard equipment
4 – Battery
5 – Wire harness for dual instrument panel (option)
6 – Buzzer
7 – Main bridge instrument panel (option)
8 – Extension wire harness (option)

Figure 7-2

Typical Two-Pole System

Note: Instrument panel combinations differ depending on the engine model. Please refer to the information for the specific engine model in vol. 2 or 3.

■ Wire harness (engine side), two-pole type

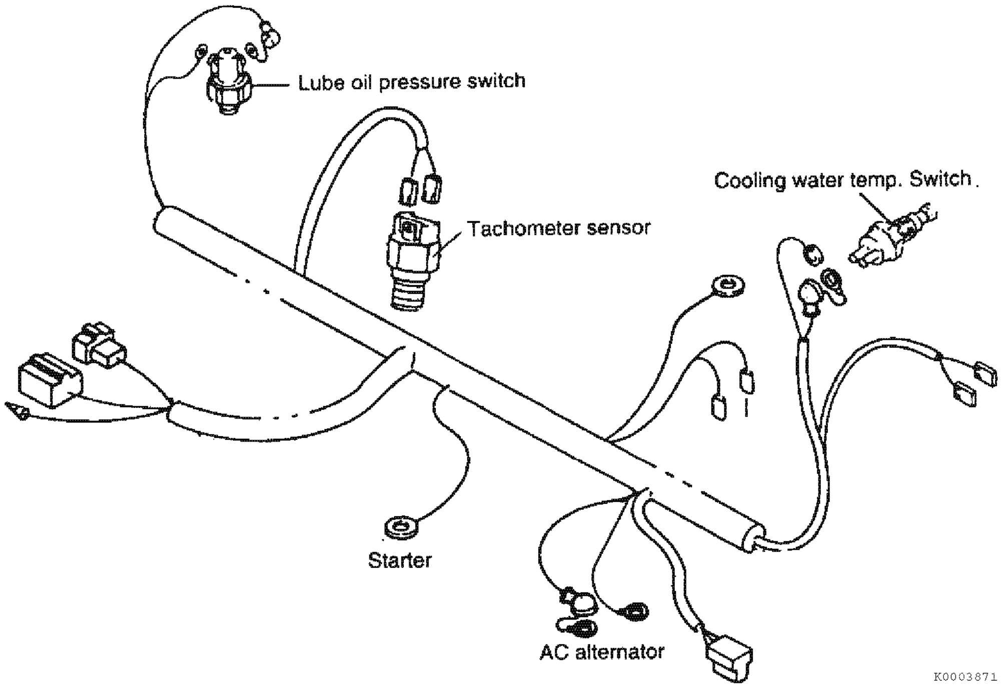


Figure 7-3

■ Applicable instrument panels

B2/new B, C/new C, D/new D and E-type

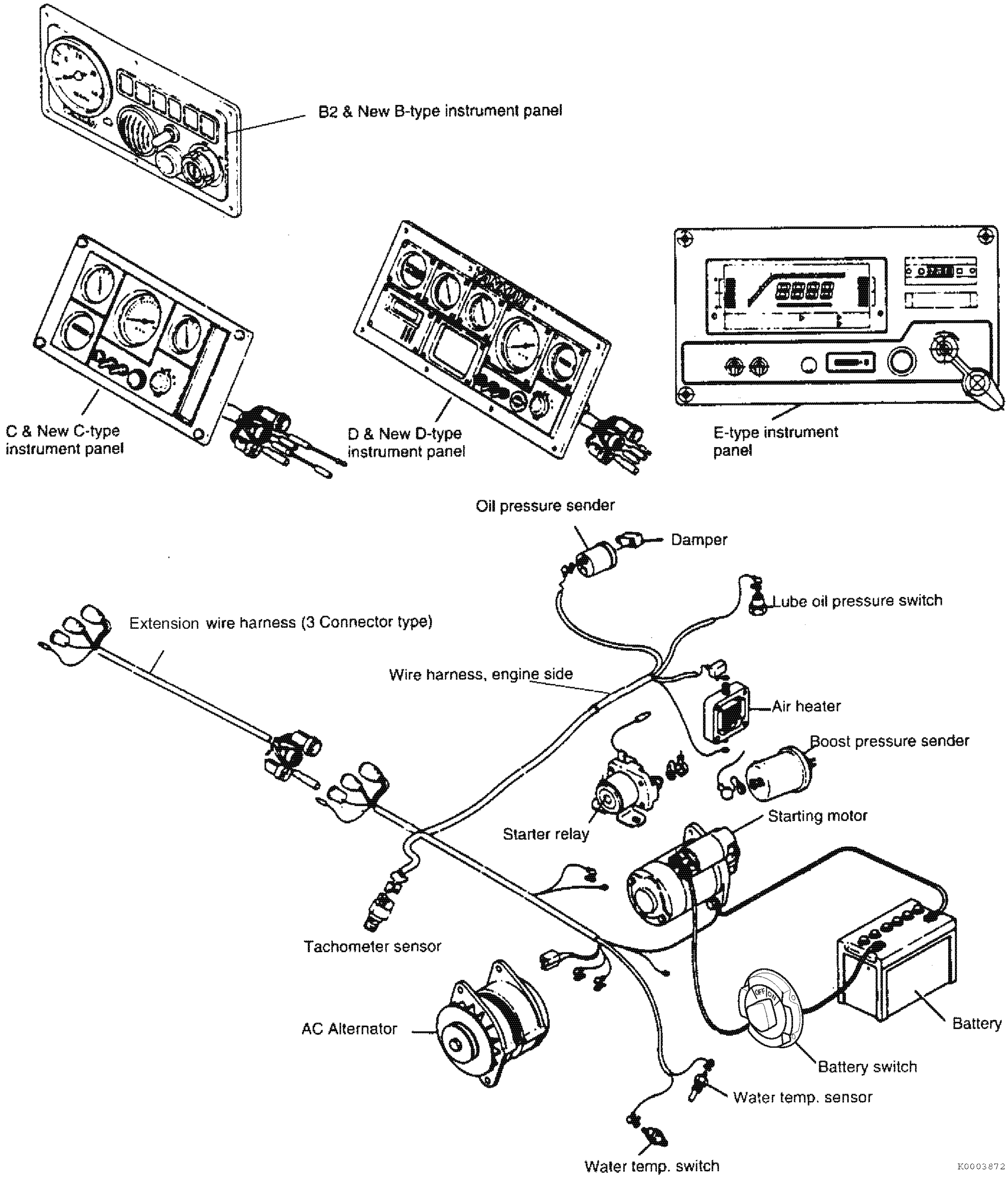


Figure 7-4

Electric Wire

■ Voltage drop in the wire

⚠ WARNING

Fire Hazard

Undersized wiring systems can cause an electrical fire. Be sure to use proper size wiring for the application.

When electric current flows in a wire conductor, the voltage drops due to conductor resistance. The voltage entering the electric device (load side) is therefore lower than the voltage at the power source outlet.

The resistance of a wire is proportional to its length and inversely proportional to its diameter. That is, a wire which is too long or too small has a larger voltage drop.

The use of such a wire could cause damage to electrical components. On electronically controlled engines, a voltage drop could cause malfunction or damage.

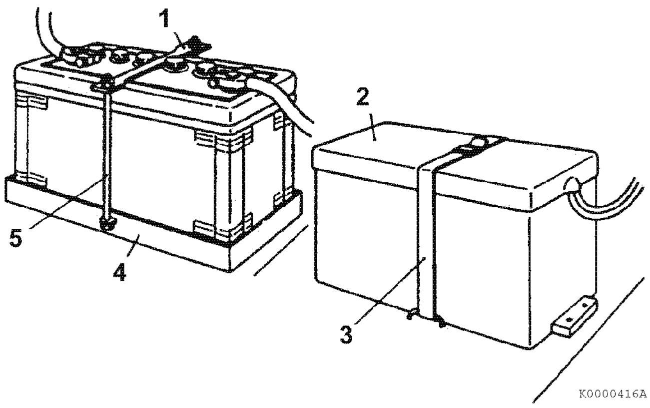
Note: Yanmar wire harnesses are designed to comply with international standards. Any additional wiring added must also comply with international standards. Refer to ISO or ABYC standards.

Batteries

A battery, or a system of batteries, provides electrical power for the engine and all DC electrical equipment on the vessel.

■ Installation

- Install batteries in a well-ventilated location.
- Place batteries in an easily accessible location for inspection, replacement and wiring.
- Use a battery box or frame to attach the battery to the hull. Use a bolt and clamp or a strap to secure the battery to the hull **(Figure 7-5)**.



1 – Clamp
2 – Battery box
3 – Strap
4 – Battery frame
5 – Frame bolt

Figure 7-5

Note: Refer to ISO or ABYC standards on battery installation.

■ Battery capacity

Required battery capacity varies depending on the amount and type of electrical equipment used in the vessel. For electrical equipment other than that needed for the engine, check the requirements for each unit and use an auxiliary battery as needed. Refer to the *Marine Installation Manual*, vol. 2 and 3, for specific information on required engine battery capacity.

■ Battery switch

⚠ WARNING

Shock Hazard

- **Always turn off the battery switch (if equipped) or disconnect the negative (–) battery cable before servicing the electrical system.**
- **Check the electrical harnesses for cracks, abrasions, and damaged or corroded connectors. Always keep the connectors and terminals clean.**

⚠ CAUTION

Never turn off the battery switch (if equipped) or short the battery cables during operation. Damage to the electric system will result.

To determine the battery switch capacity specification and installation requirements, refer to ISO or ABYC standards. To determine the engine starter ampacity, refer to the individual engine sections in installation vol. 2 and 3.

Note: *Do not place the battery switch in a place where the handle might be accidently touched or moved. If the battery switch accidently disconnects the battery circuit from the alternator circuit during engine operation, the IC regulator built into the AC alternator could be damaged.*

■ Wiring the battery

1. Connect the cable clamp on the red battery cable to the positive (+) battery post **(Figure 7-6)**.

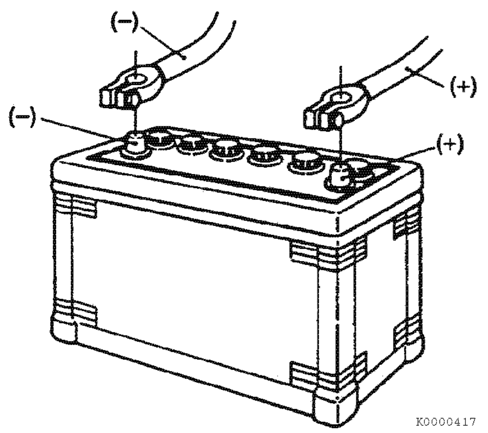


Figure 7-6

2. Connect the cable clamp on the black battery cable to the negative (–) battery post **(Figure 7-6)**.

⚠ CAUTION

Observe battery polarity. Failure to do so will damage the IC regulator of the alternator and other electronic equipment, including the engine ECU.

---

3. When you select the battery cable for the application, choose a cable that corresponds to the rated voltage, rated output of the starter motor and whether or not a battery switch is used. *Refer to Battery cables on page 7-13.*

⚠ WARNING

Fire and Explosion Hazard

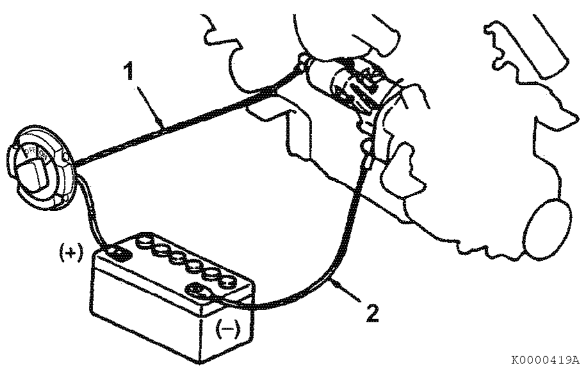
Always attach the positive (+) battery cable to the battery first, then the negative (–) battery cable.

---

4. Connect the cable clamps to the battery posts **(Figure 7-7)**. Firmly tighten the cable clamp bolt to ensure good contact. It is advisable to apply anti-corrosion material to the clamps.

NOTICE

Always use a proper battery tester to check the battery current. Never use a metal tool, such as a screwdriver, to short across the battery terminals to check for current. Always remove the battery cables before quick-charging batteries.

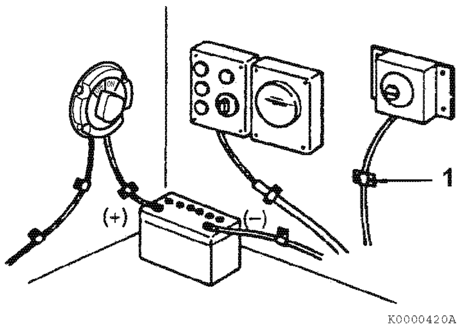


1 – Positive (+) battery cable
2 – Negative (–) battery cable

Figure 7-7

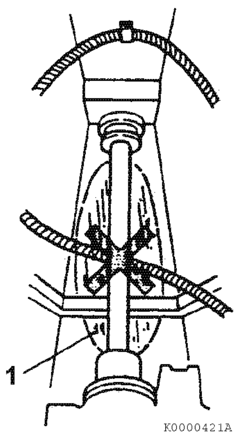
5. Secure the cables with clamps as needed to avoid damage from vibrations created by the hull of the boat **(Figure 7-8)**. Route the cables away from moving parts and make sure they do not lay in the bilge area **(Figure 7-9)**.

   Note: Refer to ISO or ABYC standards.



1 – Clamp

Figure 7-8



1 – Bilge

Figure 7-9

■ Battery wiring precautions

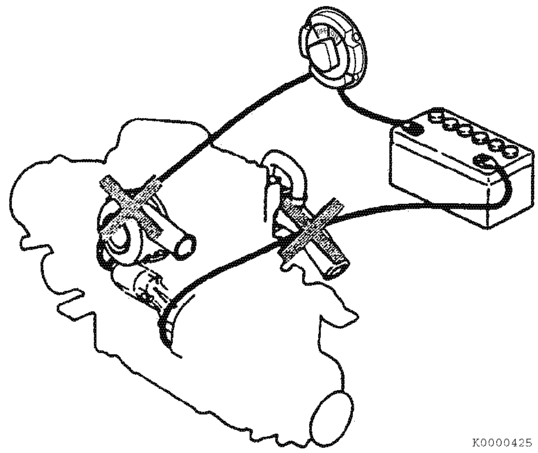
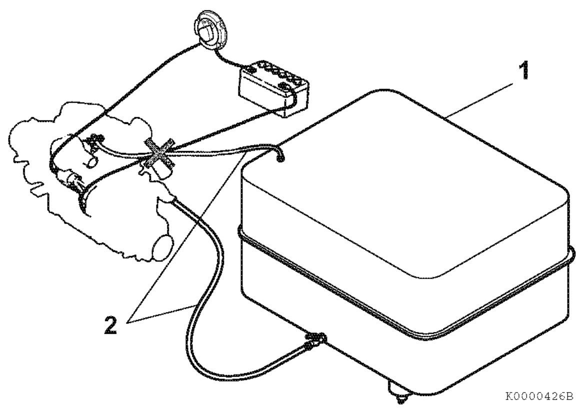


Figure 7-10

1. Route cables so they do not come in contact with sharp edges or heated areas.



1 – Fuel tank
2 – Fuel lines

Figure 7-11

2. Do not clamp the cables together with the fuel lines. Keep them away from the fuel lines.
3. Use wire of the correct size. Carry out correct wiring according to the wiring diagram for each model.
4. Refer to ISO or ABYC standards.

■ Battery cables

Note: For the allowable cable diameter and length, refer to the engine wiring diagram for the specific engine model in vol. 2 or 3, otherwise refer to table below or ABYC standards.

Allowable maximum length by battery cable diameter (YIS values)

Unit: m

Rated voltage	12 V			24 V		Resistance of wire (Ω m)	
Starting motor rated output	Below 2 kW	Over 2 kW		Below 6 kW	Over 6 kW	AV, wire	IV, wire
Battery switch / Nominal section of wire	with or without	without	with	with or without			
15 mm^2	0.86	–	–	–	–	0.00188	–
20 mm^2	1.3	–	–	–	–	0.000887	–
30 mm^2	2.3	1.5	0.76	–	–	0.00052	–
40 mm^2	2.8	1.8	0.9	2.8	–	0.000428	–
50 mm^2	3.5	2.3	1.2	2.9	2.9	0.000337	0.000378
60 mm^2	4.1	2.7	1.4	3.4	3.4	0.000287	0.000303
85 mm^2	5.5	3.7	1.8	4.8	4.8	0.000215	–
100 mm^2	7.1	4.7	2.4	6.0	6.0	0.000168	0.000180
125 mm^2	–	5.5	2.8	6.9	6.9	–	0.000144
150 mm^2	–	6.7	3.4	8.4	8.4	–	0.000118
200 mm^2	–	8.6	4.3	10.8	10.8	–	0.0000922
250 mm^2	–	–	–	13.8	13.8	–	0.0000722
Allowable resistance of wire	0.0012 Ω	0.0008 Ω	0.0004 Ω	0.001 Ω		–	

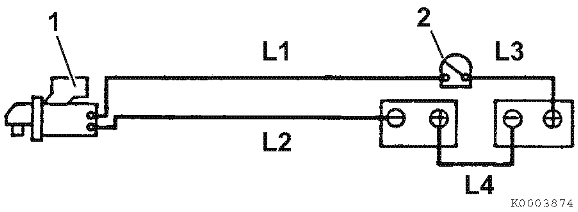
Note: AV wires are used for 15 to 100 mm^2 and IV wires (600 V vinyl insulated) for 125 to 250 mm^2.

■ Total resistance of battery cable (YIS formula)

$$L\ (m) = \frac{\text{Allowable wire resistance } (\Omega)^{*1}}{\text{Resistance of the wire used } (\Omega/m)^{*1}}$$

**1: The resistance varies depending on the wire standard of each country.*

*Note: The battery cable length, L (m), shows the full cable length of both the positive (+) and negative (–) cables (total of $L_1 + L_2 + L_3 + L_4$ in **Figure 7-12**).*



1 – Starter motor
2 – Battery switch

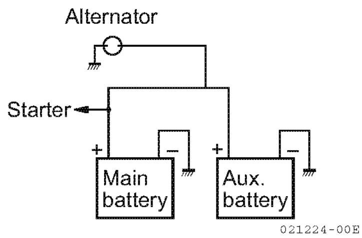
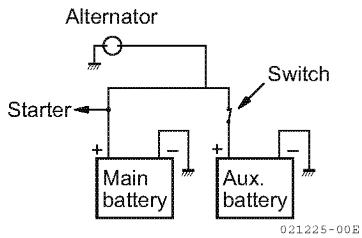
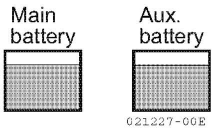
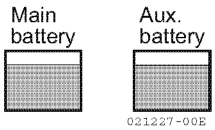
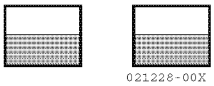
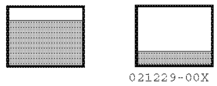
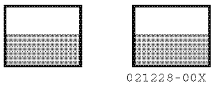
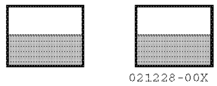
Figure 7-12

Multiple Battery Systems

Marine applications often require more than one battery to maintain sufficient power for onboard electric appliances, such as fans and refrigerators. Insufficient power can cause starter motor failure and alarm device malfunction.

Use a dedicated battery (main battery) for the engine's starter motor and alarm devices. Use a separate battery (auxiliary battery) for onboard electric appliances.

Adding a battery does not prevent main battery discharge unless a charging isolator is integrated into the charging circuit. A properly installed charging isolator can charge both the main and auxiliary batteries concurrently from one alternator. This arrangement isolates reverse current flow. The diagram in **Figure 7-13** shows three multiple battery configurations.

	(1) Simple addition of battery	(2) Switch used
Wiring		
Alternator (operating)		
Alternator (off) (Aux. battery operating)		Switch Off 
Starter started		Switch On 
Remarks	Main battery discharges due to use of aux. battery.	Main battery discharges by turning on the switch for charging aux. battery.

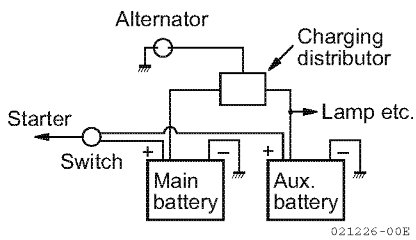
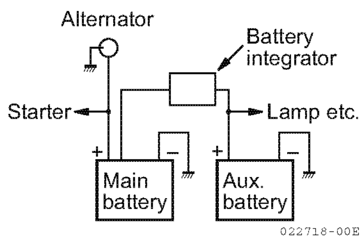
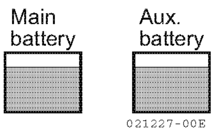
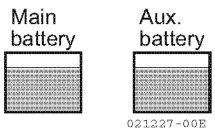
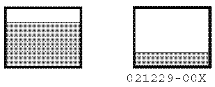
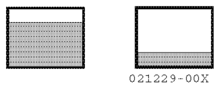
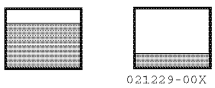
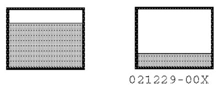
	(3) Charging distributor used	(4) Battery Integrator
Wiring		
Alternator (operating)		
Alternator (off) (Aux. battery operating)		
Starter started		
Remarks	Discharging from the main battery prevented.	This system is an automatic control system, in which charging method is adopted to avoid the discharge and charge failure problems caused by misoperation of the battery switch.

Figure 7-13

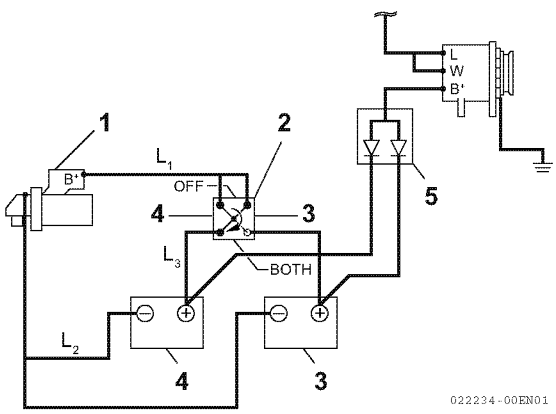
Note:

- *When adding a battery, check the battery capacity in respect to the alternator capacity.*
- *For wiring of a charging isolator, consult the manufacturer for information.*

■ When using a diode type battery isolator (VALEO 12 V - 120 A alternator mounted engine: YM/JH4/JH5 only)

VALEO 12 V - 120 A alternator is equipped with a multiple function type IC regulator. When using a diode type battery isolator, the following wiring change is required.

When 2 batteries are connected with the use of diode type battery isolator, the alternator cannot be generated as the initial exciting current does not flow.



1 – Starter motor
2 – Change over battery switch
3 – Aux. battery (house bank)
4 – Main battery (engine start bank)
5 – Diode type battery isolator

Figure 7-14

When the alternator does not generate after starting the engine, the charge failure alarm lamp is lit.

■ Procedure of wiring change

- When not using a diode type battery isolator

Default setting from the factory

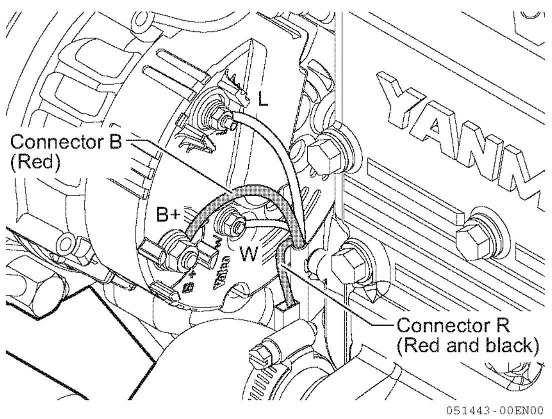


Figure 7-15

1. Remove the tape and pull out the Connector R. (with Red and Black wiring)
2. Remove the Connector B (Red wiring) from the Alternator B+ terminal and connect the Connector R to the Alternator B+ terminal.
3. Tie up the Connector B to the engine harness with tape.

- When using a diode type battery isolator

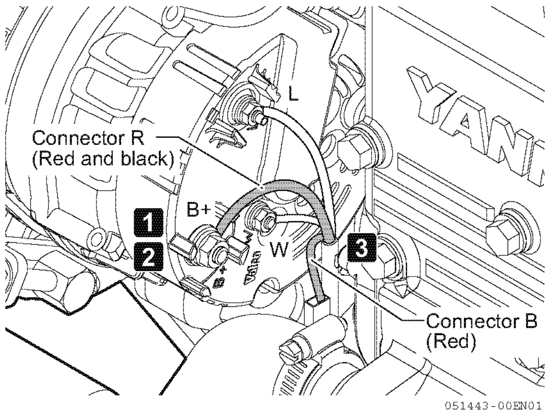


Figure 7-16

⚠ CAUTION

Be sure to isolate the Connector B with tape, otherwise there can be a short-circuit when starting the engine.

Alternator terminal (VALEO SG10S078)	Harness connector (YM/JH4/JH5)	
	When not using a diode type battery isolator	**When using a diode type battery isolator**
W	Connector W (Orange wiring)	Connector W (Orange wiring)
L	Connector L (Blue and Black wiring)	Connector L (Blue and Black wiring)
B+	Connector B (Red wiring)	Connector R (Red and Black wiring)
Tied up with tape	Connector R (Red and Black wiring)	Connector B (Red wiring)

Two-Pole Wiring

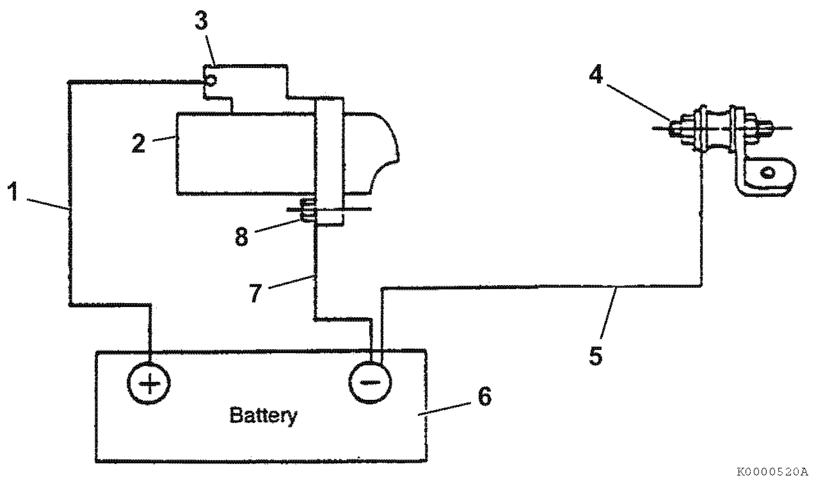
The Yanmar 12 V two-pole wiring system is a semi-two pole system that becomes an earth float system during engine operation, but not when starting. This helps to prevent electrolytic corrosion.

Battery positive (+) cable (1, **Figure 7-17**) and connection on the solenoid (3, **Figure 7-17**): Use a battery cable with the recommended diameter for each model.

Starter motor (2, **Figure 7-17**) and battery negative (–) cable (7, **Figure 7-17**): Starter current flows only when the engine is started. Connect the battery negative (–) cable to starter mounting bolt to minimize the leakage of current to the engine and hull. Use a battery cable with the recommended diameter for each model.

Earth terminal (4, **Figure 7-17**) and battery negative (–) cable (7, **Figure 7-17**): Attach the engine operation earth line between the earth terminal and battery (–). Do not connect the earth terminal to starter earth.

Note: Not applicable to meter sensor assembly for dual instrument panel type new C + C and new C + D combinations.



1 – Battery positive (+) cable (red)
2 – Starter motor
3 – Solenoid
4 – Earth terminal (earth terminal bolt)
5 – Ground cable
6 – Battery
7 – Battery negative (–) cable (black)
8 – Starter mounting bolt

Figure 7-17

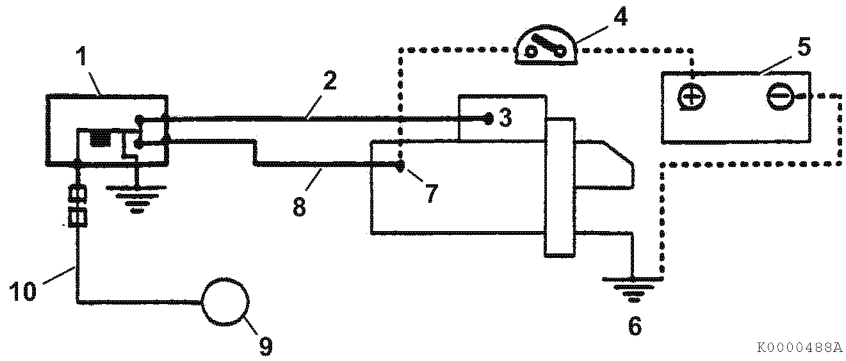
STARTER RELAY

Limit the length of extension wire harness to within 6 m (19.5 ft) (for engine models without a starter relay connection to the starter circuit).

NOTICE

Starting failure can result due to voltage drop if an extension wire harness longer than 6 m (19.5 ft) is directly connected without using the starter relay.

Wiring for Starter Relay



1 – Starter relay
2 – Red
3 – S
4 – Battery switch
5 – Battery
6 – Earth bolt
7 – B
8 – Red
9 – Starter switch
10 – White

Figure 7-18

Specifications

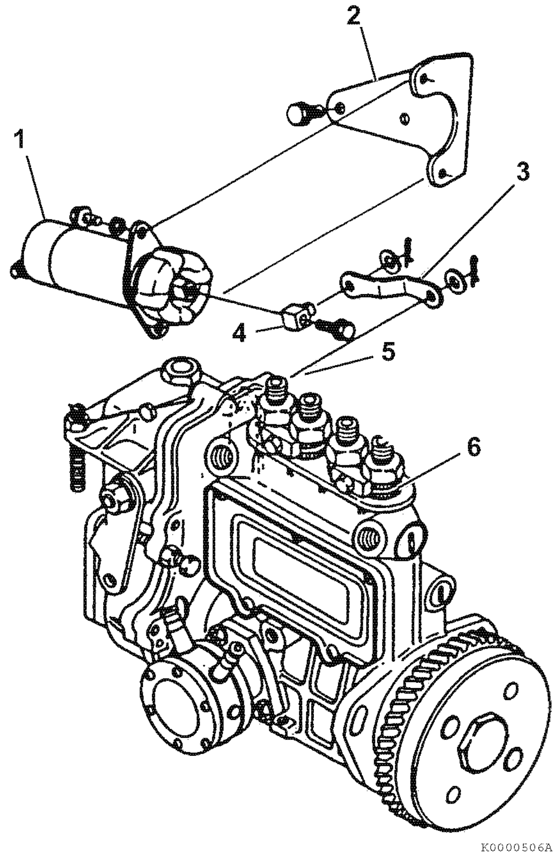
Yanmar part No.	129490-77910
Rated voltage	DC 12 V
Rated load	80 A at 30 seconds 240 A at instantaneous
Minimum operation voltage	below DC 8 V at 20 °C (68 °F)
Release voltage	below DC 4 V at 20 °C (68 °F)
Exciting current	below 4 A at 12 V

Note: The standard accessory for the JH3 series engines changed at the end of March 1999.

ENGINE STOP SOLENOID

The stop lever of the fuel injection pump is connected to the solenoid with a connecting rod.

The device is operated by the stop switch on the instrument panel.



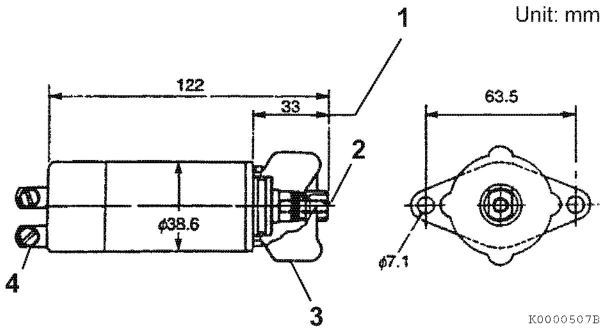
1 – Engine stop solenoid
2 – Solenoid bracket
3 – Link
4 – Pin
5 – Engine stop lever
6 – Fuel injection pump

Figure 7-19

Solenoid Specifications

Type	ES1
Solenoid model	1504-12A7U1B
Rated voltage	12 V
Loaded current	41 A
Holding force	9 kgf (19.8 lbf) at 25 °C (77 °F)
Holding current	0.75 A
Pulling force	5 kgf (11.0 lbf) at 25 °C (77 °F)

Unit: mm



1 – When the current flows
2 – M6 screw depth 20.8 mm (0.82 in.)
3 – Constant volume boot
4 – 8-32 screw terminal

Figure 7-20

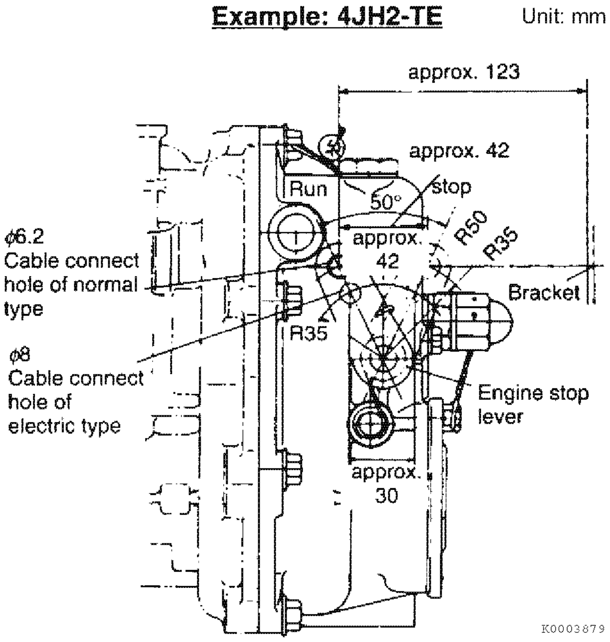


Figure 7-21

Relay

Rated voltage	12 V
Contact current	Lamp: 20 A Extra lamp: 25 A
Range of operation	-30 to +90 °C (-22 to +194 °F)
Yanmar part No.	124617-91850

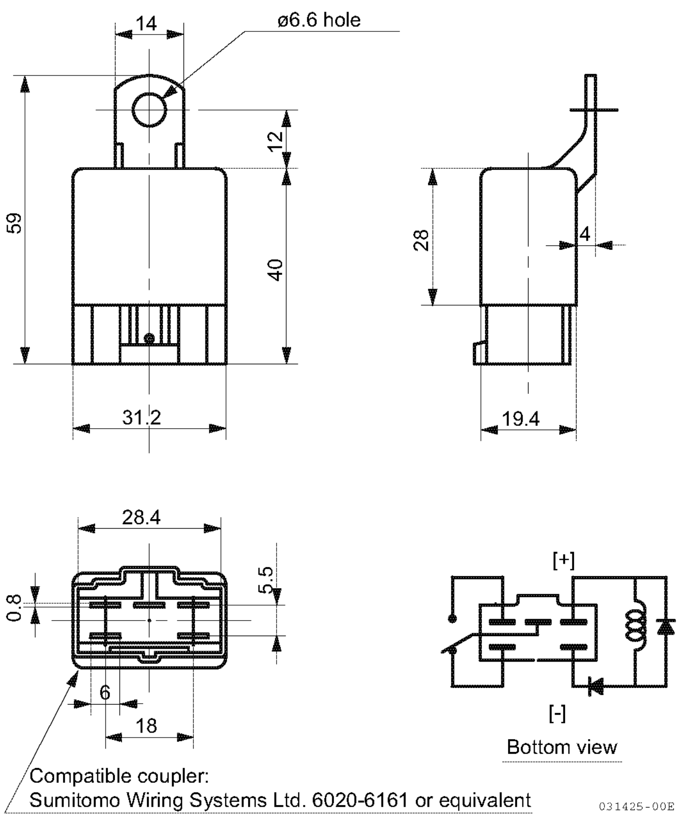


Figure 7-22

SENSOR UNITS

Sensor Assembly by Instrument Panel

Type of instrument panel / Sensor and alarm switch	A-type	B-type	B2 and new B		C and new C		D and new D		E-type
			B2	New B	C	New C	D	New D	
1. Tachometer sensor	X	O	O	O	O	O	O	O	O
2. Alarm switch									
• Cooling water temperature	O	O	O	O	O	O	O	O	O
• Lube oil pressure	O	O	O	O	O	O	O	O	O
• Sail drive seal leak	O	O	O	O	O	O	X	X	X
• Lube oil pressure for marine gear*1	X	X	O	O	O	O	O	O	O
• Cooling water (closed cooling) level*1	X	X	X	O	X	O	X	O	X
• Fuel filter (water level)*1	X	X	O	O	O	O	O	O	O
• Boost pressure high*1	X	X	X	O	X	O	X	O	X
3. Meter sensor									
• Lube oil pressure	X	X	X	X	O	O	O	O	O
• Cooling water (closed cooling) temperature	X	X	X	X	O	O	O	O	O
• Boost pressure*1	X	X	X	X	X	X	O	O	O

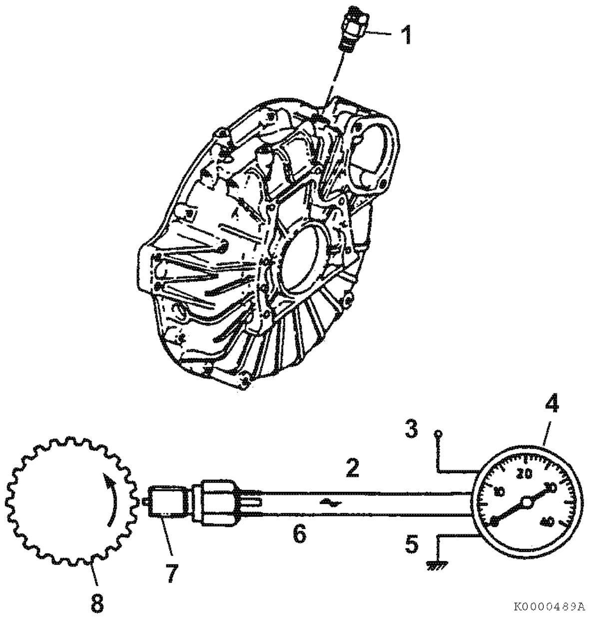
**1: Differs by engine model. Refer to the specific engine model information for available equipment.*

Note: O = Equipped on panel, X = Not equipped on panel

Tachometer

The tachometer indicates the number of revolutions per minute by means of an electrical input signal that is generated as a pulse signal from the magnetic pickup sensor.

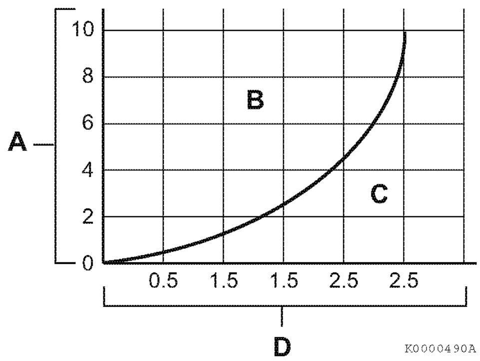
The function of the sensor is to convert the rotary motion into an electrical signal by means of counting the number of teeth of the ring gear connecting with the flywheel.



1 – Tachometer sensor
2 – Orange
3 – Red/Black
4 – Tachometer
5 – Black
6 – Blue/Red
7 – Rotation detecting sensor
8 – Ring gear

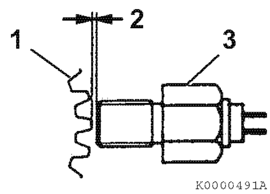
Figure 7-23

Sensitivity limit of sensor unit



A – Ring gear speed (m/sec)
B – G zone
C – NG zone
D – Sensor unit and ring gear clearance (mm)

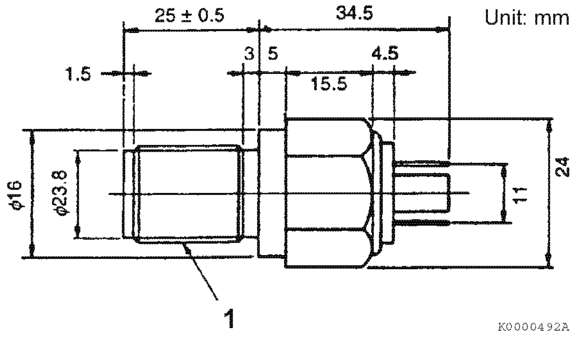
Figure 7-24



1 – Ring gear
2 – Clearance
3 – Sensor unit

Figure 7-25

Dimensions of sensor

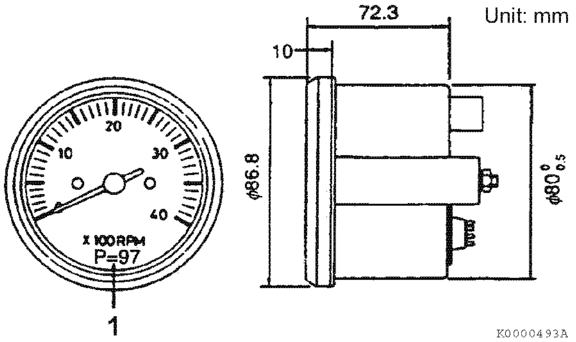


1 – M18 × P1.5

Figure 7-26

Tightening torque of sensor: 5 kgf·m, 49 N·m (36.2 ft-lb)

Dimensions



1 – Identification mark

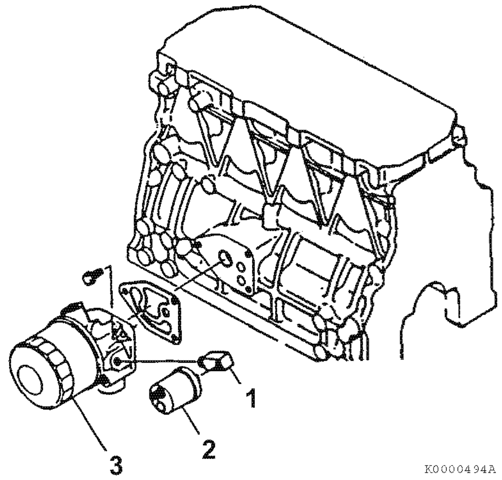
Figure 7-27

■ Specifications

Rated voltage	DC 12 V
Range of operating voltage	10 to15 V
Illumination lamp	3.4 W/12 V

Engine Oil Pressure Gauge Sensor

A sensor unit for engine oil pressure gauge is mounted on the oil filter bracket for some engine models. Oil pressure is measured when the oil enters the main gallery after being fed from the oil cooler and passing through the oil pressure control valve. Be sure to mount a vibration damper when mounting the oil pressure sensor unit.



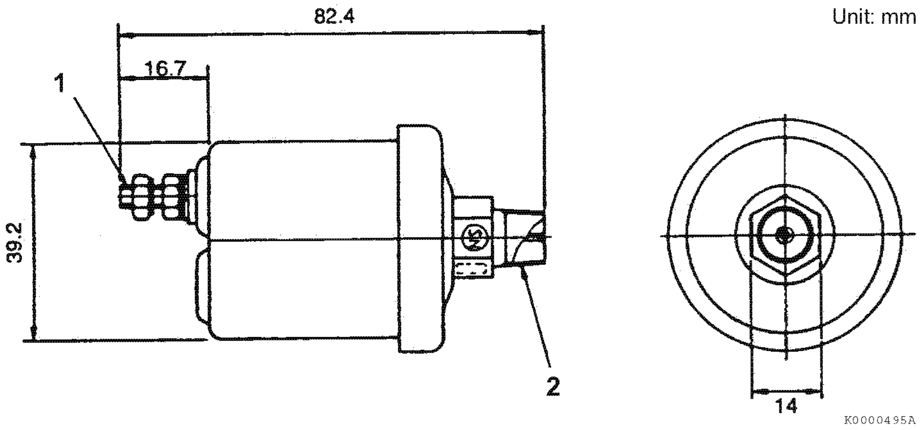
1 – Damper
2 – Engine oil pressure sensor unit
3 – Engine oil filter

Figure 7-28

■ Specifications and dimensions

Note: New design sensors are interchangeable with existing sensors.

	New design sensor	
Type	**Single meter**	**Dual meter**
Rated voltage	DC 12/DC 24	
Maximum operating pressure	800 kPa, 8 kgf/cm^2 (116 psi)	
Yanmar part No.	119773-91501	129574-91561
ID mark/ID color	LP1/Gold	8KT/Gold



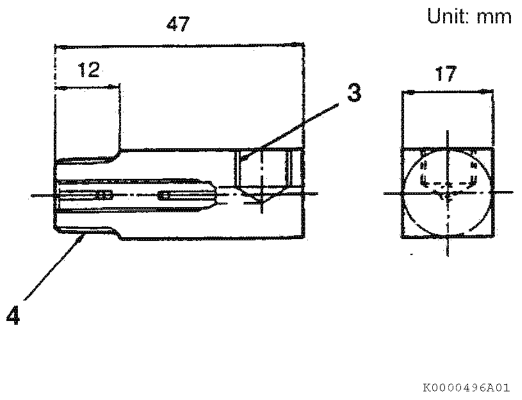
1 – M5 × P0.8

2 – PT 1/8

Figure 7-29

■ Damper

Example: 4LHA series



3 – PT 1/8
4 – PT 3/8

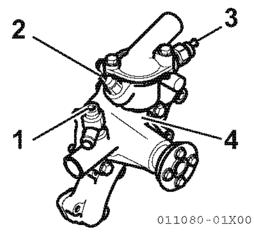
Figure 7-30

Closed Coolant Temperature Sensor

The closed coolant temperature sensor is installed where the highest expected coolant temperature will be, such as the thermostat housing, etc.

