MARINE DIESEL ENGINES

Installation Manual

Marine Diesel Engines HPE Series

- HPE 40S/80/80SD/110/135
- HPE 110JD/135JD
- HPE/P 40/150/170/190/205
- HPE 150JD/170JD/190JD/205JD
- HPE/P 100/225/250/250H
- HPE 225JD/250JD
- HPE/P 300
- HPE/P 300JD
- HPEL 45/80/65/90

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1 General information and warnings

1.1 General information

Welcome to the family of users and installers of Diesel Marine Engines branded Fratelli Negri Motori® (hereinafter FNM®). This manual will help you to properly install the engine inside the boat.

Carefully read the entire manual BEFORE starting the installation operations on the engine.

Over the years FNM® brought important innovations in the world of marine diesel engines. The FNM® engines are at the forefront for electronic control, performance, lightness and flexibility. The innovations that FNM® brought in the marine world require specific knowledge for installation, use and maintenance of the HPE marine diesel engine .

This manual will help in the installation of all the engines of the HPE family, whether they are equipped with straight, angled or V inverter, stern drive, sail drive and water-jet propulsion unit.

This installation manual was written and published by Costruzioni Motori Diesel SpA (Hereinafter CMD) owner of the trademark FNM®, to assist buyers involved in the application and installation of the products described.

It is assumed that the installers are thoroughly familiar with the application of marine products and with the installation of these products, or similar products made and sold by CMD.

CMD does not have the possibility to know each installation case by case and suggests installers the most appropriate procedures to be followed from time to time, in addition to the possible hazards and/or results of each singular application or installation. This manual is a general guideline for the engine installation and contains principles that must be generally followed. Operators who install the FNM® engine without following the instructions given here are responsible for the consequences of their work. Failure to follow the directions included in this manual will void the warranty conditions.

It is the responsibility of the boat manufacturer to select the appropriate engine/inverter/transom/stern drive assembly (including the right transmission speed and the right propeller) for a given ship. Proper selection requires specific knowledge of the boat (weight, hull length, use and operation, desired cruising speed, etc.) which only the boat manufacturer knows. CMD recommends that any connection between the hull and the engine of different power must be tested in water before delivering the product to the customer. It is necessary to check along with other things, that the performance of the boat is as desired, and that the engine works at an acceptable speed.

Do not hesitate to contact CMD for assistance if you are having specific problems related to the application or installation.

All information, images and specifications in this manual are the latest product information available at the time of publication. Upon request, the changes in this manual will be sent to all installers that require it.

1.2 Warnings about this manual

The information contained herein cannot avoid the dangers arising from incorrect installation of the engine, but are an effective preventive measure, combined with a dose of common sense in every action that you make.

Here are some symbols that indicate potential danger, indicated depending on the severity:

Serious danger of death or injury to persons.

Low hazard of injury to persons or serious damage to the engine and other objects.

Information to follow to avoid incurring in damage to the engine and in the serious dangers.

Information to be followed to prevent damage to the environment

1.3 Warranty information

In order to obtain the guarantee acknowledgement by CMD S.p.A. for marine diesel engines FNM® it is mandatory to fill in the "Installation Form" and transmit it to After Sale Management service of CMD by mail in the original copy. The shipping address is:

After Sale Management
C.M.D. Costruzioni Motori Diesel S.p.A.
Zona Industriale Valle di Vitalba
85020 Atella (PZ) - ITALY

If the installation form is not sent, it will void the engine warranty.

The installation form (*CMD Model 1408.02*, a copy attached at the end of this manual) is positioned together with the documentation accompanying the engine. A copy of the form can also be obtained by contacting the After-Sales Management at the above address or at the contacts below:

After Sale Management
Tel. +39 0972 715757
Fax. +39 0972 715696
Email: service.fnm@cmdengine.com
Web: www.fnm-marine.com

2 Engine technical data

2.1 Product identification

HPE series marine engines are divided into classes depending on the family and application to which they are intended:

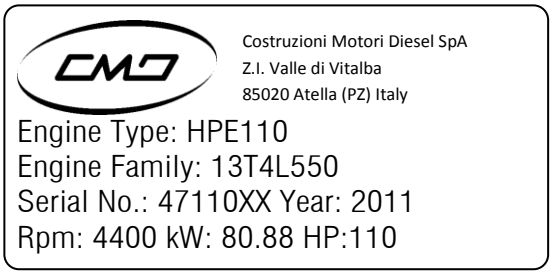
Model (or Engine Type)	Family	Application
HPE 40S/80/80SD/110 HPE 110JD/135JD	1.3HPE	Yachting
HPE/P 40/150/170/190/205 HPE 150JD/170JD/190JD/205JD	1.9HPE	Yachting
HPE/P 100/225/250/250H HPE 225JD/250JD	2.4HPE	Yachting
HPE/P 300 HPE 300JD	3.0HPE	Yachting
HPEL 45/80	1.3HPE	Work
HPEL 65/90	1.9HPE	Work

2.1.1 ID label

The ID label is applied on the engine and on the control unit (or ECU Box), in the position indicated in the table below (see also paragraph 3.3 - Engine elements on page 8):

Engine	Label position on the engine
1.3HPE 1.9HPE	On the engine crankcase.
2.4HPE	On top of the engine, attached to the intercooler housing.
3.0HPE	On the cooled exhaust manifold on the right side of the engine.

The data that are found on the identification label are given below as an example:



- Engine Type
- Engine Family according to RCD (CE).
- Engine Serial No.
- Year of manufacture
- Test speed (Rpm)
- Power in kW (kW)
- Horsepower (HP)

2.1.2 Engine serial No.

The engine serial number is also printed on the engine block. The location is shown in the table below (see also paragraph 1.6 - Main components of the engine FNM HPE Series ® - on page 16):

Engine	Engine serial number position
1.3HPE 1.9HPE 2.4HPE	On the right side of the crankcase, bell housing connection, or on the front side of the crankcase, above the bell housing.
3.0HPE	On the crankcase, front side, above the bell housing.

The serial number of the engine is constituted as follows:

Position	1	2	3	4	5	6	7
Serial number	4	7	1	1	0	X	X

Positions 1-2: Identification code of the model.

Positions 3-4: Last two figures of the engine year of production

Positions 5-7: Progressive

Besides the engine also the transmission, transom and stern drive have their own serial number, indicated on each of them by the respective manufacturers.

Communicate to CMD the serial number of each element of the propulsion system whenever you require any maintenance.

2.1.3 EPA/IMO Label

The engine can be provided with a label which indicates the presence of EPA certification and/or IMO MARPOL Annex IV pre-certification.

The label is usually affixed near the identification label and reports the EPA/IMO family number. If the engine is equipped with IMO MARPOL Annex IV (NOx), pre-certification, the information regarding the pre-certification is contained in the certificate attached to the engine.

2.2 Documentation attached

The HPE marine diesel engines are accompanied by the following documentation:

- Use and Maintenance manual
- Installation Manual (this document)
- Installation Form

- Transmission manual (if any)
- Quick Reference Guide for the CANBUS instrument use

2.3 Leisure engine technical data

	1.3HPE	1.9HPE	2.4HPE	3.0HPE
Cylinders	4	4	5	4
Displacement [cm³]	1248	1910	2387	2988
Bore [mm]	69.6	82.0	82.0	95.8
Stroke[mm]	82.0	90.4	90.4	104.0
Engine type	Four stroke diesel engine -			
Compression ratio	17,6:1		18:1	
Injection Type	Direct Common Rail Injection			
Boosting	Turbine with variable geometry		Turbine with cooled turbocarter	Turbine with cooled body
Timing system	16-Valve DOHC		20-Valve DOHC	16-Valve DOHC
Firing order	1-3-4-2		1-2-4-5-3	1-3-4-2
Alternator	75A 12V	105A 12V	140A 12V	110A 12V
Engine oil capacity (without filter) [l]	3.2	4.0	4.5	7.5
Thermostatic valve	65°C ± 1.5°C (88°C for 1.3HPE MK3)			65°C±1,5°C 80°C ±1,5°C
Cooling capacity [l]	7.5	7.5	8.5	14.0
Sea water pump flow [l/min]	90 (24,0 gal/min)	100 (26,6 gal/min)		
Engine starter	1.3 kW 12V	1.8 kW 12V		2.6 kW 12V
Wet weight (excluding transmission) [kg]	188	240	295	335
Direction of rotation of the flywheel	Counterclockwise (bell housing side)			

For all rating data (torque and power), refer to the table in paragraph 2.5 on page 4.