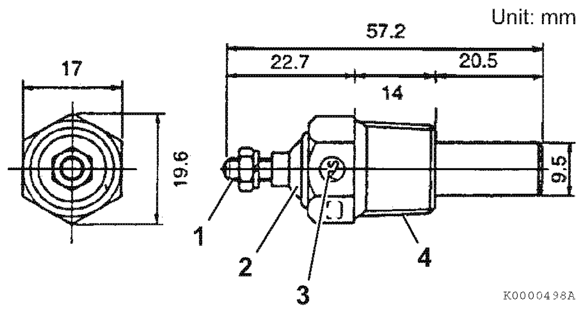
■ Specifications and dimensions

Type	Single	Dual
Rated voltage	12 V/24 V	
Yanmar part No.	144626-91570	129574-91570



1 – Inlet for water heater
2 – Cooling water temperature switch
3 – Cooling water temperature sensor unit
4 – Outlet for water heater

Figure 7-31



1 – M5 × P0.8
2 – Black insulator material
3 – ID mark 2 of dual meter sensor
4 – PT 3/8

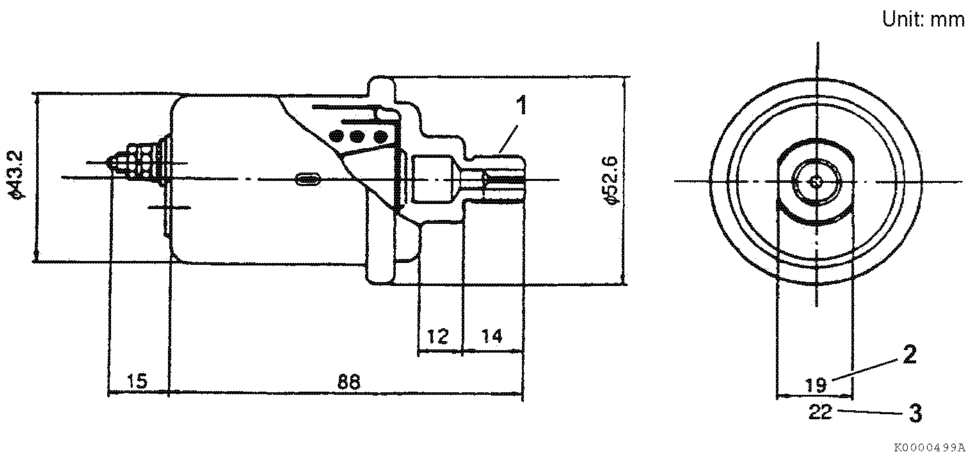
Figure 7-32

Turbocharger Boost Pressure Sensor

■ Specifications and dimensions

Note: New design sensors are interchangeable with existing sensors.

	New design sensor	
Type	**LH**	**LY/CX1**
Rated voltage	DC 12 V/DC 24 V	
Maximum operating pressure	200 kPa, 2 kgf/cm^2 (29 psi)	300 kPa, 3 kgf/cm^2 (43.5 psi)
Yanmar part No.	124413-91301	119773-91301
ID mark/ID color	2K/Gold	3K/Gold



1 – M12 × P1.25
2 – LH-type
3 – LY/CX-type

Figure 7-33

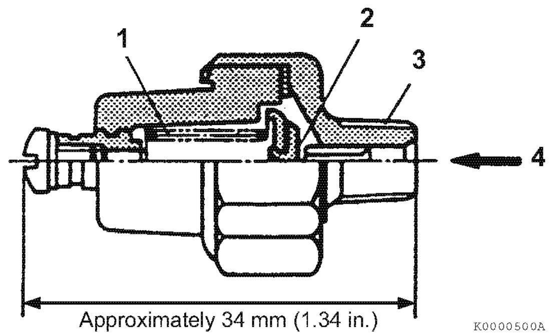
ALARM SWITCHES

Engine Oil Pressure

If the engine oil pressure drops with the key switch on, the contacts of the oil pressure switch are closed by a spring, the lamp is lit and the audible alarm sounds at the instrument panel. If the oil pressure returns to normal, the switch contacts are opened and the lamp and the audible alarm turns off.

■ Specifications

Operating pressure	0.1 to 0.3 kgf/cm^2 (0.014 to 0.043 psi)
Rated voltage	DC 12 V
Lamp capacity	5 W
Yanmar part No.	124060-39451

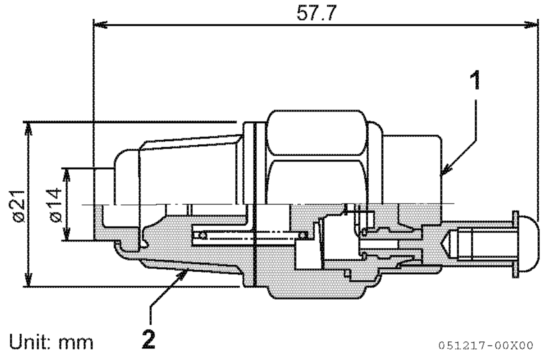


1 – Spring
2 – Contacts
3 – PT 1/8
4 – Oil pressure

Figure 7-34

Closed Cooling System Temperature Switch

If the engine coolant is too hot with the key switch on, the high-thermal expansion material contacts with the end of the cooling water temperature switch, the lamp is lit and the audible alarm sounds at the instrument panel.



1 – Identification color
2 – PT 3/8

Figure 7-35

■ Specifications

Operating temperature	ON	63 to 67 °C (145 to 153 °F)	93 to 97 °C (199 to 207 °F)	97 to 103 °C (207 to 217 °F)	103 to 109 °C (217 to 228 °F)
	Hysteresis	7 °C (12.6 °F) or less	7 °C (12.6 °F) or less	10 °C (18 °F) or less	10 °C (18 °F) or less
Rated capacity		DC 12 V, 1 A			
Response time		within 60 seconds			
Range of ambient temperature		-40 to 130 °C (-40 to 266 °F)			
Identification color		White	Green	Black	White
Yanmar part No.		128275-91340	127610-91350	120130-91370	128990-44500
Applicable engine type		Direct seawater cooling type	Coolant cooling type	Coolant cooling type	Coolant cooling type

Note: Tightening torque of PT 3/8 thread: 240 to 320 kgf·cm, 23.5 N·m (17 ft-lb).

Fuel/Water Separator Water Level Switch

The fuel/water separator separates water from the fuel. The separated water drains to the bottom of the fuel filter. When the water exceeds a certain level, the water level switch turns the alarm lamp on and sounds the audible alarm to alert the operator that water must be drained from the filter.

■ Specifications

Fuel filter		
Filtration volume	cm^3 (qt)	3200 (3.38)
Rated flow volume	L/min (qt/min)	2 (2.11)
Maximum water reservoir	mL (cu in.)	300 (18.3)
Water level switch		
Rated voltage	V	12
Operative position of water level	mL (cu in.)	ON: 80 to 120 (4.88 to 7.32)
Yanmar part No.	119773-55500	

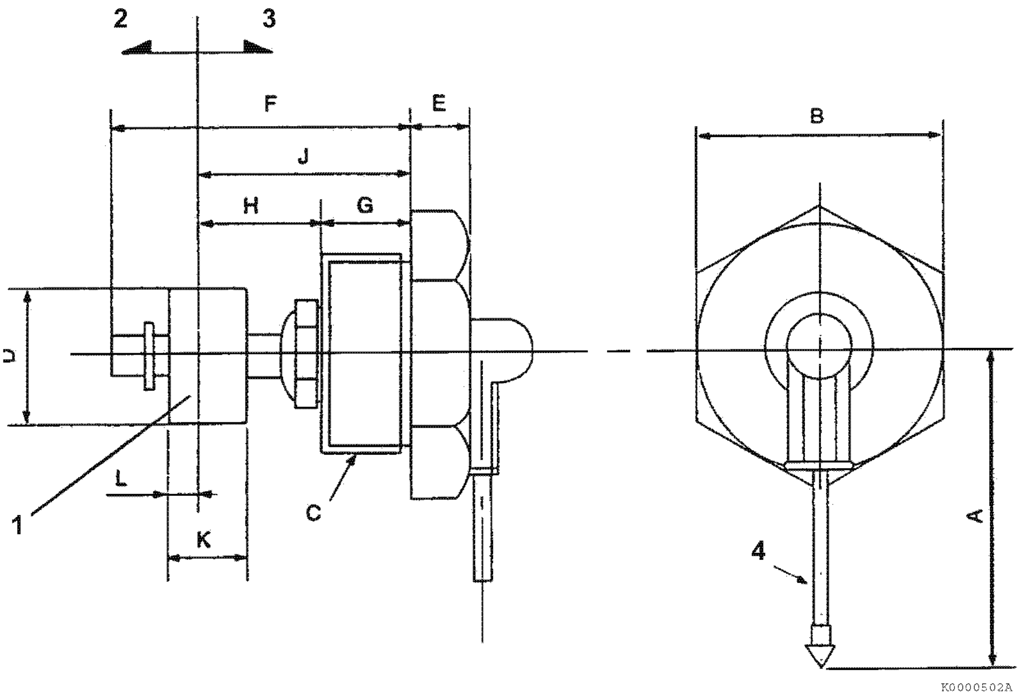
Level Switch for Closed Cooling System Tank

This coolant level switch detects the quantity of coolant in the coolant tank (heat exchanger). It is activated when the coolant quantity falls below a certain level. It turns on the alarm lamp and sounds the audible alarm to alert the operator (the new B-type instrument panel does not have this warning device). The coolant level switch is installed on the top of the coolant tank (heat exchanger).

■ Specifications

Rated capacity	DC 12 V, 3.4 W (lamp load)
Operating voltage	DC 8 to 16 V
Range of ambient temperature	-20° to +120 °C (-4° to +248 °F)
Cooling water	Engine coolant
Yanmar part No.	127695-91220

Dimensions



1 – Float
2 – ON
3 – OFF
4 – Wire harness

Figure 7-36

A mm (in.)	B mm (in.)	C	D mm (in.)	E mm (in.)	F mm (in.)	G mm (in.)	H mm (in.)	J mm (in.)	K mm (in.)	L mm (in.)
60 (2.36)	46 (1.81)	M36 × P1.5	ø25 (0.98)	10 (0.39)	55.5 (2.18)	16 (0.63)	23 (0.91)	39 ± 4 (1.5 ± 0.16)	15 (0.59)	6 (0.24)

Intake Boost Pressure Switch

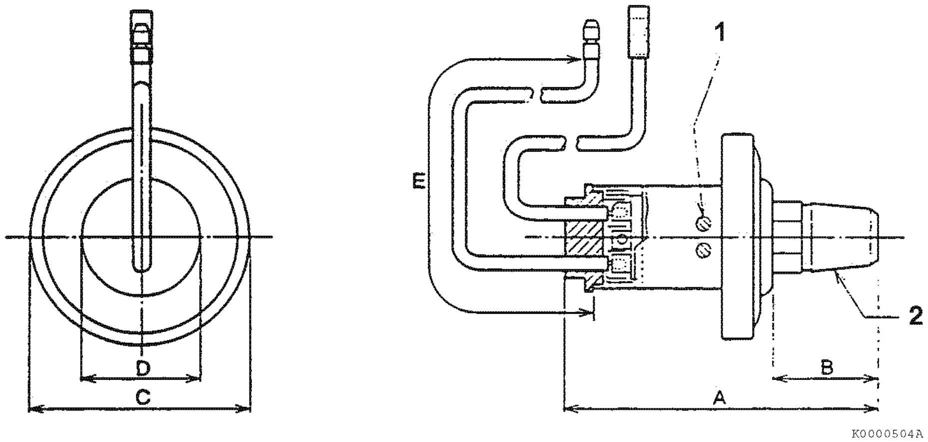
Note: This information is for reference only. The intake boost pressure switch has been discontinued for some current production models.

The wastegate valve regulates the intake pressure of the turbocharger to raise combustion efficiency. If the wastegate valve fails, the intake pressure will rise and the turbocharger will be damaged. The boost pressure switch monitors the intake pressure and when the pressure exceeds a specified level, it turns on the alarm lamp and sounds the audible alarm to warn the operator.

■ Specifications

Type	LPLHA	LY2
Rated capacity	DC 12 V, 6 A	
Operating pressure	2.4 to 2.8 kgf/cm^2 (34.1 to 39.8 psi)	2.65 to 3.05 kgf/cm^2 (37.7 to 43.4 psi)
Range of ambient temperature	-40° to +120 °C -40° to +248 °F	
Identification color	Blue	Yellow
Yanmar part No.	119773-91380	119595-91290

■ Dimensions



1 – Identification color

2 – PT 1/8

Figure 7-37

A	B	C	D	E	ID color
61.3 mm (2.41 in.)	17 mm (0.67 in.)	42.7 mm (1.68 in.)	25.5 mm (1.00 in.)	20 mm (0.79 in.)	Blue

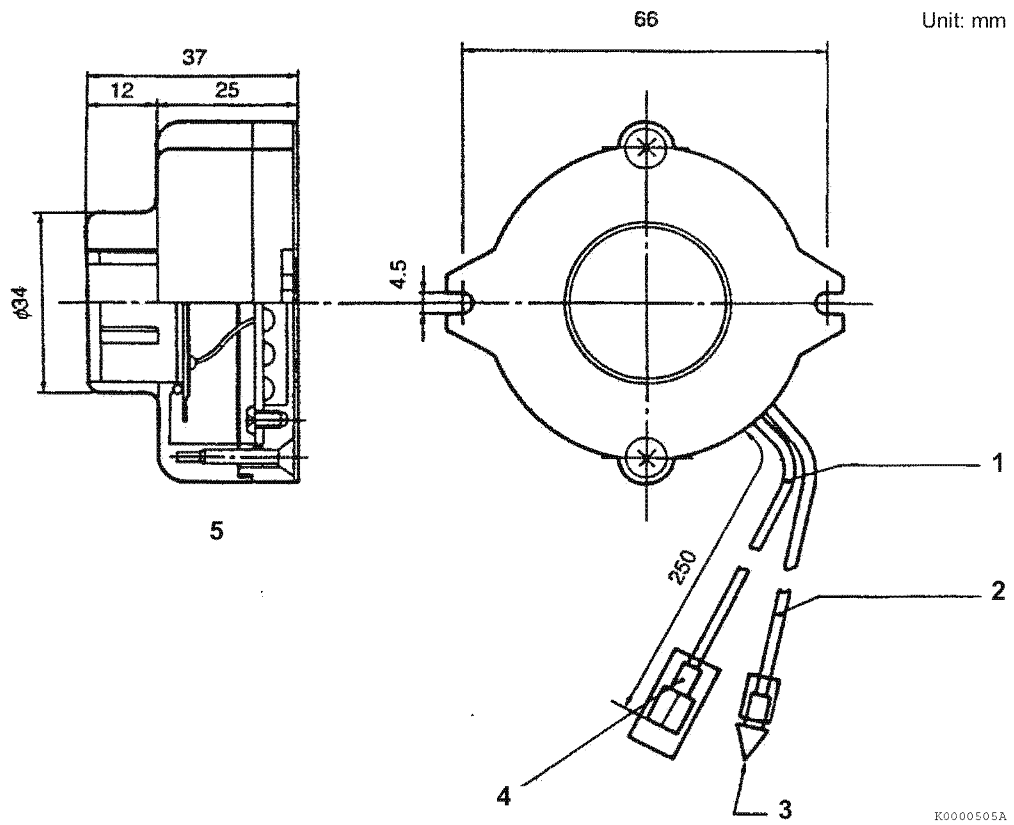
Audible Alarm

An audible alarm (buzzer) is included in the same package as the C, D, and E-type instrument panels. Install the alarm near the panel. The alarm is not designed to be installed on the instrument panel. It is the boat builder's responsibility to install an audible alarm if it is not supplied by Yanmar.

■ Installation

1. Install the alarm in a place that is well-protected from rain and seawater. The rear of the alarm is not waterproof.
2. Select a position with the least amount of hull vibration.
3. Connect the two wires of the panel (Black/White and Black/Red wires) with the wires of the alarm.

■ Dimensions



1 – Lead wire (–) White/Black
2 – Lead wire (+) Red/Black
3 – Spigot terminal (+)
4 – Socket terminal (–)
5 – Rated voltage: DC 12 V

Figure 7-38

Note: Refer to audible alarm marine service advisory for details.

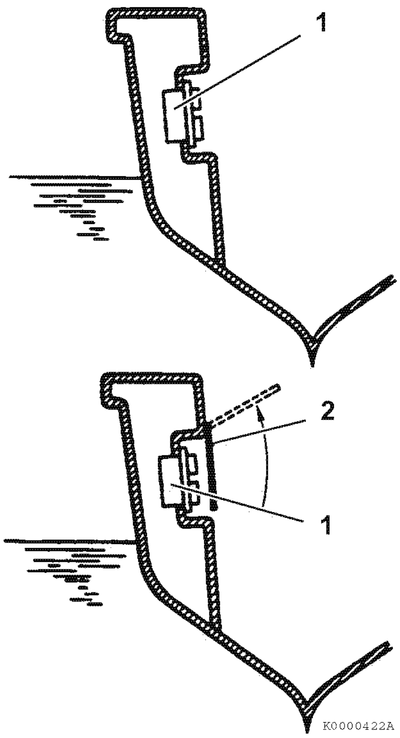
INSTRUMENT PANEL (for Panels Manufactured by Yanmar)

Panels provide critical information to the operator.

Proper Positioning of the Instrument Panel

Locate panel in a protected area. Install the instrument panel in the cabin if possible. If it must be installed outside, consider the following precautions:

1. Install in a location where there is no danger of the panel being splashed by seawater or rain.
2. If the instrument panel must be installed where it may be splashed by seawater, install it in a recessed position and add a cover **(Figure 7-39)**.
3. Install the instrument panel in a place with little vibration.



1 – Instrument panel
2 – Transparent cover

Figure 7-39

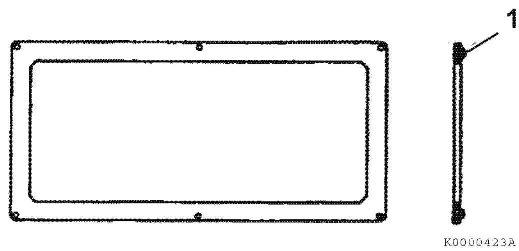
Determining the Angle of the Instrument Panel

Since the gauges on the instrument panel work within a fixed range of the installation angle, ensure that the panel is attached at a permissible angle.

Note: Allowable angle: within 45 to 75° (Instrument panel manufactured by Yanmar)

■ Procedures for installing the instrument panel

1. Drill the mounting holes in accordance with the instrument panel mounting holes.
2. The instrument panel comes with packing. When attaching the instrument panel outside the cabin, apply an auxiliary packing agent to the packing to protect the rear terminal of the panel. Point the extruded parts toward the hull.



1 – Hull side

Figure 7-40

Precautions when Installing Instruments

NOTICE

When you install instrument panels:

- Avoid wet locations
- Avoid locations subject to vibration
- Set meters at correct angle

Failure to follow these instructions may cause inaccurate or unreliable instrumentation.

1. Avoid places where rain or seawater is expected.
2. Select a position with the least amount of vibration.
3. The angle of the meter is 45 to 75° to the horizontal plane **(Figure 7-41)**.
4. Install at the specified angle to avoid errors on the meters.

Allowable installation

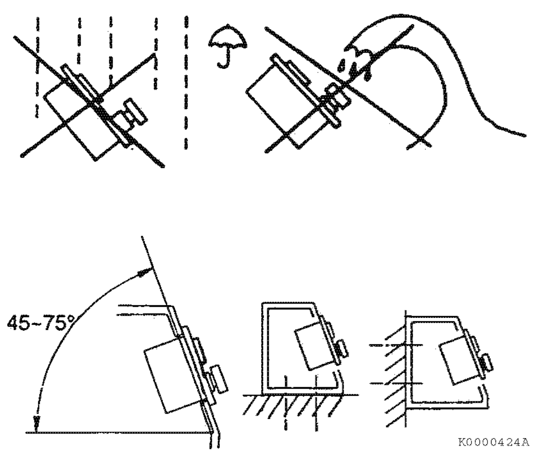


Figure 7-41

Wiring

- Provide suitable cover to protect the lead wire from friction damage and attach it firmly to the bulkhead, etc.
- When connecting the lead wire, make sure that water cannot pass along the wire to the electrical equipment.
- Route the cable so that it does not come in contact with the sharp edges of the engine or with heated areas.

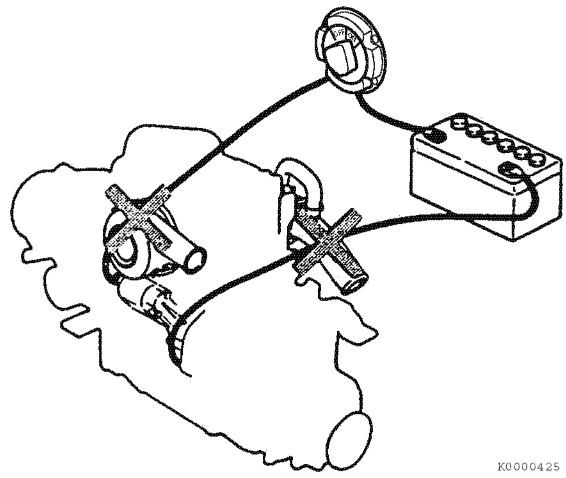


Figure 7-42

- Do not clamp the cables together with the fuel lines. Keep them away from the fuel lines as much as possible.

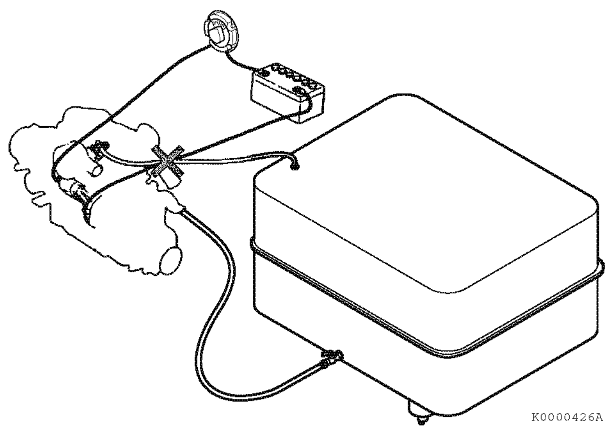


Figure 7-43

- Use wire of the correct size. Wire the panel according to the wiring diagram for each model.

NOTICE

For electronic controlled engines, please refer to appropriate Electronics Installation Manuals.

■ Extension wire harness

⚠ WARNING

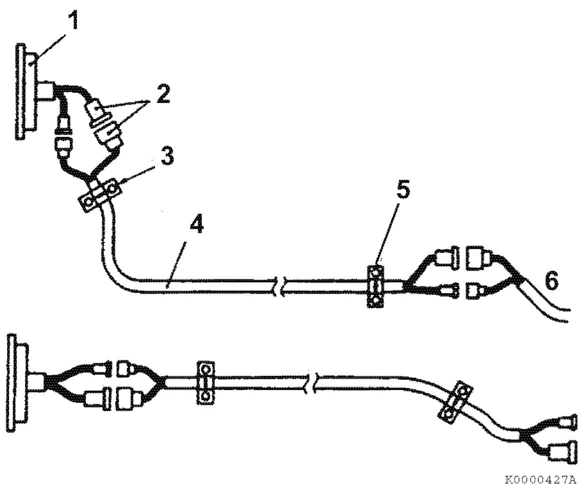
Fire Hazard

Undersized wiring systems can cause an electrical fire. Be sure to use proper size wiring for the application.

Note:

- *Limit the length of the extension wire harness to 6 m (19.5 ft). For engine models without a starter relay, connect to the starter switch.*
- *If an extension wire harness of more than 6 m (19.5 ft) is directly connected without using a starter relay, starting failure can result due to a voltage drop.*

1. Connect the wiring of the instrument panel and engine side to each coupler. Wiring between the engine installation position and the instrument panel is made by the extension wire harness (optional).
   1- The length of extension of the wire harness varies depending on engine models. For details, refer to the specific engine model options in vol. 2 and 3.
   2- The voltage will decrease excessively if the extension harness is longer than the specified length. This leads to engine starting failure and malfunction of the instrument panel gauges. The specified harness length differs depending on the engine model.
   3- It is impossible to interchange new and old harnesses, unless an adapter is used.
2. **Dual station instrument panel** - When installing the dual station instrument panel, use the correct wire harness for the dual instrument panel option. The dual instrument panel is not available for some engine models.
3. Up to two extension wire harnesses may be connected and used, but do not connect more than two.
4. **Attaching the extension wire harness** - The instrument panel and engine side terminal are connected with an extension wire harness. A coupler is provided at each connection. Be sure to clamp the wire harness near the couplers at both ends (instrument panel and engine side couplers). Take special care to prevent the coupler connected to the instrument panel side from falling out under the weight of the extension wire harness.

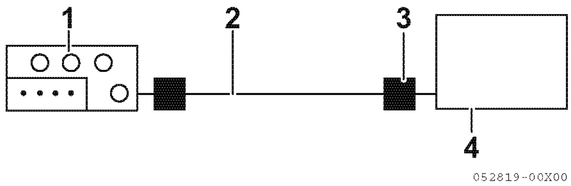


1 – Instrument panel
2 – Coupler
3 – Clamp
4 – Extension wire harness
5 – Clamp
6 – Engine side

Figure 7-44

Layout of new extension wire harness

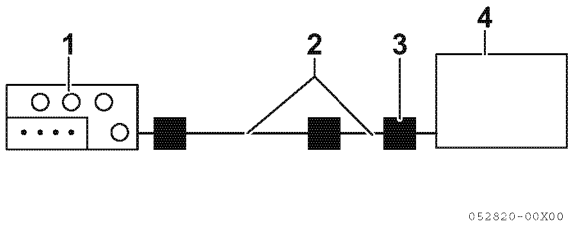
Single panel, one extension wire harness



1 – New panel
2 – New extension wire harness
3 – New connector
4 – Engine

Figure 7-45

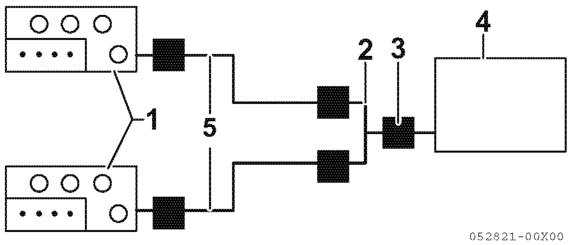
Single panel, two extension wire harness



1 – New panel
2 – New extension wire harness
3 – New connector
4 – Engine

Figure 7-46

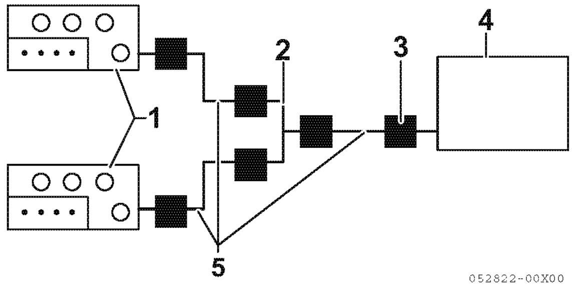
Dual panel, two extension wire harness



1 – New panel
2 – New connector wire harness for dual panel
3 – New connector
4 – Engine
5 – New extension wire harness

Figure 7-47

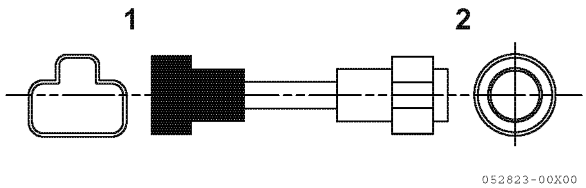
Dual panel, three extension wire harness



1 – New panel
2 – New connector wire harness for dual panel
3 – New connector
4 – Engine
5 – New extension wire harness

Figure 7-48

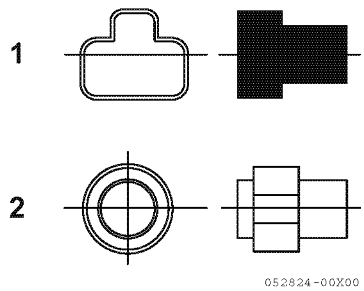
New and old connectors



1 – New connector (coupler)
2 – Old connector (coupler)

Figure 7-49

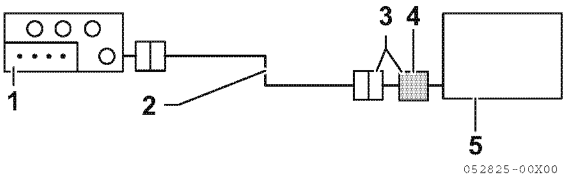
New and old extension wire harness layout



1 – Connector (coupler) of new extension wiring harness
2 – Connector (coupler) of old extension wiring harness

Figure 7-50

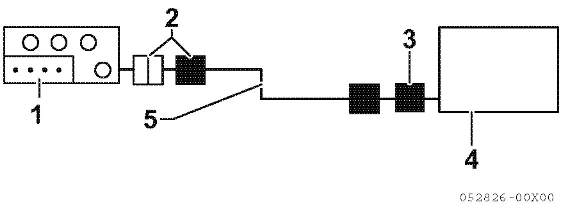
Old panel, old extension wire harness with new and old connectors



1 – Old panel
2 – Old extension wire harness
3 – New and old connectors
4 – New connector
5 – Engine

Figure 7-51

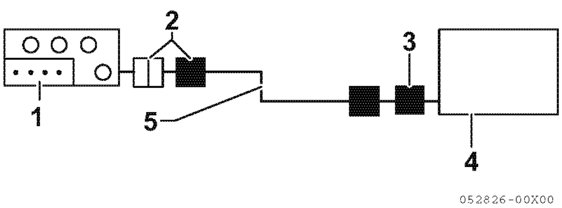
Old panel, new extension wire harness with new and old connectors



1 – Old panel
2 – New and old connectors
3 – New connector
4 – Engine
5 – New extension wire harness

Figure 7-52

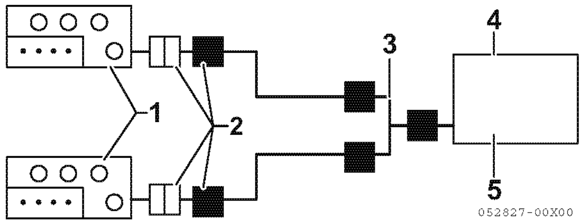
Old dual panel, old two extension wire harness with new and old connectors



1 – Old panel
2 – New connector wire harness for dual panel
3 – New connector
4 – Engine
5 – New and old connectors

Figure 7-53

Old dual panel, new two extension wire harness with new and old connectors



1 – Old panels
2 – New and old connectors
3 – Old connector wire harness for dual panel
4 – New connector
5 – Engine
6 – New extension wire harness

Figure 7-54

■ Wiring for drawing additional electricity

When drawing additional electricity to power a radio, fan, light, pump, wireless, or other electrical apparatus used in the boat, connect these loads to the positive (+) terminal of the battery by way of the main battery switch.

■ Functions by instrument panel

Type of instrument panel	A type		B type	B2 type				C type				D type		E/E1 type		
Functions	**A-1**	**A-2**		**B2-1**	**B2-2**	**B2-3**	**B2-4**	**C-1**	**C-2**	**C-3**	**C-4**	**D-1**	**D-2**	**E-1**	**E-2**	**E-3**
1. Switch unit																
1-1. Key switch for ON/OFF power source (2-position switch)	O	O	O	X	X	X	X	X	X	X	X	X	X	X	X	X
1-2. Key switch for GLOW/OFF/ON/ START (4-position switch)	X	X	X	O	O	O	O	O	O	O	O	O	O	O	O	O
1-3. Push button switch for engine start	O	O	O	X	X	X	X	X	X	X	X	X	X	X	X	X
1-4. Push button switch for engine stop	X	X	X	O	O	O	O	O	O	O	O	O	O	O	O	O
1-5. Illumination switch for meters and alarm lamps	X	X	O	O	O	O	O	O	O	O	O	O	O	O	O	O
1-6. Buzzer stop switch	X	X	X	X	X	X	X	O	O	O	O	O	O	O	O	O
2. Alarm buzzer	O	O	O	O	O	O	O	●	●	●	●	●	●	●	●	●
• Cooling water high temperature	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
• Lube oil low pressure	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
• Sail drive seal leak*	O	O	O	O	O	X	O	O	O	X	O	X	X	X	X	X
• Lube oil low pressure for marine gear*	X	X	X	X	X	O	X	X	X	O	X	X	O	X	X	O
3. Alarm lamp unit																
• Battery not charging	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
• Cooling water high temperature	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
• Lube oil low pressure	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
• Sail drive seal Leak*	X	O	O	O	O	X	O	O	O	X	O	X	X	X	X	X
• Lube oil low pressure for marine gear*	X	X	X	X	X	O	X	X	X	O	X	X	O	X	X	O
• Lube oil filter clogged*	X	X	X	X	X	O	X	X	X	O	X	X	O	X	X	O
• Fuel water separator (water level)*	X	X	X	X	X	X	X	X	X	X	X	X	X	X	O	X
4. Tachometer																
• Tachometer I.D. No. P = 97			O	X	X	X	X	X	X	X	X	X	X	X	X	X
• Tachometer I.D. No. P = 114			X	O	X	X	X	O	X	X	X	X	X	X	X	X
• Tachometer I.D. No. P = 116			X	X	X	X	O	X	X	X	O	X	X	X	X	X
• Tachometer I.D. No. P = 127			X	X	O	X	X	X	O	X	X	O	X	O	O	X
• Tachometer I.D. No. P = 129			X	X	X	O	X	X	X	O	X	X	O	X	X	O
5. Meters																
• Lube oil pressure meter								O	O	O	O	O	O	O	O	O
• Cooling water temperature meter								O	O	O	O	O	O	O	O	O
• Boost meter (turbo)								X	X	X	X	X	O	X	O	O
5-1. Operation hour meter								O	O	O	O	O	O	O	O	O
6. Other																
6-1. Quartz clock								X	X	X	X	O	O	O	O	O
6-2. Fuse box								O	O	O	O	O	O	O	O	O

Note:

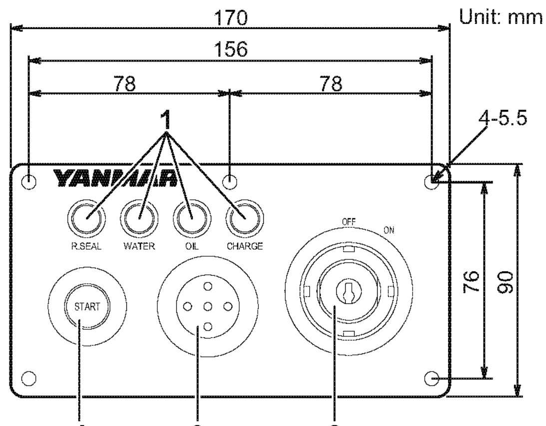
- *O = Equipped on panel, X = Not equipped on panel, ● = Installed by boatbuilder*
- *Depending on the instrument panel type, the asterisk (*) functions may not be activated because the corresponding sensors are not installed on the engine.*

■ Internal Yanmar code

Type of panel	ID number
Panel	Yanmar part No.
A1	D28270-91101
A2	D28371-91100
B	D28170-91110
B2-1	29171-91101
B2-2	D24411-92890
B2-3	D27675-91200
B2-4	D29670-91110
C-1	D29171-91201
C-2	D24411-92920
C-3	D27675-91170
C-4	D29171-91180
D1	D24411-92850
D-2	D27675-91300
E-1	D19171-91130
E-2	D19182-91130
E-3	D27675-91100
E-4	D27675-91110

Instrument Panel Configurations

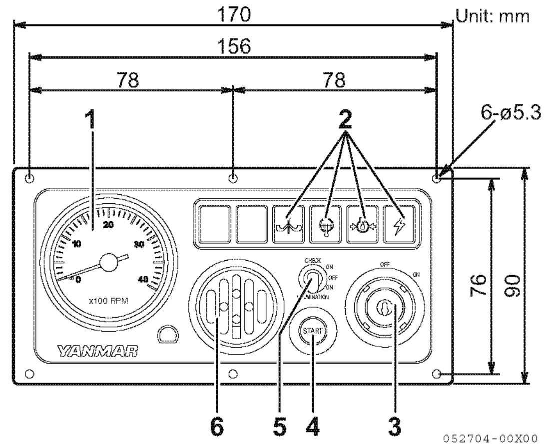
■ A-type



1 – Alarm lamps
2 – Key switch
3 – Alarm buzzer
4 – Engine start push button

Figure 7-55

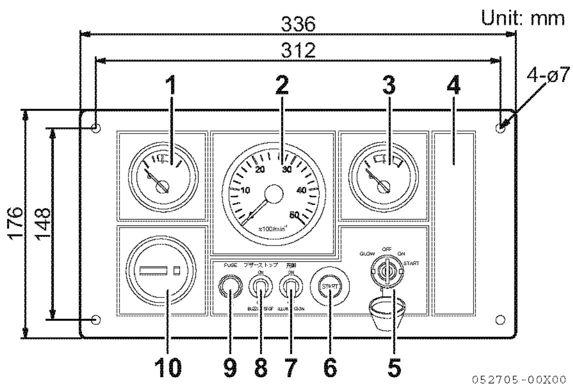
■ B and B2-type



1 – Tachometer
2 – Alarm lamps
3 – Key switch
4 – Engine start push button
5 – Panel illumination switch
6 – Alarm buzzer

Figure 7-56

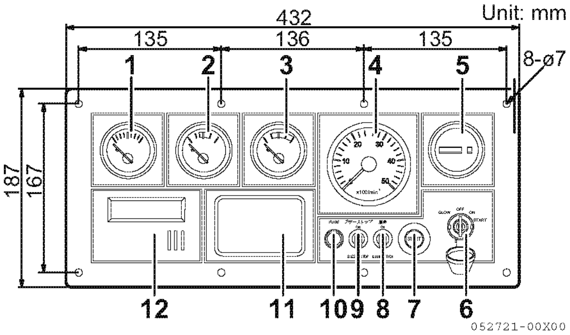
■ C-type



1 – Meter
2 – Tachometer
3 – Meter
4 – Alarm lamps
5 – Key switch
6 – Engine stop push button
7 – Panel illumination switch
8 – Buzzer stop switch
9 – Fuse box
10 – Hour meter

Figure 7-57

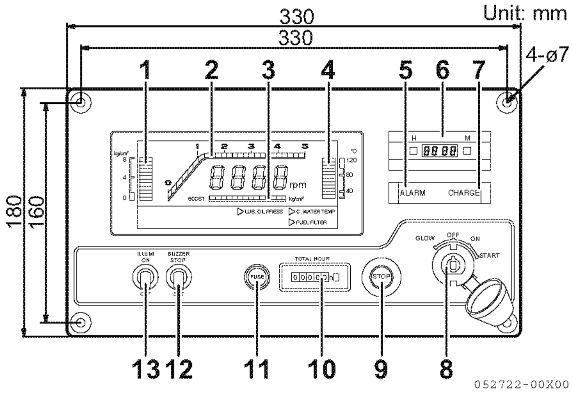
■ D-type



1 – Meter
2 – Meter
3 – Meter
4 – Tachometer
5 – Hour meter
6 – Key switch
7 – Engine stop push button
8 – Panel illumination switch
9 – Buzzer stop switch
10 – Fuse box
11 – Alarm lamp unit
12 – Quartz clock

Figure 7-58

■ E-type



1 – Meter
2 – Tachometer
3 – Meter
4 – Meter
5 – Alarm lamp
6 – Quartz clock
7 – Alarm lamp
8 – Key switch
9 – Engine stop push button
10 – Hour meter
11 – Fuse box
12 – Buzzer stop switch
13 – Panel illumination switch

Figure 7-59

■ Functions by new type instrument panel

Type of new instrument panel	New B											New C									New D						
Functions	B2-N1	B2-N2	B2-N3	B2-N4	B2-N5	B2-N6	B2-N7	B2-N8	B2-N9	B2-N10	B2-N11	C-N1	C-N2	C-N3	C-N4	C-N5	C-N6	C-N7	C-N8	C-N9	D-N1	D-N2	D-N3	D-N4	D-N5	D-N6	D-N7
1. Switch unit																											
1-1. Key switch for GLOW/OFF/ON/START	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
1-2. Push button switch for engine stop	X	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
1-3. Alarm buzzer	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
1-4. Alarm buzzer stop switch	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
1-5. Illumination switch for meters	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
1-3. Alarm buzzer																											
• Cooling water high temperature	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
• Lube oil low pressure	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
• Sail drive seal leak*1	O	O	O	X	X	O	X	X	X	X	X	O	O	X	X	O	X	X	X	X	X	X	X	X	X	X	X
• Hydraulic oil low pressure for marine gear or sterndrive gear oil level*1	X	X	X	O	X	X	X	X	X	X	X	X	X	O	O	X	O	O	O	O	X	O	O	O	O	O	O
• Fuel water separator (water level)*1	X	X	X	X	O	X	X	X	O	X	X	X	O	X	O	X	X	O	X	X	X	X	O	X	X	O	X
• Seawater flow	X	X	X	X	O	X	O	X	O	O	X	X	X	O	O	X	X	O	O	X	X	O	O	X	O	O	X
• Cooling water level for closed cooling tank*1	X	X	X	O	X	X	O	X	X	O	X	X	X	O	O	X	X	O	O	X	X	O	O	X	O	O	X
• Boost pressure high*1	X	X	X	X	O	X	O	O	X	X	X	X	X	O	O	X	O	O	O	O	X	O	O	O	O	O	O
2. Alarm unit (6-lamp type)																											
• Battery not charging	O	O	O	O	O	O	O	O	O	O	O																
• Cooling water high temperature	O	O	O	O	O	O	O	O	O	O	O																
• Lube oil low pressure	O	O	O	O	O	O	O	O	O	O	O																
• Sail drive seal leak*1	O	O	O	X	X	O	X	X	X	X	X																
• Hydraulic oil low pressure for marine gear or sterndrive gear oil level*1	X	X	X	O	X	X	X	X	X	X	X																
• Lube oil filter clogged*1	X	X	X	O	X	X	X	X	X	X	X																
• Fuel water separator (water level)*1	X	X	X	X	O	X	X	X	O	X	X																
• Seawater flow*1	X	X	X	X	O	X	O	X	O	O	X																
• Cooling water level for closed cooling tank*1	X	X	X	O	X	X	O	X	X	X	X																
• Boost pressure high*1	X	X	X	X	O	X	O	O	X	X	X																
• Preheat*1	X	X	X	X	X	X	X	X	O	O	O																

Type of new instrument panel	New B											New C									New D						
Functions	B2-N1	B2-N2	B2-N3	B2-N4	B2-N5	B2-N6	B2-N7	B2-N8	B2-N9	B2-N10	B2-N11	C-N1	C-N2	C-N3	C-N4	C-N5	C-N6	C-N7	C-N8	C-N9	D-N1	D-N2	D-N3	D-N4	D-N5	D-N6	D-N7
3. Alarm unit (10-lamp type)																											
• Battery not charging												O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
• Cooling water high temperature												O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
• Lube oil low pressure												O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
• Sail drive seal Leak*1												O	O	X	X	X	X	X	X	X	X	X	X	X	X	X	X
• Hydraulic oil low pressure for marine gear or sterndrive gear oil level*1												X	X	O	O	X	O	O	O	O	X	O	O	O	O	O	O
• Lube oil filter clogged*1												X	X	O	X	X	X	X	O	X	X	O	X	X	O	X	X
• Fuel water separator (water level)*1												X	O	O	O	X	X	O	X	X	X	X	O	X	X	O	X
• Seawater flow*1												X	X	O	O	X	X	O	O	X	X	O	O	X	O	O	X
• Cooling water level for closed cooling tank*1												X	X	O	O	X	X	O	O	X	X	O	O	X	O	O	X
• Boost pressure high*1												X	X	O	O	X	O	O	O	O	X	O	O	O	O	O	O
• Preheat*1												X	X	X	X	X	X	O	O	O	X	X	X	X	O	O	O
4. Tachometer unit																											
• Tachometer with hour meter, I.D. No. P = 97	O	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
• Tachometer with hour meter, I.D. No. P = 114	X	O	X	X	X	X	X	X	X	X	X	O	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
• Tachometer with hour meter, I.D. No. P = 116	X	X	X	X	O	O	X	X	O	X	X	X	X	X	O	O	X	O	X	X	X	X	O	X	X	O	X
• Tachometer with hour meter, I.D. No. P = 127	X	X	O	X	X	X	X	O	X	X	O	X	O	X	X	X	O	X	X	O	O	X	X	O	X	X	O
• Tachometer with hour meter, I.D. No. P = 129	X	X	X	O	X	X	O	X	X	O	X	X	X	O	X	X	X	X	O	X	X	O	X	X	O	X	X
5. Sub meters																											
5-1. Lube oil pressure meter												O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
5-2. Cooling water temperature meter												O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
5-3. Boost meter (turbocharger)												X	X	X	X	X	X	X	X	X	X	O	O	O	O	O	O
6. Clock unit																											
6-1. Quartz clock												X	X	X	X	X	X	X	X	X	O	O	O	O	O	O	O

**1: Varies by engine model. Refer to information for specific engine model in vol. 2 or 3.*

Note: O = Equipped on panel, X = Not equipped on panel

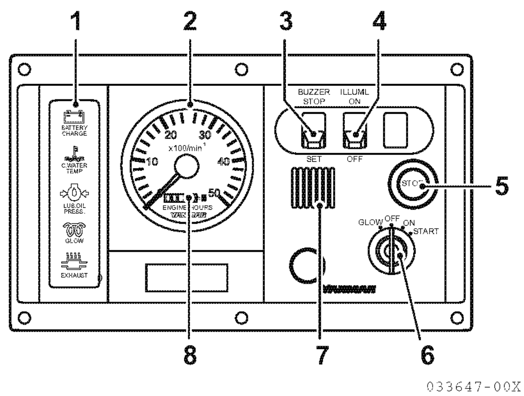
Note: The instrument panel ID number is specified at the instrument panel frame.