2.4 Work engines technical data:

	HPEL 45	HPEL 80	HPEL 65/90
Cylinders	4		4
Displacement [cm³]	1248		1910
Bore [mm]	69.6		82.0
Stroke[mm]	82.0		90.4
Engine type	Four stroke diesel engine -		
Compression ratio	17,6:1		18:1
Injection Type	Direct Common Rail Injection		
Boosting	aspirated	Turbine with variable geometry	
Timing system	16-Valve DOHC		
Firing order	1-3-4-2		
Alternator	75A 12V		105A 12V
Engine oil capacity (without filter) [l]	3.2		4.0
Thermostatic valve	65°C ± 1.5°C		
Cooling capacity [l]	7.5		7.5
Sea water pump flow [l/min]	90 (24,0 gal/min)		100 (26,6 gal/min)
Engine starter	1.3 kW 12V		1.8 kW 12V
Wet weight (excluding transmission) [kg]	158	188	240
Direction of rotation of the flywheel	Counterclockwise (bell housing side)		

For all rating data (torque and power), refer to the table in paragraph 2.5 on page 4.

2.5 Power, Torque and Operating cycles of Diesel Marine Engines FNM® series HPE

FNM® diesel marine engines are designed to operate within the range of minimum and maximum speeds shown in the table.

Power and maximum torque are achieved at the speeds indicated:

Model	Minimum [rpm]	Maximum no-load speed [rpm]	Maximum Power			Maximum Torque	
			[HP]	[kW]	[rpm]	[Nm]	[rpm]
HPE 80/80SD	850	4700-5300	75	55.1	3800	157	2200
HPE 110/110JD	850	4700-5300	110	80.8	4000-4400	230	2600
HPE 135/135JD	850	4700-5300	129	95	4000-4400	260	2600
HPE/P 40	850	-	40	29.4	3200	91.4	2600
HPE/P 150/150JD	850	-	150	110	4000	311	2500
HPE/P 170/170JD	850	-	170	125	4000	338	2200
HPE/P 190/190JD	850	-	190	139.7	4000	372	2400
HPE/P 225/225JD	-	-	225	165.4	4000	416	2500
HPE/P 250/250JD	800/850	-	250	184	4200	460	2600
HPE/P 250H	850	-	110	80.8	3000	-	-
HPEP/P 300/300JD	800	-	295	217	4000	560	2600
HPEL 45	800-850	-	45	33	3000	-	-
HPEL 80	800-850	-	90	66	4000	-	-
HPEL 65	800	-	65	47.8	4000	-	-
HPEL 90	800	-	90	66	4000	-	-

Use at maximum power only for short periods of time.

The damage caused by improper use or lack of compliance with the range of use in terms of crankshaft speed, will not be covered by the guarantee by CMD.

2.6 Power-rating for commercial use

Some units of the range, while having the same set-up of the above versions can be supplied with calibrations at reduced power for commercial use.

The power reduction is needed when the engine is used in harsh conditions or for long continuous periods.

There are four classes and one sub-class of power-rating:

- **Class A - Leisure Boats**: The use at full load is limited to 10% of the total period of use. The maximum power can be used for 1 hour every 10 hours of use. Outside of periods of use at maximum load, the speed must be reduced by at least 10% compared to that of maximum power. The cruising speed must be 90% less than the maximum power speed. Limit of use: 300 hours per year.
- **Subclass A1 - Light Commercial Applications for Special Use**: For light boats in commercial applications for special use. The guarantee conditions may vary depending on the application, check the warranty terms with the company representative.
- **Class B - Light Commercial Applications**: The use at full load is limited to 12.5% of the total period of use. The maximum power can be used for 1 hour every 15 hours of use. Outside of periods of use at maximum load, the speed must be reduced by at least 10% compared to that of maximum power. The cruising speed must be 90% less than the maximum power speed. Limit of use: 800 hours per year.
- **Class C - Medium-Heavy Commercial Applications**: The use at full load is limited to 20% of the total period of use. The maximum power can be used for 1 hour every 5 hours of use. Outside of periods of use at maximum load, the speed must be reduced by at least 15% compared to that of maximum power. The cruising speed must be 90% less than the maximum power speed. Limit of use: 1200 hours per year.
- **Class D - Heavy Commercial Applications**: The use at full load is limited to 60% of the total period of use. The maximum power can be used for 1 hour every 2 hours of use. Outside of periods of use at maximum load, the speed must be reduced by at least 15% compared to that of maximum power. The cruising speed must be 90% less than the maximum power speed. Limit of use: 3000 hours per year.

The limits of use are summarized in the following tables:

Power Rating Class	Limit use [h/year]	Use limit at full load		Use limit at maximum power	
		[%]	[h/year]	[%]	[h/year]
A	300	10	30	10	30
A1			(*)		
B	800	12.5	100	7	53
C	1200	20	240	20	240
D	3000	60	1800	50	1500

(*): Check the terms of use with the company representative.

Model	Power Rating Class	Maximum Power		
		[HP]	[kW]	[rpm]
HPE/P 300	A	295	217	4000
	A1			
	B	250	184	4100
	C	180	132.3	4000
	D	130	95	4000
HPE/P 250	A	250	184	4200
	A1			
	B	225	165	4200
	C	150	110	4200
	D	100	73.5	4200
HPE/P 190	A	200	147	4100
	A1			
	B	170	125	4100
	C	140	103	4100

3 Engine installation

3.1 Engine and transmission combinations

The transmission system of marine engine changes depending on the equipment chosen. Different configurations are available:

- Engines with inverter, indicated by the abbreviation HPE followed by rated power (in HP). The inverters are configured:
  - in lineshaft (with centre distance or coaxial)
  - with angled axis (A)
  - with inversion of the axis (V)
- Engines with stern drive, indicated by the abbreviation HPEP followed by the rated power.
- Engines with sail drive, indicated by the abbreviation HPE followed by the rated power. The model name can be followed by the initials SD (Saildrive).
- With water-jet engines, indicated by the abbreviation HPE followed by rated power. The model name can be followed by the initials JD (JetDrive).

Work use engines are generically indicated with the abbreviation HPEL followed by the rated power, regardless of the transmission to which they are coupled.

The name of uncalibrated engines with power-rating (see paragraph 2.6 - Power-rating for commercial use on page 5), can be followed by the letter of the power rating at which the engine has been calibrated (e.g. HPE 300-B indicates the rating class B).

3.2 Engine Disassembling and Handling

At moment of receiving an HPE engine please check:

- The integrity of the packaging: the wood box must be integral; the engine must be fixed on the wood support and secured to it.
- The metal box sealed watertight containing the electronic control unit. The set must be intact with no obvious signs of breakage or tampering.
- The engine wiring and any extension cables must be integral with no cuts, the Amphenol® connectors (between control unit and engine wiring) must be integral and all the pins of the connector must be correctly deformed.
- The integrity of the instrument panel and the associated wiring. The panel must be free from cosmetic defects.
- The absence of spots or dripping due to leakage of liquids.

At the presence of leakage or spots, check the cause of the leak. The product may contain dripping caused by the operation on the test bench.

Before shipping all engines are tested at the bench and packed carefully. FNM® is not responsible for damages caused by the carrier/transport company.

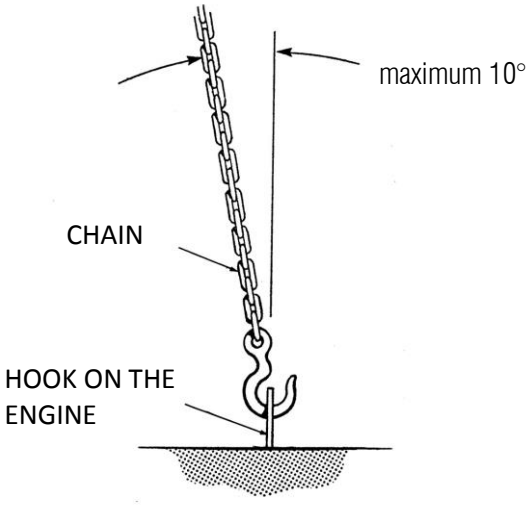


Figure 1 – Engine lifting

Lift the engine exclusively with chain or lifting ropes of adequate capacity. Make sure that the chain is sufficiently long so that it doesn't to lean on lifting hooks with an angle greater than 10°, as shown in Figure 1. Also make sure that the chain does not damage the engine parts during lifting.