Type of panel	ID number
Panel	**Yanmar part No.**
B2-N1	128391-91130
B2-N2	129170-91130
B2-N3	129574-91130
B2-N4	119573-91130
B2-N5	119773-91130
B2-N6	129670-91130
B2-N7	119575-91130
B2-N8	119175-91130
B2-N9	119773-91131
B2-N10	119575-91131
B2-N11	119175-91131
C-N1	129170-91161
C-N2	129574-91161
C-N3	127675-91161
C-N4	119773-91160
C-N5	129670-91161
C-N6	119175-91160
C-N7	119773-91162
C-N8	127675-91163
C-N9	119175-91162
D-N1	129574-91191
D-N2	127675-91193
D-N3	119773-91190
D-N4	119175-91190
D-N5	127675-91193
D-N6	119773-91192
D-N7	119175-91192

Instrument Panel Configuration (New-Type Panel)

This is a module-type instrument panel. It consists of the switch unit, alarm lamp unit and meter unit. Each module unit can be used separately in a panel frame.

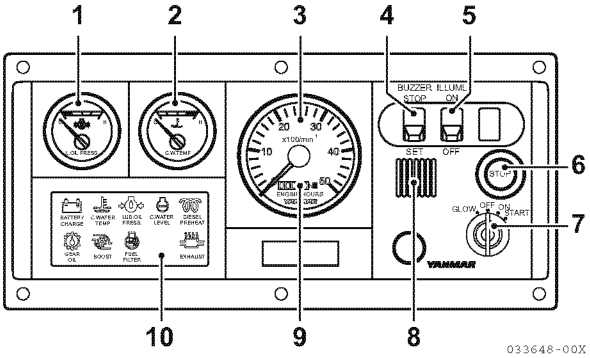
■ New B-type



1 – Alarm lamp unit - 6-lamp type
2 – Tachometer
3 – Buzzer stop switch
4 – Panel illumination switch
5 – Engine stop switch
6 – Key switch
7 – Alarm buzzer
8 – Hour meter

Figure 7-60

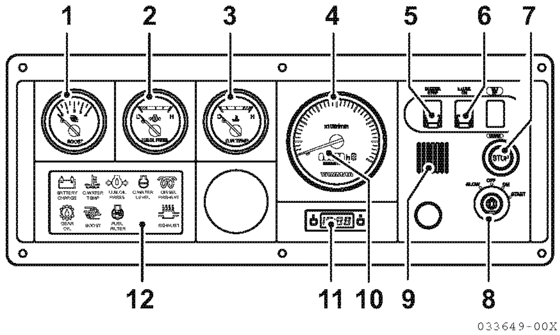
■ New C-type



1 – Oil pressure meter
2 – CW temperature meter
3 – Tachometer
4 – Buzzer stop switch
5 – Panel illumination switch
6 – Engine stop switch
7 – Starter key switch
8 – Alarm buzzer
9 – Hour meter
10 – Alarm lamp unit - 10-lamp type

Figure 7-61

■ New D-type

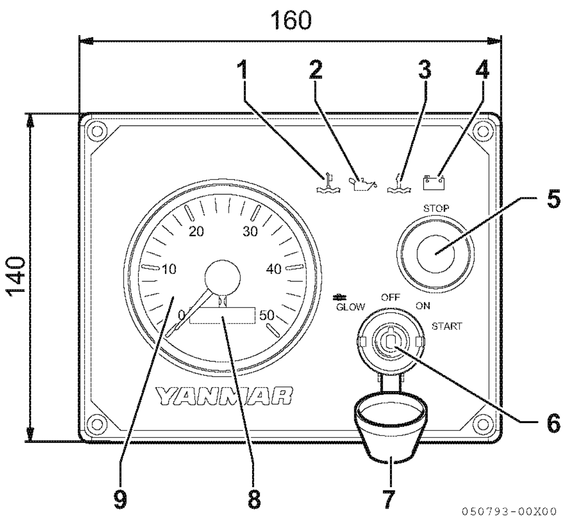


1 – Turbocharger boost pressure meter
2 – Engine oil pressure meter
3 – CW temperature meter
4 – Tachometer
5 – Buzzer stop switch
6 – Panel illumination switch
7 – Engine stop switch
8 – Starter key switch
9 – Alarm buzzer
10 – Hour meter
11 – Quartz clock
12 – Alarm lamp unit - 10-lamp type

Figure 7-62

Instrument Panel Parts (New Type VDO Panel)

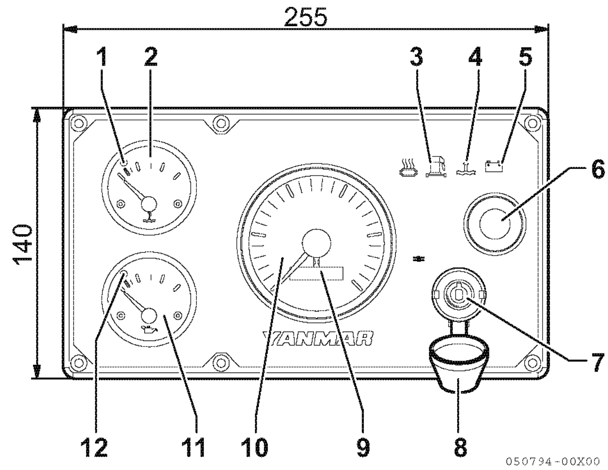
■ New type B (VDO) - JH4, JH5 and YM series



1 – Coolant high temperature indicator and alarm
2 – Engine oil low pressure indicator and alarm
3 – Water in sail drive seal indicator and alarm
4 – Battery low charge indicator
5 – Stop switch
6 – Key switch
7 – Moisture cap for key switch
8 – Hour meter
9 – Tachometer

Figure 7-63

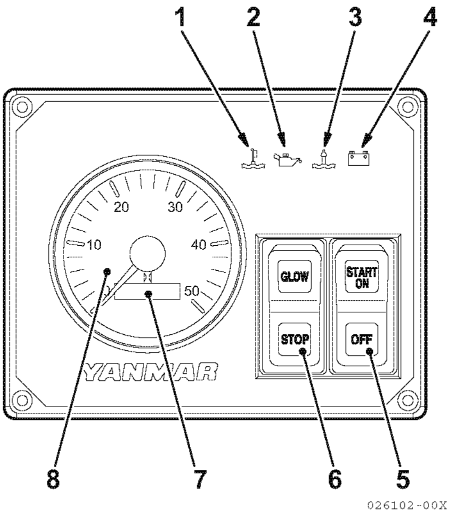
■ New type C (VDO) - JH4, JH5 series



1 – Coolant high temperature indicator and alarm
2 – Coolant temperature gauge
3 – Water in fuel filter indicator and alarm (4JH4-TE, 4JH4-HTE1 and 4JH4-HTE engines only)
4 – Water in sail drive seal indicator and alarm
5 – Battery low charge indicator
6 – Stop switch
7 – Key switch
8 – Moisture cap for key switch
9 – Hour meter
10 – Tachometer
11 – Engine oil pressure gauge
12 – Engine oil low pressure indicator and alarm

Figure 7-64

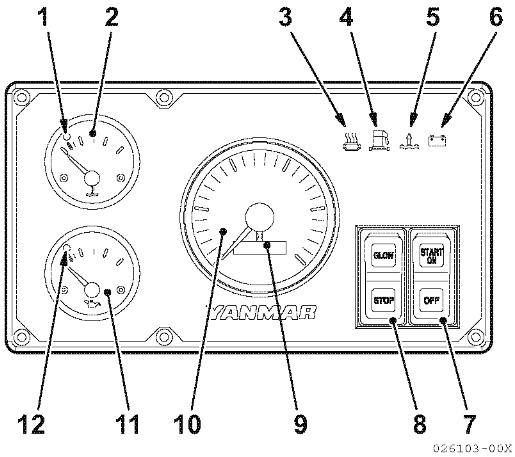
■ B (keyless) - type



1 – Coolant high temperature indicator
2 – Engine oil low pressure indicator
3 – Water in sail drive seal indicator
4 – Battery low charge indicator
5 – ON/OFF/START switch
6 – GLOW/STOP switch
7 – Hourmeter
8 – Tachometer

Figure 7-65

■ C (keyless) - type



1 – Coolant high temperature indicator
2 – Coolant temperature gauge
3 – Not used on this engine
4 – Water in fuel filter indicator
5 – Water in sail drive charge indicator
6 – Battery low charge indicator
7 – ON/OFF/START switch
8 – GLOW/STOP switch
9 – Hourmeter
10 – Tachometer
11 – Engine oil pressure gauge
12 – Engine oil low pressure indicator

Figure 7-66

■ Functions by JH4, JH5 and YM series - VDO type instrument panels

Type of instrument panel	New type B (VDO) for JH4, JH5 and YM series	New type C (VDO) for JH4 and JH5 series
Function		
Switch unit		
Key switch for GLOW/OFF/ON/START (4-position switch)	O	O
Engine stop switch	O	O
Alarm lamp unit		
Battery low charge indicator	O	O
Cooling water high temperature indicator and alarm	O	X
Engine oil low pressure indicator and alarm	O	X
Water in sail drive seal indicator and alarm	O*2	O*2
Water in fuel filter indicator and alarm	X	O*1
Meters (gauges)		
Engine oil pressure gauge	X	O
Coolant temperature gauge	X	O
Hour meter	O	O
Tachometer	O	O

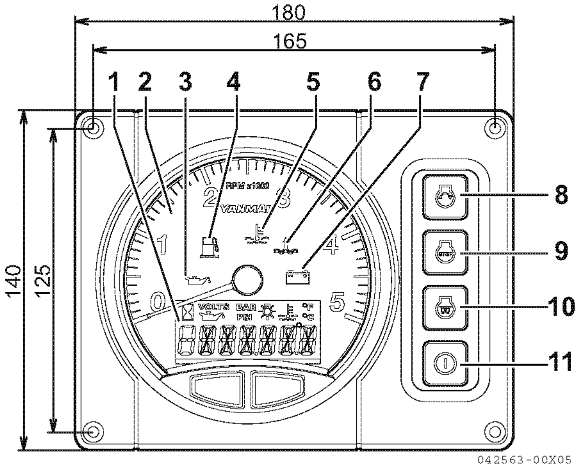
**1: 4JH4-TE, 4JH4-HTE1 and 4JH4-HTE engines only*
**2: Sail drive only*

Note: O = Equipped on panel, X = Not equipped on panel

Type of panel	Yanmar part No.
New type B (VDO) for JH4, JH5 and YM series	129271-91113
New type C (VDO) for JH4 and JH5 series	129271-91163

Note: Refer to marine service advisory regarding the adjustment of tachometer for tooth count of flywheel.

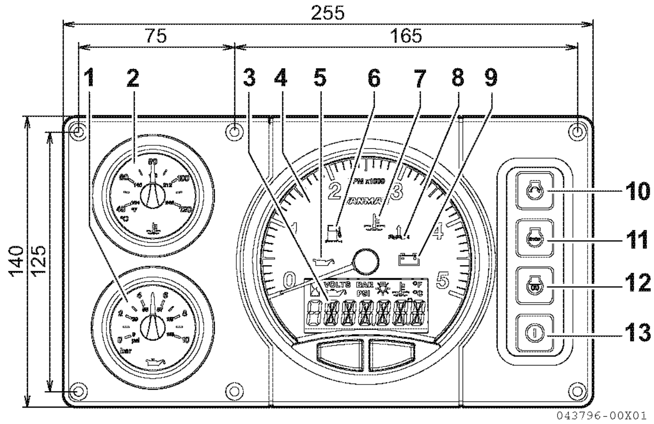
■ B20 type (Medallion) - JH4, JH5 and YM series



1 – LCD
2 – Tachometer
3 – Engine oil low pressure indicator and alarm
4 – Water in fuel filter indicator and alarm (4JH4-TE, 4JH4-HTE1 and 4JH4-HTE engines only)
5 – Coolant high temperature indicator and alarm
6 – Water in sail drive seal indicator and alarm
7 – Battery low charge indicator
8 – Start switch
9 – Stop switch
10 – Glow switch
11 – Power switch

Figure 7-67

■ C30 type (Medallion) - JH4, JH5 series



1 – Engine oil pressure gauge
2 – Coolant temperature gauge
3 – LCD
4 – Tachometer
5 – Engine oil low pressure indicator and alarm
6 – Water in fuel filter indicator and alarm (4JH4-TE, 4JH4-HTE1 and 4JH4-HTE engines only)
7 – Coolant high temperature indicator and alarm
8 – Water in sail drive seal indicator and alarm
9 – Battery low charge indicator
10 – Start switch
11 – Stop switch
12 – Glow switch
13 – Power switch

Figure 7-68

■ Functions by JH4, JH5 and YM series - Medallion type instrument panels

Type of instrument panel	B20 for JH4, JH5 and YM series	C30 for JH4 and JH5 series
Function		
Switch unit		
Start switch	O	O
Stop switch	O	O
Glow switch	O	O
Power switch	O	O
Alarm lamp unit		
Engine oil low pressure indicator and alarm	O	O
Water in fuel filter indicator and alarm (4JH4-TE, 4JH4-HTE1 and 4JH4-HTE engines only)	O*1	O*1
Coolant high temperature indicator and alarm	O	O
Water in sail drive seal indicator and alarm	O*2	O*2
Battery low charge indicator	O	O
Meters (gauges)		
Tachometer	O	O
LCD	O	O
Engine oil pressure gauge	X	O
Coolant temperature gauge	X	O

**1: 4JH4-TE, 4JH4-HTE1 and 4JH4-HTE engines only*
**2: Sail drive only*

Note: O = Equipped on panel, X = Not equipped on panel

Type of panel	Yanmar part No.
B20 type (Medallion) for JH4, JH5 and YM series	164100-30101
C30 type (Medallion) for JH4 and JH5 series	164100-30200

Note: Refer to marine service advisory regarding the adjustment of tachometer for tooth count of flywheel.

Setup Screen Access and Control (Setting the engine speed pulse value for B20/C30 type panel)

Use the buttons on the bottom of the LCD display to set the instrument panel.
Press the left button to switch between displays.

1. Press and hold both buttons until "SET UP" appears.
2. Press the left button and go to the screen "UNIT".
3. Press the left button and go to the next screen "ENGINE".
4. Confirm that the display says "ENGINE". Press the right button and "P∗∗∗∗" appears.

   Note: The pre-set value of speed pulse is indicated on the box of each panel.
5. Next, press the left button and select the speed pulse value for each engine model.

Engine model	Speed pulse value
1GM10	97
YM/JH4/JH5 with HITACHI alternator	10.29
YM/JH4/JH5 with VALEO alternator	12.10
JH3-T	127

6. After confirming the value is changed correctly, press the right button to return to the "ENGINE" screen.
7. Press the left button again to go from the "ENGINE" screen to the "EXIT" screen.
8. After confirming the display, press the right button to re-start the panel and return to the hourmeter display.

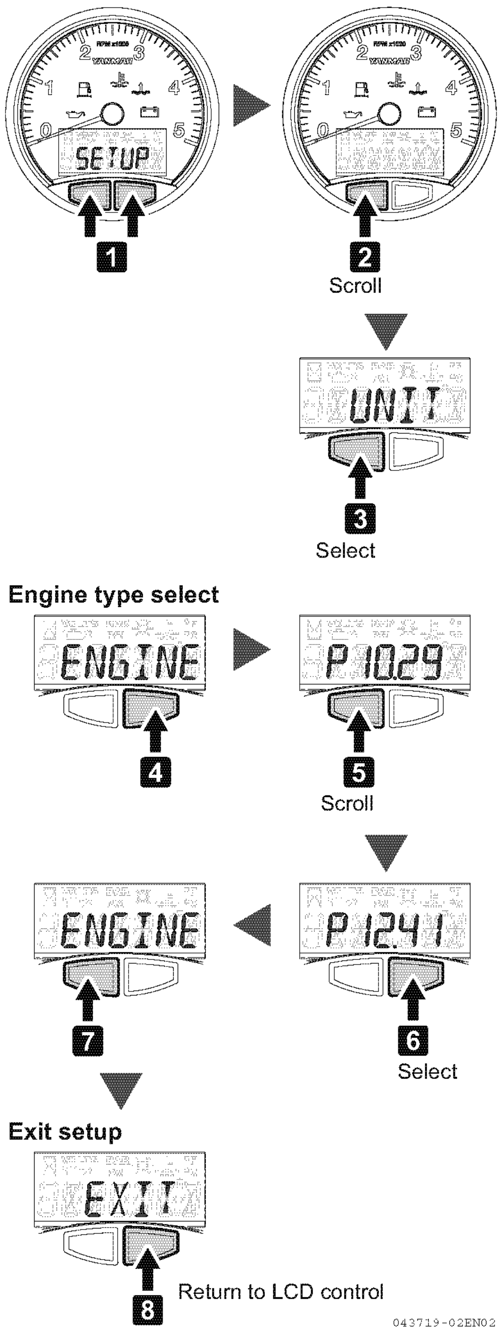
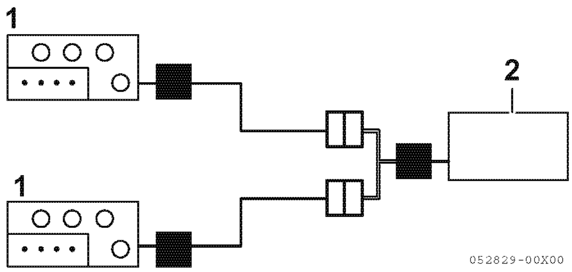


Figure 7-69

Combination of Dual Instrument Panels

Instrument panel combinations differ depending on the engine model. Please refer to the specific engine model information in vol. 2 or 3.

	New type panel	Old type panel	New/old mixed
Panel type	B × B	B2 × B2	B2 × New B
	B × C	B2 × C	B2 × New C
	B × D	B2 × D	B2 × New D
	C × C	E1 × E	–
	C × D	–	–

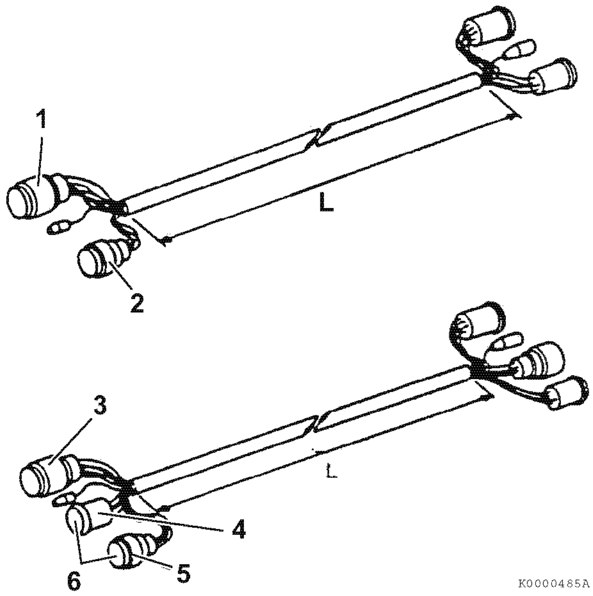


1 – Panel
2 – Engine

Figure 7-70

■ Length of extension wire harness (old and new type)

Type	Name	L m (ft)	Yanmar part No. (old type code)
EWN3	Extension wire harness, 3 m (9.8 ft)	2.75 to 2.85 (9.02 to 9.35)	D28391-94500 2-connector type (D28170-91500)
EWN4	Extension wire harness, 4 m (13.1 ft)	3.75 to 3.85 (12.30 to 12.63)	D29574-91510 3-connector type (D24611-77840)
EWN6	Extension wire harness, 6 m (19.7 ft)	5.75 to 5.85 (18.86 to 19.19)	D29574-91520 3-connector type (D19171-91501)

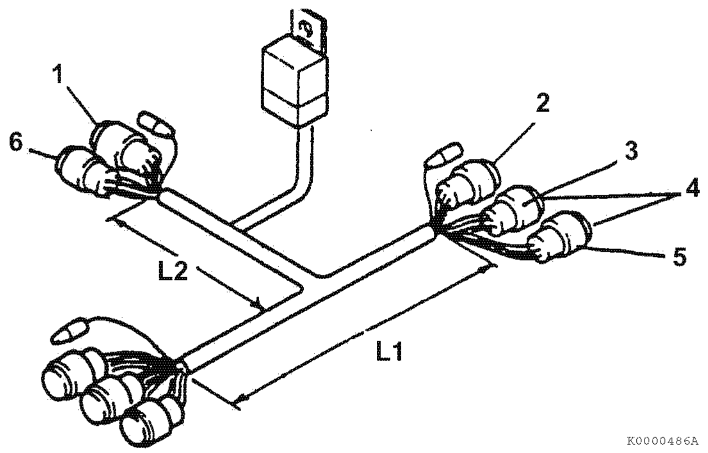


1 – 6P, connector (8P, connector, new type)
2 – 4P, connector (3P, connector, new type)
3 – 6P, connector (8P, connector, new type)
4 – 4P, connector (3P, connector, new type)
5 – 4P, connector (8P, connector, new type)

Figure 7-71

■ Extension wire harness for dual instrument panel

Type	L1 (old type)	L2 (old type)	Yanmar part No. (old type code)
CWN1	370 mm (14.6 in.) (340 mm (13.4 in.))	200 mm (7.9 in.) (200 mm (7.9 in))	D29574-91590 (D19171-91590)

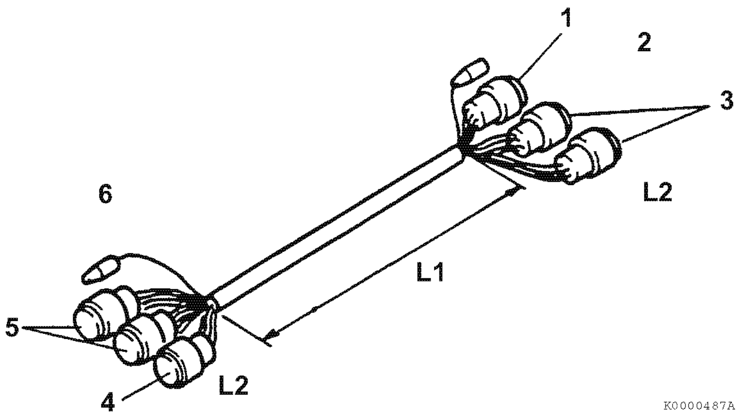


1 – 6P, connector (8P, connector, new type)
2 – 6P, connector (8P, connector, new type)
3 – 4P, connector (3P, connector, new type)
4 – 4P, connector (8P, connector, new type)
5 – 4P, connector (3P, connector new type)

Figure 7-72

■ New and old connectors

L1	L2	Yanmar part No.
100 mm (3.9 in.)	100 mm (3.9 in.)	129574-77860



1 – 6P, connector
2 – Old type connector
3 – 4P, connector
4 – 3P, connector
5 – 8P, connector
6 – New type connector

Figure 7-73

COLD STARTING AID

An air heater or glow plug may be available for warming intake air during starting in low temperatures. The air heater is mounted between the intake manifold and intake manifold coupling.

The device may be automatic or may activated by a preheat switch. Refer to the *Operator's Manual* or *Service Manual* of your equipment for specifics.

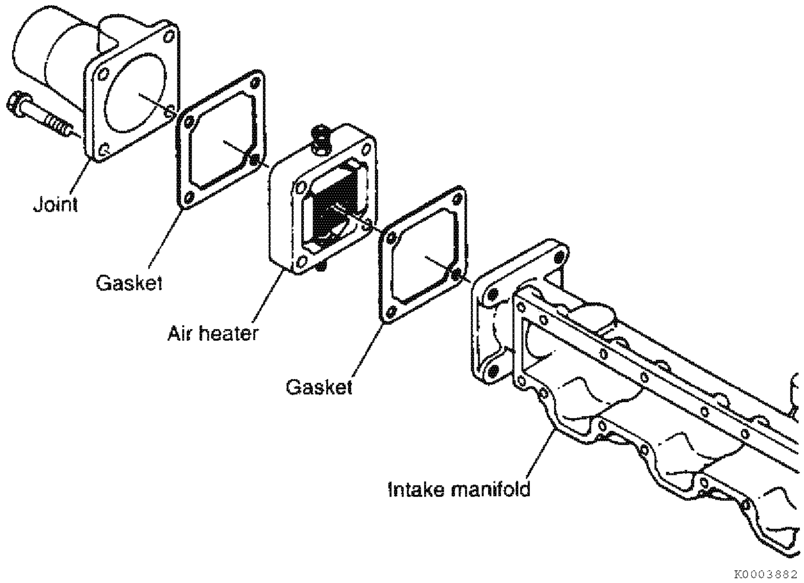


Figure 7-74

Air Heater

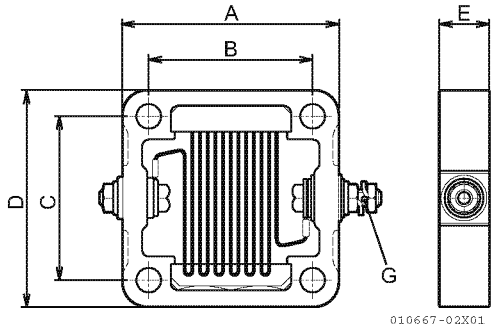


Figure 7-75

■ Specifications

Type	Unit	AH 1	AH 2	AH 3
Yanmar part No.		129100-77500	119005-77050	127695-77500
Rated output	W	400	500	500 (2000)
Rated current	A	35	42	42 (90)
Rated voltage	V	12		12 (24)
Rated operation interval	Seconds	ON: 60, OFF: 30		
Dimensions				
A	mm (in.)	78 (3.07)	88 (3.47)	178 (7.00)
B	mm (in.)	60 (2.36)	70 (2.76)	80 + 80 (3.15 + 3.15)
C	mm (in.)	60 (2.36)	70 (2.76)	90 (3.54)
D	mm (in.)	78 (3.07)	88 (3.47)	108 (4.25)
E	mm (in.)	18 (0.71)	18 (0.71)	20 (0.79)
F	mm	4 × ø9	4 × ø9	4 × ø9
G (thread size)	mm	M6 × P1		

Heater Plug

The heater plug heats the areas around the combustion chamber to make the engine starting easier. The plug is installed in the cylinder head or intake manifold. The number of plugs varies depending on the engine model.

Note: Production started end of September, 1999.

Besides the conventional function of heating intake air for easy starting, the function of reducing exhaust (bluish white smoke), which is emitted soon after starting in cold areas, has also been added.

Specifically, the heater function as described below was added to the conventional starting operation of turning the key switch manually to GLOW to start the heater and starter motor.

Note: Low cetane number diesel fuels cause the engine to emit more bluish white smoke. We recommend the use of diesel fuels with a minimum cetane number of 45.

■ Specifications

Rated voltage	DC 12 V
Rated current	58 A
Yanmar part No.	119775-77600

■ Dimensions

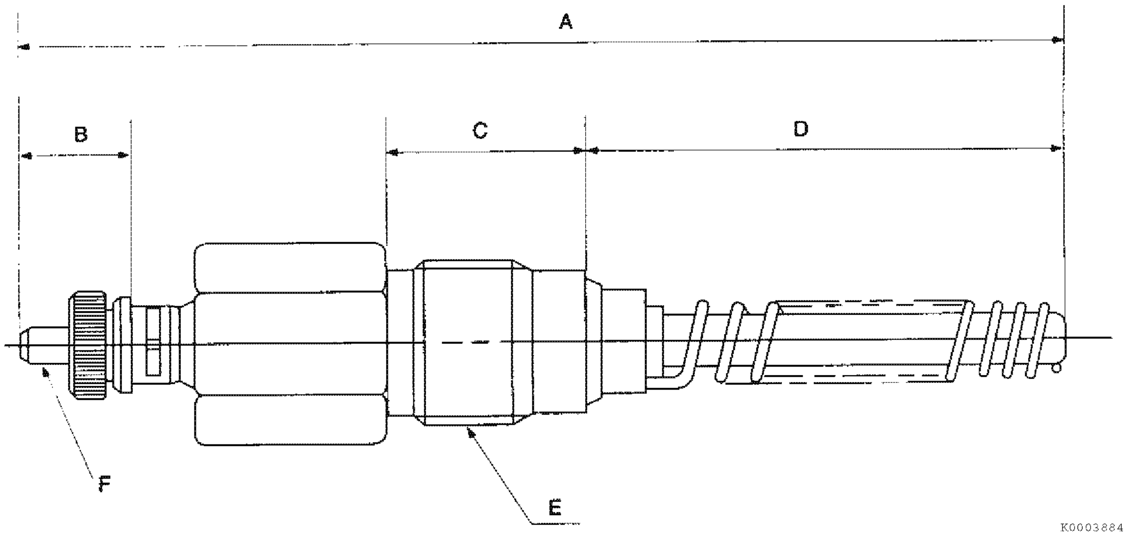


Figure 7-76

Type	A	B	C	D	E	F
AG 1	115 mm (4.53 in.)	12 mm (0.47 in.)	22 mm (0.87 in.)	53 mm (2.09 in.)	M18 × P 1.5	M4 × P0.7

Note: Tightening torque:
M18: 3 to 4 kgf·m, 29.4 to 39.2 N·m (21.6 to 28.9 ft-lb)
M4 Nut: 0.1 to 0.15 kgf·m, 0.98 to 1.47 N·m (8.7 to 13.0 in.-lb)

■ Operation of cold starting aid

The heater starts with the key switch on GLOW; turning key switch to OFF turns off the heater. Turning the key switch to ON will cause the heater to start and the preheat lamp to go on. The heater stays turned off when cooling water temperature exceeds 42 °C (108 °F), and the preheat lamp will also remain off. When the key switch is turned to the START position (engine starts), the preheat lamp goes out and heater continues to work even after releasing the key switch to the ON position. The heater, however, will automatically turn off within 3 minutes maximum or when cooling water temperature reaches 42 °C (108 °F), whichever happens first.

Except for key operation, all operations of the preheat lamp and heater are automatically controlled by the timer.

Note: To reduce bluish white smoke during engine starting (if preheat lamp goes on when the key switch is turned to the ON position), hold the key in the ON position until preheat lamp goes out.

Operation of key switch	Operation timing	
	Heater plug	**Preheat lamp**
GLOW	ON	OFF
OFF	OFF	OFF
ON	ON (maximum 30 seconds or engine cooling water temperature reaches 42 °C (108 °F))	ON (when key turned from OFF to ON). Alarm buzzer not activated.
START	ON (3 minutes or until engine cooling water temperature reaches 42 °C (108 °F))	OFF
ON (engine running)		OFF

Specifications

Rating	11 V 58 A
Used heater plug	2 pieces/engine
Install thread diameter	M20 × P1.5
Tightening torque	1.5 kgf·m, 14.7 N·m (130 in.-lb)

Note: Engines with new cold starting aid system have large heater capacity. Accordingly, install a large capacity battery.

Dimensions

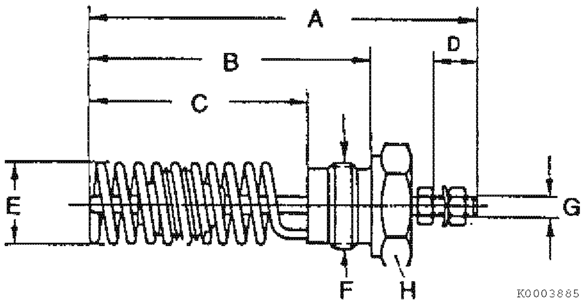


Figure 7-77

Type	A	B	C	D	E	F	G	H
AG 2	89 mm (3.50 in.)	65 mm (2.56 in.)	50 mm (1.97 in.)	10 mm (0.39 in.)	18 mm (0.71 in.)	M20 × P1.5	M5	26 mm (1.02 in.)
Yanmar part No.	119575-77050							

Cooling Water Temperature Switch

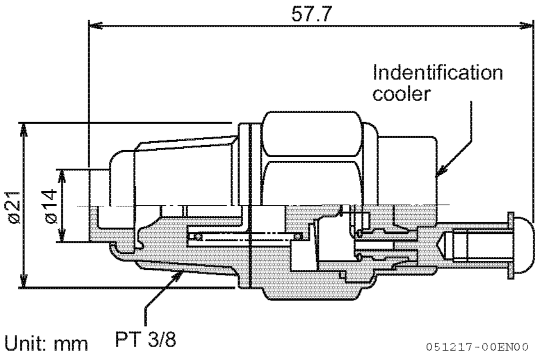


Figure 7-78

■ Specifications

Operating temperature	ON	40 to 44 °C (104 to 110 °F)
	Hysteresis	7 °C (12.6 °F)
Rated capacity		DC 12 V, 1 A
Response time		Within 60 seconds
Range of ambient temperature		-40 to 130 °C (-40 to 266 °F)
Identification color		Orange
Applicable engine type		Heater plug type for cold starting aid (optional)
Yanmar part No.		124616-91370

Note: Tightening torque of PT 3/8 thread:
240 to 320 kgf·cm, 23.5 to 31.4 N·m
(208 to 278 in.-lb)

REMOTE CONTROL SYSTEM

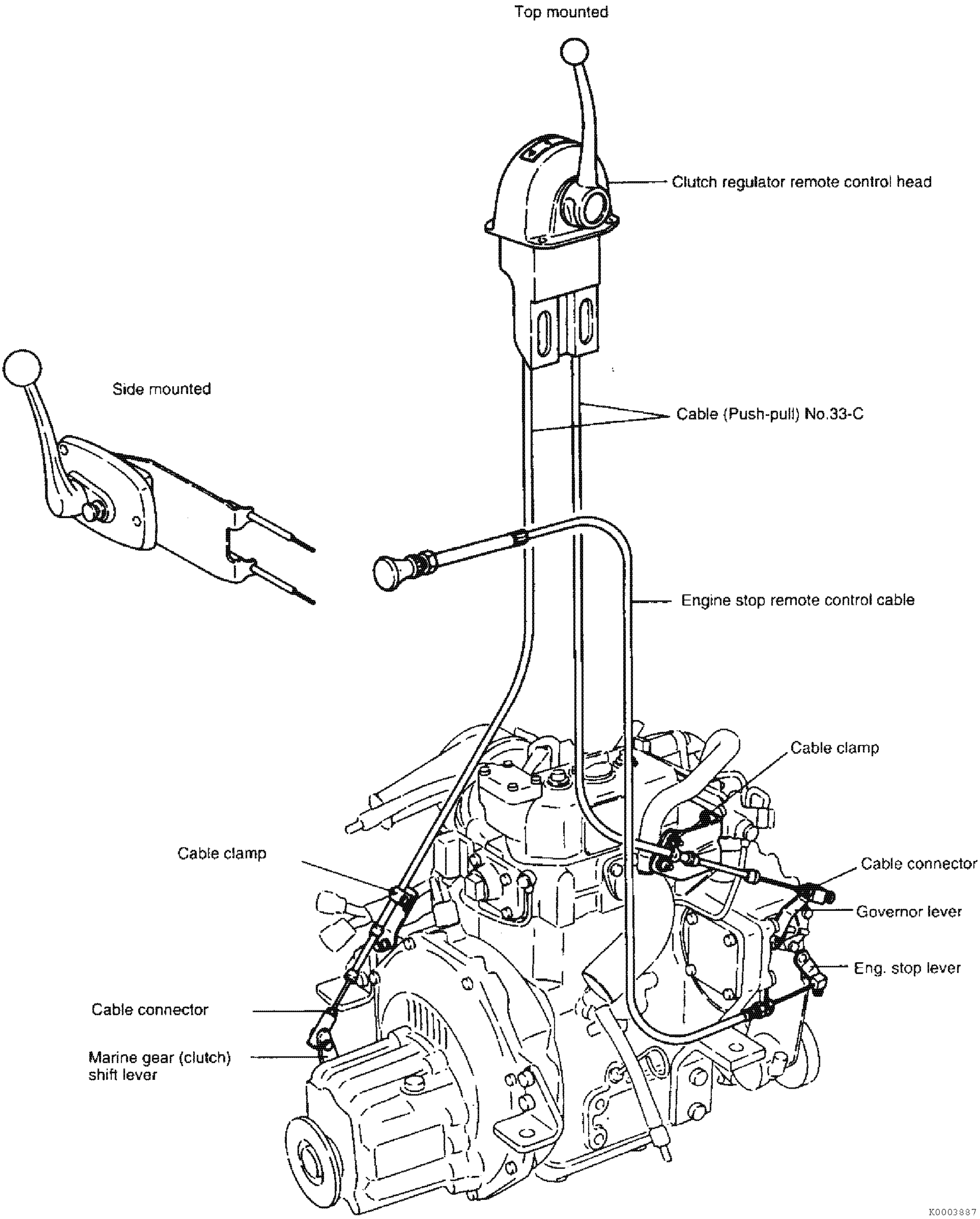


Figure 7-79

Remote Control Head and Cable

Use only super-responsive MORSE control cables. These are designed specifically for use with MORSE control heads.

This engineered system of MORSE cables, control head and engine connection kits ensures dependable and smooth operation with an absolute minimum of backlash.

■ Remote control head

Note:

- *Only use the single lever remote control head for the Yanmar mechanical clutch marine gear.*
- *The two-lever remote control head cannot be used because too large a torque is need to operate the marine gear shift lever at engine high speeds (over 1800 min^{-1}). This exceeds its capacity, and makes the mechanical clutch inoperable.*

Refer to the specifications for each engine model to select the appropriate marine gear.

There are two types of remote control heads, the top-mounted control and the side-mounted control. Select the type for the installation position.

Top-mounted control type

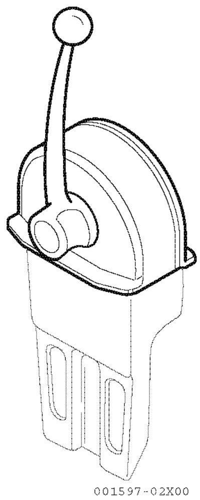


Figure 7-80

Side-mounted control type

New expanded side-mounted series controls include right- and left-hand models designed for easier installation and servicing. The side-mounted control can be pre-assembled and installed without removing the side panels.

A pull-out button disengages the clutch for the full throttle range in NEUTRAL for safe starting and warm-up.

Controls have FORWARD, NEUTRAL and REVERSE detents and built-in friction to prevent throttle creep.

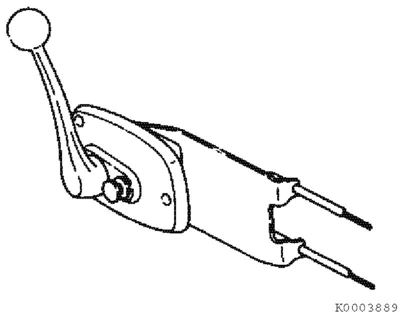


Figure 7-81

■ Dual station control

The following methods are available for operating an engine from two positions (such as flybridge and cabin).

A: Series type

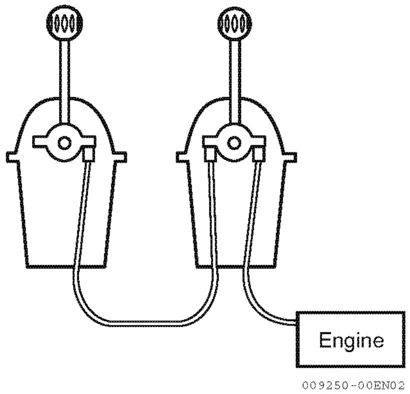


Figure 7-82

The handling force has more resistance because of the use of the relay cable between the No. 1 and No. 2 units. Ensure that the cable stroke at the No. 2 unit has some allowance to compensate for the cable stroke loss caused by the relay to the No. 1 control head.

B: Dual station unit type

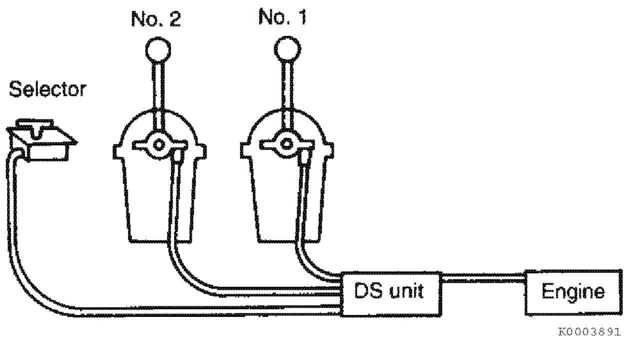


Figure 7-83

Consult the remote control unit maker (MORSE) for the dual station unit.

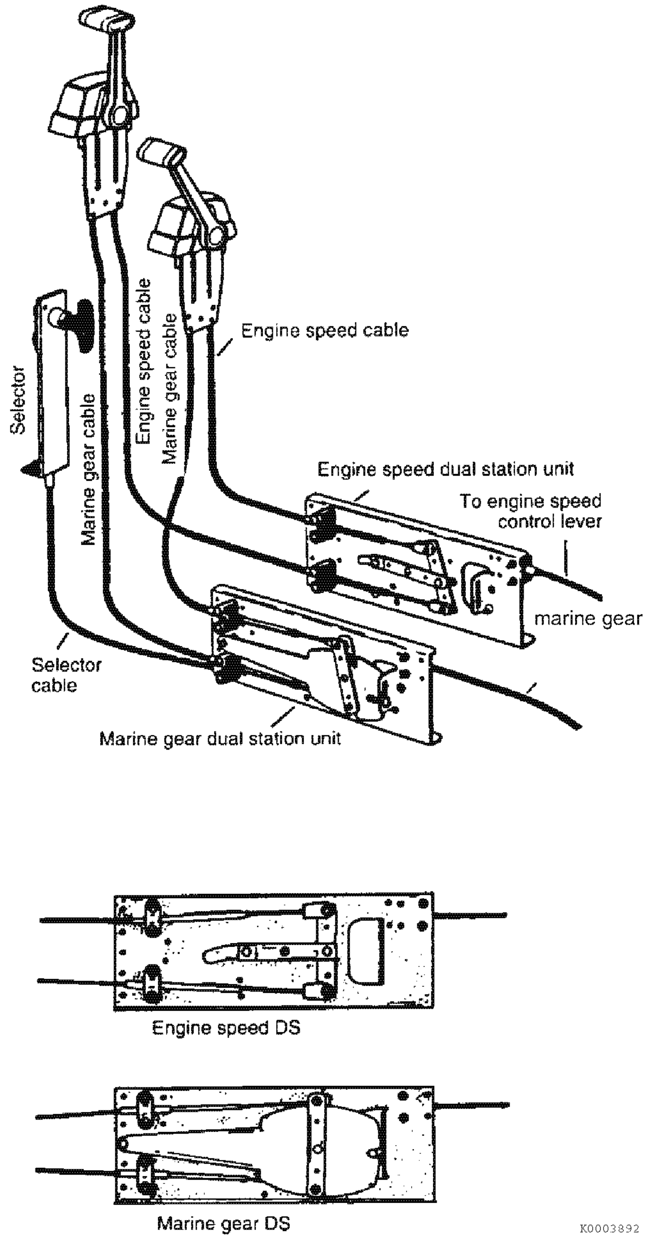


Figure 7-84

C: Hydraulic and electric remote control unit

The operating force of the control head of the hydraulic/electric remote control device can be smaller than with the mechanical type.

Examples of electric or hydraulic type

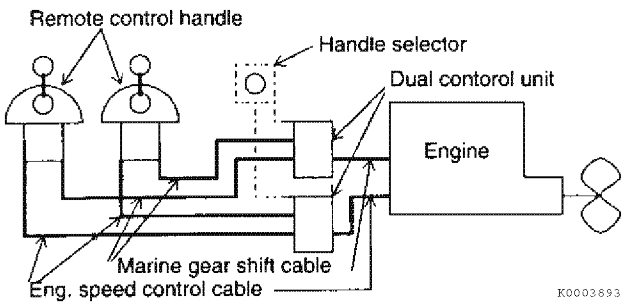


Figure 7-85

These control heads operate the marine gear shift lever or engine throttle lever via the hydraulic cylinder or DC motor by activating the hydraulic valve or sensor unit.

Accordingly, these devices are ideal for 2-station remote control of twin-engine two-shaft propulsion boats or inboard outdrive boats on which shift and throttle lever operation is heavy.

NOTICE

When selecting remote control heads:

- The unit must have sufficient operating force for the engine throttle and marine gear levers.
- The unit must have an adequate operating stroke for the engine throttle and marine gear levers.

Construction of Remote Control System

The remote control permits one-handed control of the engine speed, changes from forward to reverse and stopping.

Fittings that allow for easy connections to the remote control cables with the governor lever and marine gear are provided with the remote control set.

The use of MORSE remote control cables, clamps and a remote control head are also provided. The engine stopping device is electric and was explained in *Engine Stop Solenoid on page 7-19*.

Remote Control Device Components

Component	Description	Type	Yanmar part No.
Remote control head	MORSE, MT3 top mount	MT3	D24070-86310
	MORSE, MV side mount	MV	D28170-86300
Remote control cable	MORSE, 33C × 4 m (13.1 ft)	RC4	D24070-86500
	MORSE, 33C × 7 m (23.0 ft)	RC7	D29470-86500
Engine stop cable (manual engine stop)	YANMAR made, 3 m (9.8 ft)	SC1	D28170-67500
	YANMAR made, 4 m (13.1 ft)	SC2	D29470-67500
	YANMAR made, 7 m (23.0 ft)	SC3	D29470-67510

■ MT3-type

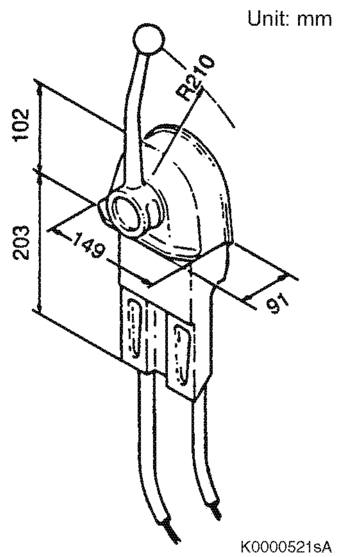


Figure 7-86

■ MV-type

Newly expanded MV-series controls **(Figure 7-87)** include right- and left-hand models designed for easier installation and servicing. The MV control can be pre-assembled and installed without removing the side panels.

A pull-out button disengages the clutch for the full throttle range in NEUTRAL for safe starting and warm-up.

MV controls have forward, neutral and reverse detents and built-in friction to prevent throttle creep.

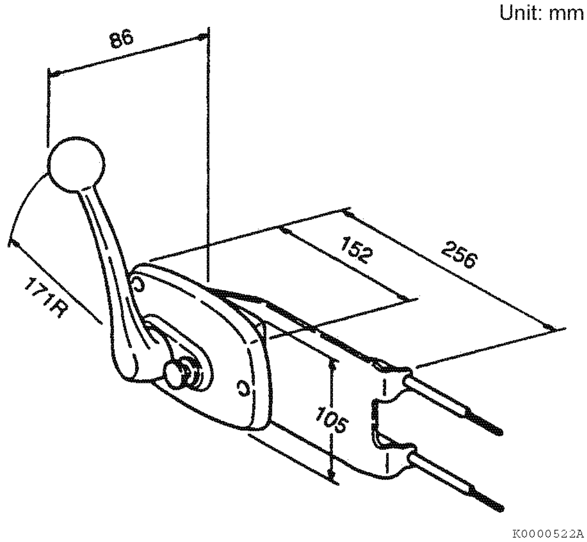


Figure 7-87

Remote Control Cable

MORSE-type 33-C push-pull control cables.

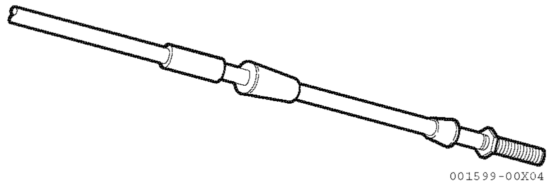
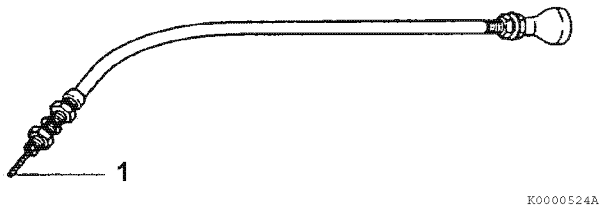


Figure 7-88

Use only Super-Responsive MORSE Control Cables. These are designed specifically for use with MORSE control heads. This engineered system of MORSE cables, control head and engine connection kits ensures dependable, smooth operation with an absolute minimum of backlash. The thread size on the cable ends is 10-32, UNF-2A. Travel is up to 76.2 mm (2.99 in.).

Engine Stop Cable

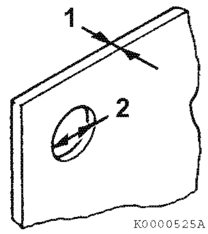
The stop lever of the fuel injection pump is connected to the solenoid with a connecting rod. The device is operated by the stop switch on the instrument panel.



1 – Yanmar-made ø1.5 mm (0.06 in.)

Figure 7-89

Installation of Engine Stop Knob

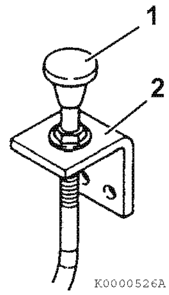


1 – 3 to 5 mm (0.12 to 0.20 in.)
2 – ø11.5 to 12 mm (0.45 to 0.47 in.) hole

Figure 7-90

The engine stop knob is common to both stop remote control and decompression remote control.

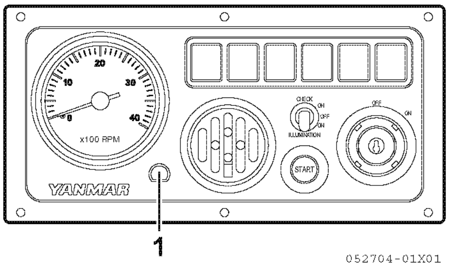
Firmly install the knob with a bracket in a suitable place that is convenient for operation.



1 – Knob
2 – Bracket

Figure 7-91

When using the B, B2 and new B-type instrument panel, install the knob at the knob hole **(Figure 7-91)** provided in the panel.



1 – Knob installation hole

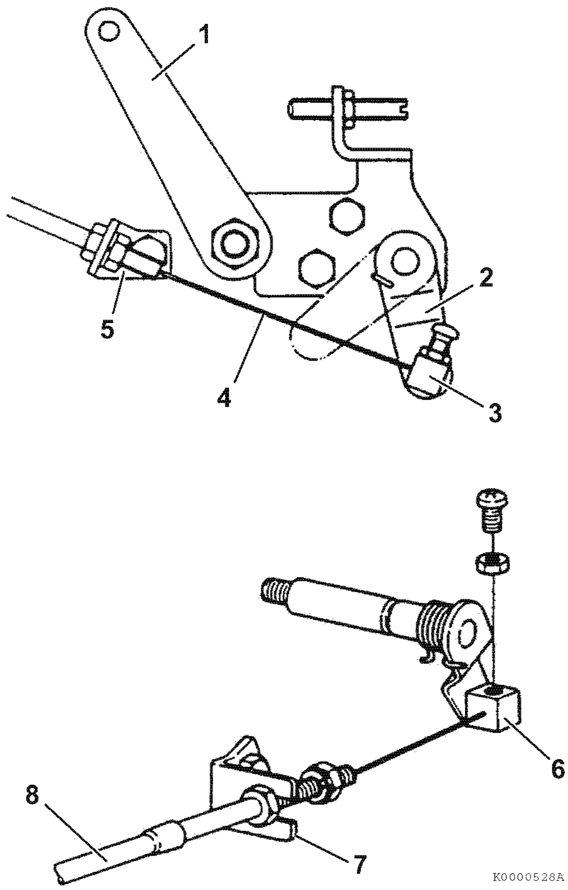
Figure 7-92

The knob installation hole is not completely stamped out. Remove the knockout to install the engine stop knob.

■ Wiring of engine side

Connect the engine stop control cable as shown **(Figure 7-93)**. After installation, ensure that the cable moves freely throughout its full range.

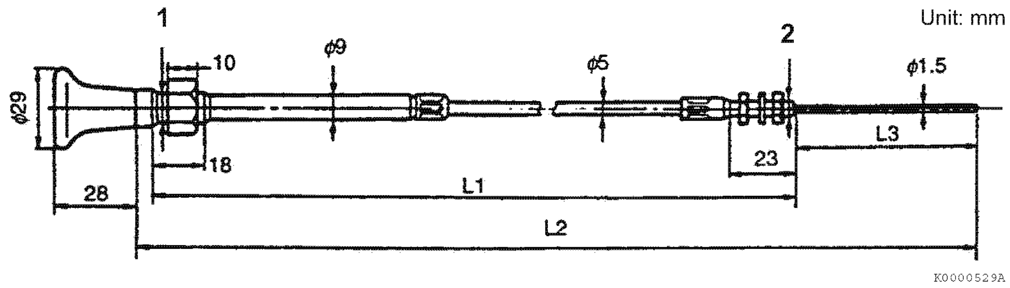
The metal connector fitting has a hole diameter of 2.5 mm (0.1 in.) to accommodate the cable. A cable of 1.5 to 2.5 mm (0.06 to 0.1 in.) diameter can be used in the connector.



1 – Governor lever
2 – Engine stop lever
3 – Cable connector
4 – Remote control cable
5 – Bracket
6 – Cable connector
7 – Bracket
8 – Remote control cable

Figure 7-93

■ Dimensions of engine stop cable (Yanmar-made)



1 – M11 × P1.25 (thread diameter)

2 – M6 × P1.0 (thread diameter)

Figure 7-94

Type	Part name	L1	L2	L3	Yanmar part No.
SC1	Engine stop cable 3 m (9.8 ft)	3000 mm (118.1 in.)	3140 mm (123.6 in.)	134 mm (5.28 in.)	D28170-67500
SC2	Engine stop cable 4 m (13.1 ft)	3854 mm (151.7 in.)	4000 mm (157.5 in.)	140 mm (5.51 in.)	D29470-67500
SC3	Engine stop cable 7 m (23.0 ft)	–	7000 mm (275.6 in.)	–	D29470-67510

Cable Clamp

Yanmar cable clamps **(Figure 7-95)** are standard parts. They are fitted to the brackets on the engine and marine gear.

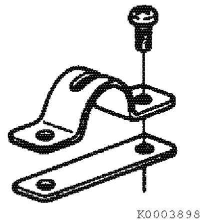


Figure 7-95

Cable Connector

Yanmar cable connectors are standard parts. They are fitted to the marine gear shift lever and engine speed governor (throttle) lever.

Engine Speed Lever Installation

The metal connector, which joins with the damping spring, is at the tip of the governor (throttle) lever. Screw the cable into the fitting.

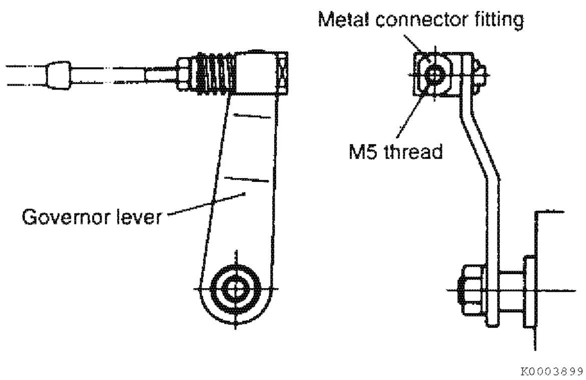


Figure 7-96

Control Cable Installation

1. The minimum radius of cable bending should be 200 mm (7.87 in.).
2. The outer cable should be bent, if required, at a point more than 100 mm (3.94 in.) from the outer cable clamp in order to protect the clamp from strain **(Figure 7-97)**.

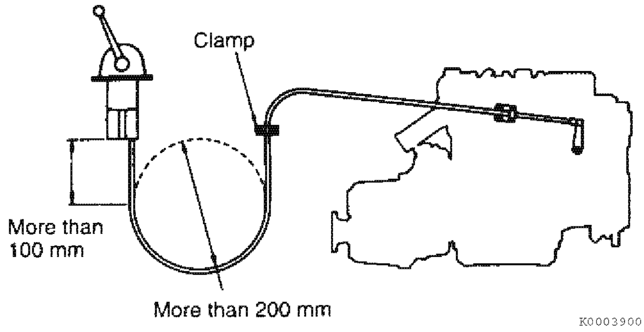


Figure 7-97

3. The exposed portion of the inner cable should be coated with a water-resistant grease for rust prevention and smooth movement of the cable **(Figure 7-98)**.

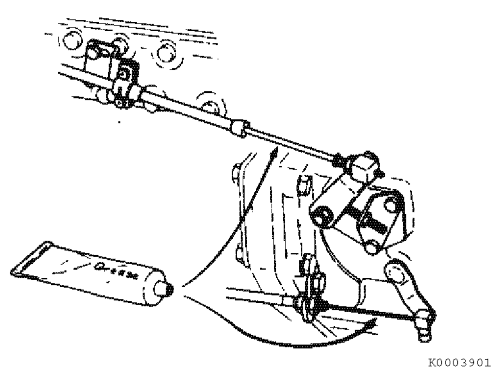


Figure 7-98

4. The cable should be routed so that it does not come into contact with the heated area of the engine, sharp edges or moving parts.
5. Do not clamp wire harnesses or other electrical wires to the cable **(Figure 7-99)**.

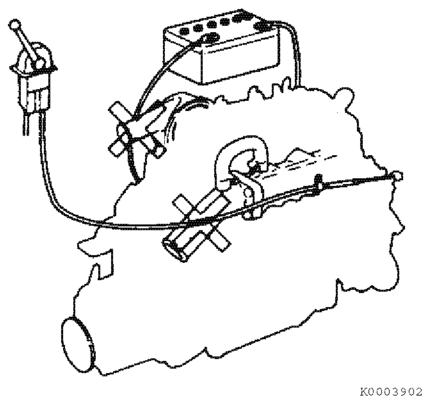


Figure 7-99

NEUTRAL SAFETY SWITCH

To prevent the engine from starting when the shift lever is in FORWARD or REVERSE, a neutral safety switch is installed.

The neutral safety switch prevents the starting motor from running except when the shift lever is in NEUTRAL; the engine will not start when the shift lever is in FORWARD or REVERSE.

The neutral safety switch can be installed to either the remote control handle or to the marine gear.

Note: Installation of this device on pleasure boats is required by law in some countries including Japan.

■ Neutral safety switch wiring example

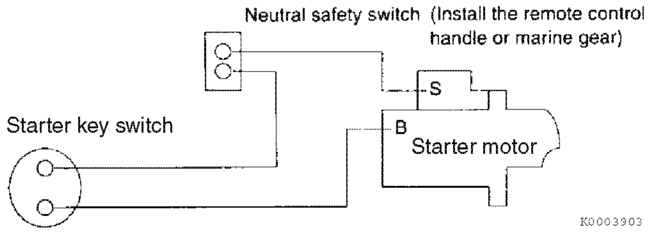


Figure 7-100

■ Remote control head with neutral safety switch

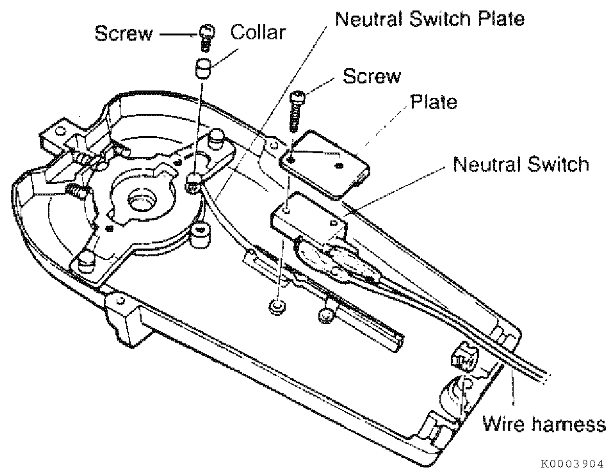
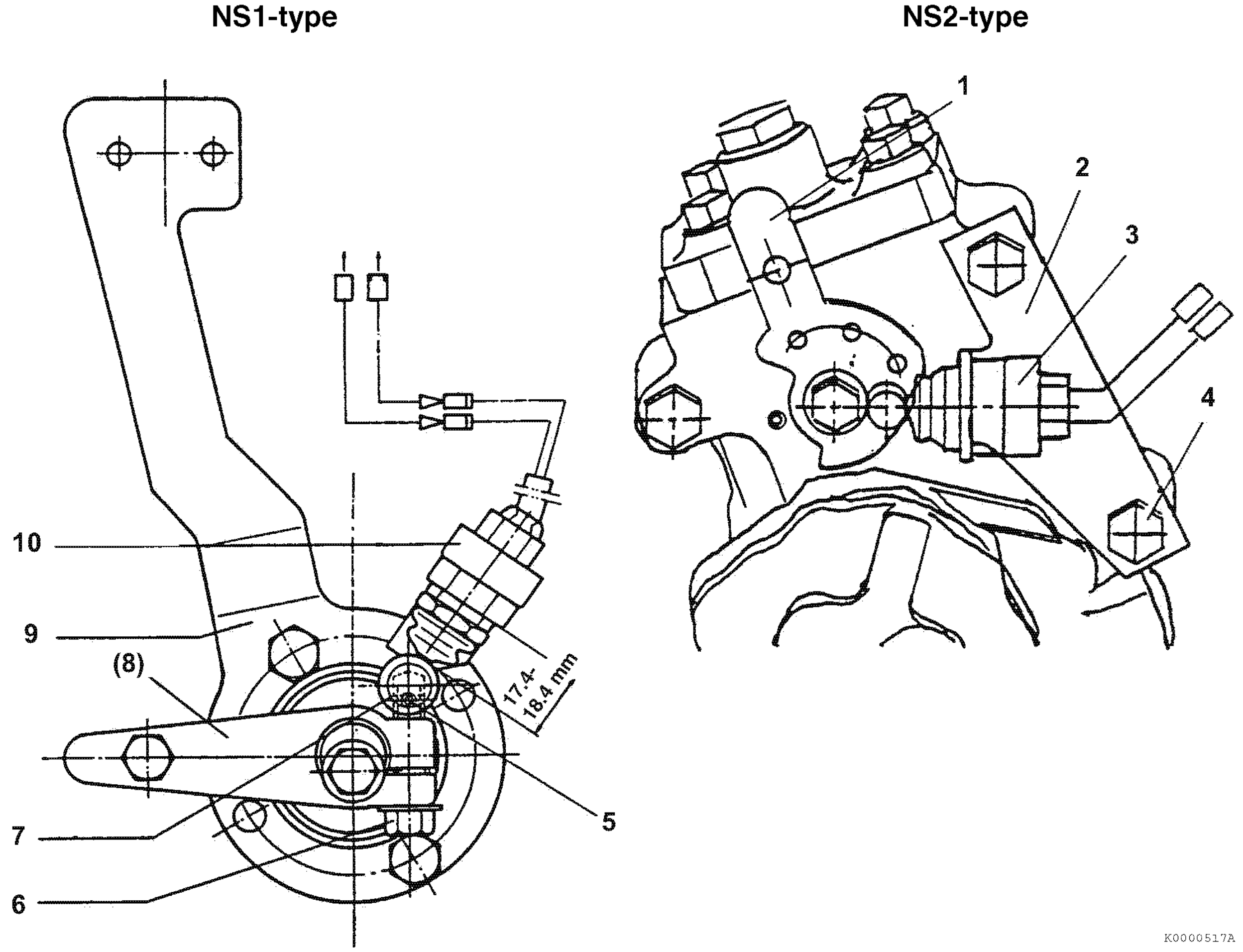


Figure 7-101

Type	Yanmar part No.
NS1	D77074-06020
NS2	D19573-77110



1 – Shift lever
2 – Switch bracket
3 – Neutral safety switch
4 – Bolt, M10 × 85
5 – Clamp bolt, M4 × 8
6 – Bolt, M8 × 30
7 – Activator of safety switch
8 – Shift lever
9 – Cable bracket
10 – Safety switch rated capacity: DC12 V, 30 A

Figure 7-102

ELECTRONICALLY CONTROLLED ENGINES

Electronically controlled engine installation requires special considerations that are not generally encountered in mechanically controlled installations. While electronically controlled engines have added features like data logging, and precision timing algorithms, they are susceptible to electrical noise caused by voltage variations, inadequate shielding or poor grounding practices.

Battery Requirements

Electronically controlled engines are equipped with sensitive circuitry that requires a constant, well-regulated voltage supply. Batteries must be properly sized to accommodate the engine electrons and auxiliary electrical equipment onboard.

Battery Connection Designs

Battery post connections must be solid bolt-type with tight contact. Loose or undersized connections could introduce excessive electrical resistance, causing unacceptable voltage drop.

Grounding Requirements

Electronically controlled engines usually have traditional or two-pole starter wiring systems. In either case, grounding must be in one central location. Multiple grounding points can produce ground loops. These ground loops can cause electrical noise problems that interfere with normal electronics operation.

FUEL SYSTEM

⚠ WARNING

Fire and Explosion Hazard

Diesel fuel is flammable and explosive under certain conditions:

- **Always fill the fuel tank only with specified diesel fuel. Filling the fuel tank with gasoline may result in a fire and will damage the engine.**
- **Place an approved container under the air bleed port when you prime the fuel system. Never use a shop rag to catch the fuel. Wipe up any spills immediately. Always close the air bleed port after you complete priming the system.**
- **Always put an approved container under any opening to catch the fuel when removing any fuel system component to perform maintenance (such as changing the fuel filter).**

⚠ WARNING

Exposure Hazard

Wear eye protection. The fuel system is under pressure and fuel could spray out when you open the air bleed port.

NOTICE

- If the unit has an electric fuel pump, turn the key switch to the ON position for 10 to 15 seconds, or until the fuel coming out of the air bleed port is free of bubbles, to allow the electric fuel pump to prime the system.
- If the unit has a mechanical fuel pump, operate the fuel priming pump several times until the fuel coming out of the air bleed port is free of bubbles.

NOTICE

- Only use diesel fuels recommended by Yanmar for the best engine performance, to prevent engine damage and to comply with EPA warranty requirements.
- Only use clean diesel fuel.

The fuel system includes the fuel tank, fuel piping from the fuel tank to the fuel feed pump, and fuel return piping from the fuel injection pump to the fuel tank.

An extra fuel feed pump may be attached when the installation position of the fuel tank is low. Also, an extra fuel filter with a fuel/water separator may be installed to remove water and sediment from the fuel.

Both the fuel feed pump inlet and fuel injection nozzle fuel return outlet on the engine side are provided with rubber hose joint, to which a rubber hose can be connected.

Note: *Be sure that the fuel tank specifications and fuel line piping comply with local safety regulations where applicable.*

Fuel Tank

■ Capacity of fuel tank

The capacity of the fuel tank is determined during the design stage of the boat with consideration to the cruising range, inboard space, fuel consumption of the engine to be installed, etc.

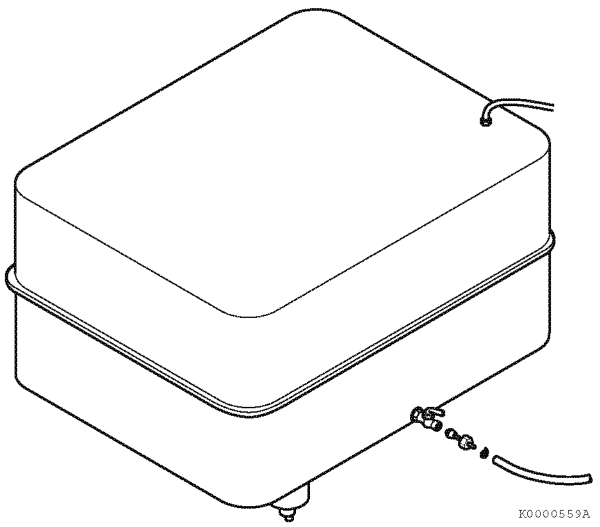


Figure 7-103

To find the fuel consumption of the engine, use the specific fuel consumption curve (g/hp-hr or g/kW-hr).

The calculation is as follows:

$$\text{Fuel consumption: } F = \frac{f \times hp(\text{or } kW)}{S \times 1000} \text{ L/hr}$$

S = Specific gravity of diesel fuel (diesel fuel: 0.83)
f = Specific fuel consumption: g/hp-hr or g/kW-hr
Refer to the performance curve for the engine data of each engine.

Example:

What is the fuel consumption of the 6LY-UTE (315 hp/3300 min^{-1}) when used for 2 hours at continuous rating (assume the specific fuel consumption to be 165 g/hp-hr.)?

$$F = \frac{165 \times 315}{0.83 \times 1000} = 62.62 \text{ L/hr} \times 2\text{hrs} = 125.24 \text{ L}$$

Note: *For power boat applications, it is recommended to allow some reserve in the capacity of the fuel tank and to install the tank on the hull bottom or close to hull side where indirect cooling is expected. Surplus fuel returning from the engine to the fuel tank is heated to a high temperature. This raises the overall temperature of the fuel in the tank when the tank's capacity is small. The output of diesel engines tends to drop when fuel of over 40 °C (104 °F) is supplied.*

■ Fuel tank installation

The fuel tank must be installed within the distance of the suction capacity of the engine's fuel feed pump. Install the fuel tank as follows:

1. Install the fuel tank within the head of the fuel feed pump of the engine.
2. When installing the fuel tank lower than the engine's fuel feed pump, install the fuel tank within the suction head capacity of fuel feed pump.
3. It is not necessary to consider the suction head of the fuel feed pump when the fuel tank is installed higher than the engine's fuel feed pump (fuel at a higher level flows smoothly under gravity to the lower fuel feed pump).
4. Refer to the engine data for each engine model for the suction capacity of the fuel feed pump.

Note:

Except for the higher installation position above, when installing the fuel tank beyond the suction capacity of the fuel feed pump, you must also install an auxiliary fuel feed pump and a fuel service tank. The fuel piping layout is as follows:

Main fuel tank → auxiliary fuel feed pump → fuel service tank → water trap → fuel filter → fuel feed pump.

The auxiliary fuel feed pump supplies fuel to the fuel service tank from the main fuel tank. The engine's fuel feed pump supplies fuel from the main fuel tank.

Select a service tank that can hold sufficient fuel for engine operation. The auxiliary feed pump is activated by a sensor installed in the service tank when a given amount of fuel is consumed. It replenishes the service tank with the same amount of fuel from the main tank.

■ Fuel tank height

The fuel tank should be installed at the highest possible point as close to the engine as possible. For the suction head, refer to the fuel feed pump capacity information in the engine data for each engine.

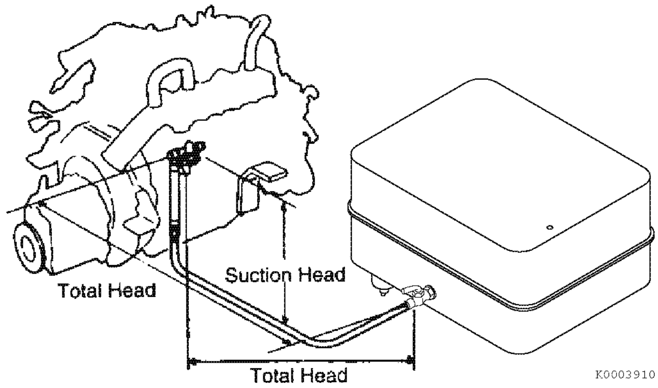


Figure 7-104

Piping

1. The hose must be as straight as possible. Minimum bend radius: 50.0 mm (2.0 in.) or more.
2. Be careful that the fuel piping does not touch the engine exhaust manifold or other hot parts.
3. Make sure that there are no leaks.
4. When using separately purchased copper or steel tube for the fuel piping, secure the pipe with clamps **(Figure 7-105)** approximately every 150 to 200 mm (5.0 to 8.0 in.) on the bulkhead or hull to prevent the pipe from breaking due to vibrations.

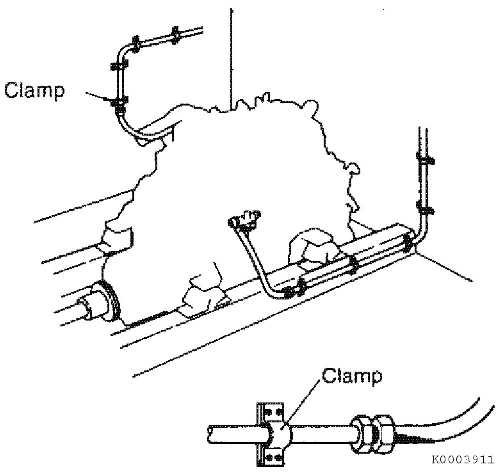


Figure 7-105

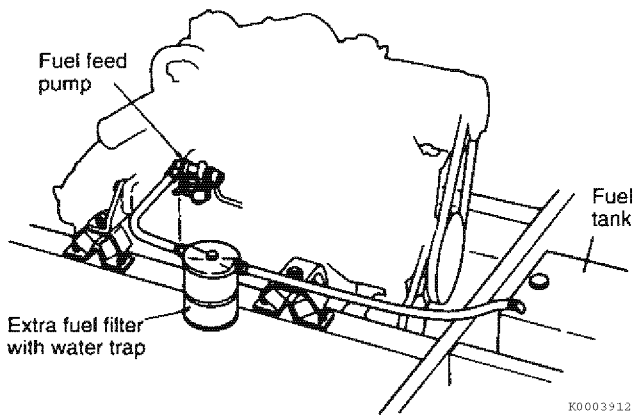


Figure 7-106

Auxiliary Fuel Feed Pump

When the installation position of the fuel tank is considerably lower than the engine, or the piping is long, calculate the suction head of the fuel feed pump and install an auxiliary fuel feed pump. When using an electric fuel feed pump, wire it so the pump operates only during engine operation.

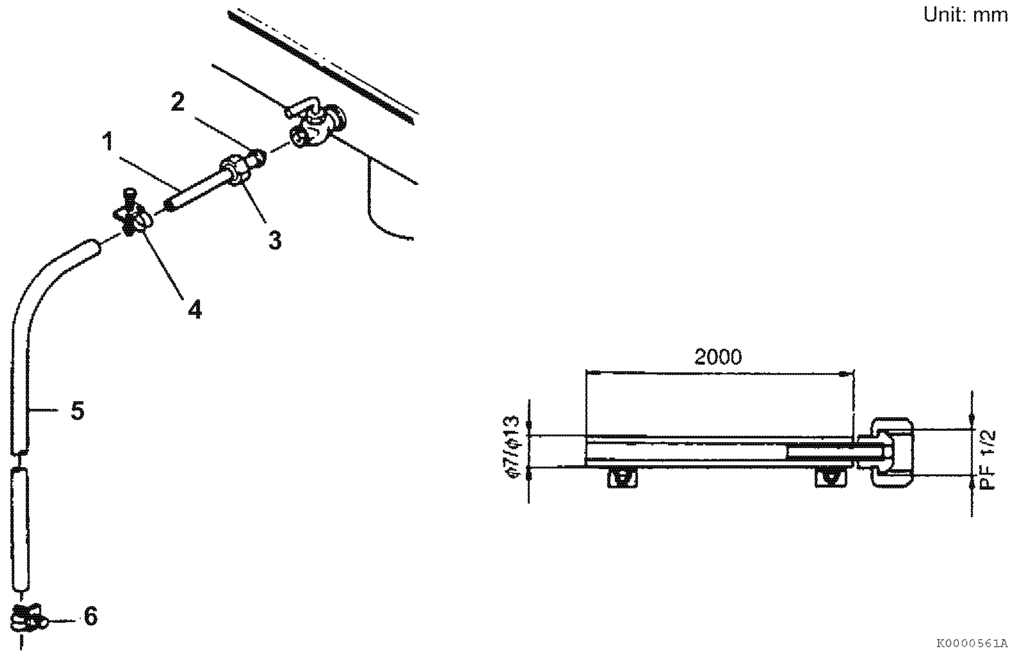
■ Additional fuel filter with water trap

The engine is provided with an element-type fuel filter, but in order to eliminate water and dirt completely, it is recommended to install an extra fuel filter with a water trap. Select a suitable position in the piping between the fuel feed pump and the fuel tank. The location must be free from vibrations and be accessible for filter inspection and replacement.

Note: Do not install the extra fuel filter onto the engine.

1. Extra fuel filter capacity: The extra fuel filter with water trap should have a current velocity performance of more than 1.5 times the delivery volume of the fuel feed pump.
2. Direct injection engine: Always use an extra fuel filter and water trap for direct injection engines.

■ Rubber hose



1 – Copper pipe ø6 mm (0.24 in.)/ ø8 mm (0.31 in.) × 45 mm (1.77 in.)
2 – Fitting
3 – Cap nut
4 – Clamp ø14 mm (0.55 in.)
5 – Rubber hose ø7 mm (0.28 in.)/ ø13 mm (0.51 in.) × 2000 mm (78.7 in.)
6 – Clamp ø14 mm (0.55 in.)

Figure 7-107

The fuel return pipe is not available from Yanmar. Use an oil-proof rubber hose with a 13 mm (0.51 in.) inner diameter. Connect return pipe to the fittings of the fuel tank and the fuel injection valve sides. Secure the hose with clamps.

Note: Consult ISO or ABYC standards for compliant materials and installation.

Fuel/Water Separator

■ Specifications

Type		FWS 1	FWS 2
Yanmar part No.		D19187-55200 D27692-55200	D27610-55150
Filter material	Unit	Glass wool	
Pore size	μm	150	
Flow resistance	mmHg/L/min (in.Hg/gal/min)	30/3 (1.18/0.79)	12/2 (0.47/0.53)
Filtration volume	cm^3 (cu in.)	100 (6.10)	42.6 (2.60)
Dimensions			
A	mm (in.)	216 (8.50)	163 (6.42)
B	ø mm (in.)	102.8 (4.05)	85 (3.35)
C	mm (in.)	40 (1.57)	
D	ø mm (in.)	116 (4.57)	99 (3.90)
E	mm (in.)	2 × ø10.5 (0.08 × 0.41)	2 × ø11 (0.08 × 0.43)
F (Thread hole)	mm (in.)	M14 × 1.5	
G (Thread hole)	mm (in.)	M14 × 1.5	
H (Thread hole)	mm (in.)	M14 × 1.5	M8 × 1.25

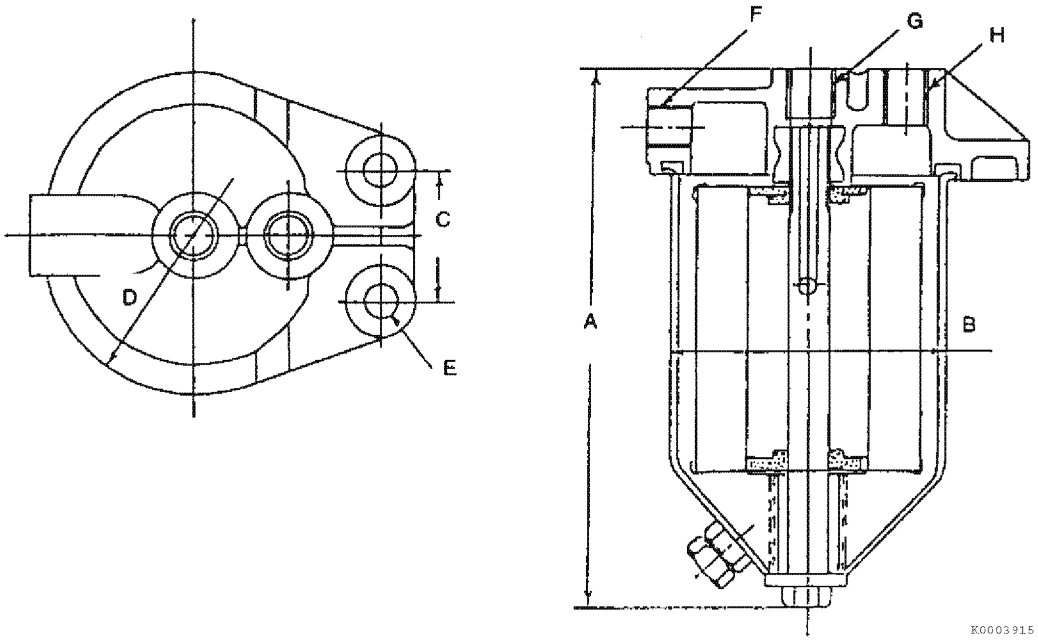


Figure 7-108

COOLING SYSTEMS

The seawater is drawn up by the seawater pump through a seacock installed on the hull. The water from the seawater pump enters the heat exchanger and various coolers.

The heat exchanger, oil cooler and charge air cooler are cooled with seawater.

For the detailed cooling circuit, refer to the piping diagrams in the engine data for each engine.

CLOSED COOLING SYSTEM

Engine coolant from the heat exchanger is circulated around the cylinder block and cylinder head by the engine coolant pump. The pump forces the coolant through the cylinder block and cylinder head cooling passages and back to the heat exchanger, where seawater carries away the heat. The coolant circulation is controlled by the thermostat.

The thermostat is closed while the coolant temperature is low. Engine coolant flows through the bypass passage to the suction side of the engine coolant pump and circulates inside the engine bypassing the heat exchanger.

Some engine models equipped with a closed cooling system have a water-cooled turbocharger, intake air cooler and engine oil cooler. For details of the cooling circuit, refer to the piping diagrams in the engine data for each engine.

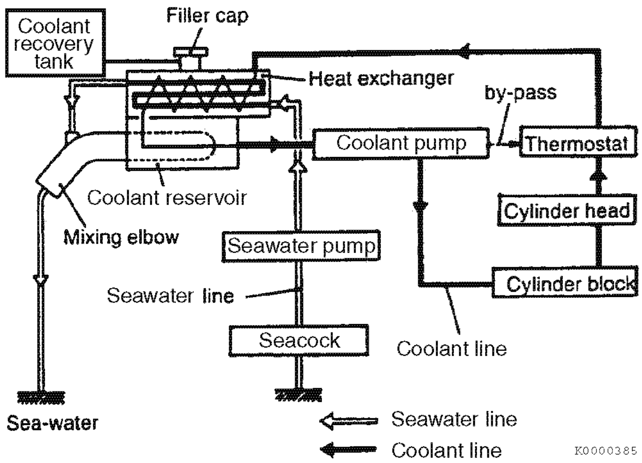
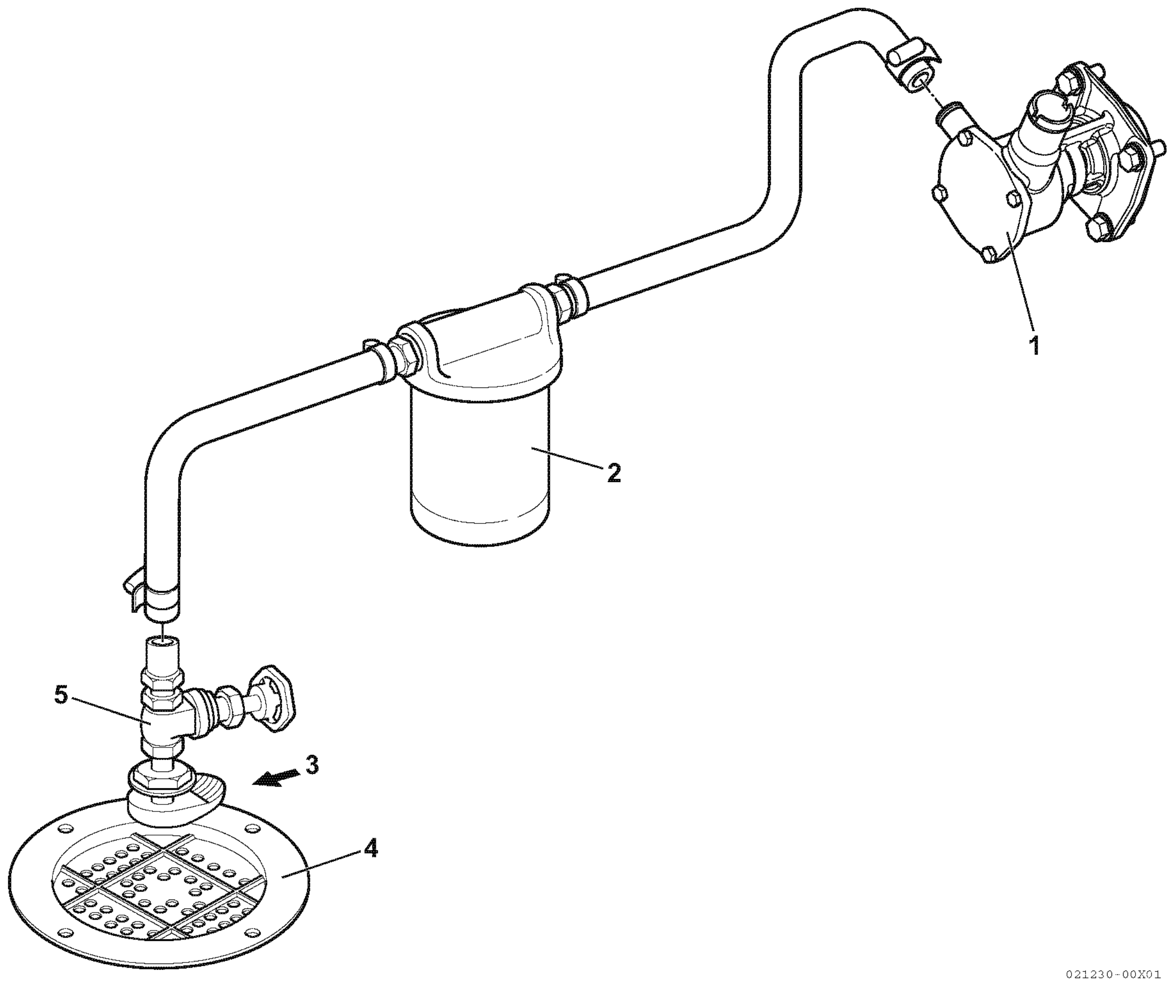


Figure 7-109

SEAWATER COOLING SYSTEM



1 – Seawater pump
2 – Seawater strainer
3 – Cooling water
4 – Seacock cover
5 – Seacock

Figure 7-110

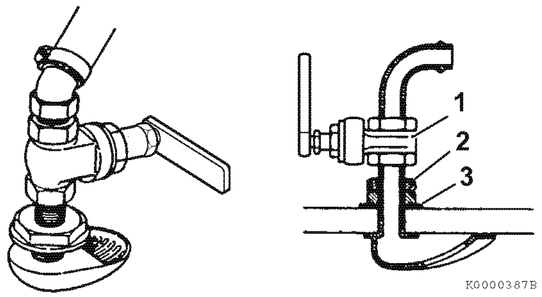
Seawater is drawn from the seawater inlet by the seawater pump and flows through the cooling system or heat exchanger to cool the engine.

After cooling the engine components, the seawater then passes through the exhaust/water mixing elbow and is discharged together with the exhaust.

The seawater inlet consists of the seacock and the water hose which connects to the cock to the seawater pump. When the boat is operated in dirty water, provide a seawater strainer between the seacock and the cooling water pump.

Note: *Install the seawater pump at an appropriate distance from the seacock, considering the seawater pump capacity and the total head and suction head. If the pump is installed in an inappropriate location, the resulting insufficient cooling water causes engine overheating.*

Seacock



1 – Seacock
2 – Double nut
3 – Washer

Figure 7-111

■ Dimensions

Unit: mm

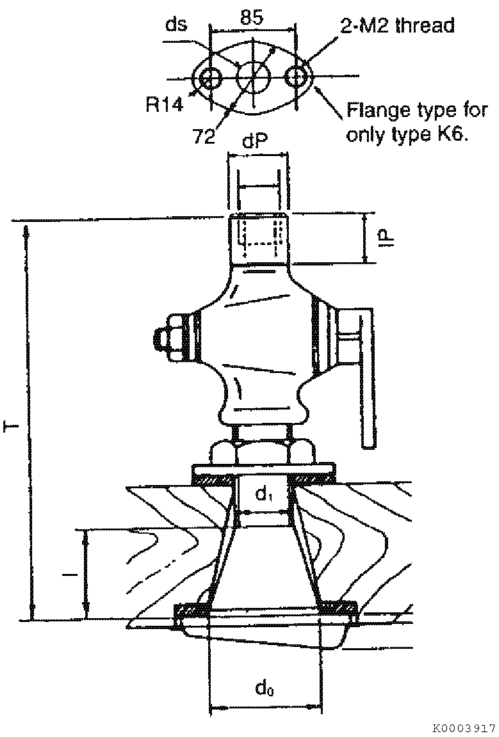


Figure 7-112

Type	Yanmar part No.	dp mm (in.)	ds mm (in.)	IP mm (in.)	d_1 mm	d_0 mm (in.)	l mm (in.)	T mm (in.)
K1	D04214-48501	ø14 (0.85)	–	13 (0.79)	M16	ø31 (1.89)	34 (2.07)	103 (6.29)
K2	D24770-48101	ø18 (1.10)	–	13 (0.79)	M22	ø50 (3.05)	42 (2.56)	120 (7.32)
K3	D29795-48100	ø26 (1.59)	–	28 (1.71)	M32	ø79 (4.82)	33 (2.01)	190 (11.59)
K4	D24411-48100	ø32 (1.95)	–	35 (2.14)	M32	ø79 (4.82)	33 (2.01)	195 (11.90)
K5	D27610-48201	–	PT1-1/4	–	M39	ø86 (5.25)	–	179 (10.92)
K6	D28610-48100	–	ϕ40 (2.44)	–	M50	ø112 (6.83)	–	204 (12.45)

Positioning the Seacock

Locate the seawater inlet well under the waterline. When the hull rolls, the inlet must remain submerged beneath the waterline.