Do not apply additional weight to the engine during its lifting! The hooks are designed to support only the weight of the engine. In the case of engines fitted with inverter, lift the assembly also from the hook of the inverter.

Never stand underneath a raised engine with chain and always check the maximum capacity of the equipment used (hoist or forklift and chain).

Make sure that when lifting the engine it always remains perfectly level horizontally. Some engines requires the use of a lifting bar (or a spacer) that appropriately distributes the chain tension.

Figure 2- Lifting bar for engine levelling.

Consult the length of the lifting bar in the following table:

Model	Length of the lifting bar [mm]
1.3HPE	not necessary
1.9HPE	570
2.4HPE	630
3.0HPE	not necessary Lift on 3 points

See the position of the hooks in paragraph 3.3 - Engine elements on 8.

In the case of engines with the inverter connected, remember that the weight of the inverter offsets the centre of gravity of the engine. Be careful when lifting the engine.

The case containing the engine must be preserved and reused in the cases of resending the engine to the manufacturer, since it is the only packaging able to ensure the integrity of the engine during transport. For storage of the case, disassemble the banks folding them on themselves and stack the platform, sides and lid in a cool, dry place.

3.3 Engine elements

The main components present on HPE marine engines are listed below.

1. **Intercooler** (except HPEL45): reduces the temperature of the compressed air from the compressor that flows into the engine intake duct using a bundle of finned tubes crossed by seawater.
2. **Expansion tank:** contains engine coolant.
3. **Oil sump:** contains engine lubrication oil.
4. **Zinc anodes:** prevent the galvanic oxidation of metal parts.
5. **Oil exchanger:** reduces the temperature of the engine lubrication oil.
6. **Diesel fuel exchanger:** reduces the temperature of the fuel in the return line to the exchanger.
7. **Air filter:** retains the impurities in the air intake.
8. **Double exchanger** (as an alternative to the diesel exchanger in the presence of fuel and power steering): reduces the steering oil and diesel temperature.
9. **Turbocharger** (except HPEL45):compresses the intake air exploiting the energy of exhaust gases through the use of a turbine-compressor group.
10. **Diesel fuel filter:** filters diesel fuel in inlet to the supply line of the engine. It can be wall-mounted in the engine compartment.
11. **Raiser or discharge elbow:** reduces the temperature of the exhaust gases coming out of the turbine, conveys fumes towards the exhaust and prevents the return of sea water into the turbine.
12. **Starter:** starts the engine.
13. **Water/water exchanger:** reduces the temperature of engine coolant through heat exchange with sea water.
14. **Low-pressure electric fuel pump**: sucks fuel from the low pressure line and sends it to the high pressure line.
15. **Thermostat housing:** contains the thermostatic valve of the cooling circuit.
16. **Sea water pump:** sucks water from the sea water intake and pushes it in the cooling circuit.
17. **Alternator:** generates electric power, the output voltage is 12 Volt.
18. **Oil filler cap:** useful in filling the engine oil.
19. **Lifting eyes:** allow the movement of the engine outside the engine compartment.
20. **Engine label position**
21. **Serial number position on the crankcase**
22. **Oil drain valve**