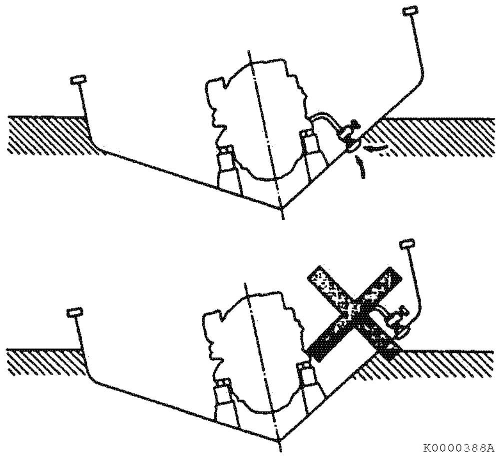


Figure 7-113

Determining the Direction of the Seacock

In power boat applications, the inlet of the seacock and the cover must be fixed in the cruising direction. In the sailboat applications, the direction must be reversed.

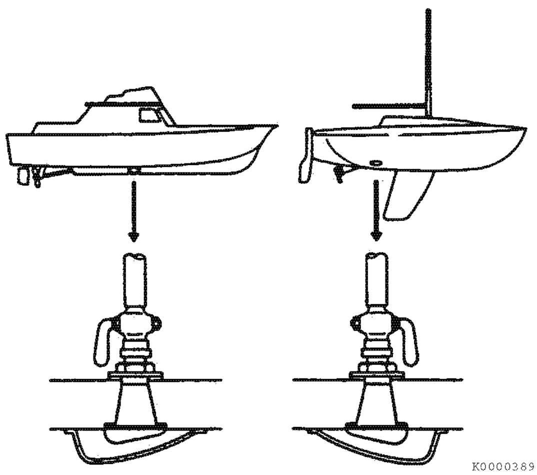


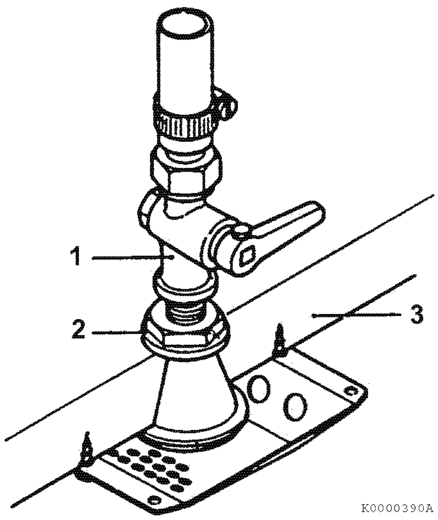
Figure 7-114

Seacock Installation

1. Determine the position of the cooling water pipe and the direction of the cooling water pump inlet joint.
2. Grind the contact face of the seacock hole drilled in the hull bottom.
3. Install the cock using canvas on the outside of the hull and canvas or rubber packing on the inside.
4. After tightening the nuts of the seacock, coat the attachment at both the inside and outside hull surfaces with a sealing agent (silicone rubber, etc.).
5. After installing the seacock, ensure that the cock operates properly. If necessary, change the intake direction of the cock and coat the threaded parts with sealing agent.

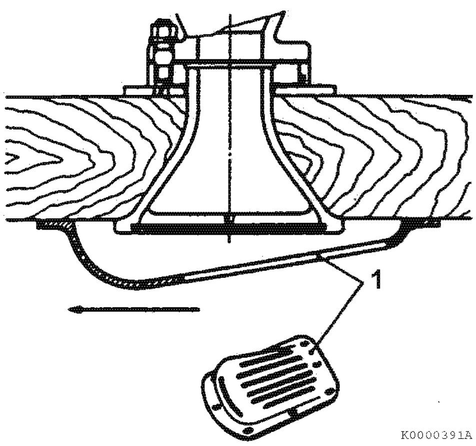
■ Scoop strainer

The inlet section must have a double bottom to prevent obstructions and engine overheating. This can arise when foreign matter is sucked in at the seacock inlet port.



1 – Seacock
2 – Packing
3 – Hull

Figure 7-115



1 – Scoop strainer

Figure 7-116

Attach the scoop strainer firmly to the hull with screws.

■ Piping

Install a seawater-resistant, oil-proof rubber hose between the seacock and the seawater pump.

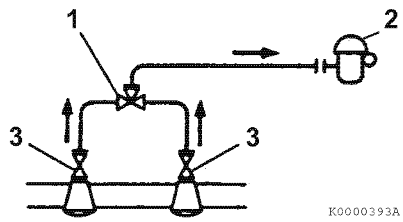
Use a length of hose that is as short as possible and with as few bends as possible. A long, sharply bent hose may not draw water efficiently.

Do not apply tensile stress between the seacock and the seawater pump. Allow enough length in the hose to allow for engine vibration and movement.

When the hose passes through the bulkhead, protect it from damage caused by rubbing. Connect the rubber hoses to the seacock and seawater pump inlet. Secure with hose clamps. Seal with a non-hardening compound.

■ Using two seacocks

When one of the seacocks becomes clogged, operation can be switched to the other while the clogged seacock is being cleaned. If a three-way cock is installed, this operation can be performed while underway.



1 – Three-way cock
2 – Cooling water pump
3 – Seacock

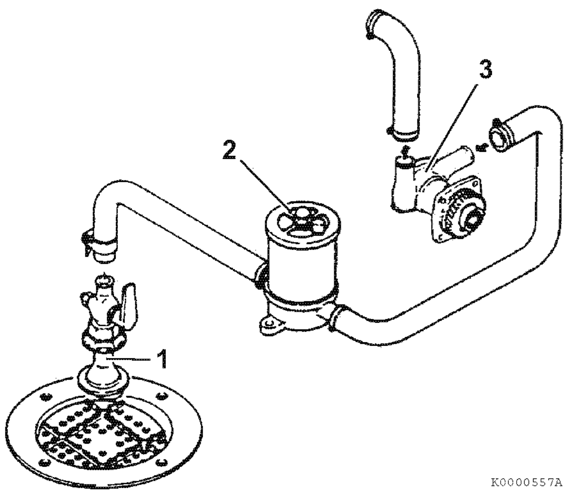
Figure 7-117

Seawater Strainer

When operating the engine in areas where the seawater contains a large amount of mud, sand or other foreign matter, a seawater filter must be installed between the seacock and the seawater pump.

Inspect the seawater filter periodically and clean as needed. Remove the dirt and sand from the bottom of the filter.

Note: Consult seawater strainer manufacturer's literature for sizing and installation data.



1 – Seacock
2 – Seawater strainer
3 – Seawater pump

Figure 7-118

Test for seawater inlet restriction at the pump inlet. Do not exceed maximum suction head. Check individual engine sections in vol. 2 and 3 for pump specifications.

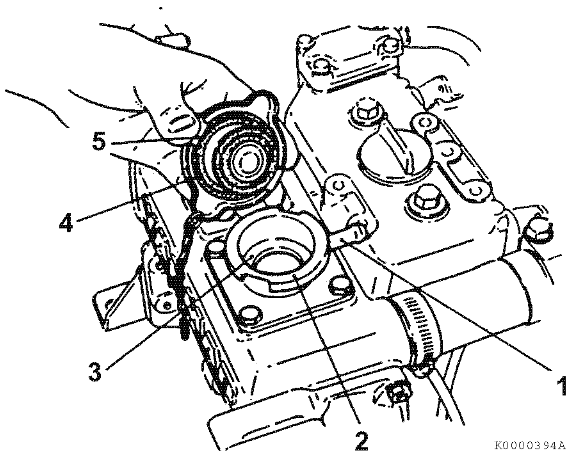
Closed Cooling System

■ Filler cap (pressure cap) and coolant recovery tank

Filler cap construction

The filler cap that is installed on the closed cooling system (typically on the heat exchanger) equipped with a pressure control valve. To install the pressure cap, align the locking tab and the flyneck cam and turn to tighten the cap.

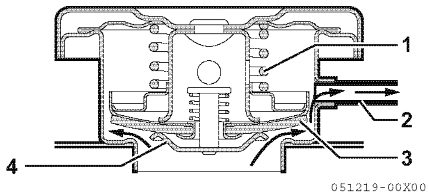
The top seal touches the flyneck tap seat while the pressure valve touches the lower seat.



1 – Overflow pipe
2 – Top seat
3 – Lower seat
4 – Top seal
5 – Locking tab

Figure 7-119

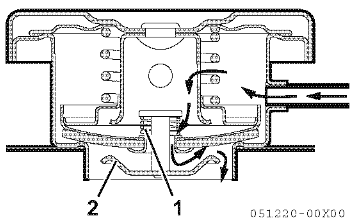
Pressure valve operation



1 – Pressure valve spring
2 – Overflow pipe
3 – Pressure valve
4 – Rubber seal

Figure 7-120

Vacuum valve operation



1 – Vacuum valve spring
2 – Vacuum valve

Figure 7-121

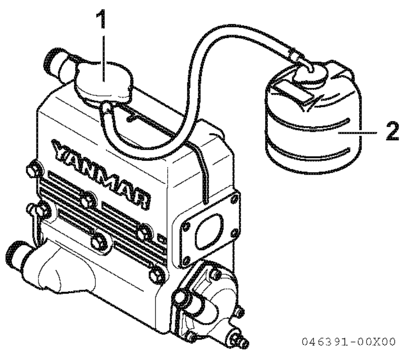
When the cooling system pressure is within the specified range of 0.9 kgf/cm^2 (12.8 psi) the pressure valve and vacuum valve are tightly seated on the valve seats. When the pressure rises, the pressure valve opens and vapor is discharged from the overflow pipe. When the water cools and pressure in the system is lower than atmospheric pressure, the vacuum valve opens and air enters the system through the overflow pipe.

To prevent coolant loss due to the pressure valve opening, the cooling system can be equipped with a coolant recovery tank.

Pressure valve	Opens at 0.9 kgf-cm^2 (12.8 psi) G
Vacuum valve	Opens at 0.05 kgf-cm^2 (0.711 psi) G or below

Coolant recovery tank function

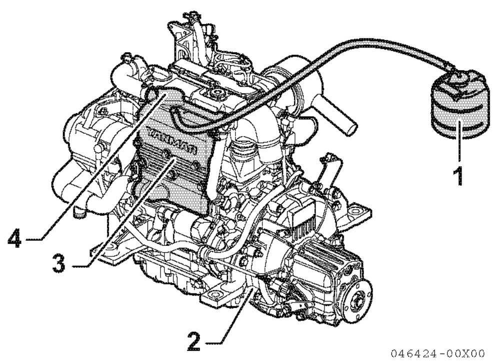
When the cooling system pressure rises above the 0.9 kgf-cm^2 (12.8 psi), the pressure valve opens and vapor is released, reducing the amount of coolant in the cooling system. The coolant recovery tank collects this vapor as it condenses. When the cooling system pressure falls below atmospheric pressure, the coolant in the coolant recovery tank is siphoned back to the main tank on the heat exchanger. Install a coolant recovery tank to allow the engine to be operated for longer periods and eliminate the need to open the filler cap on the heat exchanger.



1 – Filler cap
2 – Coolant recovery tank

Figure 7-122

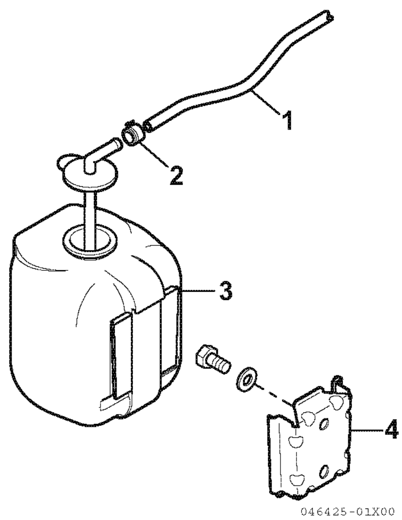
■ Coolant recovery tank installation



1 – Coolant recovery tank
2 – Overflow pipe
3 – Filler cap
4 – Heat exchanger tank

Figure 7-123

1. Mount the coolant recovery tank at the same height as the heat exchanger.
2. Ensure that the overflow pipe is not damaged or leaking and the holes are not obstructed.



1 – Hose
2 – Hose clamp
3 – Coolant recovery tank
4 – Bracket

Figure 7-124

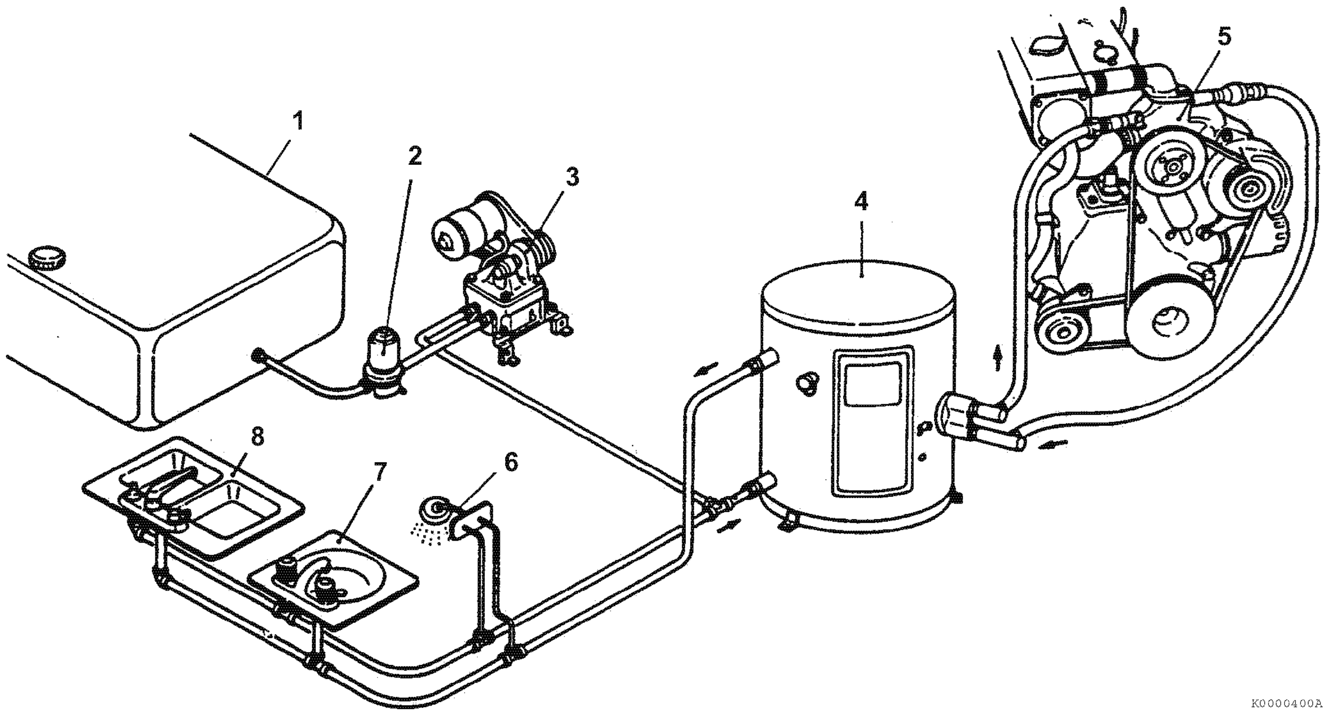
■ Cabin water heaters

The temperature of the engine coolant during operation is maintained by the engine thermostat at a constant 70 to 85 °C (158 to 185 °F). This heated coolant can be used to heat water for showers, wash basins and other onboard hot water needs by installing commercially available water heater tanks.

Some commercially available water heater tanks use electric heaters, liquid propane or engine coolant as heat sources. Typically, these water heaters operate on AC shore power, onboard electric AC generator power, onboard DC battery power or liquid propane.

Figure 7-125 illustrates a typical layout for an inboard hot water supply system.

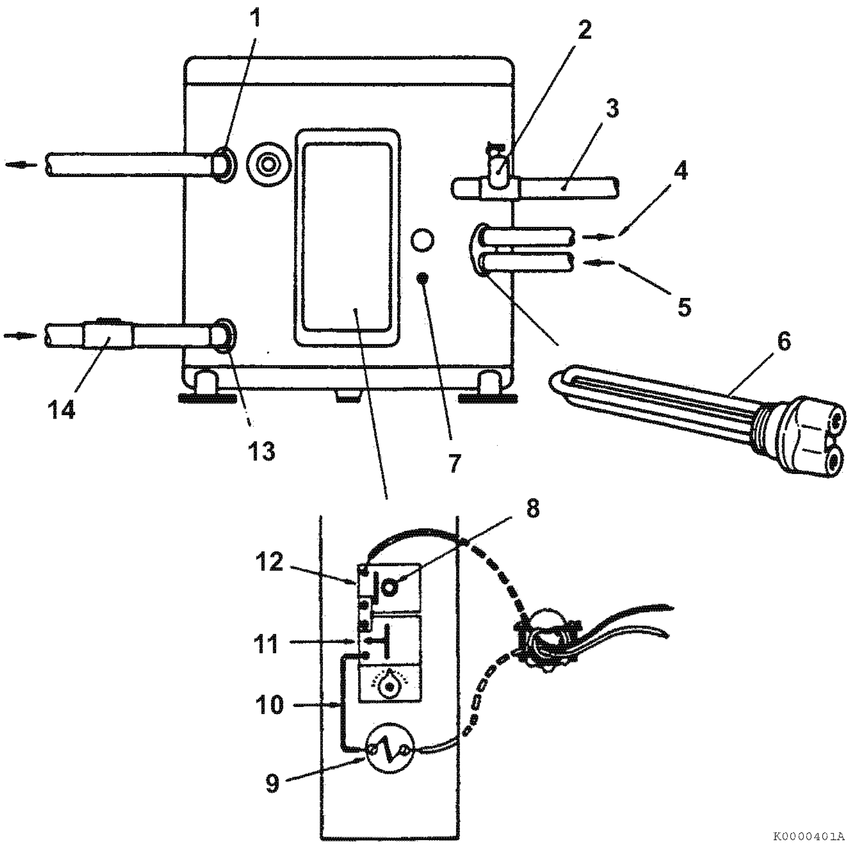
Typical onboard hot water supply system



1 – Coolant (potable) tank
2 – Filter
3 – Coolant pressure pump
4 – Water heater tank
5 – Engine coolant circulation pump
6 – Shower
7 – Wash basin
8 – Other onboard water needs

Figure 7-125

Typical water heater tank construction

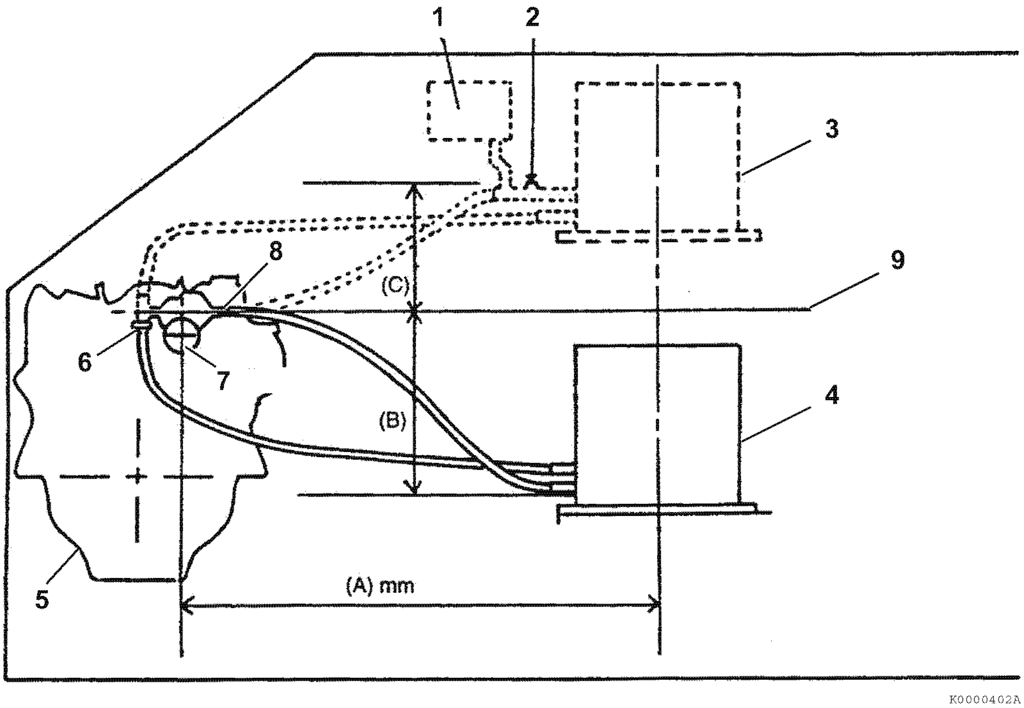


1 – Hot (potable) water out
2 – Excess pressure/temperature safety valve
3 – To overboard
4 – Coolant return to engine
5 – Hot coolant from engine
6 – Heat exchanger
7 – Water heater tank
8 – Reset button
9 – Heating element
10 – Black wire
11 – Thermostat
12 – High temperature limit switch
13 – Cold (potable) water inlet
14 – Pressure system check valve

Figure 7-126

Allowable installation position of water heater tank

A	B	C	Running condition
2 m (6.6 ft)	0.5 m (19.7 in.)	0.5 m (19.7 in.)	1. Engine output: 4/4 load 2. Connect rubber hose, inner dia. f: 16 mm (5/8 in.) 3. Installed reserve tank of (C) dimension



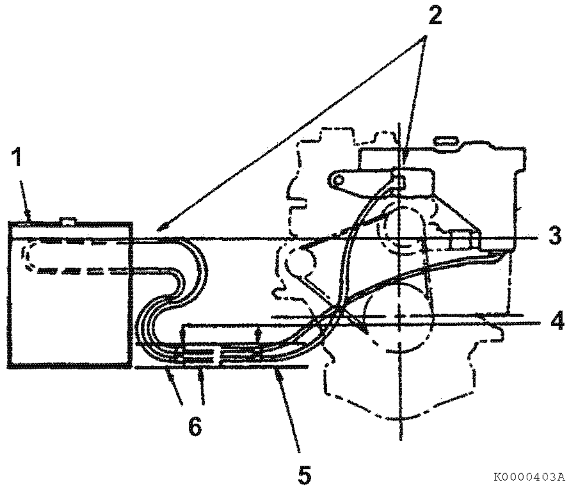
1 – Reserve tank
2 – Air vent hole
3 – Water heater - Installation above closed cooling pump outlet level (C)
4 – Water heater - Installation below closed cooling pump outlet level (B)
5 – Engine
6 – Inlet
7 – Engine coolant circulation pump
8 – Outlet
9 – Engine coolant outlet level

Figure 7-127

Installation

When designing for and installing a water heater tank:

- **Avoid air locking** - The highest point in the system must be lower than the engine coolant recovery tank level. The water flow system must be designed to flow upward.
- **Prevent damage from vibration or chafing** - Piping to and from the engine must be installed with flexible connections.
- **Avoid cold weather freezing damage** - Install drain cocks or plugs at the lowest part of the piping system.
- **Prevent back-flow** - Install a check valve in the piping on the engine side to check the flow of the cooling water when the water heater is not in use.



1 – Water heater
2 – Vent valves (necessary to release trapped air at high points of the system)
3 – Water heater tank piping must be below this level.
4 – Stainless steel pipe clamps
5 – Drain cocks necessary at lowest points of the system
6 – Clamps to engine bearers; flexible pipes to engine.
Water heater plumbing must not kink or chafe and must allow for engine vibration

Figure 7-128

- Pipes must be as short as possible with the minimum number of bends.
- **Avoid inverted "U" bends when possible** - If inverted "U" bends must be used, they must be fitted with vent valves or plugs to provide proper venting.
- Increase the engine's closed cooling tank capacity and the piping leading to the cooling water tank.

NOTICE

Where an internal piping coil is mounted horizontally in the tank, forming a series of inverted "U" bends, particular care must be paid to air venting. The engine coolant level must be rechecked several times to ensure that the total system is free of air and that the heater tank level is correct.

Note: If a water heater tank is installed, more water will be needed than can be handled by a single engine unit. A larger tank and more piping is required. Since this additional water capacity varies depending on the piping length, boat builders must measure the additional water requirements when fabricating the water heater tank piping. Insufficient cooling water could cause engine overheating.

Selection test (at Yanmar) water heater tank with engine

Water heater capacity and dimensions for test:

Water Capacity	A mm in.	B mm in.	C mm in.	D mm in.	E mm in.	F mm in.	G mm in.
22.7 L	35.5	41.12	28.26	7.94	14.61	19.05	19.69
6 gal	14.0	16.188	11.125	3.125	5.75	7.50	7.75

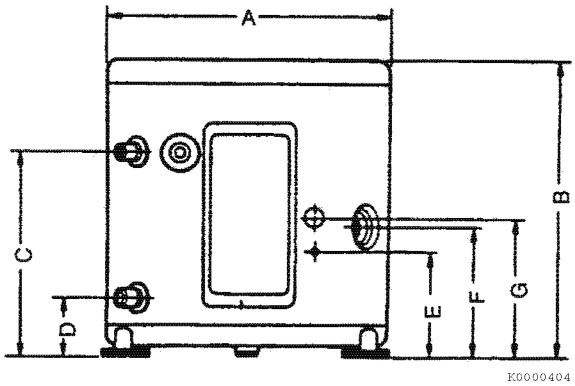


Figure 7-129

Test conditions:

Bench test, temperature:
12.5 to 14 °C (54.5 to 57.2 °F)

Engine - Yanmar model:
3HMF, 22.4 kW (30 hp) @ 3400 min^{-1},
coolant cooling

Engine thermostat temperature:
Operating temperature 71 °C (159.8 °F)
Fully open temperature 85 °C (185 °F)

Connecting pipe for engine to water heater:
Engine outlet: Inner diameter ø11 mm (0.43 in.),
Length: 2 m (6.56 ft)

Engine inlet: Inner diameter ø13 mm (0.51 in.),
Length: 2 m (6.56 ft)

■ Test data

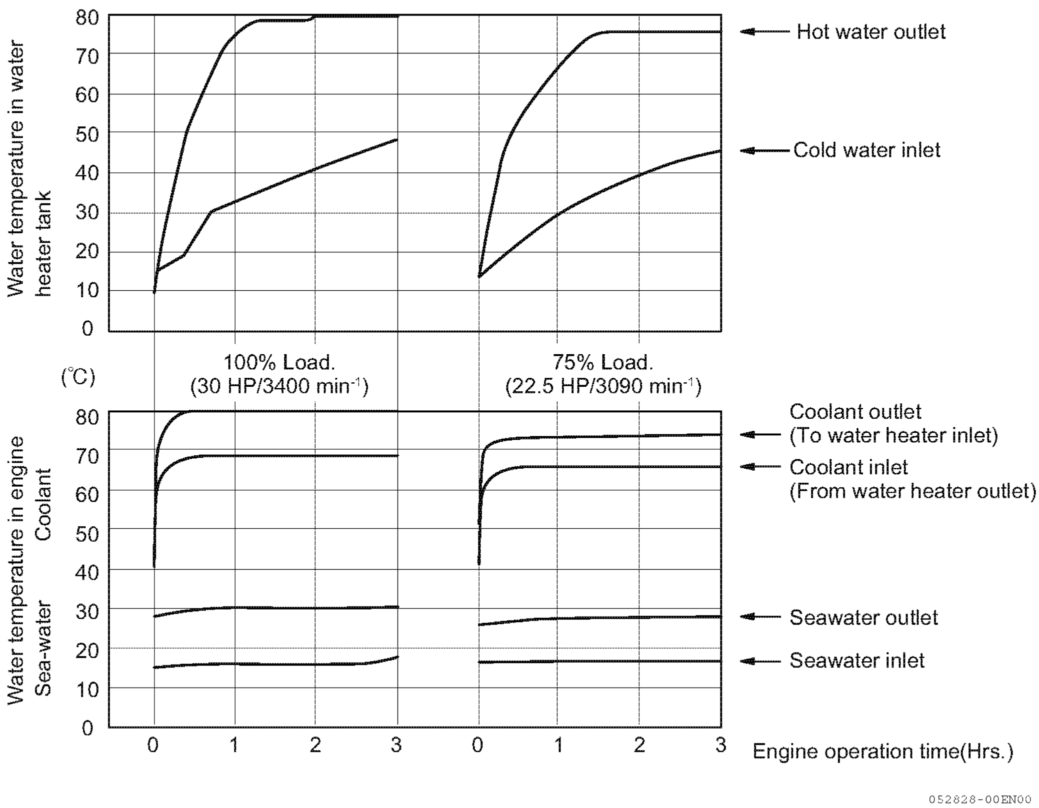


Figure 7-130

LUBRICATION SYSTEM

⚠ WARNING

Burn Hazard

Always stay clear of the hot engine oil to avoid being burned.

⚠ CAUTION

Improper Operation Hazard

Make sure the engine is installed on a level surface. If a Yanmar Marine engine is installed at an angle that exceeds the specifications stated in the Yanmar Marine Installation Manuals, engine oil may enter the combustion chamber causing excessive engine speed, white exhaust smoke and serious engine damage. This applies to engines that run continuously and those that run for short periods of time.

NOTICE

- Always use only the engine oil specified. Other engine oils may affect warranty coverage, cause internal engine components to seize and/or shorten engine life.
- Always prevent dirt and debris from contaminating the engine oil. Carefully clean the oil cap/dipstick and the surrounding area before you remove the cap.
- Never mix different types of engine oil. This may adversely affect the lubricating properties of the engine oil.
- Never overfill the engine with engine oil. Overfilling may result in white exhaust smoke, engine overspeed or internal damage.
- Always keep the oil level between the upper and lower lines on the oil cap/dipstick.

NOTICE

- On the initial engine start-up, allow the engine to idle for approximately 15 minutes while you check for proper engine oil pressure, diesel fuel leaks, engine oil leaks, coolant leaks, and for proper operation of the indicators and/or gauges.
- During the first hour of operation, vary the engine speed and the load on the engine. Short periods of maximum engine speed and load are desirable. Avoid prolonged operation at minimum or maximum engine speeds and loads for the next 4 to 5 hours.
- During the break-in period, carefully observe the engine oil pressure and engine temperature.
- During the break-in period, check the engine oil and coolant levels frequently.

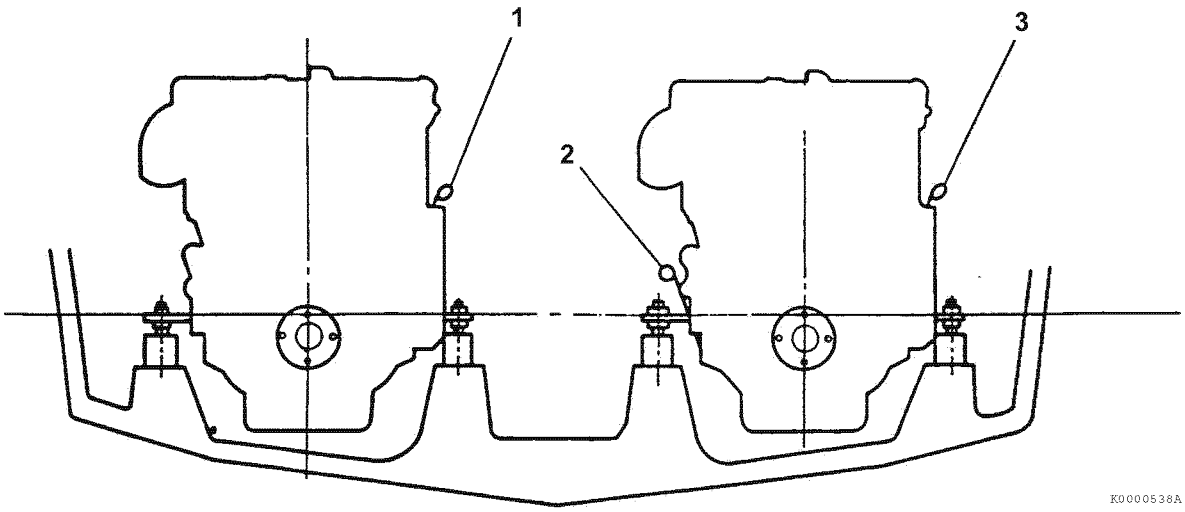
NOTICE

- Always be environmentally responsible.
- Follow the guidelines of the EPA or other governmental agencies for the proper disposal of hazardous materials such as engine oil, diesel fuel and engine coolant. Consult the local authorities or reclamation facility.
- Never dispose of hazardous materials irresponsibly by dumping them into a sewer, on the ground, or into ground water or waterways.
- Failure to follow these procedures may seriously harm the environment.

The purpose of the lubrication system is to reduce friction that causes wear and to cool critical parts of the engine. Heat energy is transfered to the oil and distributed through the engine. Some engines use heat exchangers to cool the engine oil.

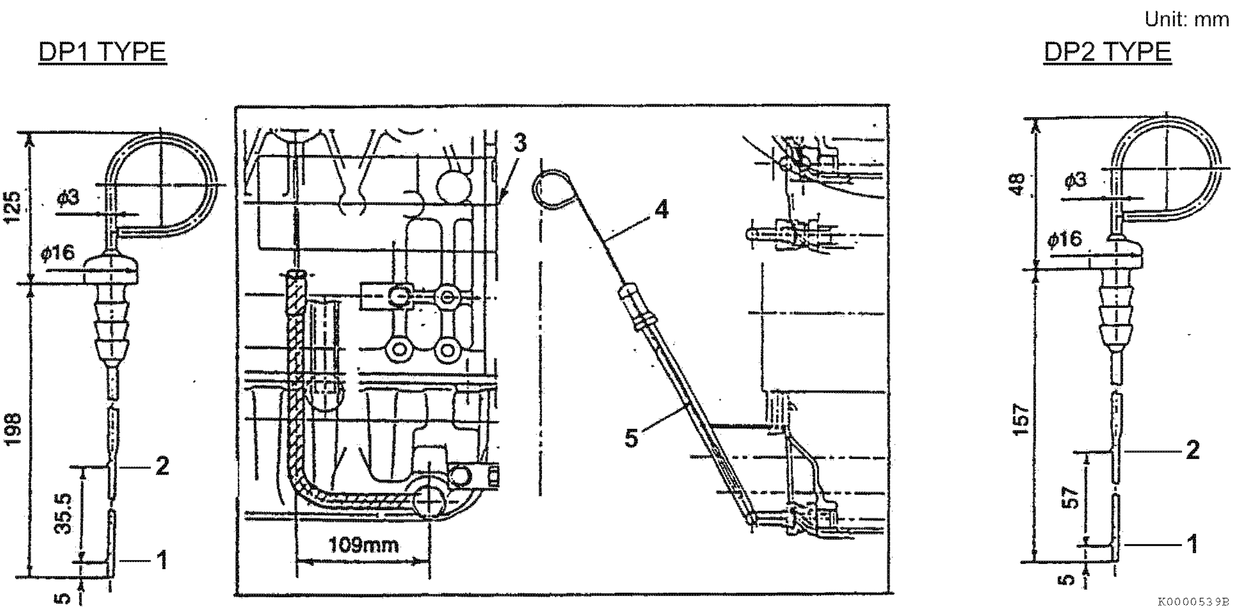
Oil must be maintained to minimum levels and changed at regular maintenance intervals.

Some applications have opposite side dipsticks that allow easy access for twin engine installations. To use, remove the dummy plug located below the starter motor and insert the opposite side oil dipstick.



1 – Crankcase oil dipstick - standard
2 – Oil dipstick - optional
3 – Crankcase oil dipstick - standard

Figure 7-131



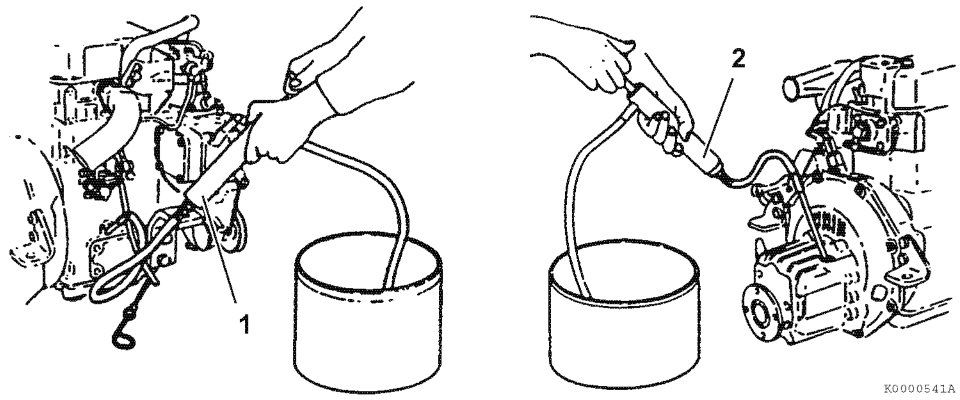
1 – Lower limit
2 – Upper limit
3 – Flywheel side
4 – Dipstick
5 – Guide tube

Figure 7-132

Draining Engine Oil

Generally, engine oil drain plugs at the bottom of the engine are not readily accessible. The same can be said of the marine gear.

Using an oil evacuation pump eliminates the need to drain oil from the drain plug.



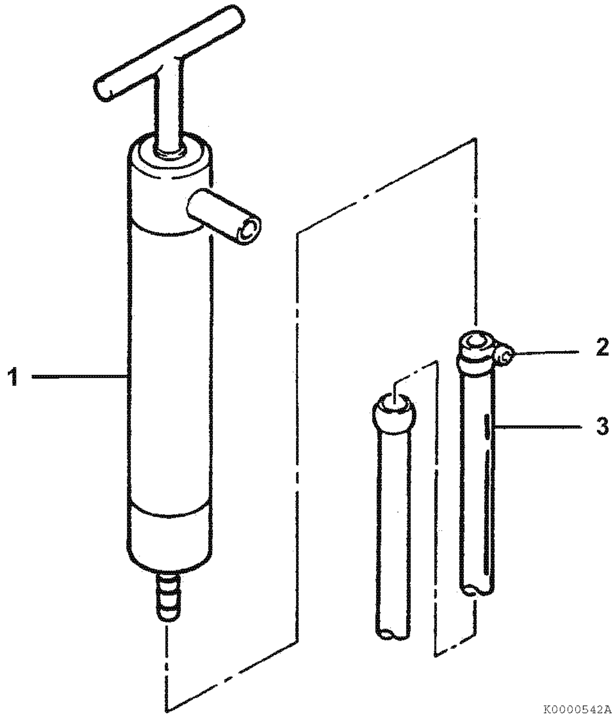
1 – Oil evacuation pump (engine)

2 – Marine gear

Figure 7-133

■ Piston-type oil evacuation pump

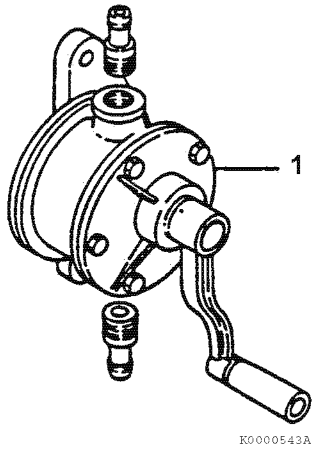
Type	Yanmar part No.
EPP 1	D05584-39501



1 – Piston-type oil evacuation pump
2 – Hose clamp
3 – Hose - Inner diameter ø15 mm (0.59 in.)
Length: 1000 mm (3.28 ft)

Figure 7-134

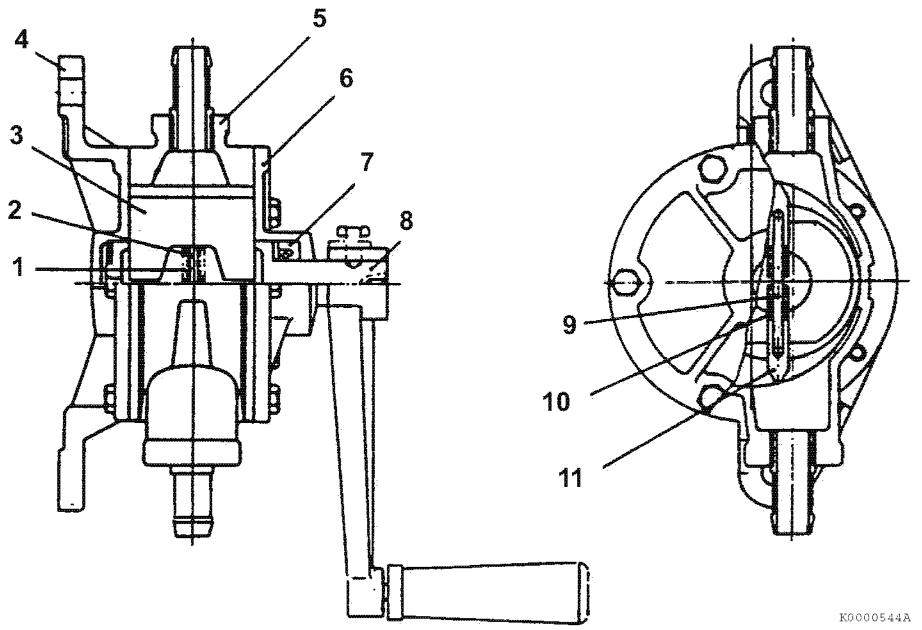
■ Rotary-type oil evacuation pump



1 – Rotary-type oil evacuation pump

Figure 7-135

Type	Yanmar part No.
EPR 1	D20130-37100
EPR 2	D27695-37210



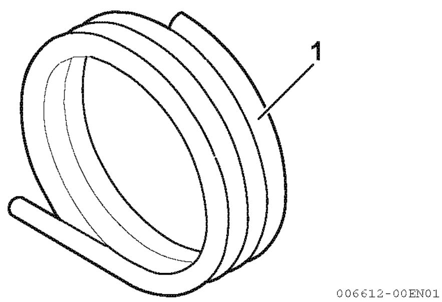
1 – Spring
2 – Spindle
3 – Vane
4 – Cover
5 – Body
6 – Cover
7 – Oil seal
8 – Shaft
9 – Spindle
10 – Spring
11 – Vane

Figure 7-136

■ Specifications

Delivery capacity of one stroke	0.13 L (0.137 qt)
Delivery pressure	1.5 kgf/cm^2 or less (21.3 psi or less)
Suction head	less than 1.0 m (39.37 in.)

■ Rubber hose



1 – Rubber hose

Figure 7-137

Inner diameter × length	ø12 × 1000 mm (0.47 in. × 3.28 ft)
Yanmar part No.	43720-001220

EXHAUST SYSTEM

⚠ WARNING

Exhaust Hazard

- **Never operate the engine in an enclosed area, such as a garage, tunnel, underground room, manhole or ship's hold, without proper ventilation.**
- **Never block windows, vents or other means of ventilation if the engine is operating in an enclosed area. All internal combustion engines create carbon monoxide gas during operation. Accumulation of this gas within an enclosure could cause illness or even death.**
- **Make sure that all connections are tightened to specifications after repair is made to the exhaust system.**

⚠ WARNING

Burn Hazard

Never touch hot engine surfaces, such as the muffler, exhaust pipe, turbocharger (if equipped) and engine block, during operation and shortly after you shut the engine down. These surfaces are extremely hot while the engine is operating and could seriously burn you.

NOTICE

For maximum engine life, Yanmar recommends that when shutting the engine down, allow the engine to idle, without load, for 5 minutes. This will allow the engine components that operate at high temperatures, such as the turbocharger (if equipped) and exhaust system, to cool slightly before the engine itself is shut down.

The exhaust systems of all Yanmar pleasure boat engines are wet-type. Exhaust gas and cooling water are gathered in the exhaust/water mixing elbow (standard or optional) of the exhaust port for discharge together. Accordingly, a heat-resistant rubber hose can be used for the exhaust pipe. This permits a simple exhaust pipe layout.

Exhaust Piping System

It is necessary to arrange the piping to allow for inspection of the whole system. Also, a suitable arrangement is necessary to prevent seawater from flowing back into the engine. A water lock must be installed to prevent water remaining in the hose from flowing back to the engine side when stopping the engine or immediately after starting.

The water lock must be fixed at the lowest possible position and the hose must be tilted downward as much as possible. It is also necessary to elevate the exhaust hose at the exhaust outlet to more than 350 mm (13.77 in.) above the loading draft line.

NOTICE

Avoid corrosion failure of exhaust/water mixing elbow.

The exhaust/water mixing elbow has a partial double-pipe construction where the inner pipe is for exhaust gas and the outer pipe is for the cooling water (seawater) to flow. The exhaust and the seawater are mixed on the way to the exhaust port for discharge together.

Typical diesel engine exhaust contains the following:

- Carbon monoxide = CO
- Hydrocarbon = HC
- Nitrogen oxide = NOx
- Sulfur dioxide = SO2

When mixed with seawater, these gases chemically cause sulfuric acid corrosion of the exhaust/water mixing elbow, which is made of cast iron or a stainless steel alloy. **Replace the exhaust/water mixing elbow once every two years.**

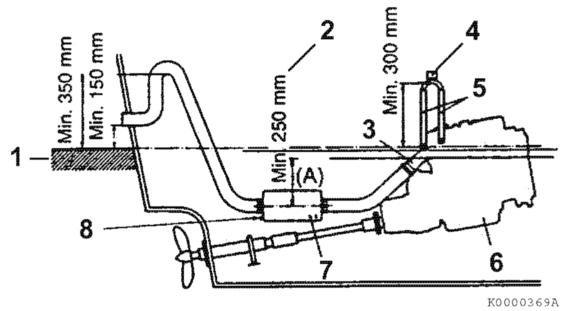
■ Water lock

The water lock is used when the engine's exhaust port is located below the waterline. This device is especially useful for sailboats, which do not use their engines frequently.

The installation of a water lock does not cause a large horsepower loss due to the increase of exhaust back pressure.The use of a water lock is inappropriate for power boats, which use the engine's full output. If a water lock is installed on the exhaust piping, back pressure will increase and engine output will drop. In power boats, a high-type exhaust/water mixing elbow must be used for the piping layout to prevent the reverse flow of exhaust water.

NOTICE

Be sure to install a drain plug or cock at the bottom of the water lock. This is to prevent possible engine damage due to the entry of remaining water into the engine's exhaust port when the hull is tilted stern side up for transportation, etc.



1 – Waterline
2 – Below waterline
3 – Mixing elbow
4 – Vacuum valve
5 – Cooling water pipe
6 – Engine
7 – Water lock
8 – Drain cock

Figure 7-138

■ Exhaust piping layout

Cooling water/exhaust piping varies according to the hull shape and engine room position.

1. When the water outlet of engine is below the waterline (2, **Figure 7-138**), attach a vacuum valve to the exhaust/water mixing elbow of the cooling water pipe (recommended for sailboats).

2. Install wet exhaust line. Install anti-siphoning valve if needed.

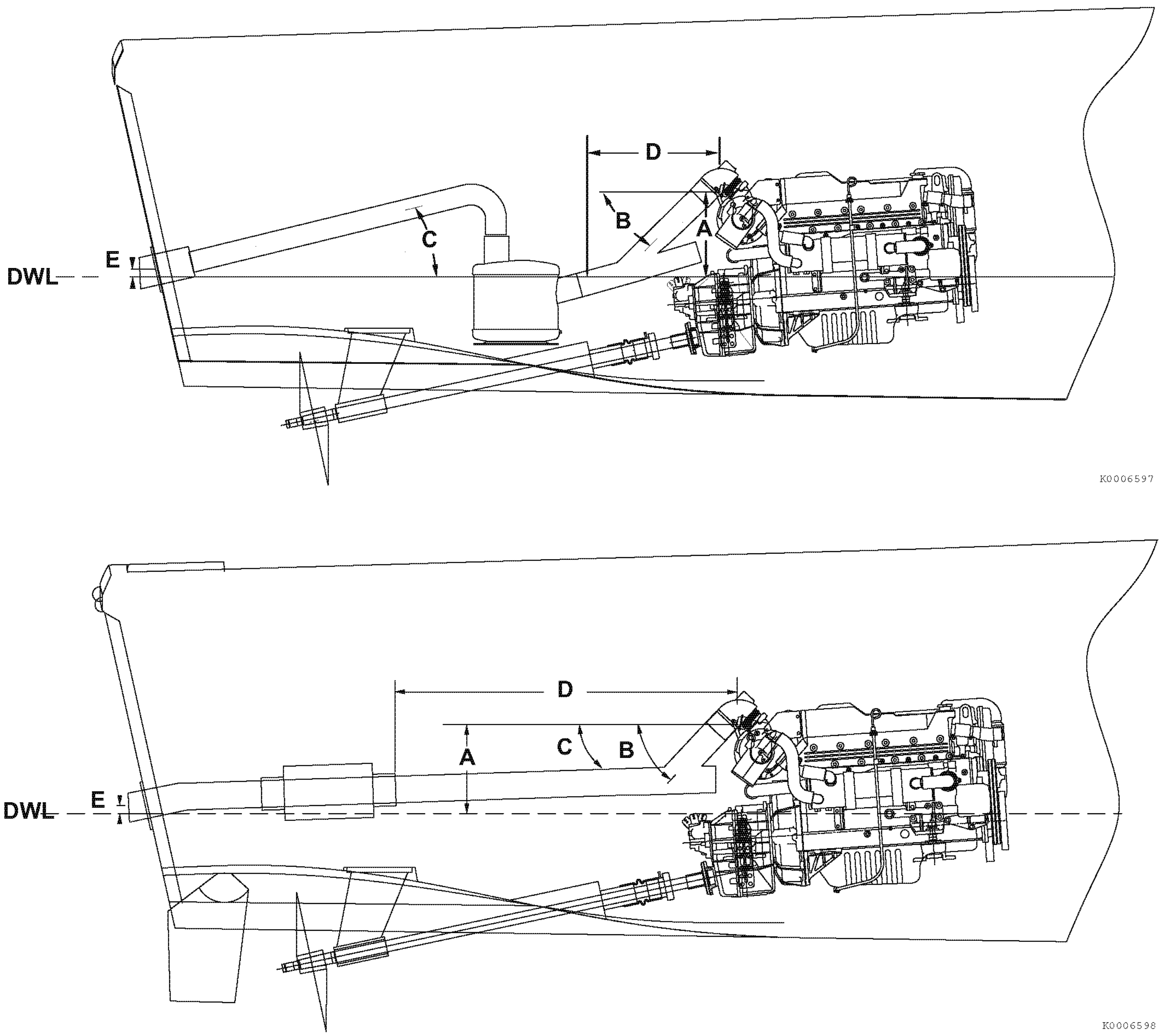
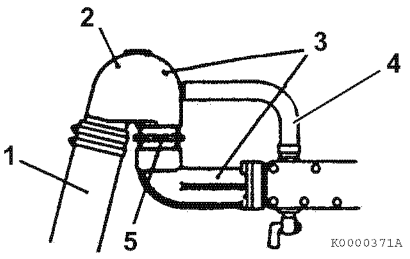


Figure 7-139

Dimension	Description	Value
A	Distance from DWL to apex of riser (Lift muffler and/or surge tube mandatory)	Minimum 305 - 380 mm (12 - 15 in.)
B	Down angle of riser relative to DWL	15° minimum
C	Declination of exhaust hose/pipe	~2° or 8.3 cm/m (1 in./ft.)
D	Distance from riser to muffler inlet. Must allow sufficient volume to crank engine for15 seconds without flooding engine.	–
E	Exhaust outlet relative to DWL (distance must be checked under loaded water line (LWL)). If partially or fully submerged, exhaust back pressure will increase. Back pressure must be checked under loaded waterline (LWL). Do not exceed 30 kPa (118 in. Aq) at any RPM.	150 mm (6 in.) above DWL (optimal)

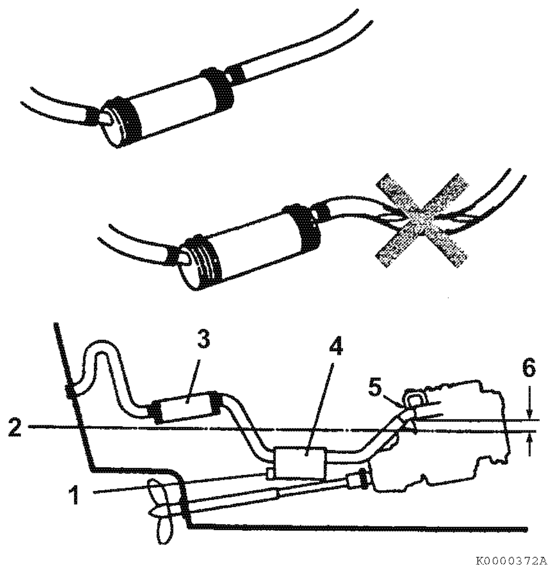
3. Wrap lagging around the water mixing elbow to prevent the engine room temperature from rising. The engine room space in pleasure boats is generally narrow, so be sure to provide lagging to prevent excessive temperature rise in the engine room and also as a safety precaution.



1 – Rubber hose
2 – Exhaust/water mixing elbow
3 – Lagging
4 – Cooling water hose
5 – Exhaust pipe riser

Figure 7-140

4. Exhaust system with water injection point (5, **Figure 7-141**) 150 mm (5.9 in.) or more above waterline:

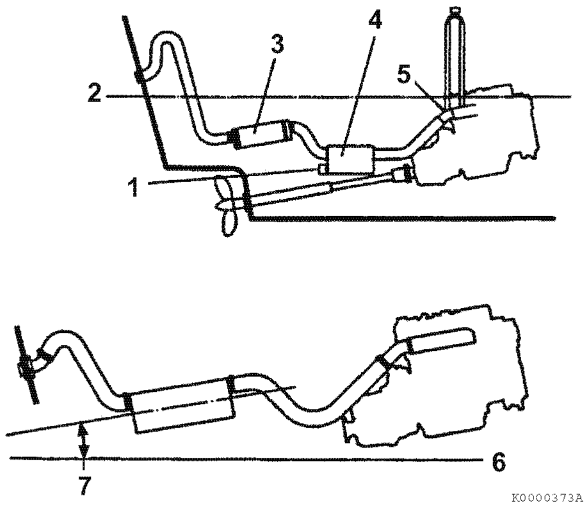


1 – Drain cock
2 – Waterline
3 – Muffler
4 – Water lock
5 – Water injection point
6 – 150 mm (5.9 in.) or greater

Figure 7-141

5. Exhaust system with water injection point (5, **Figure 7-142**) less than 150 mm (5.9 in.) above the waterline:

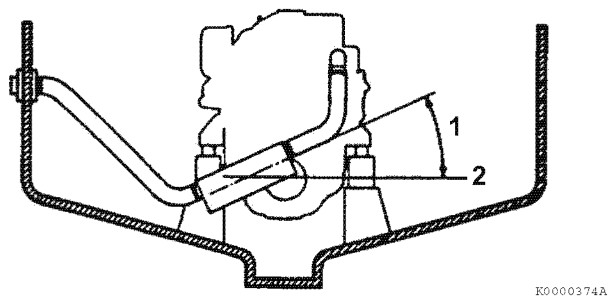
   Fore-and-aft inclination of muffler: 5 to 7.5° (7, **Figure 7-142**).



1 – Drain cock
2 – Waterline
3 – Muffler
4 – Water lock
5 – Water injection point
6 – Waterline
7 – Inclination of muffler

Figure 7-142

6. Athwart inclination of silencer, A = 25 to 45°



1 – A
2 – Waterline

Figure 7-143

■ Exhaust back pressure

Exhaust piping which develops an excessive back pressure causes incomplete engine combustion, the emission of abnormally-colored exhaust, increased fuel consumption, engine speed (output) drop and a rise in the exhaust temperature. To prevent back pressure, observe the following points with regard to the exhaust piping:

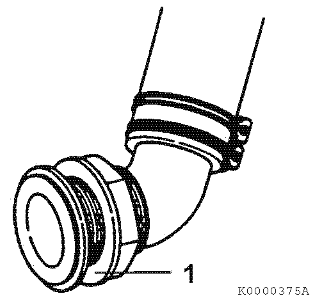
1. Do not use a hose with a diameter smaller than that of the exhaust hose of the engine exhaust/water mixing elbow.
2. The back pressure rises when an exhaust silencer or water lock is used. Make the hose diameter at the outlet of the exhaust silencer or water lock 25 mm (1.0 in.) larger than that of the hose on the inlet side in such cases.
3. Avoid sharp bends in the exhaust piping hose.
4. Excessive rise in back pressure causes surging in turbocharged engines and this may result in damage to the turbocharger. Accordingly, do not use a water lock for turbocharged engines.

   Note: When it is suspected that the exhaust piping is causing excessive back pressure, it is necessary to de-rate the engine output and select a more suitable propeller.

   Refer to Appendix C on page 10-1.

Scupper

1. The scuppers should be at least 150 mm (5.9 in.) higher than the loaded waterline of the boat.
2. Use seawater-resistant material for the metal fixtures of the scupper.
3. Provide complete sealing with a silicone rubber-based sealing agent at the exhaust outlet location in the hull and on the threaded parts of the outlet.

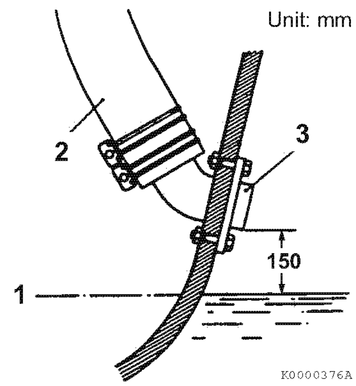


1 – Scupper

Figure 7-144

The bow and stern rise and fall during cruising. The exhaust port on the stern should be fitted to be 150 mm (5.9 in.) above the waterline during cruising.

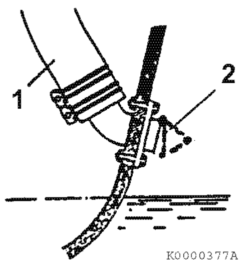
Note: When the exhaust port falls below the waterline, the back pressure rises and engine output is lowered causing abnormally colored exhaust and engine trouble.



1 – Waterline
2 – Exhaust rubber hose
3 – Through-hull fitting

Figure 7-145

4. Installation of a butterfly (flapper) cover on the end of the scupper helps to prevent seawater from entering the exhaust port when the engine is stopped.



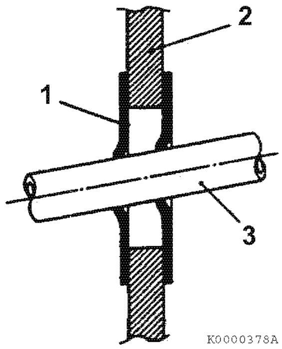
1 – Exhaust rubber hose
2 – Flapper cover

Figure 7-146

■ Precautions for exhaust piping

1. Use an all-weather, heat-resistant, oil-proof rubber hose.

   When the hose passes through the cabin or other section where people enter or exit, use a hose with high durability.
2. When bending the hose, bend it in a large curve so that the hose diameter is not altered.
3. Keep the hose away from substances which may damage or distort it.
4. When the hose goes through a bulkhead or other walls, protect the hose from distortion or friction damage.
5. Attach the hose in a way which allows for the flexible movement of the hose during engine vibration.



1 – Flexible protection material
2 – Bulkhead or wall
3 – Exhaust rubber hose

Figure 7-147

6. Use at least two non-overlapping clamps at each end.

Measuring Engine Output (Exhaust Temperature)

A thermometer, thermocouple and tachometer must be used to take this measurement.

Prior to measurement, be sure to measure the ambient temperature (open air, engine room and seawater) and the temperatures of the engine oil and fresh cooling water.

For exhaust temperature values, refer to the engine data sheet for each engine.

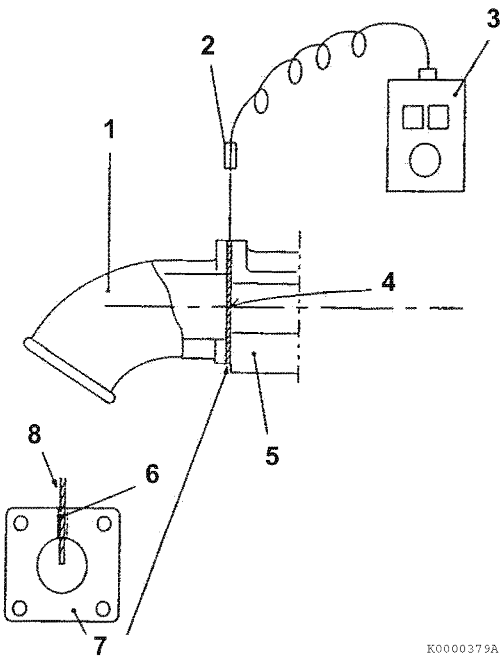
These values are based on the atmospheric conditions of the Yanmar Industrial Standard (YIS).

Note: Keep the top end of the thermocouple in the center of the exhaust port or the temperature measurements will fluctuate.

■ Naturally aspirated engines

1. Make a slit in the gasket packing installed between the exhaust/water mixing elbow and exhaust manifold. Insert the thermocouple into the slit and fasten the tip in the center of the exhaust port.

   Note: Use a thermocouple with a cable diameter of less than 2.0 mm (0.079 in.). If larger than 2.0 mm (0.079 in.), more than two pieces of gasket packing are required.



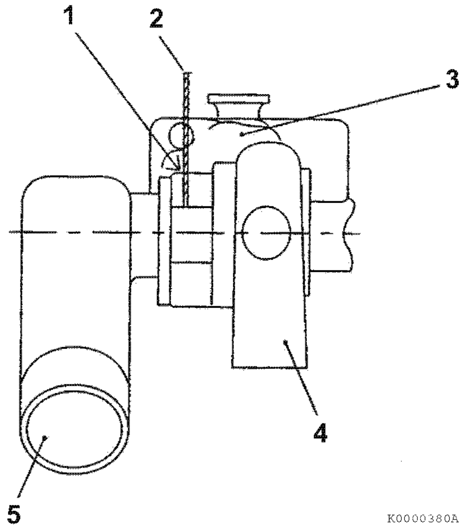
1 – Exhaust/water mixing elbow
2 – Thermocouple
3 – Thermometer
4 – Center line
5 – Exhaust manifold
6 – Slit
7 – Gasket
8 – Thermocouple

Figure 7-148

2. Start the engine. Measure the engine speed and exhaust temperature at 1/4, 1/2, 3/4, 4/4 and 11/10 of maximum loads.

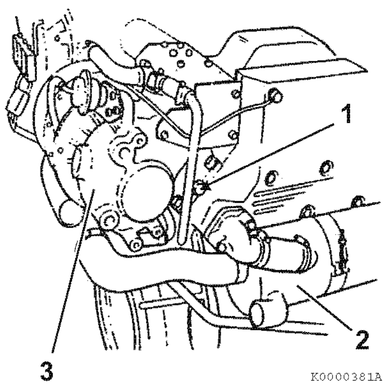
■ Turbocharged engine

1. Remove the blind plug, PF 1/8 (1, **Figure 7-150**) or PF 3/8 (1, **Figure 7-149**), located between the exhaust manifold and turbocharger inlet, insert the thermocouple, and fasten the tip in the center of the exhaust port.
2. Start the engine. Measure the engine speed and exhaust temperature at 1/2, 1/4, 1/2, 3/4 and 11/10 of maximum loads.



1 – Blind plug, PF 3/8
2 – Thermocouple
3 – Exhaust manifold
4 – Turbocharger
5 – Exhaust/water mixing elbow

Figure 7-149



1 – Blind plug, PF 1/8
2 – Heat exchanger
3 – Turbocharger

Figure 7-150

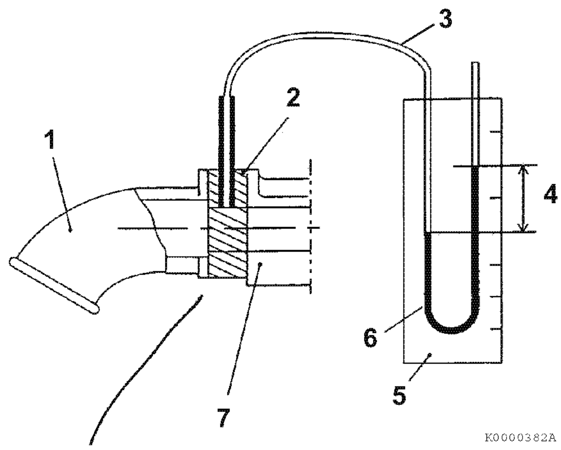
Measuring Exhaust Back Pressure

If no test port is provided, it is necessary to prepare a spacer for the manometer before measuring the exhaust back pressure. When a manometer is not available, install a vinyl hose and measure the water level difference with a scale.

Refer to Appendix C on page 10-1.

■ Naturally aspirated engine

1. Install the spacer for the manometer between the exhaust/water mixing elbow and exhaust manifold.



1 – Exhaust/mixing elbow
2 – Spacer
3 – Vinyl hose
4 – Water level difference (mmAq or in.Aq)
5 – Manometer
6 – Water
7 – Exhaust manifold

Figure 7-151

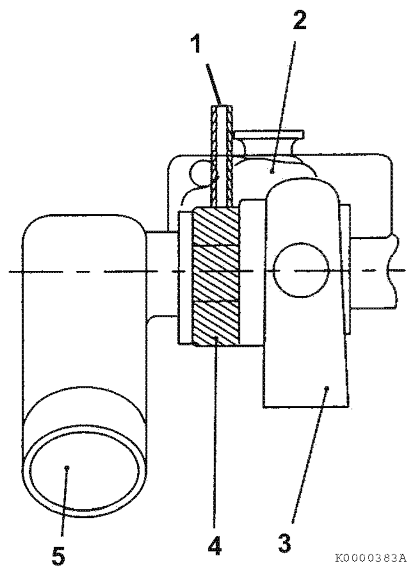
2. Connect the vinyl hose of the spacer to the vinyl hose of the manometer at one side and pour water into the hose.
3. Start the engine, raise the load gradually and measure the back pressure. The water level difference of the manometer hose shows the back pressure.

NOTICE

The fitting at the manifold end of the hose of the spacer must be heat-resistant.

■ Turbocharged engine

1. Install the spacer for the manometer between the exhaust/water mixing elbow and turbocharger. Follow the procedure for the naturally aspirated engines.



1 – To manometer
2 – Exhaust manifold
3 – Turbocharger
4 – Spacer
5 – Exhaust/water mixing elbow

Figure 7-152

Note: Beginning in 2006, many engines were built with an exhaust sampling plug in the exhaust elbow.

Measuring Exhaust Gas Emission

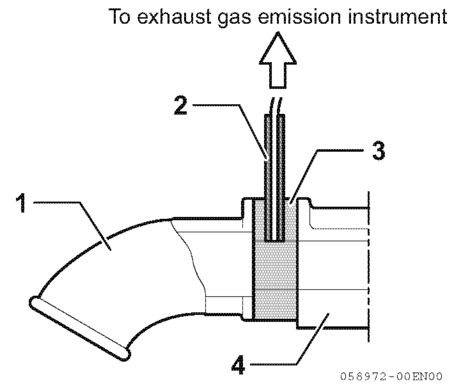
Method for measuring the exhaust gas emission depends on the type of engine.

■ YM series engine

In order to measure the exhaust gas emissions, installation of the spacer is required because test port is not provided on the engine. Specifications of a spacer to adapt to each engine model are described as "EPA exhaust test port size" in a table in the section "Air Intake and Exhaust Specifications" in "Installation Manual - Volume 2" issued for each engine model.

1. Install the spacer between the exhaust/water mixing elbow and an exhaust manifold.
2. Install a pipe, which has been threaded to the same size as the test port of the spacer, to the test port in the spacer.
3. Connect the pipe and an exhaust emission instrument.

Note: No dilution of the exhaust gas by the ambient air occurs because the pipe and the spacer are screwed together.



1 – Exhaust/mixing elbow
2 – Pipe
3 – Spacer
4 – Exhaust manifold

Figure 7-153

■ Other engines except for YM series

A test port is equipped on the engine or in the mixing elbow of each engine. The location and the specifications of the test port are described as "EPA exhaust test port size" in a table in the section "Air Intake and Exhaust Specifications" in "Installation Manual - Volume 2 and 3" issued for each engine model.

1. Install a pipe, which has been threaded to the same size as the test port on the engine or in the mixing elbow of each engine, to the test port.
2. Connect the pipe and an exhaust emission instrument.

Note: No dilution of the exhaust gas by the ambient air occurs because the pipe and the spacer are screwed together.

PTO SYSTEM

⚠ WARNING

Sever Hazard

Keep hands and other body parts away from moving/rotating parts such as the flywheel or PTO shaft.

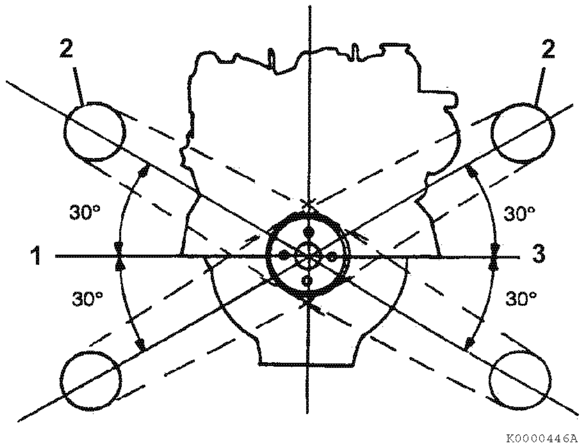
⚠ WARNING

Stop the engine before you begin to service it and make sure all rotational parts have stopped.

When operating a generator, pump or compressor using the power from the power take-off (PTO) crankshaft pulley on the front side (i.e., non-marine gear side) of marine propulsion engines, be sure to observe the following precautions:

General Precautions for Front PTO

1. The horsepower required to drive the machinery must be within the allowable output of the engine's front PTO.
2. Pulleys and other rotating parts must be balanced.
3. Use light material (aluminum, etc.) parts for the pulleys and other rotating parts.
4. In belt drive systems, the belt tension must be adjustable.
5. The alignment and surface run-out between the engine's PTO crankshaft pulley and the driven machinery must be within the allowable values.
6. In belt drives, keep the crankshaft pulley within 30° of horizontal for both starboard and port operation **(Figure 7-154)**. When driving machinery at both starboard and port sides concurrently, keep this angle within 15°.



1 – Starboard
2 – Pulley
3 – Port

Figure 7-154

7. Use the following formula to obtain the engine side pulley diameter. Pay careful attention to the thread hole size and the pitch circle diameter (PCD) of the crankshaft pulley face. Refer to the engine outline drawing for the

■ Engine side pulley diameter

$$\text{Engine side pulley dia. (D)} = \frac{\text{Machinery speed (R)} \times \text{Machinery pulley dia. (d)}}{\text{Engine speed (N)}}$$

D	: Engine side pulley diameter	mm
R	: Machinery speed	min^{-1}
d	: Machinery pulley diameter	mm
N	: Engine speed	min^{-1}

Note: Pulley ratio within 3:1

Front PTO Drive System

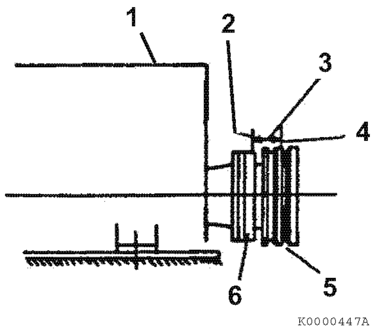
The front PTO drive systems of most marine propulsion engines belong to the following types: A-types or D-types. The criteria for selecting a specific drive system are:

1. Engine horsepower, usable front PTO horsepower, and the required horsepower of the driven machine
2. Engine room space
3. Engine installation (flexible engine mount or direct engine mount)

NOTICE

For flexible engine mount installations, drive systems are recommended. When using these drive systems, however, the conditions for use must be strictly observed. Misjudgment of steps 1 and 3 above could cause serious engine trouble such as damaging the crankshaft.

■ A-type - Side-pull belt drive system

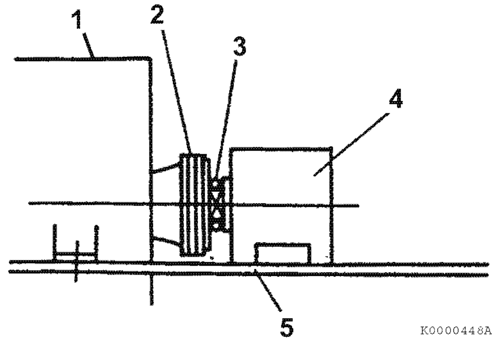


1 – Engine
2 – Face of crankshaft pulley
3 – Overhang (L)
4 – V-pulley center
5 – V-pulley
6 – Crankshaft pulley

Figure 7-155

Note: Overhang (L) varies depending on engine models. Strictly adhere to the overhang (L) specifications for each model. Surface run-out: 0.2 mm (0.008 in.) or less.

■ D-type - Direct coupling to machinery using flexible coupling

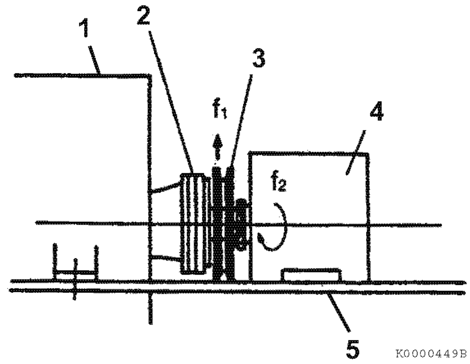


1 – Engine
2 – Crankshaft pulley
3 – Flexible coupling
4 – Machinery
5 – Plate (securely fastened)

Figure 7-156

Note: Alignment must be within 0.2 mm (0.008 in.).

■ D-type - Direct coupling with belt combination drive



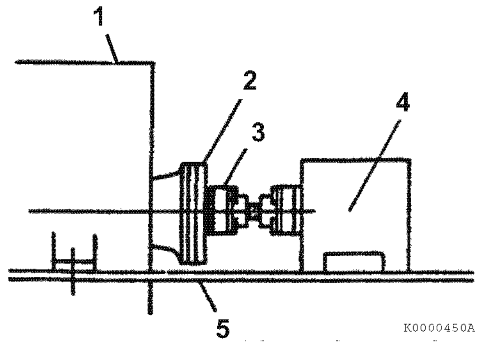
1 – Engine
2 – Crankshaft pulley
3 – V-pulley
4 – Machine
5 – Plate (securely fastened)

Figure 7-157

Note:

- *Maximum take-off output: $f_1 + f_2$.*
- *Alignment: 0.05 mm (0.002 in.) or less.*
- *Surface run-out: 0.2 mm (0.008 in.) or less.*

■ D-type - Direct coupling to machinery using flexible joint

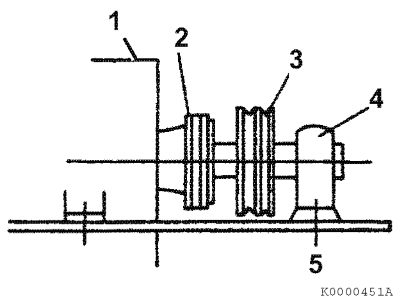


1 – Engine
2 – Crankshaft pulley
3 – Flexible joint
4 – Machinery
5 – Plate (securely fastened)

Figure 7-158

Note: Alignment must be within 0.2 mm (0.008 in.). This is dependant, however, on the alignment capacity of the flexible coupling.

■ D-type - Belt drive using one outside bearing

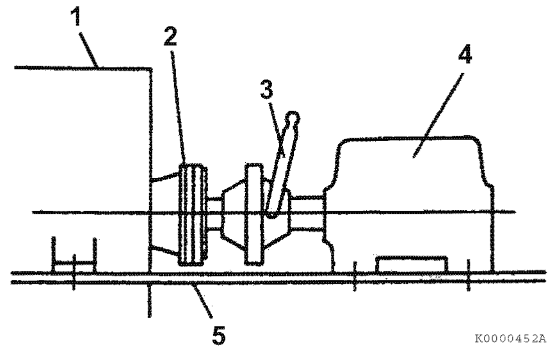


1 – Engine
2 – Crankshaft pulley
3 – V-pulley
4 – Bearing
5 – Plate (securely fastened)

Figure 7-159

Note: Alignment must be within 0.05 mm (0.002 in.).

■ D-type - Direct coupling to driven machinery without belt drive

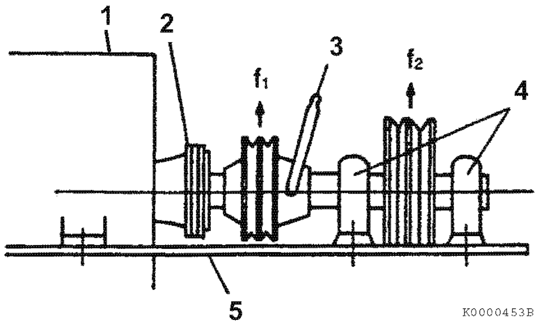


1 – Engine
2 – Crankshaft pulley
3 – Clutch
4 – Driven machine (generator, pressure pump, etc.)
5 – Plate (securely fastened)

Figure 7-160

Note: Alignment must be within 0.1 mm (0.004 in.).

■ D-type - Belt drive using two or more outside bearings



1 – Engine
2 – Crankshaft pulley
3 – Clutch
4 – Bearings
5 – Plate (securely fastened)

Figure 7-161

Note:

- *Maximum take-off output: $f_1 + f_2$.*
- *f_1 must be less than output possible with A-type system.*
- *Alignment: 0.05 mm (0.002 in.) or less. Surface run-out: 0.2 mm (0.008) or less.*

■ Conditions of use for front PTO when the engine has vibration-proof rubber mounts

Note: All models of Yanmar pleasure craft use marine diesel engines with flexible engine mounts.

The vibration-proof flexible mounts attached to Yanmar engines cannot be used for installing the engine and the driven machine on the common bed. The Yanmar vibration-proof flexible mount is manufactured for the weight and vibration of the engine unit and the hull vibration as tested during sea trials. Use of the engine's front PTO increases the weight of the common bed and driven machine, and the driven machine's vibrations are added. Accordingly, the vibration-proof flexible mounts attached to Yanmar engines will not provide enough protection. Purchase suitable vibration-proof flexible mounts locally.

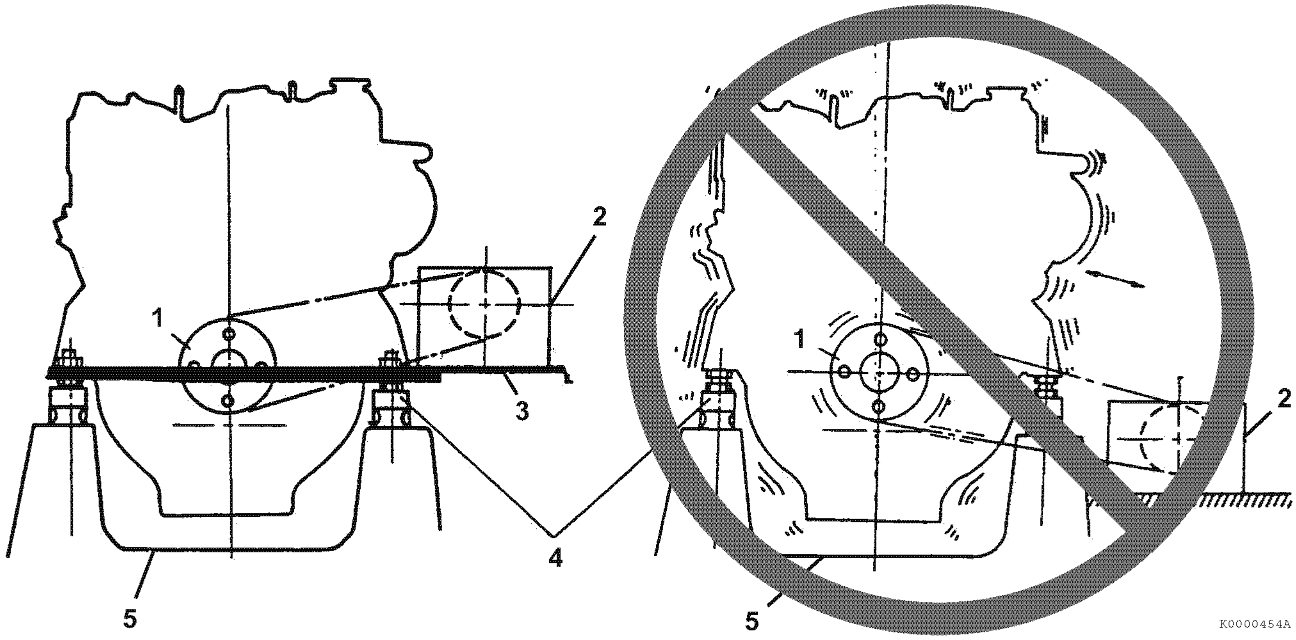
Front PTO: Side-pull belt drive system engine: Vibration-proof mounting

Machine: Direct mounting on hull

When using the front PTO of the engine with flexible mounts, install both the engine and the driven machine on the common bed. Install the common bed on flexible mounts.

If only the engine is installed on the flexible mounts and the engine drives the machine via its front PTO, amplitudes will develop. These amplitudes will be transmitted from the engine's front pulley to the driven machine and then to the hull, causing the following problems:

- Increased hull vibrations
- Damage to vibration-proof flexible mounts
- Breaking of crankshaft
- Crankshaft bearing damage



1 – Front pulley
2 – Machinery on the common bed
3 – Common bed
4 – Flexible mounts
5 – Engine bed

Figure 7-162

Note: Front PTO: Side-pull belt drive system
Engine: Vibration-proof mounting
Machine: Direct mounting on hull

■ Criteria for selecting vibration-proof flexible mounts locally

The positions for vibration-proof flexible mount installation and the engine feet are determined by calculating the center of gravity of the engine. When the engine's front PTO is used, however, the loads of the common bed and the driven machine are added to the engine load. Also, the center of gravity of the engine varies according to the common bed shape and the installation position of the driven machine.

Where possible, it is recommended to determine the center of gravity by setting the driven machine on the common bed with the engine installed and to install the vibration-proof flexible mounts where they are actually needed.

In practice, this is extremely difficult for boat builders as it necessitates modifications to the engine bed. In such cases, Yanmar has to prepare vibration-proof flexible mounts with the equivalent spring constant to the compression ratio of the vibration-proof flexible mounts under the engine's static load and then measure the hull vibrations in a boat test.

It has been verified in hull vibration tests that when the resonance point appears as a large vibration in the engine's service speed range, using soft vibration-proof flexible mounts with a lower spring constant moves the resonance point to a lower speed range, while using hard vibration-proof flexible mounts with a high spring constant makes the resonance point rise to a higher speed range.

When using vibration-proof flexible mounts with a low spring constant to lower the resonance point speed, be sure to fully check the durability of the vibration-proof flexible mounts, vibration amplitude and thrust load at the time of engine starting.

Torsional Vibration

In addition to the vibrations caused by the engine torque, torsional vibrations cause additional twisting of the crankshaft and external shafting.

Excessive torsional vibrations can cause high stresses leading to failure of these components. It is necessary to ensure that the characteristics of the total system (i.e., engine, flywheel, marine gear, propeller shaft and propeller, and front end PTO drive) are such that excessive torsional vibration stresses will not occur. Fortunately, unless a very long propeller shaft, heavy couplings, propeller or massive front end PTO drive are used, torsional vibration problems are unlikely to occur in the normal speed range. On six- and eight-cylinder engines a viscous type damper is fitted to the crankshaft pulley and effectively “detunes” the system, reducing the amplitude of vibrations and the resulting stresses in the crankshaft, etc.

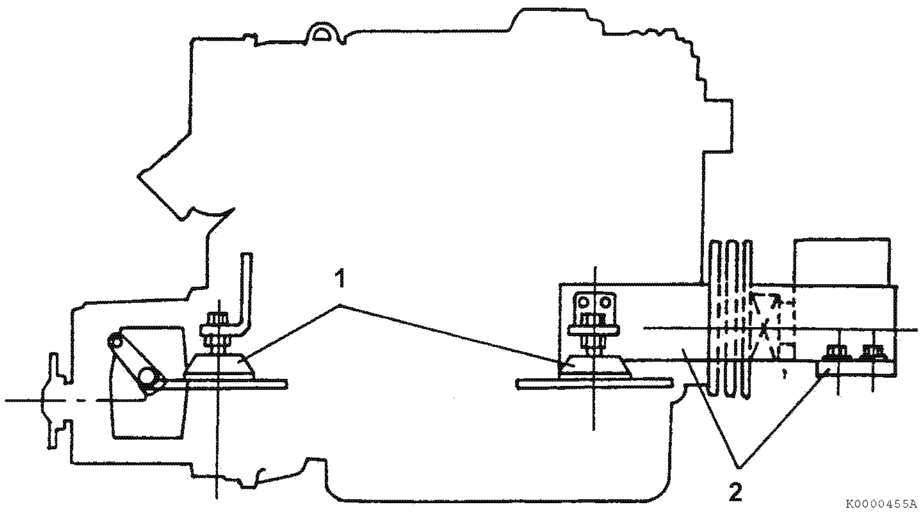
A calculation to check the probability of torsional vibration problems can be made if full details of the external shafting, etc. can be provided.

Information required is:

1. Length, diameter and material of shaft.
2. Detailed drawings of coupling with stiffness values. When the drawings are not sufficiently detailed for the moment of inertia to be calculated, this information should be obtained from the manufacturer.
3. Moment of inertia of propeller (including entrained water).
4. Detailed drawings, stiffness value and moment of inertia (if this cannot be readily calculated from the drawings) for any driven components at the front end (pump, generator, winches and clutch or gearbox, if fitted to the front end).

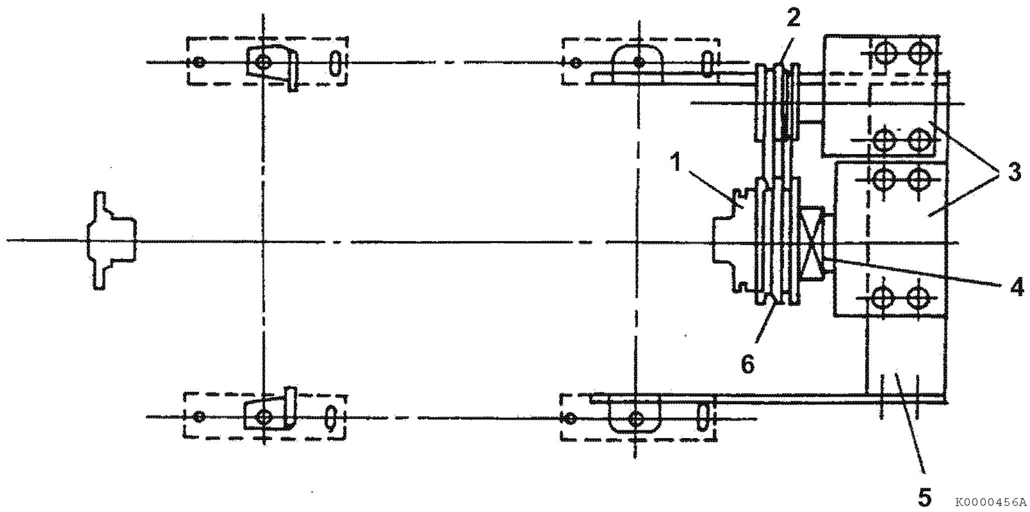
Note: Any Yanmar part used in a front end PTO drive or special propeller shaft drive, etc. should be identified by a part number.

Example: Front PTO drive system using common bed



1 – Special type engine flexible mount
2 – Common bed

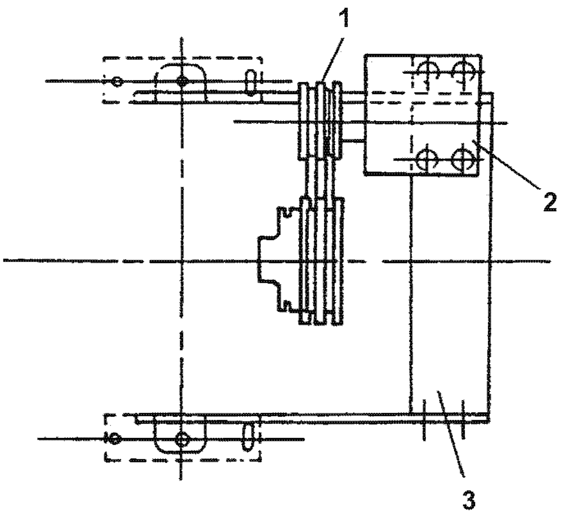
Figure 7-163



1 – Crankshaft pulley
2 – V-pulley
3 – Machinery
4 – Flexible coupling
5 – Common bed
6 – V-pulley

Figure 7-164

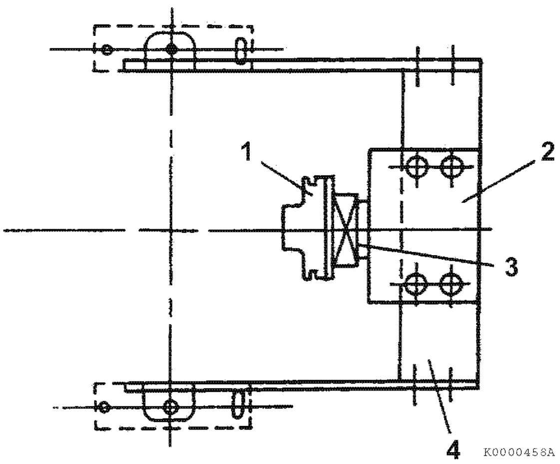
Side-pull driven system



1 – V-pulley
2 – Machinery
3 – Common bed

Figure 7-165

Direct driven system



1 – Crankshaft pulley
2 – Machinery
3 – Flexible coupling
4 – Common bed

Figure 7-166

Horsepower Required for the Front PTO Drive Machinery

Use the following formula to decide the capacity of typical front PTO machinery within the engine's allowable horsepower.

■ Required horsepower for hydraulic pumps (L_p)

$$L_p = \frac{P_p \times Q_p}{450 \times \eta_p}$$

$$hp = \frac{P_p \times Q_p}{612 \times \eta_p} kw$$

L_p	:	Required horsepower for hydraulic pumps	kW
η_p	:	Total power efficiency	%
P_p	:	Pump discharge pressure	kgf-cm^2
Q_p	:	Pump discharge volume	L/min

$$Q_p = \frac{qp \times N \times \eta_v}{1000} L/min$$

q_p	:	Volume	cc/rev
η_v	:	Volume efficiency	%
N	:	Pump speed	min^{-1}

Note: *To obtain the values for p and v, either refer to the performance curves of the pump or contact the pump manufacturer. The pump efficiency and volume efficiency totals differ depending on the pump manufacturer.*

■ Horsepower (hp) required for generators

Formula generator capacity, kVA rating:

$$hp = \frac{kVA \times \cos\theta}{0.736 \times G\eta}$$

hp	:	Horsepower required for generators	
kVA	:	Generator capacity	
$\cos\theta$	:	Power factor	80 %
$G\eta$	:	Generator efficiency	%

Note: The $G\eta$ value varies depending on the manufacturer. Contact the manufacturer for details.