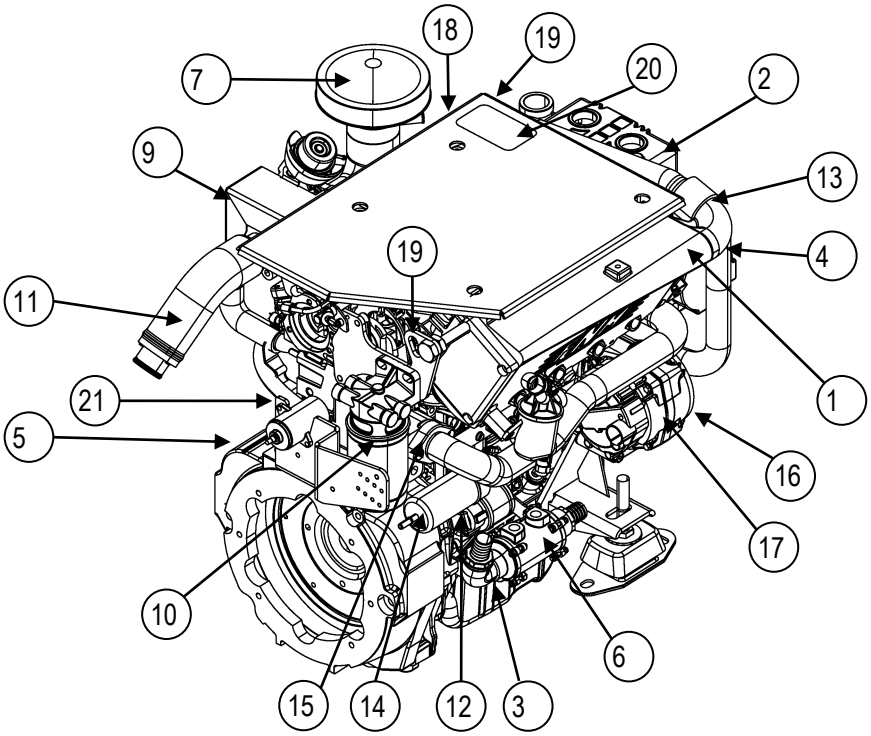


Figure 3 – FNM® HPEL 40S/80/80SD/110/110JD and HPEL 80

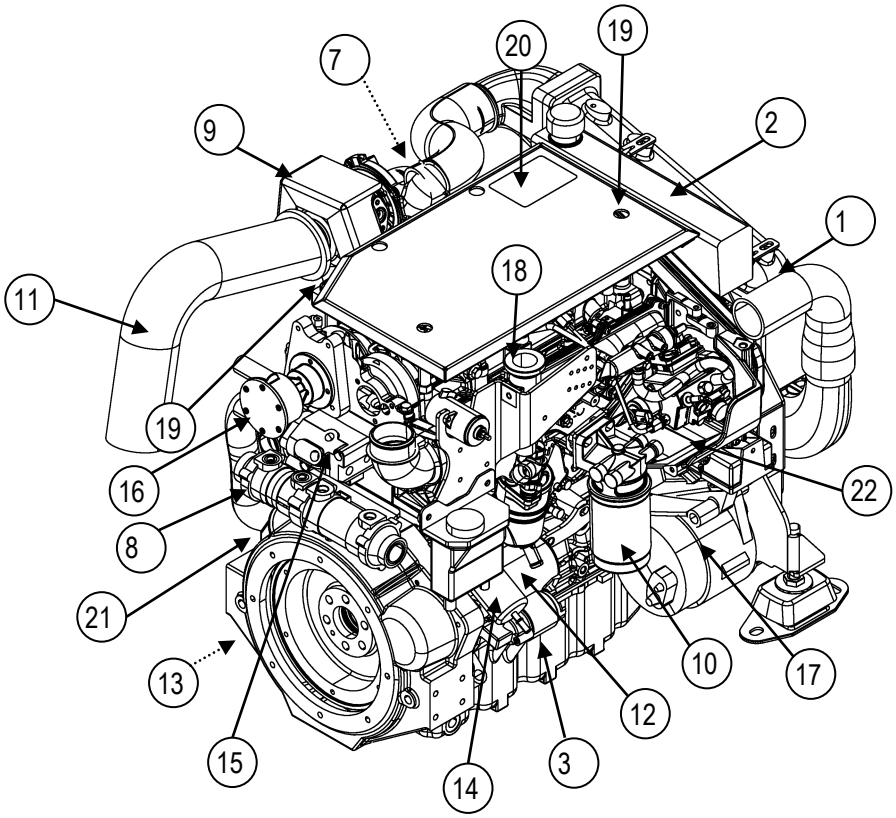


Figure 4 – FNM® HPE/P 40/150/170/190, HPE 150JD/170JD/190JD and HPEL 65/90

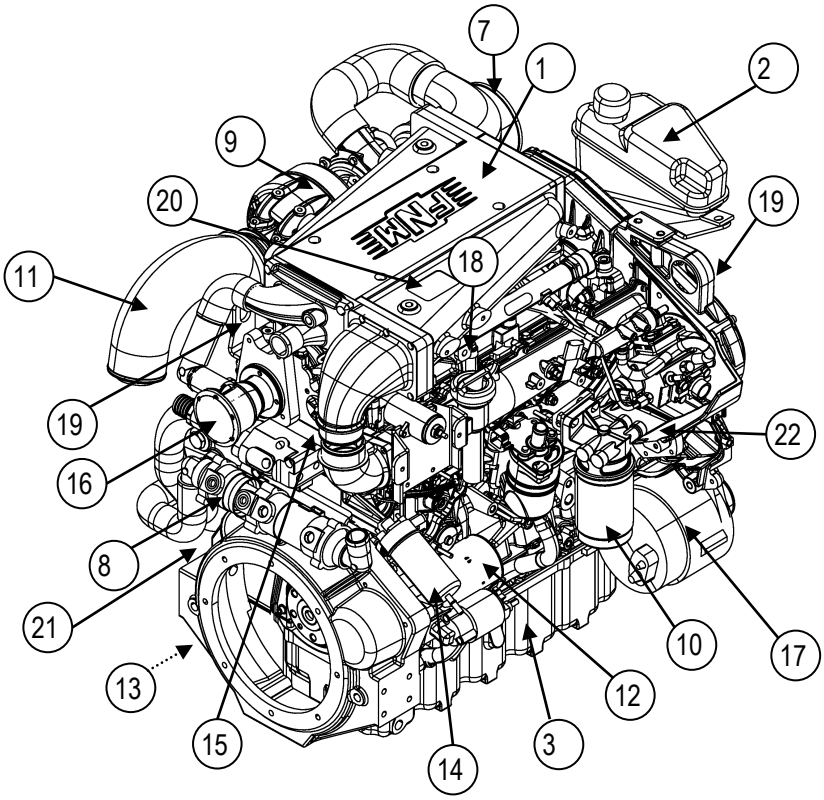


Figure 5 – FNM® HPE/P 100/225/250/250H and HPE 225JD/250JD

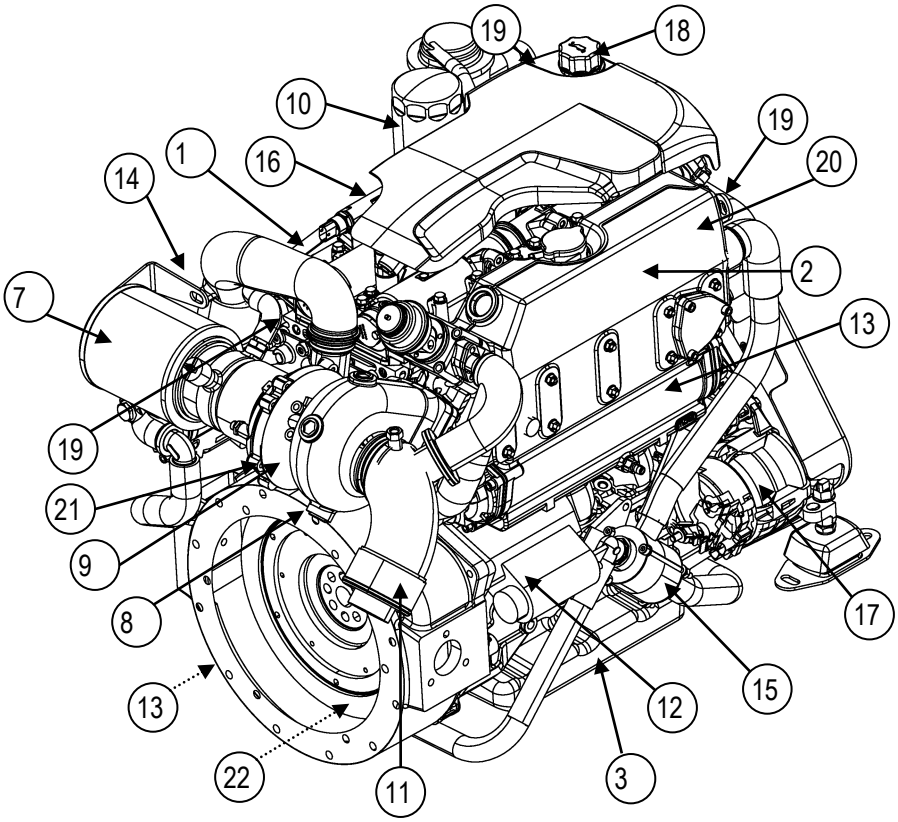


Figure 6 – FNM® HPE/P 300

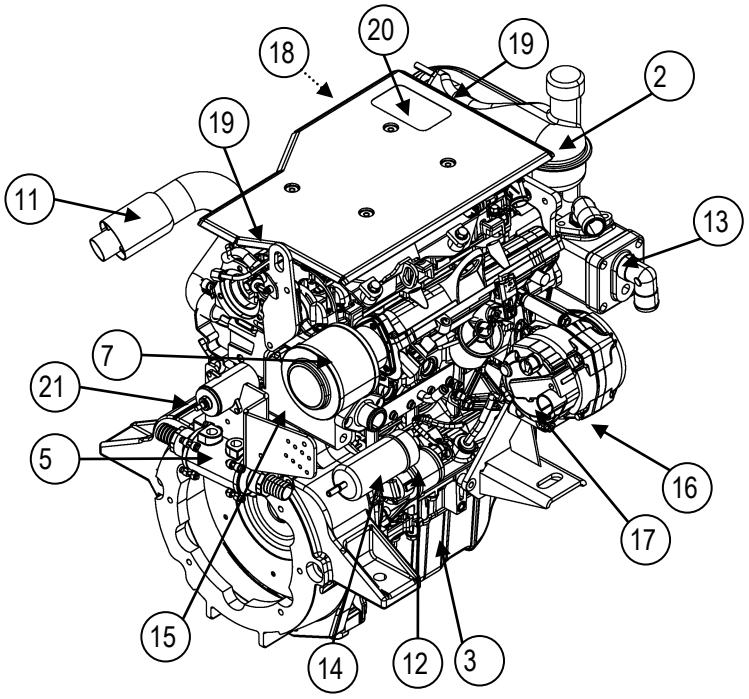


Figure 7 – FNM® HPEL 45

3.4 Principles of preparation of the engine compartment

The engine compartment houses the propulsive units and has several functions: it allows to keep the engine cool and dry, still on the longitudinal members, ensuring ventilation and the air flow required for its operation. Finally it contains all the accessories and auxiliary parts necessary for the operation of the entire propulsion system.