Formula generator capacity, kW rating:

$$hp = \frac{kW}{0.736 \times G\eta}$$

■ Other machinery

Refer to the manufacturer's catalog to obtain the horsepower required for driving other machinery or contact the manufacturer.

$$hp = H_c \times K$$

H_c	:	Horsepower required for machinery	hp
K	:	Load coefficiency	%

Key Lock-Type for Crankshaft Pulley

When using the front PTO through the crankshaft V-pulley, use a key lock-type crankshaft pulley.

The standard specification crankshaft pulley is not the key lock-type and cannot be used for front PTO. If used, the pulley and crankshaft will be damaged due to slippage.

■ Specifications

Type	Yanmar part No.
VK1	D29170-21300
VK 2	D29490-21300

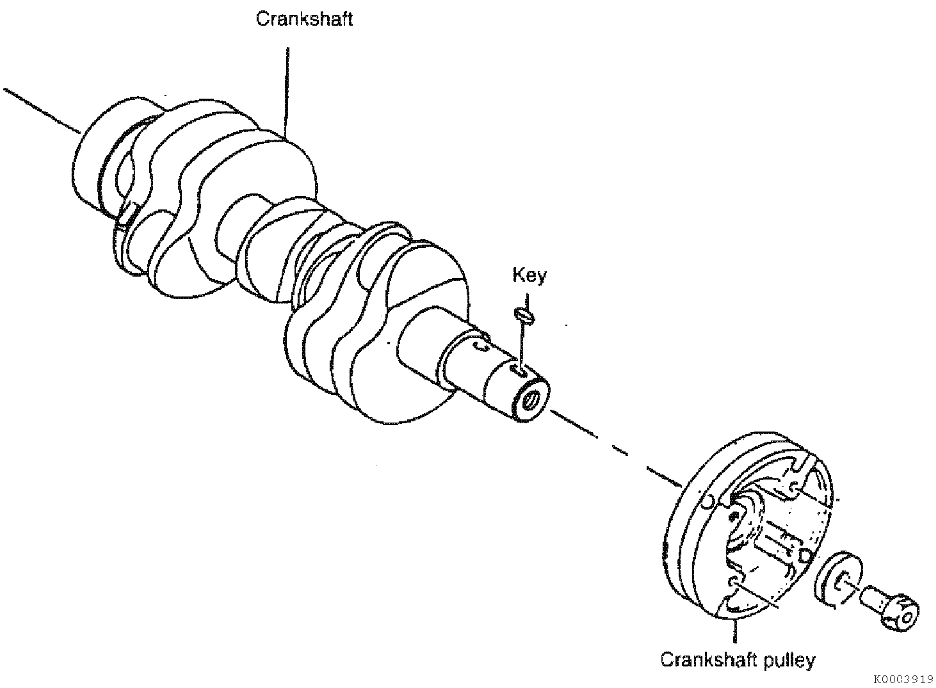


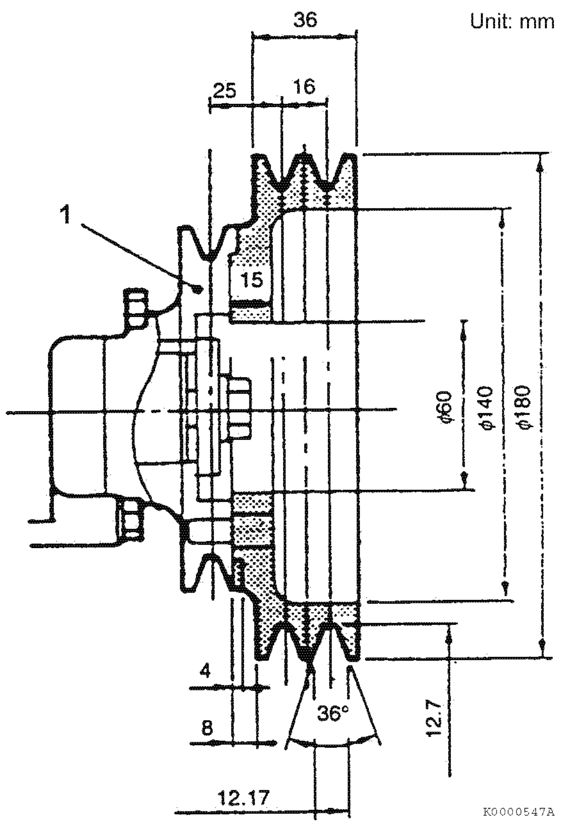
Figure 7-167

Front PTO Pulley

■ Specifications

Type	Yanmar part No.
PV1	D19171-21400

■ Dimensions



1 – Crankshaft pulley

Figure 7-168

MARINE GEAR PTO (KMH SERIES)

■ PTO spline sleeve and flange

Specifications

Item	Specification
Spline size	SAE Z = 9, DP16/32, 30° Class I
Flange size	SAE type A
Permissible input torque	120 N·m (88.5 lb-ft)

Installation of the PTO spline sleeve and the flange

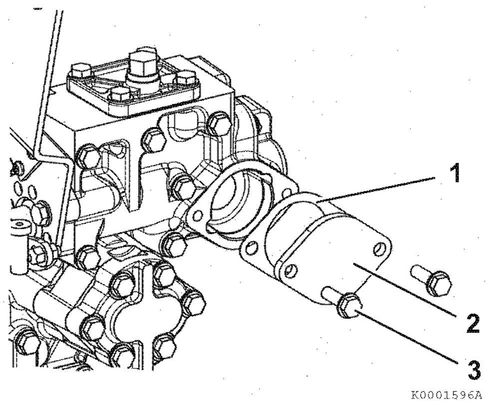


Figure 7-169

1. Remove the PTO cover bolts (3, **Figure 7-169**).
2. Remove the PTO cover (2, **Figure 7-169**) and the gasket (1, **Figure 7-169**). Discard the gasket.

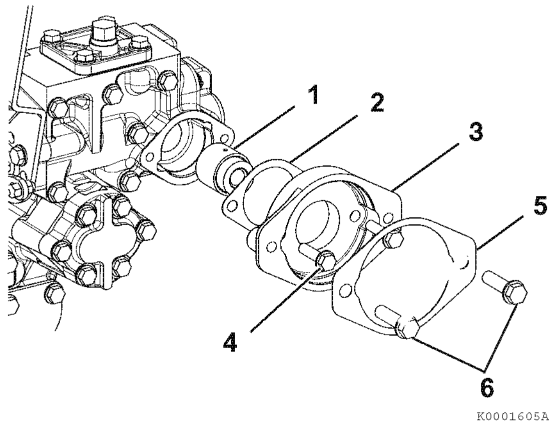


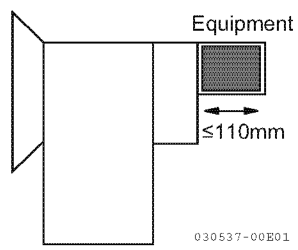
Figure 7-170

3. Insert the spline sleeve (1, **Figure 7-170**) onto the input shaft.
4. Use a new gasket (2, **Figure 7-170**), position the PTO flange with the M8 × 30 hex head bolts (3, **Figure 7-170**). Torque the hex head bolts (4, **Figure 7-170**) to 22.6 N·m (204 - 252 in-lb).
5. Install the PTO device with the M10×35 hex head bolts (6, **Figure 7-170**).

NOTICE

Never operate the marine gear without a PTO cover plate or a device installed. Operating the marine gear without a PTO cover plate or a device installed will cause the marine gear oil to leak out.

Note: The PTO device is purchased separately by the customer.

PTO (flange and fitting)	Permissible torque	120 N·m (89 ft-lb)	
	Permissible mass	2.5 kg (5.5 lb)	
	Permissible length	Less than 110 mm (4.3 in.)	

PROPELLER SHAFT COUPLING

There are three types of propeller shaft couplings: taper bore, slit and straight bore.

Both the slit and the straight bore types are rough-bored, so it is necessary to provide finishing when matching with the propeller shaft.

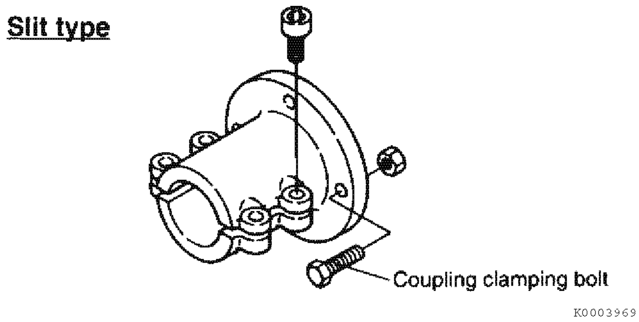


Figure 7-171

Tightening Torque of Coupling Clamping Bolts

Bolt size	Tightening torque
M10	4.7 to 5.3 kgf·m, 44.1 to 52.0 N·m (34.0 to 38.3 ft-lb)
M12	8.5 to 9.5 kgf·m, 83.4 to 93.2 N·m (61.5 to 69.0 ft-lb)
M14	12.0 to 13.0 kgf·m, 118 to 127.5 N·m (87.0 to 94.0 ft-lb)

Slit-Type

øD indicates rough bores. These should only be used after fine boring within the range of the maximum re-bore diameter.

For re-boring, insert a 4.0 mm (0.16 in.) spacer in the slits, clamp with 4 or 6 hexagon socket head cap screws, and re-bore.

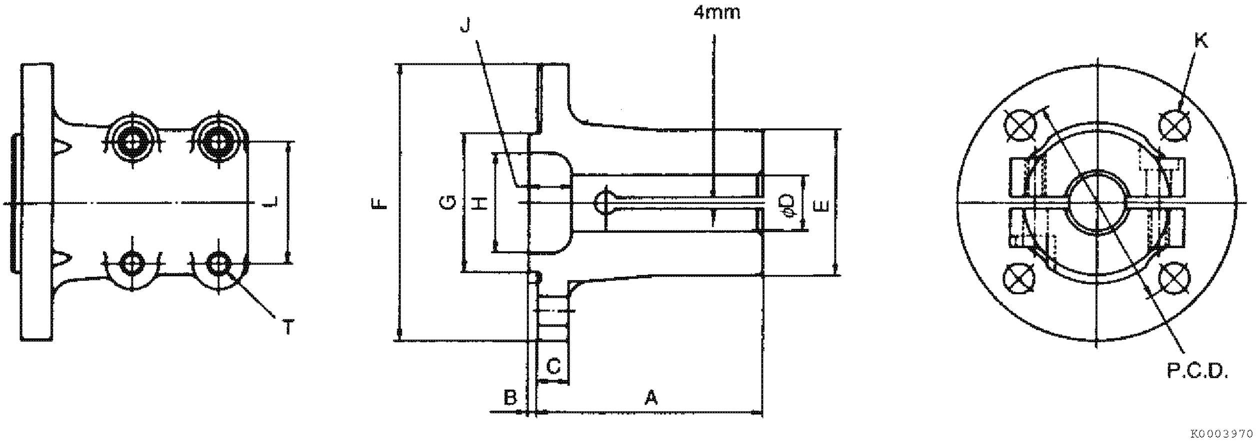


Figure 7-172

■ Dimensions

Type	Maximum re-bore diameter mm (in.)	øD mm (in.)	PCD mm (in.)	K	T	L mm (in.)	A mm (in.)	B mm (in.)	C mm (in.)	E mm (in.)	F mm (in.)	G mm (in.)	H mm (in.)	J mm (in.)	Yanmar part No.
CSG1	31.75 (1.250)	20 (0.79)	78 (3.07)	4 × 10.5	4 × M8	40 (1.57)	80 (3.15)	3 (0.12)	11 (0.43)	52 (2.05)	100 (3.94)	50 (1.97)	36 (1.42)	15 (0.59)	D04214-85500
CSJ1	40 (1.57)	25 (0.98)	100 (3.94)	4 × 10.5	6 × M12	59 (2.32)	110 (4.33)	3 (0.12)	13 (0.51)	62 (2.44)	120 (4.72)	65 (2.56)	56 (2.21)	17 (0.70)	D29470-85500

Taper Type (1/10 Taper)

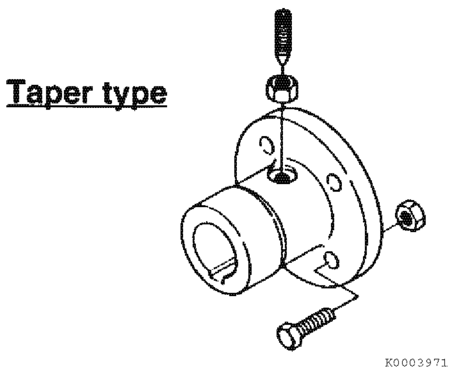


Figure 7-173

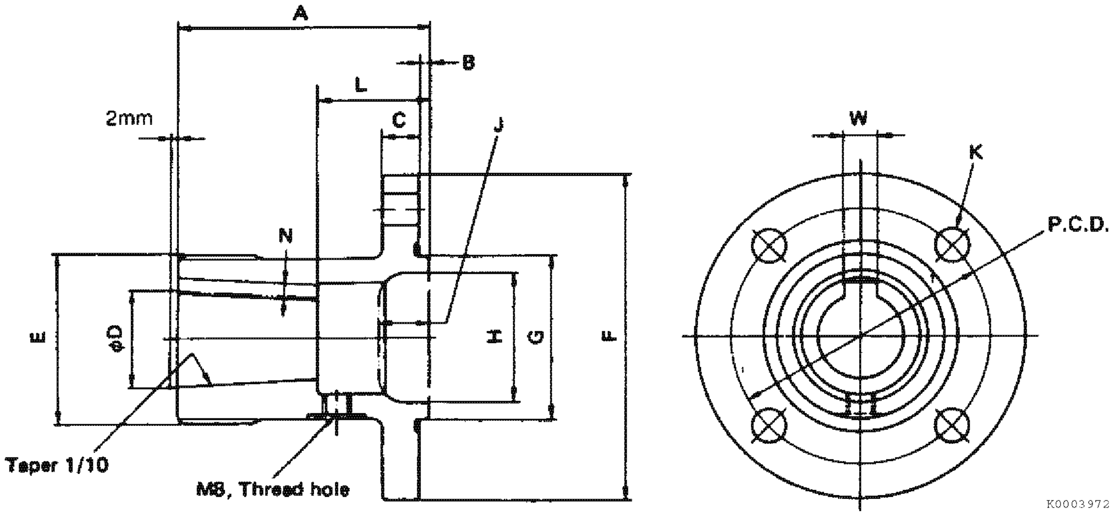


Figure 7-174

■ Dimensions

Type	øD mm (in.)	PCD mm (in.)	K mm	A mm (in.)	B mm (in.)	C mm (in.)	L mm (in.)	E mm (in.)	F mm (in.)	G mm (in.)	H mm (in.)	J mm (in.)	W mm (in.)	N mm (in.)	Yanmar part No.
CTG1	22 (0.87)	78 (3.07)	4 × 10.5	73 (2.87)	3 (0.12)	11 (0.43)	43 (1.69)	52 (2.05)	100 (3.94)	50 (1.97)	36 (1.42)	27 (1.06)	7 (0.28)	3.5 (0.14)	D05282-85100
CTG2	25 (0.98)	↑	↑	↑	↑	↑	34 (1.34)	↑	↑	↑	40 (1.57)	15 (0.59)	↑	↑	D05582-85100
CTG3	28 (1.10)	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	D05583-85100
CTG4	30 (1.18)	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	10 (0.39)	4 (0.16)	D24771-85100
CTG5	32 (1.26)	↑	↑	76 (2.99)	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	D29171-85100
CTG6	34 (1.34)	↑	↑	80 (3.15)	↑	↑	↑	54 (2.13)	↑	↑	↑	↑	↑	↑	D29670-85100
CTJ1	28 (1.10)	100 (3.94)	↑	88 (3.46)	4 (0.16)	13 (0.51)	35 (1.38)	62 (2.44)	120 (4.72)	65 (2.56)	50 (1.97)	16 (0.63)	↑	↑	D24790-85100
CTJ2	30 (1.18)	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	D24791-85100
CTJ3	32 (1.26)	↑	↑	↑	↑	↑	37 (1.46)	↑	↑	↑	↑	↑	↑	↑	D28696-85100
CTJ4	34 (1.34)	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	D21391-85100
CTJ5	38 (1.50)	↑	↑	↑	↑	↑	-	75 (2.95)	↑	↑	52 (2.05)	33 (1.30)	12 (0.47)	↑	D29473-85100
CTJ6	40 (1.57)	↑	↑	↑	↑	↑	-	↑	↑	↑	↑	↑	↑	↑	D29473-85200
CTJ7	42 (1.65)	↑	↑	94 (3.70)	↑	↑	33 (1.30)	↑	↑	↑	↑	-	↑	↑	D29574-85100

Straight-Type, Rough Bore

øD shows rough bores. For use, provide fine boring within the maximum re-boring range.

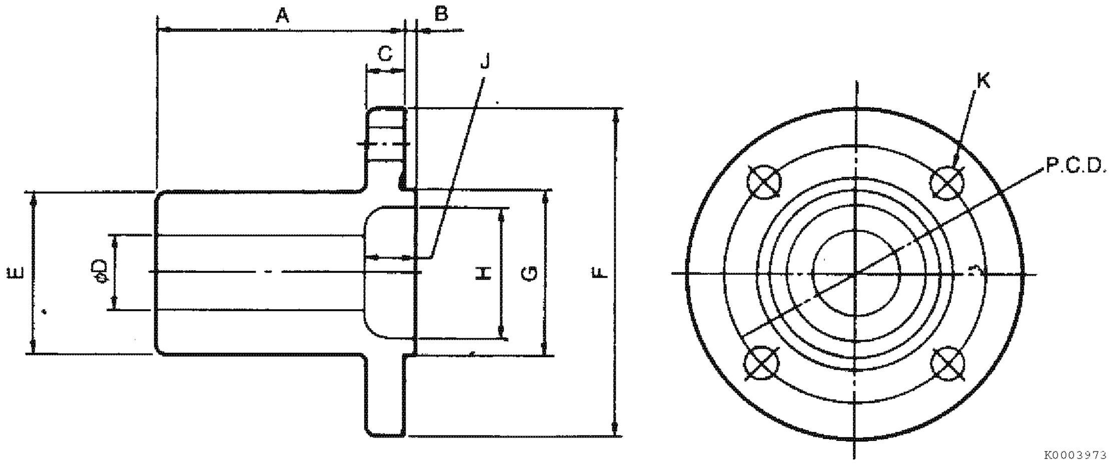


Figure 7-175

■ Dimensions

Type	Maximum re-bore diameter	øD mm (in.)	PCD mm (in.)	K mm	A mm (in.)	B mm (in.)	C mm (in.)	E mm (in.)	F mm (in.)	G mm (in.)	H mm (in.)	J mm (in.)	Yanmar part No.
CRG1	32 (1.26)	16 (0.63)	78 (3.07)	4 × 11	73 (2.87)	3 (0.12)	11 (0.43)	52 (2.05)	100 (3.94)	50 (1.97)	40 (1.57)	27 (1.06)	D04271-85300
CRG2	32 (1.26)	22 (0.87)	78 (3.07)	4 × 11	73 (2.87)	3 (0.12)	11 (0.43)	52 (2.05)	100 (3.94)	50 (1.97)	40 (1.57)	15 (0.59)	D05283-85100
CRJ1	42 (1.65)	20 (0.79)	100 (3.94)	4 × 10.5	88 (3.46)	4 (0.16)	13 (0.51)	62 (2.44)	120 (4.72)	65 (2.56)	50 (1.97)	16 (0.63)	D29470-85100
CRL1	50 (1.97)	30 (1.18)	108 (4.25)	4 × 12.3	95 (3.74)	5 (0.20	12 (0.47)	75 (2.95)	130 (5.12)	63 (2.48)	57 (2.24)	40 (1.57)	D19171-85100
CRY1	60 (2.36)	28 (1.10)	120.65 (4.750)	6 × 16.3	104 (4.09)	–	14 (0.55)	96 (3.78)	146 (5.75)	–	76.2 (3.00)	5 (0.20)	D19593-85100
CRX1	70 (2.76)	35 (1.38)	146 (5.75)	6 × 15.2	124 (4.88)	4 (0.16)	16 (0.63)	120 (4.72)	175 (6.89)	110 (4.33)	100 (3.94)	42 (1.65)	177066-03750

Note: Type CRX1 for standard accessories.

FLEXIBLE ENGINE MOUNT

Separate Type

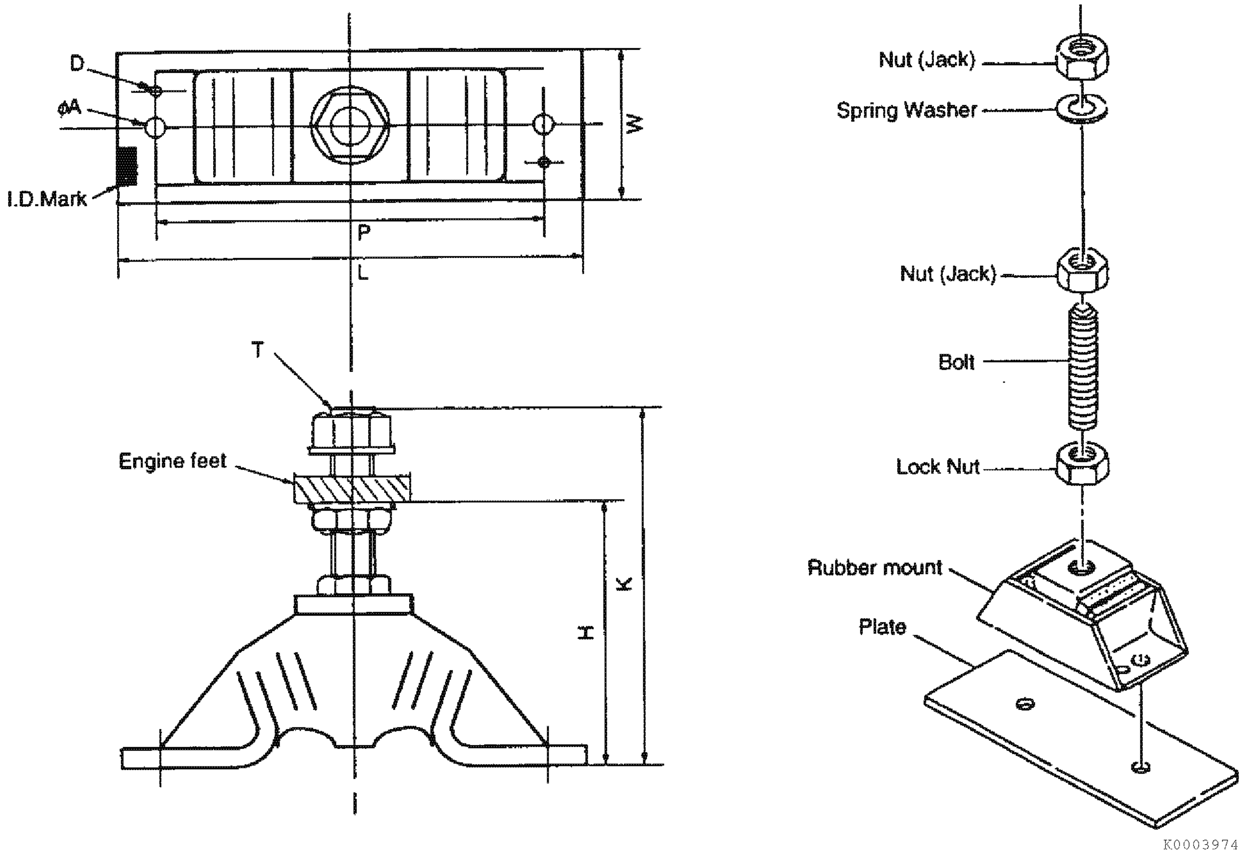


Figure 7-176

■ Dimensions

Type	ID mark	H Minimum mm (in.)	H Maximum mm (in.)	K mm (in.)	L mm (in.)	P mm (in.)	W mm (in.)	øA mm	D Thread Hole	T Thread diameter
Separate	600	100 [80] (3.94 [3.15])	120 [100] (4.72 [3.94])	189 [166] (7.44 [6.54])	210 (8.27)	170 (6.69)	105 (4.13)	2 × 18.5	2 × M12 × 1.75	M27 × 2.0
	900	↑	↑	↑	↑	↑	↑	↑	↑	↑

Note: Values in [ ] indicate applicable engine model for 6LY(A)-Series.

■ Tightening torque of clamp nut

Nut size	Tightening torque
M27 × 2.0	27 to 32 kgf·m, 265 to 314 N·m (195 to 232 ft-lb)

Fixed-2 Type

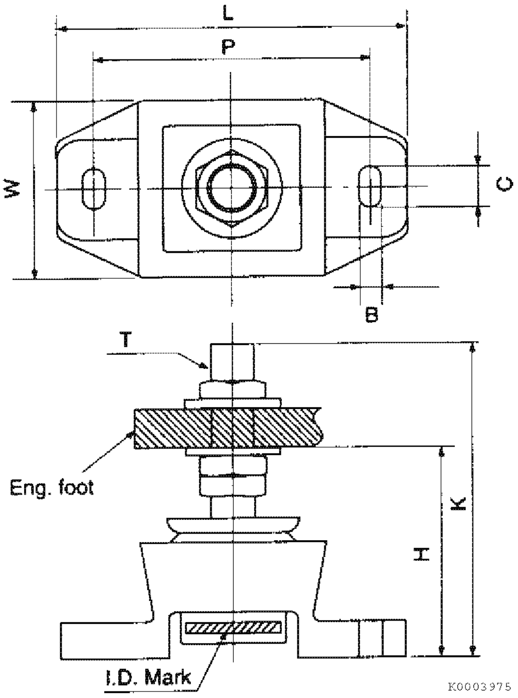


Figure 7-177

■ Dimensions

Type	ID mark	H		K mm (in.)	L mm (in.)	P mm (in.)	B mm (in.)	C mm (in.)	W mm (in.)	T Thread diameter mm (in.)	ID color
		Minimum mm (in.)	Maximum mm (in.)								
Fixed-2	81860 27391-10	110 (4.33)	120 (4.72)	184 (7.24)	165 (6.50)	127 (5.00)	15 (0.59)	25 (0.98)	96 (3.78)	25.4 (1)	Blue
	81860 27391-11	110 (4.33)	120 (4.72)	184 (7.24)	165 (6.50)	127 (5.00)	15 (0.59)	25 (0.98)	96 (3.78)	25.4 (1)	Red

■ Tightening torque of clamp nut

Nut size	Tightening torque
25.4 (1 in.)	25 to 30 kgf·m, 245 to 294 N·m (181 to 217 ft-lb)

Installed Position

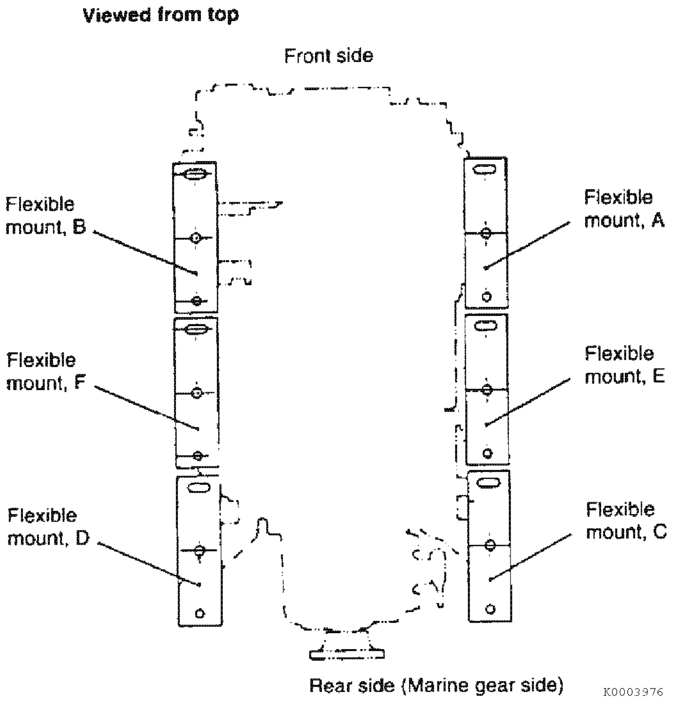


Figure 7-178

Rubber Static Distortion Value

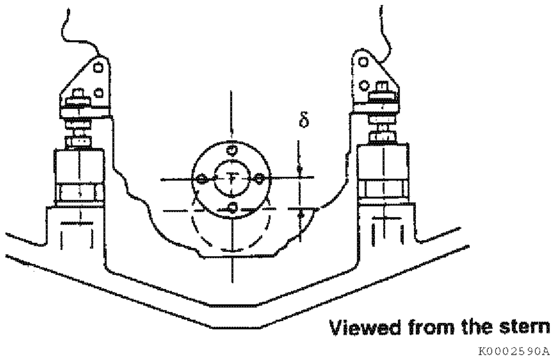


Figure 7-179

Note: *Even with the use of flexible engine mounts specified for each engine model, large hull vibrations may still result depending on the hull strength and the engine installation position. In such cases, the use of different flexible mounts may be advisable (flexible engine mounts with higher ID number have a larger spring constant).*

ENGINE ROOM

The overall layout of the engine room is planned for easy inspection, servicing and handling of the engine front PTO and auxiliary equipment.

Allow space for the fuel tank, battery and seacock and their related piping, wiring and remote control cables. Thoroughly study all equipment and devices to be installed, consult with the boat builder, and draw up a plan to provide optimum engine room space. The following conditions should be met:

Ventilation of the Engine Room

Refer to the air intake and exhaust section of the individual engine in vol. 2 and 3 of the Installation Manual. Specific data is given in this section.

1. Calculation of the required ventilation volume (Q):
   Naturally aspirated engines:
   Q = 0.13 × Maximum output (hp) = m^3/min.
   Turbocharged engine:
   Q = 0.15 × Maximum output (hp) = m^3/min.

■ Engine room temperature

1. Heat resistance of electrical devices: At 20 mm (0.79 in.) from the generator or alternator, the temperature should not exceed 60 °C (140 °F).
2. Temperature of the engine intake air: At the inlet of the intake air cleaner, the temperature should not exceed 45 °C (113 °F).

■ Ventilation by air duct

The simplest ventilation is made by the intake and exhaust air ducts. An air intake cover is attached at the aperture end of the intake air duct to receive the air while the boat is cruising. The intake air from the duct is released near the engine's air inlet.

Proper arrangements must be made to prevent seawater from entering the inlet of the duct.

1. Calculations of duct area (S) (ventilation using ducts only):

$$\text{Duct Area}(S) = \frac{(Q)}{(V)} = m^2$$

(Q): Required ventilation volume = m^3/min.
(V): Duct area velocity = m/min.

Note:

- *Substitute the boat speed (m/sec) with the duct velocity (V) when installing a duct on the engine room front.*
- *V = Maximum 10 m/sec when installing a duct on the engine room side.*
- *1 knot = 1852 m/hr.*
- *The piping resistance for a duct pipe or hose is not considered in this calculation. This piping resistance should be included when relevant.*

2. Ventilation using ducts only: Install both inlet and outlet ducts. However, if the engine room is not completely closed, it is sufficient only to install an inlet duct and to use the engine room door or window as the air outlet.

   Example: Ventilation for a boat equipped with a naturally aspirated engine (maximum 100 hp), boat speed 10 knots:
   From ventilation volume: (Q)
   Q = 0.13 × 100 = 13 m^3/min. or greater

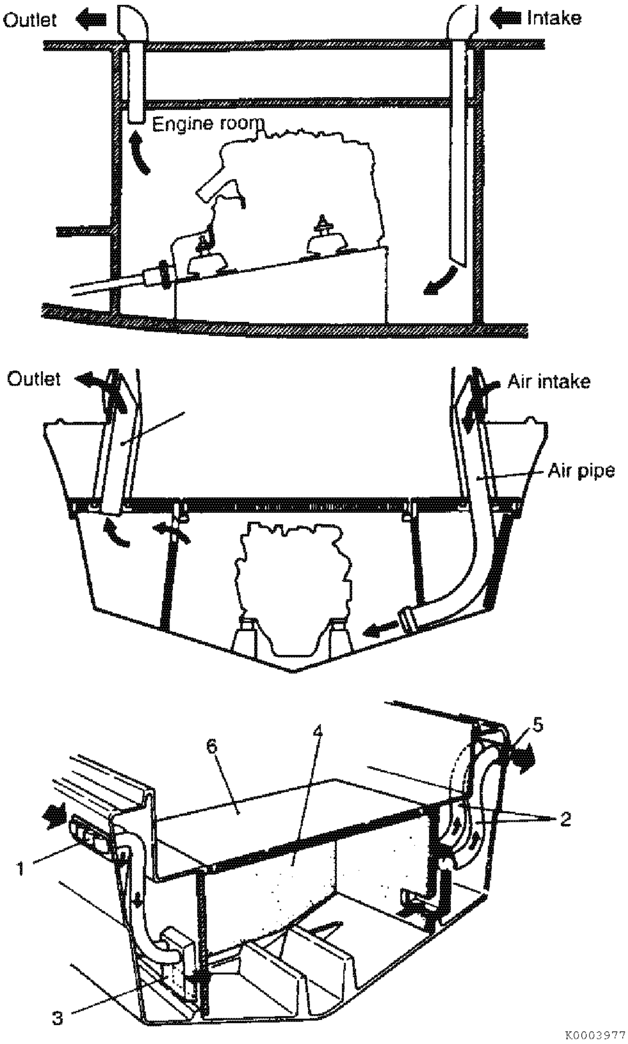
   From intake duct air: (S)

* Calculation for V:

$$308.6 = 10 \text{ knots} \times \frac{1852 \text{ m}}{60 \text{ min}}$$

$$S = \frac{13}{308.6*} = 0.0421 \text{ m}^2 = 421 \text{ cm}^2 \text{ or greater}$$

Example of layout of air intake and ventilation for engines:



1 – Air intake, water separator (free area)
2 – Double air pipes
3 – Sound baffle (insulation)
4 – Sound insulated engine room
5 – Outlet for ventilating air (free area same as 1)
6 – Sound insulated hatches

Figure 7-180

Attach the exhaust duct at the lowest possible position opposite the intake duct, and place the duct end in the open air outboard.

The duct pipe should be as short as possible.

Avoid bending as much as possible.

If the temperature of the engine room cannot be lowered, use a larger diameter duct pipe, or increase the number of pipes.

■ Ventilation using electrical draft fans

There are two ventilation methods of this type: the forced draft fan (attached to the intake duct side) system, and the induced draft fan (attached to the exhaust duct side) system.

In both cases, use a fan within the rated capacity of the electrical equipment.

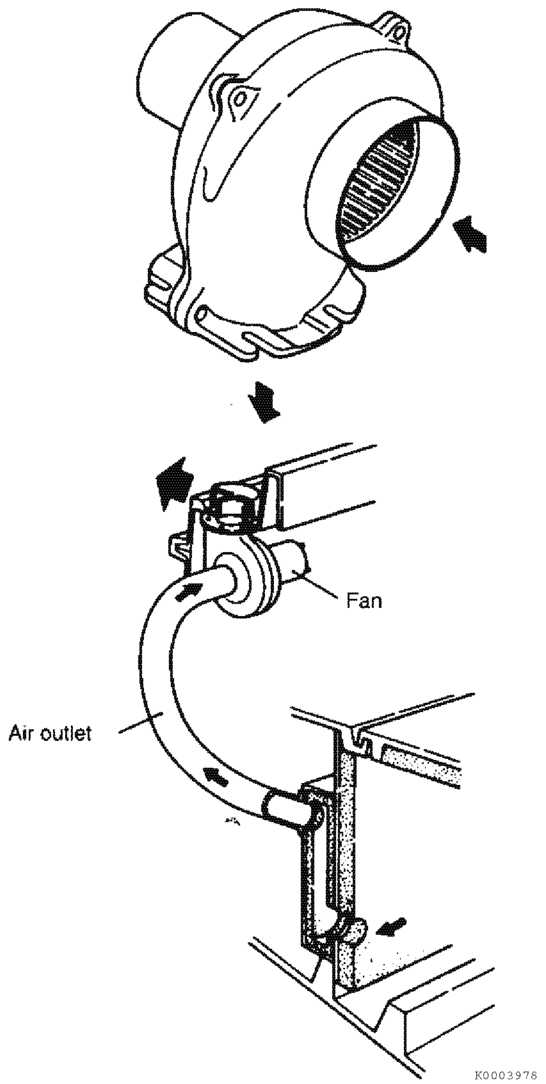


Figure 7-181

Capacity of electrical type draft fan:
Draft fan capacity = Identical to the required ventilation volume: (Q) m^3/min.

- Ventilation by draft fans only.
  Two draft fans with the same capacity (Q) are used for the inlet and outlet.
- Combination of draft fan and duct.
  The draft fan should be used for the outlet.

Soundproofing the Engine Room

■ Soundproof structure

To prevent noise from the engine room, it is necessary to separate the engine room from other sections of the boat and to cover all noise sources such as the engine and marine gear or sail drive.

Construct the engine room out of wood or MDF, and provide a hinged door or lid in the roof. When the engine room wall vibrates, the secondary noise caused by this vibration is transmitted outside the engine room, so make the engine room walls strong as possible and extend the wall to the bottom of the hull. Attach it firmly to the bottom of the boat. Also, install soundproof material inside the engine room.

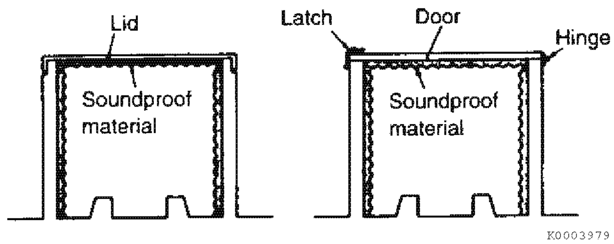
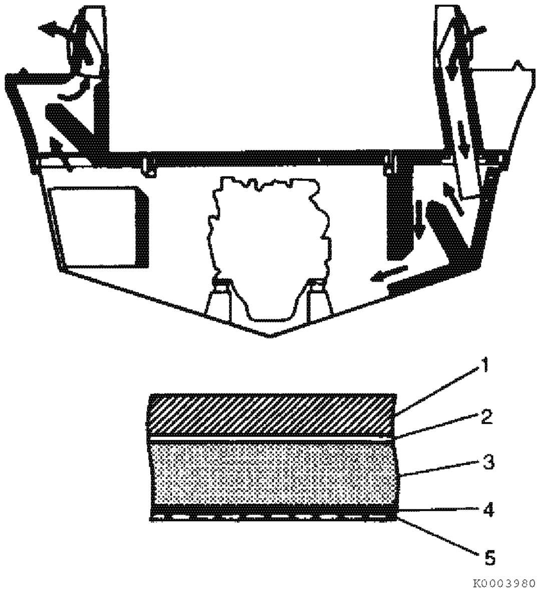


Figure 7-182

Example of soundproofing

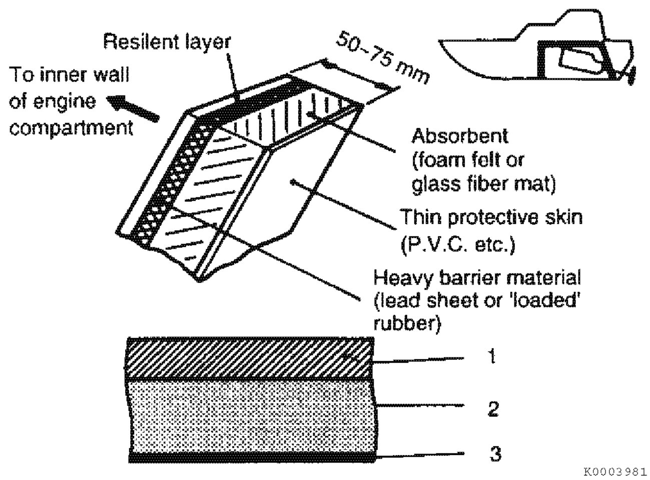
Note: The sizes and materials shown here are for reference only. They vary depending on the hull size and the size of the engine compartment.



1 – Engine casing
2 – Lead plating, thickness = 1 mm (0.04 in.)
3 – Mineral-wool, thickness = 50 mm (1.97 in.)
4 – Plastic sheeting
5 – Perforated aluminum sheet, thickness = 1 mm (0.04 in.), 20 % perforated

Figure 7-183

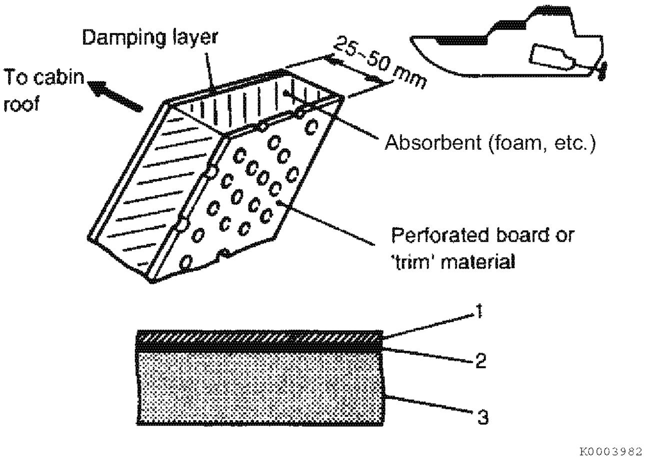
Insulation material (alternative): Plywood engine casing - 15 mm (0.59 in.); sheet metal casing - 2 mm (0.08 in.).



1 – Engine casing
2 – Flame-proof absorption sheeting (such as manufactured by Porolon, Revertex Acoustics or Baryfol)
3 – Flame-proof reflection sound-insulation sheeting (Iron-PVC, 2.5 mm thick). The face exposed to the engine should be about 15 % covered with absorption sheeting.

Figure 7-184

Insulation material for engine casing: 2 mm (0.08 in.) thick sheet metal or 15 mm (0.59 in.) thick plywood.



1 – Engine casing
2 – Iron-PVC 2.5 mm (0.0984 in.)
3 – Absorption sheeting
When fiberglass engine casings are to be insulated, use the same material as specified in the above example, but in reverse order so that the hard layer is placed next to the fiberglass casing.

Figure 7-185

Insulation material for fiberglass engine casing.

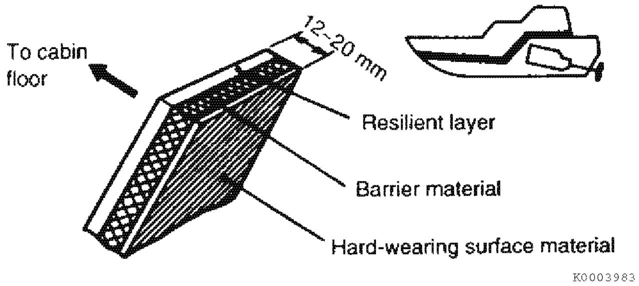


Figure 7-186

Note: For heat insulation requirements refer to ISO 4589.

Air Venting the Cooling Water Tank (V-Drive Version)

NOTICE

If a V-drive marine gear is used, this air-venting device must be installed onto engine.

An air vent releases air from the air sump of cooling water tank (heat exchanger) to prevent engine overheating. Be sure to install this vent when using the V-drive marine gear set engine. It is possible to install this equipment after installing the engine.

When engines are installed with the parallel and angle drive marine gears, it is common to direct the engine's flywheel to stern and the crankshaft pulley to bow. The engine installed in this case causes the crankshaft pulley to nose up to the waterline. This means that the bow will nose up and the engine inclination will further increase when the boat cruises at a high speed.

Yanmar, assuming the cruising condition like this, determines the capacities of the engine's lube oil tank and heat exchanger. The allowable engine installation angle, too, is specified to prevent any trouble due to air being sucked into the lube oil or cooling water.

However, when installing engines with a V-drive marine gear, the crankshaft pulley faces toward the stern and the flywheel to bow. The engines are installed in the reverse direction to the installation of the parallel and angle drive set engines. In this case, the crankshaft pulley side of the engine noses down and the bow will further rise when the boat cruises at a high speed, causing the engine to further nose down. In this condition, air is trapped in the cooling tank. The air in the air sump expands as the temperature of cooling water rises, causing the cooling water to blow out to the coolant recovery tank from the pressure cap. This causes the cooling water in the coolant recovery tank to decrease and the engine to overheat. The air venting equipment releases air of the air sump in the cooling water tank.

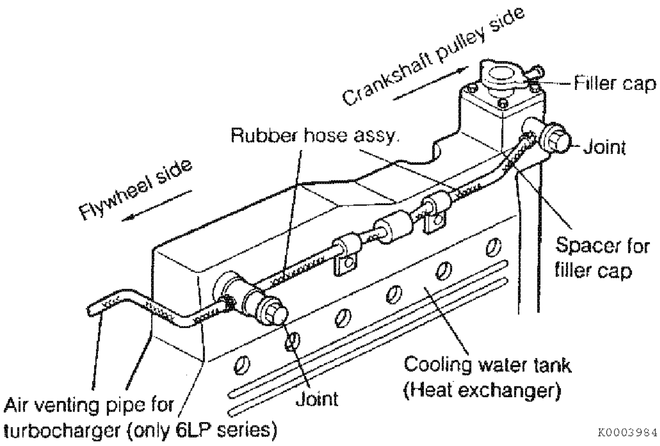


Figure 7-187

■ Arrangement of marine gears

- Parallel drive
- Angle drive
- V-drive

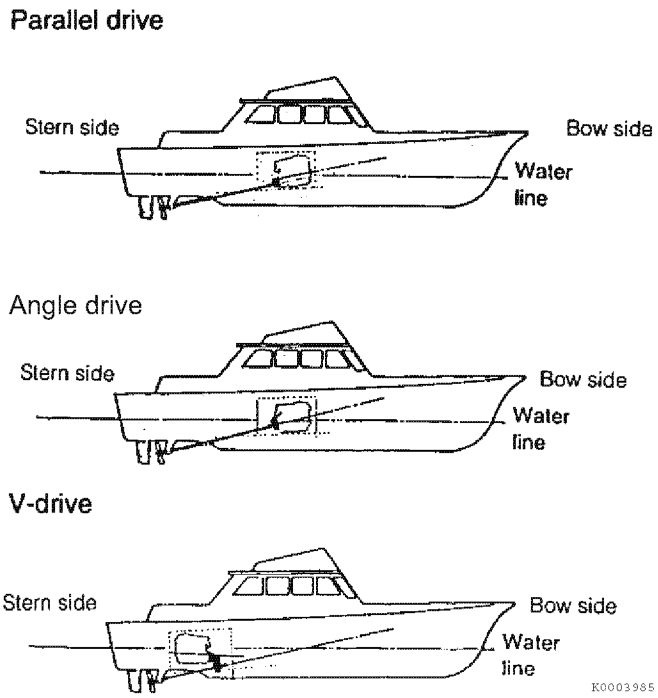


Figure 7-188

■ Specifications

Type	Accessories name	Allowable engine installation angle for nose down, maximum			Yanmar part No.
		Static	Cruising Condition		
LHA	Air vent device for heat exchanger (V-drive version)	-2° (0°)	Constant: -7° (-5°)	Peak: -12° (-10°)	D19175-13150
6LP		-2° (0°)	Constant: -7° (-5°)	Peak: -12° (-10°)	D19773-13150
LYA		-2° (0°)	Constant: -7° (-5°)	Peak: -12° (-10°)	D19573-13150

Note:

- *The values in ( ) are for the standard specification engine.*
- *Minus angle means the nose down of the engine.*

BILGE PUMP

Construction and Functions

The bilge pump consists of the motor, pump and auto-stop mechanism. The auto-stop is a unique mechanism. When all bilge is drained, a built-in diaphragm senses that there is no water pressure in the water passage and stops the motor quickly. This prevents premature bilge pump wear.

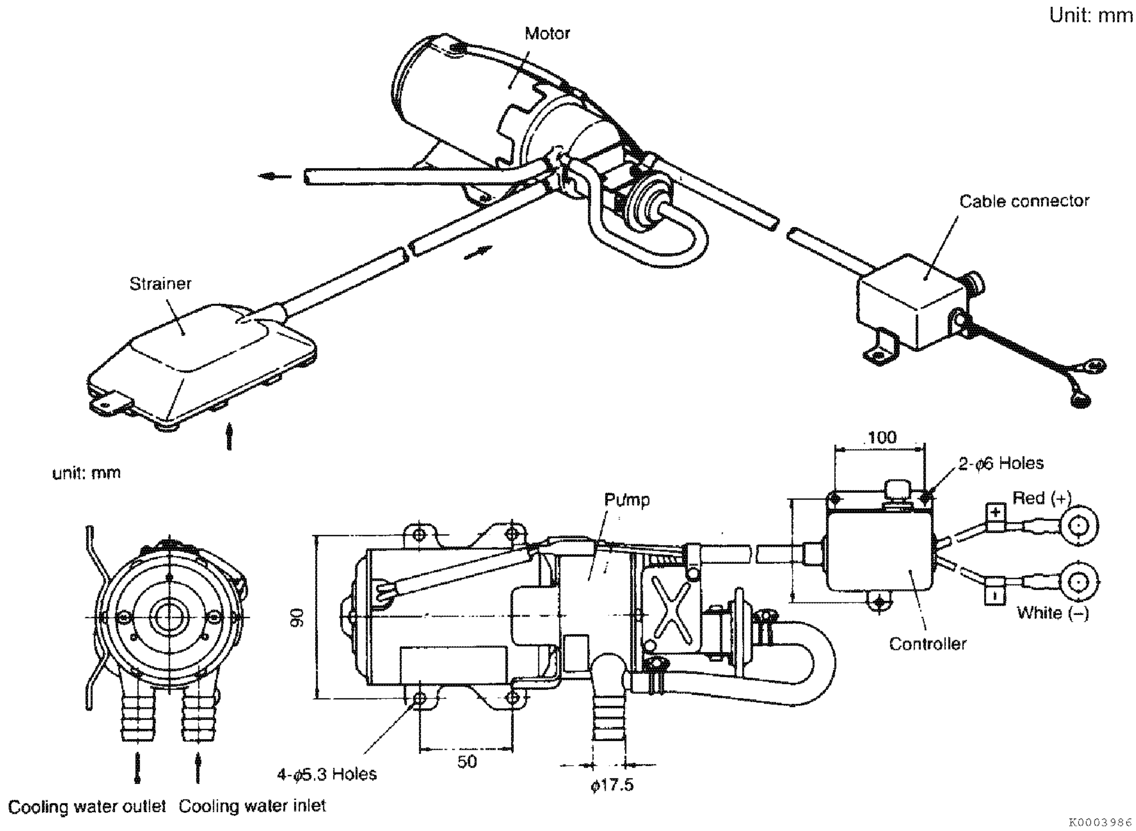


Figure 7-189

Strainer

Unit: mm

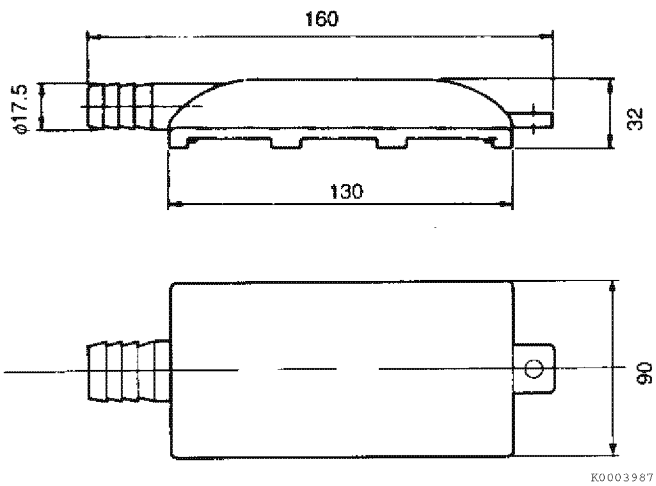


Figure 7-190

Specifications

Type		BP1
Yanmar part No.		D27675-461001
Motor		
	Model	WP-1220
	Rated operation time	10 minutes
	Rated voltage	12 V
	Rated output	100 W
Pump capacity		
	Self-suction head (maximum)	1.0 m (39.4 in.)
	Self-suction time	2 seconds
	Loaded current	10 A
	Flow volume	20 L/min. (21.1 qt/min.)

Installation of Bilge Pump

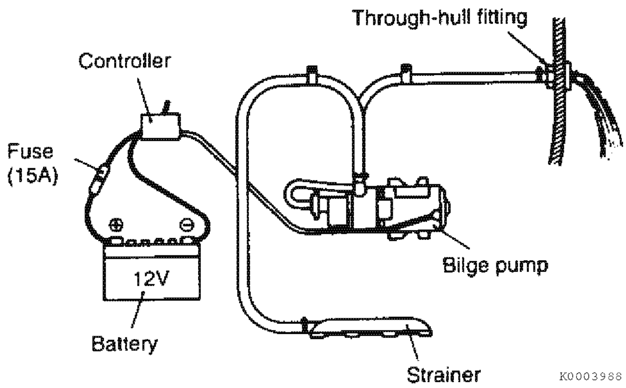


Figure 7-191

■ Angle of installation

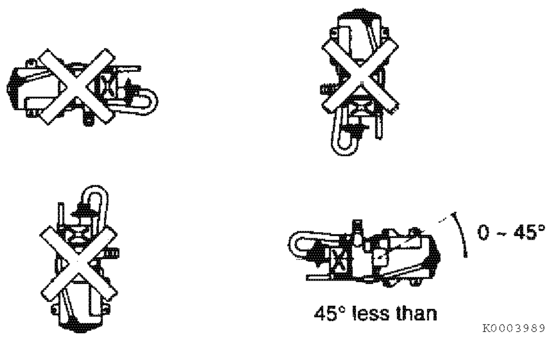


Figure 7-192

■ Height of installation

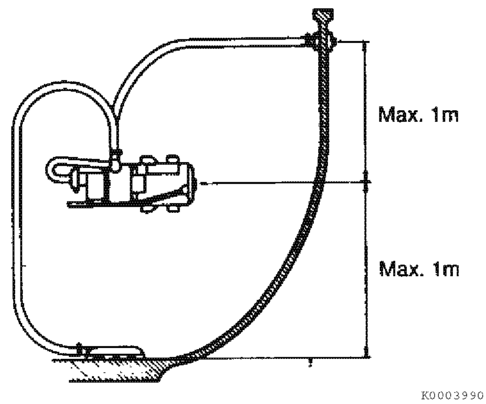


Figure 7-193

■ **Clamping position**

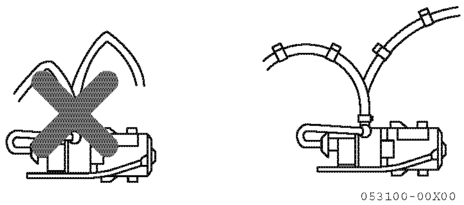


Figure 7-194

■ **Through-hull fitting**

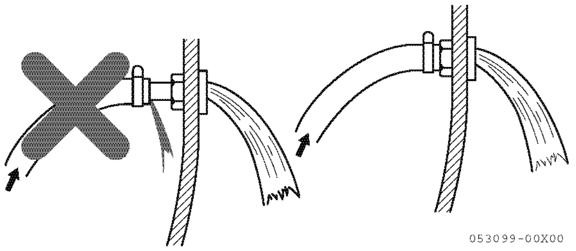


Figure 7-195

MARINE GEAR

The marine gear is installed to convert the fixed direction of the crankshaft into AHEAD, ASTERN and STOPPED operation. The gear does this by means of reversing and reduction mechanisms, with careful reference to the propeller efficiency.

In general, lower revolutions and a large propeller diameter produce higher propeller efficiency and higher boat speeds. The decisive factor in boat speed, however, is the selection of the appropriate reduction ratio and propeller match to the shape and weight of the hull and the engine output.

In general, a large reduction ratio is used for boats with a big displacement, such as sailboats, in order to reduce propeller revolutions. These boats usually use a large propeller. Powerboats, which have a light hull and fast boat speeds, use a small reduction ratio to raise propeller speed and a specially shaped propeller with a small diameter but high efficiency.

Type of Marine Gear

■ Clutch shift mechanism

The basic types are the mechanical and the hydraulic mechanisms for AHEAD, ASTERN and NEUTRAL shifts. These are operated by the remote control handle.

1. **Mechanical type**: The mechanical gear is usually used with pleasure craft engines under 100 hp. More force is needed though, to shift gears when using the mechanical type.
2. **Hydraulic type**: The hydraulic type is usually used for boats with high output engines, especially powerboats. The hydraulic type makes shifting easier and is often used for dual station control systems.

■ Propeller drive mechanism

1. **Parallel drive**: The output shaft of marine gear is parallel to the crankshaft. The engine is installed at a slant.
2. **Angle drive**: Also called the down-angle drive system. The output shaft of the marine gear is inclined at 7 to 10° to the crankshaft. The gentle inclination of the engine/marine gear package reduces the engine room space requirements.
3. **V-drive**: The output shaft of the marine gear makes a V-shape with the input shaft. The propeller shaft is angled backward compared with propeller angle drive, and the engine is installed the opposite way around. The advantage of this type is that more cabin space is available.

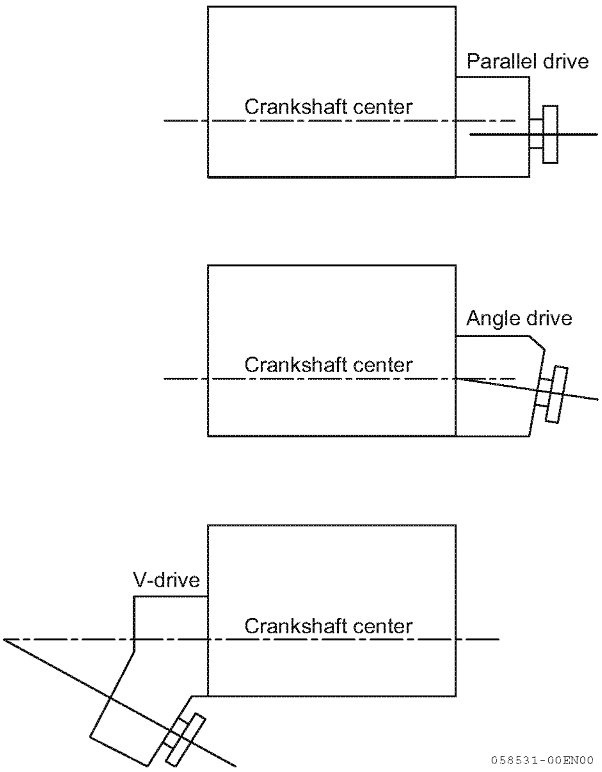


Figure 7-196

Selection of the Marine Gear Capacity

When coupling a locally purchased marine gear to the engine, give the following data to your marine gear supplier:

1. Engine
   - Maximum rating output at flywheel: hp or kW/min^{-1}
   - Maximum engine torque: kgf·cm at rpm
   - Idle speed: min^{-1}
   - Torsional vibration data
2. Marine gear
   - Maximum allowable input torque: kgf·cm
   - Maximum allowable transmission horsepower: hp or kW/min^{-1}
   - Maximum allowable input speed: min^{-1}

Engine Foot Kit for Marine Gear

In the case of engines supplied by Yanmar without a marine gear, two pieces of engine foot must be installed at the front side (anti-flywheel side). When you install the marine gear recommended by Yanmar to an engine without a marine gear, the engine foot, engine oil cooler hose, etc. (to be installed at the marine gear side) are available as an option.

NOTICE

Mounts are installed at both sides of the flywheel housing of the engine. These mounts are the dummy feet for transport and packing and cannot be used for engine installation. Discard before installing the foot kit. Also, note that the installation positions of these dummy feet are not the correct positions for actual marine gear installation. If you install the marine gear and engine with the dummy feet, excessive engine vibrations and other troubles will be caused due to insufficient strength of the dummy feet. Any trouble due to the use of the dummy engine feet or engine installation at the dummy engine foot installation position will not be covered by Yanmar's warranty.

■ Kit type

Type	Components	Applicable marine gear	Yanmar part No.
LH	• Engine foot (2 pieces) and bolts, M12 × 35 (8 pieces) • Rubber hoses (2 pieces) and clamps (6 pieces) • Hose joints (2 pieces) • Clamp bolts, M10 × 25 (18 pieces)	ZF, HSW630A1 HSW630H1	4LHA-HTP: D19172-49170, D19172-08200 4LHA-DTP: D19173-49140, D19172-08200 4LHA-STP: D19175-49120, D19175-08150
LH-1	• Engine foot (2 pieces) and bolts, M12 × 35 (8 pieces) • Rubber hoses (2 pieces) and joint and clamps (2 pieces) • Clamp bolts, M10 × 25 (18 pieces)	ZF, HSW450A2 HSW450H2	D19173-08140
LP	• Engine foot (2 pieces) and bolts, M10 × 30 (6 pieces) • Bracket for lube oil cooler	ZF, HSW630A1 HSW630H1	D19773-85620
LY	• Engine foot (2 pieces) and bolts, 5/8 × 35 (8 pieces) • Bracket and bolts, M10 × 14 (5 pieces) for lube oil cooler • Hose joints (2 pieces) and clamps (2 pieces)	TWIN DISC MG5061A	6LYA: D19575-85600 6LY2A: D19575-85610 6LY3: D19578-85610

LH-type

Unit: mm (in.)

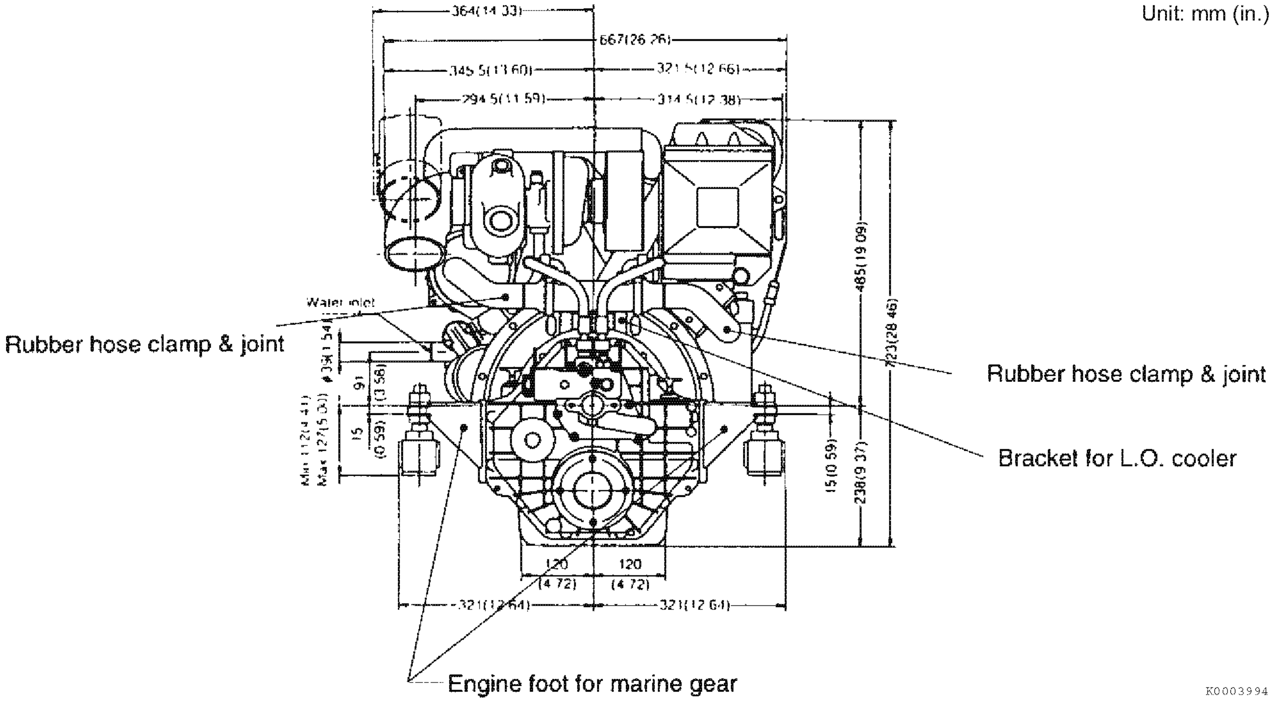


Figure 7-197

LP-type

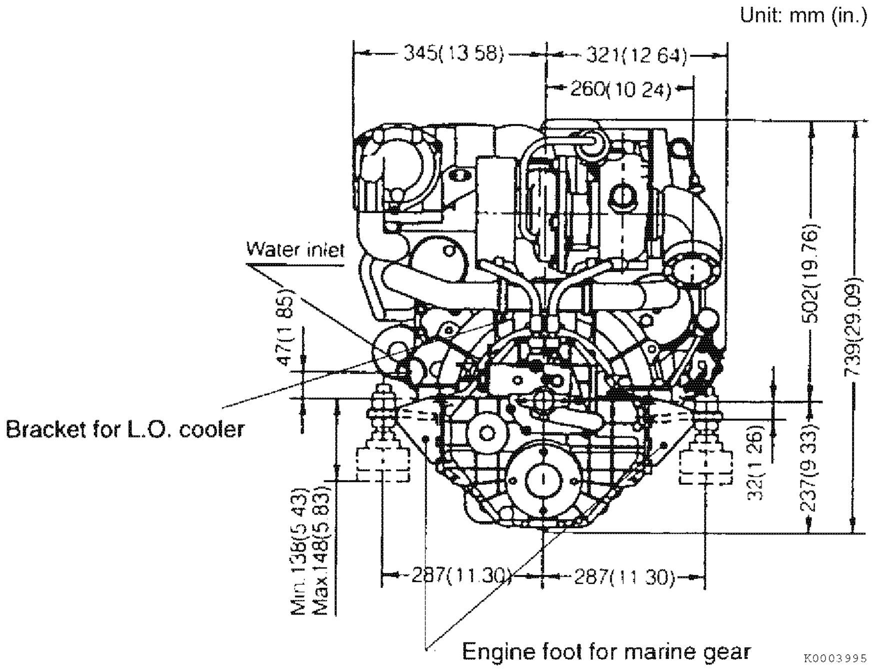


Figure 7-198

LY-type

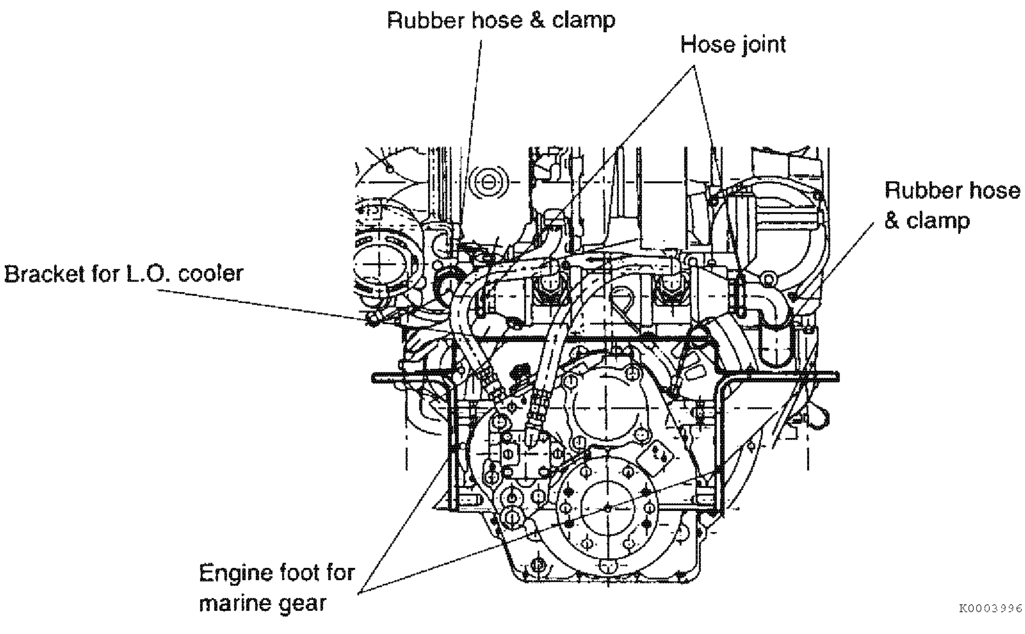


Figure 7-199

Section 8

APPENDIX A

Page

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CONVERSION TABLE

Weights and Measures

■ Linear distance

Unit	mm	cm	m	km	in.	ft	yd	mile
mm	1	0.1	0.001	0.0000001	0.03937	0.0032808	0.0010936	6.214×10^{-7}
cm	10	1	0.01	0.0001	0.3937	0.032808	0.010936	6.214×10^{-6}
m	1000	100	1	0.001	39.37	3.28083	1.0936	6.214×10^{-4}
km	–	100000	1000	1	39370	3280.83	1093.61	0.62137
in.	25.40	2.540	0.02540	2.54×10^{-5}	1	0.0833	0.02778	1.578×10^{-5}
ft	304.8	30.48	0.3048	3.048×10^{-4}	12	1	0.3333	1.894×10^{-4}
yd	914.4	91.44	0.9144	9.144×10^{-4}	36	3	1	5.682×10^{-4}
mile	1609347.0	160934.70	1609.35	1.60935	63360	5280	1760	1

■ Area

Unit	mm^2	cm^2	m^2	Acre	Hectare	km^2
mm^2	1	0.01	1.0×10^{-6}	1.0×10^{-8}	1.0×10^{-10}	1.0×10^{-12}
cm^2	100	1	0.0001	1.0×10^{-6}	1.0×10^{-8}	1.0×10^{-10}
m^2	1.0×10^{6}	10000	1	0.1	0.0001	1.0×10^{-6}
Are	1.0×10^{8}	1.0×10^{6}	100	1	0.01	0.0001
Hectare	1.0×10^{10}	1.0×10^{8}	10000	100	1	0.01
km^2	1.0×10^{12}	1.0×10^{10}	1.0×10^{6}	10000	100	1
$in.^2$	645.2	6.452	6.452×10^{-4}	6.452×10^{-6}	6.452×10^{-8}	6.452×10^{-10}
ft^2	92900	929	0.09290	9.290×10^{-4}	9.290×10^{-6}	9.290×10^{-8}
yd^2	836100	8361	0.8361	0.008361	8.361×10^{-5}	8.361×10^{-7}
Acre	4.04684×10^{9}	40468700	4046.87	40.47	0.4047	4.047×10^{-3}
$mile^2$	2.589999×10^{12}	2.589999×10^{10}	2589999	25899.99	259.0	2.590

Unit	$in.^2$	ft^2	yd^2	Acre	$mile^2$
mm^2	0.00155	1.0764×10^{-5}	1.19599×10^{-6}	2.471×10^{-10}	3.861×10^{-13}
cm^2	0.154999	0.0010764	1.19599×10^{-4}	2.471×10^{-8}	3.861×10^{-11}
m^2	1549.99	10.7639	1.19599	2.471×10^{-4}	3.861×10^{-7}
Are	154999	1076.39	119.6	0.02471	3.861×10^{-5}
Hectare	15499969	107639	11959.9	2.471	0.003861
km^2	–	10763867	1195985	247.1	0.3861
$in.^2$	1	0.006944	7.716×10^{-4}	1.594×10^{-7}	2.491×10^{-10}
ft^2	144	1	0.11111	2.296×10^{-5}	3.587×10^{-8}
yd^2	1296	9	1	2.066×10^{-4}	3.228×10^{-7}
Acre	6272640	43560	4840	1	0.001563
$mile^2$	–	27878400	3097600	640	1

■ Volume

Unit	cm^3	m^3	L	kL	$in.^3$	ft^3	yd^3	gal (liquid) (USA)
cm^3	1	1.0×10^{-6}	0.001	1.0×10^{-6}	0.06102	3.531×10^{-5}	1.308×10^{-6}	2.642×10^{-4}
m^3	1000000	1	1000	1	61020	35.31	1.308	264.2
L	1000	0.001	1	0.001	61.02	0.03531	0.001308	0.2642
kL	1000000	1	1000	1	61020	35.31	1.308	264.2
$in.^3$	16.39	1.639×10^{-5}	0.01639	1.639×10^{-5}	1	5.787×10^{-4}	2.143×10^{-5}	0.004329
ft^3	28320	0.02832	28.32	0.2832	1728	1	0.03704	7.48055
yd^3	764500	0.7645	764.5	0.7645	46660	27	1	201.974
gal (liquid) (USA)	3785	0.003785	3.785	0.003785	231	0.1337	0.004951	1

■ Weight

Unit	kg	oz	lb	(2000 lb) nt	(2240 lb) gt	mt
kg	1	35.2740	2.20462	0.001102	9.842×10^{-4}	0.001
oz	0.02835	1	0.06250	3.125×10^{-5}	2.790×10^{-5}	2.835×10^{-5}
lb	0.45359	16	1	0.00050	0.89286	0.90719
nt	907.185	32000	2000	1	0.89286	0.90719
gt	1016.05	35840	2240	1.12	1	1.01605
mt	1000	35274	2204.6	1.10231	0.98421	1

Note: mt (metric), nt (USA), gt (UK)

■ Weight per unit length

Unit	g/cm	kg/m	in.-lb	ft-lb	yd-lb	nt/mile	gt/mile
g/cm	1	0.10	0.00560	0.06720	0.20159	0.17740	0.15839
kg/m	10	1	0.0560	0.67197	2.0159	1.7740	1.58393
in.-lb	178.579	17.8579	1	12	36	31.680	28.2857
yd-lb	4.96054	0.49605	0.02778	0.333	1	0.8800	0.78571
nt/mile	5.63698	0.56370	0.03157	0.37879	1.13636	1	0.89286
gt/mile	6.31342	0.63134	0.03535	0.42424	1.27273	1.12	1

Note: nt (U.S.), gt (U.K.)

■ Pressure

Bar	kgf-cm^2	in.^{2}-lb	gt/ft^2	Standard atmospheric pressure (760 mm)	Mercury column height at 0 °C (32 °F)		Mercury column height at 15 °C (59 °F)	
					m	in.	m	in.
1	1.0204	14.51	0.9330	0.9869	0.75055	29.55	10.213	33.51
0.98	1	14.22	0.9144	0.9672	0.7355	28.96	10.009	32.84
0.06895	0.07031	1	0.06429	0.06800	0.05171	2.036	0.7037	2.309
1.072	1.094	15.56	1	1.058	0.8044	31.67	10.95	35.91
1.0133	1.0340	14.706	0.9454	1	0.76052	29.94	10.35	33.90
1.3324	1.3595	19.34	1.243	1.3149	1	39.37	13.61	44.64
0.03384	0.03453	0.4912	0.03158	0.03340	0.02540	1	0.3456	1.134
0.09791	0.09991	1.421	0.09136	0.09663	0.07349	2.893	1	3.281
0.02984	0.03045	0.4331	0.02785	0.02945	0.02240	0.8819	0.3048	1

Note: gt (UK)

■ Density

Unit	g/cm^3	kg/m^3	in.^{3}-lb	ft^3-lb	yd^3-lb	gal (liquid) (USA)
g/cm^3	1	1000	0.03613	62.4283	1685.56	8.34545
kg/m^3	0.001	1	3.613×10^{-5}	0.06243	1.68556	8.345×10^{-3}
in.^{3}-lb	27.6797	27679.7	1	1728	46656	231
ft^3-lb	0.01602	16.0184	5.787×10^{-4}	1	27	0.13368
yd^3-lb	5.933×10^{-4}	0.59327	2.143×10^{-5}	0.03704	1	4.651×10^{-3}
gal (liquid) (USA)	0.11983	119.826	4.329×10^{-3}	7.48052	201.974	1

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Section 9

APPENDIX B

Page

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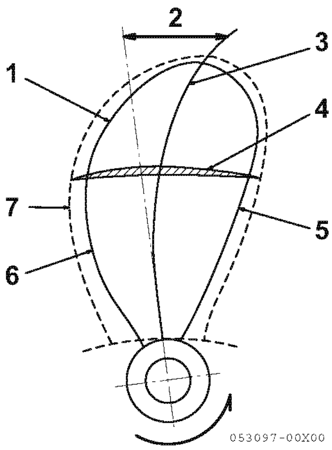
Definition of Terms - Engines and Boats

Engine/boat term	Definitions
Acceleration	The time required to bring a vessel from one speed to a faster speed.
Accelerometer	An instrument used to measure acceleration.
Aft	Toward the rear or stern of the vessel.
Alignment device	A type of hitching device that allows for one-person hitching of a tow vehicle and trailer.
Amidship	Center or middle of the vessel.
Angle drive	A drive configuration is sometimes called the down-angle drive system. The output shaft of the marine gear is inclined at 7 - 10° to the crankshaft.
Bilge	The lowest section of a boat's floor on either side of the keel where water is likely to collect. The area of the hull that sits below the waterline.
Bilge blower	Exhaust fan used to ventilate gases from the bilge.
Bilge pump	A mechanical, electrical or manually operated device used to pump water from the bilge.
Blower	Exhaust fan used to ventilate gases from the engine compartment, galley or head.
Bow	The front of a vessel.
Cabin	Living quarters on a vessel.
Cabin cruiser	A cruising vessel with living quarters on board.
Cargo	Luggage or material other than fuel, food and consumable provisions onboard. Cargo has mass and contributes to the vessel's displacement.
Center line	A lengthwise imaginary line which runs fore and aft with the vessel's keel.
Cockpit	An opening in the deck of the boat from which the boat is handled or the recessed area in the deck of the boat in which the crew works.
Continuous output	The peak power that an engine can develop for an extended period of time at any given rpm.
Displacement	The weight of water displaced by the total mass of a vessel.
Displacement hull	Displacement hulls are driven through the water, rather than being pushed up on top of the water.
Down drive	Refer to angle drive.
Duty cycle	The sea time imposed on the engine and hull during a single use.
Economy	The cost of exhausting the vessel's fuel capacity and full range.
Engine	Machine used to convert various forms of energy into mechanical force or motion.
Engine bed	Structure that supports the boat's engine.
Engine efficiency	The fuel consumption as it relates to the hull performance characteristics.
Engine intake air	Air provided by the air intake system and used by the engine during the combustion process.
Engine mounts	Flexible supports, usually rubber, that are between the lugs on the engine and engine bed.
Engine room	Space in the vessel for the engine and other equipment. It is generally located aft, but can also be amidship for some inboard installations.
Engine room ventilation	The process of replacing air in the engine room with fresh air from outside the vessel.
Flexible engine mounts	A system of engine mounts that allow limited movement of the engine relative to the rest of the vessel. Flexible mounts reduce hull vibration.
Fore	Toward the front or bow of the vessel. Opposite of aft.
Gear reduction	A marine gear with a reduction ratio between the engine and the propeller.
Horsepower (hp)	A unit of power. It can also be expressed as kilowatts.

Engine/boat term	Definitions
Hull	The body of the vessel.
Hull efficiency	The hull power requirements as they relate to the hull performance characteristics.
Hull speed	The speed at which a hull can no longer increase with added power.
Jig	A device used to stabilize and direct a tool while cutting through a material.
Kilowatt (kW)	A unit of power. It can also be expressed as horsepower.
Kilometers per hour (kM/h)	A unit of speed. It can also be expressed as knots or mph.
Knot	Nautical miles per hour. A unit of speed. It can also be expressed as kMh or mph
Marine gear	The component of the propulsion system that transmits and controls power from the engine to the propeller.
Maximum output	The peak power that an engine can develop for a short duration at any given rpm.
Miles per hour (mph)	A unit of speed. It can also be expressed as kMh or knots.
Output de-rating	The adjusted power output based on parasitic losses imposed by other equipment.
Parallel drive	The output shaft of a marine gear that is parallel to the crankshaft.
Pickup	A vessel’s capacity for acceleration.
Pilot hole	An initial hole that is drilled using a smaller bit in order to make it easier to drill using a larger bit.
Pitch	The forward-to-aft motion that lowers the bow or stern portion of the vessel near the waterline.
Planing hull	A hull that is driven up on top of the water rather than being driven through the water.
Pleasure vessel	A vessel used for recreational purposes, usually having a light-duty cycle.
Port	1. The left side of a vessel when facing the bow. 2. A destination or harbor.
Propeller	The component that transfers marine gear power to the water, resulting in vessel motion.
Roll	The side-to-side motion that lowers the port or starboard portion of the vessel near the waterline.
Revolutions per minute (min^{-1})	Unit of measure. Measures the rotational speed of the motor’s spindle.
Sailboat	A vessel that is driven primarily by the wind.
Scoop strainer	Device placed on the seawater intake that prevents objects, such as debris or seaweed, from entering and clogging the engine’s cooling system.
Screw	Refer to propeller.
Seaworthy	A term used to describe the degree to which a vessel can tolerate adverse weather conditions.
Semi-displacement hull	Semi-displacement hull designs represent a compromise in performance between planing and displacement hull designs.
Single-screw configuration	A vessel with one propeller.
Ski boat	A power vessel designed to pull multiple water skiers at a constant speed in a relatively straight line.
Snubber-style mount	Style of engine mount that uses a cushioning device, usually rubber, to decrease the amount of engine vibration.
Starboard	The right side of the vessel when looking towards the bow.
Stern	The back of the vessel.
Stern tube	The bearing that supports the propeller shaft where it emerges from the hull.
Strainer	Refer to scoop strainer.

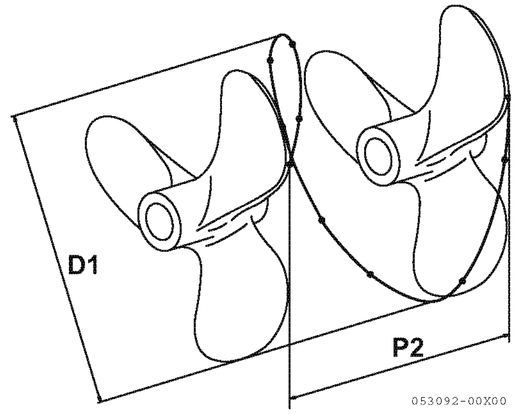
Engine/boat term	Definitions
Stringer	A lengthwise stiffener for the side of a boat.
Three-way cock	A valve with three ports.
Torque	The theoretical force required to move a shaft with a given length of leverage.
Transmission	Refer to *Marine gear*.
Twin-screw configuration	A vessel with two propellers.
User's performance requirements	The vessel performance characteristics demanded by the user or owner.
V-drive	The output shaft of the marine gear forms a V-shape with the input shaft.
Vessel purpose	Placing a vessel into either pleasure or work categories.
Work vessel	A vessel used for commercial or government purposes, usually having a heavy-duty cycle.
Yaw	The change of direction or position, port-to-starboard or starboard-to-port.

Definition of Terms - Propellers



1– Projected outline
2– Skewback
3– Line of maximum thickness
4– Cross-section of blade with round back
5– Trailing edge
6– Leading edge
7– Developed outline

Figure 9-1



1– D = Diameter
2– P = Pitch

Figure 9-2

Propeller term	Definitions
Area	The area or the disk area is the space enveloped by the circle constructed by the blade tips.
Blade back	Also called the suction or negative pressure side. The blade back is the face of the blade facing the vessel that creates suction by drawing water into the propeller when it is moving forward.
Blade face	Also called the pushing or pitch face. The blade face is the face of the area of the blade facing away from the vessel that creates forward thrust by pushing water away from the propeller.
Blade numbering	The blade located at the keyway is considered blade number 1. Blade numbers 2, 3, etc. are determined by starting from blade 1 and counting clockwise (on right-hand propellers) or counterclockwise (on left-hand propellers).
Blade root	Also called the filet. The blade root is the base of the blade that extends out from the hub. It is also the thickest section of the blade to provide structural rigidity.
Blade thickness	The blade is thickest at the root and becomes thinner as it extends outward toward the tip. It takes less power to push a thinner blade through water than it does to push a thicker blade. A thinner blade has less surface area to create drag.
Blade tip	The point on the propeller that reaches the farthest distance from the center of the hub.
Camber	The curvature of the line of maximum thickness that runs from the hub to the blade edge.
Cavitation	Cavitation is the phenomenon that occurs when the force of the spinning blades causes an extreme reduction of pressure on the back side of the propeller and vaporizes or “boils” the water around it. Cavitation results when the propeller is spinning but produces relatively little thrust due to slippage, causing microscopic air bubbles to impact and damage the blades. There are numerous causes of cavitation, such as: physical damage to blades, mismatching of propeller style to the engine or application, incorrect propeller pitch, or extremely high rates of speed. **Not to be confused with ventilation.**

Propeller term	Definitions
Cleaver propeller	Cleaver propellers are for high-performance vessels used in competitive racing and ski boat applications. They perform well at high rpm through step-up marine gears. The blades are typically heavily skewed and raked aft. Cleaver propellers provide top end acceleration performance through the full rpm range and typically have large blade area for greater thrust.
Controllable pitch	Also called adjustable pitch. Controllable pitch allows blade angle adjustments while underway. Adjustments increase fuel efficiency, or speed and performance. Propellers with adjustable pitch have a hollow shaft.
Cross-section of blade with round back (4, **Figure 9-1**)	The profile of a cross-section of the propeller blade at the thickest portion.
Cup	The cup is the small curved portion on the trailing edge of the blade. The cup helps the blade to gain a better grip on the water and reduces ventilation and slipping. It provides increased lift capability. Cupping typically increases the overall pitch of a propeller by 12.7 to 25.4 mm (0.5 to 1.0 in.).
Developed outline (7, **Figure 9-1**)	A theoretical dimensional limit that represents the maximum distortion when the propeller is operating.
Diameter (D, **Figure 9-2**)	The distance across the imaginary circle constructed by the blade tips as the propeller is spinning.
Folding propeller	Propeller for sailboats that is able to collapse when the vessel is operating under wind power in order to reduce the drag created by the propeller blades. By using a folding propeller versus a fixed propeller, a sailboat can effectively reduce the amount of drag created by the propeller by up to 35 %.
Hub	The hub is the section at the center of the propeller from which the blades extend. It attaches to the engine shaft. Hubs can be cylindrical, radial, conical or barreled.
Keyway	The keyway is the thin rectangular groove milled into the hub that carries the key and prevents the propeller from slipping on the shaft.
Leading edge (6, **Figure 9-1**)	The leading edge is the edge of the propeller blade closest to the boat that starts at the hub and extends to the blade tip. It is the first part of the blade to cut through the water when the vessel is moving forward.
Left-hand propeller	Viewed from the aft, the left-hand propeller rotates counterclockwise when providing forward thrust.
Line of maximum thickness (3, **Figure 9-1**)	That portion of the propeller that represents the thickest section.
Over-hub exhaust	Over-hub exhaust exits the vessel and is directed over the blades and hub.
Pitch (2, **Figure 9-2**)	Assuming a theoretical 100 % efficient propeller and hull, pitch is defined as the distance that a propeller advances a vessel during one complete 360° revolution. It is expressed in linear distance. Propellers are manufactured in constant pitch or progressive pitch configurations. Constant pitch propellers have a constant pitch throughout the radial length of the propeller blades. Progressive pitch propellers have a relatively low pitch at the leading edge of the blades which increases toward the trailing edge. **Not to be confused with pitch angle.**
Pitch angle	Pitch angle is the angle of the blade face as it moves along the pitch line in relation to the plane of rotation. Pitch angle decreases from the blade root to the tip in order to maintain a constant pitch. **Not to be confused with pitch.**
Projected outline (1, **Figure 9-1**)	A theoretical dimensional limit that represents the maximum distortion when the propeller is operating.

Propeller term	Definitions
Rake	Rake is defined as the blade angle relative to the center of the shaft. It is expressed in degrees. High-performance propellers that are raked aft give vessels greater lift without ventilation. Propellers are manufactured in forward, aft, parabolic and straight rake configurations. A forward or negative rake is slanted toward the forward end of the hub. An aft rake is slanted toward the aft end of the hub. A parabolic rake is slightly off-center and gives the blade a spoon-like appearance. A straight rake is flat across the blade.
Right-hand propeller	Viewed from the aft, the right-hand propeller rotates clockwise when providing forward thrust.
Rotation	The clockwise or counterclockwise motion of the propeller as it provides forward thrust.
Skew or skewback (2, **Figure 9-1**)	Skew is the degree to which the contour of the blade is swept aft. The more swept back and asymmetrical a blade is, the higher the level of skew.
Slip	Slip is the difference between that actual distance that the propeller travels in one revolution and the theoretical distance (pitch) that it should travel. A properly matched propeller will only have a slip of 10 to 20 %.
Screw	Another term for propeller.
Through-hub exhaust	The through-hub exhaust is a hollow barrel within the hub that channels the exhaust through the hub and out the rear of the propeller. Through-hub exhaust reduces the chance of exhaust being drawn into the blades (ventilation).
Track	Track is the spread between the individual blade rake and the other blade rakes.
Trailing edge (5, **Figure 9-1**)	The trailing edge is the edge of the propeller blade that extends from the blade tip to the hub. It is where water exits the blade.
Variable pitch	Variable pitch propellers are those with skew and cup properties that change the pitch depending on the rpm. The pitch is higher at the trailing edge and blade tip, and lower at the leading edge and hub.
Ventilation	Ventilation occurs when air from the water's surface or engine exhaust are drawn into the propeller blades, causing the rpm to increase and thrust to decrease. **Not to be confused with cavitation.**

Section 10

APPENDIX C

Page

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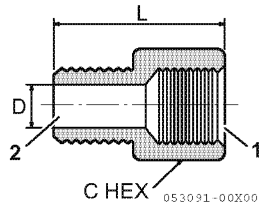
Thread Adapters BSPT to NPTF

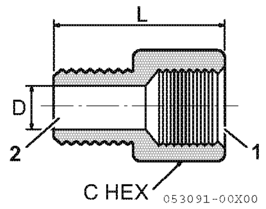
Parker Hannifin Brass Fittings (Catalot 3501E, http://www.parker.com/BRASSPROD/CAT05/3501-TOC.pdf)

Refer to *Installation Manual* vol. 2 and 3 for more information.

FHG4 Adapter Male NPTF BSPP

Part No.	BSPP 1	NPTF 2	C HEX	L	FLOW D	
1/8FHG4-B	1/8	1/8	0.562	0.870	.22	
1/4FHG4-B	1/4	1/4	0.750	1.125	.31	
3/8FHG4-B	3/8	3/8	0.875	1.125	.44	
1/2FHG4-B	1/2	1/2	1.062	1.660	.60	

F3HG Adapter NPTF Male BSPT

Part No.	NPTF 1	BSPT 2	C HEX	L	FLOW D	
1/8F3HG-B	1/8	1/8	9/16	0.93	.22	
1/4F3HG-B	1/4	1/4	3/4	1.35	.31	
3/8F3HG-B	3/8	3/8	7/8	1.35	.44	
1/2F3HG-B	1/2	1/2	1-1/16	1.76	.56	

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