It is necessary to pay attention to the design and construction of the engine compartment. The walls must be built so that rainwater and splashes of sea water do not go directly against the engine or suction devices.

3.4.1 Longitudinal members

The longitudinal members must be straight and oriented in the direction of the hull length. They must be quite stiff and firm to hold the engine and keep its alignment over time.

The distance provided for each engine (indicated by the letter *d* in the image of Figure 8) between the centre of the right longitudinal member and of the left longitudinal member is shown in the following table:

Engine	Distance *d* between the longitudinal members centres [mm]
1.3HPE	440
1.9HPE	from 560 to 640
2.4HPE	from 560 to 650
3.0HPE	570

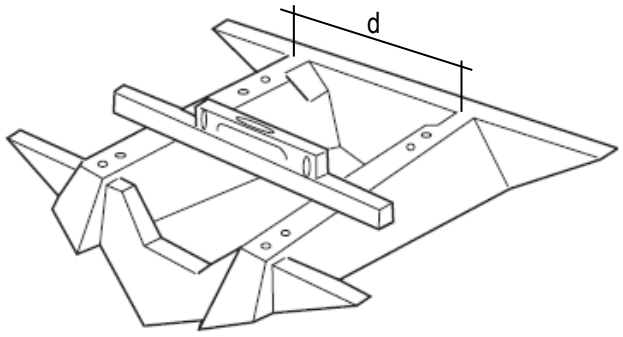


Figure 8 – Longitudinal members

The side members must completely contain the basis of the anti-vibration mountings and have margin to be able to move in the future, in case it is necessary to realign the engine.

Use screws of adequate size to secure the engine to the supports. All the forces exerted by water on the hull of the boat are transmitted to the engine through the side members, and therefore to the fixing screws. Also make sure there is enough space on the bottom of the boat between the engine and the hull.

3.5 Ventilation

The requirements for engine ventilation vary considerably among the different ship designs. The manufacturer of the boat is responsible for their construction and the correct application of the principles of ventilation, in accordance with regulations.

The ventilation of the engine compartment has multiple functions. It must supply the engine with air for combustion and maintain the temperature inside low. The purpose is to ensure a correct air flow rate necessary for the proper operation of the engine and to reduce the risk of moisture and condensation.

3.5.1 Reduction of condensation

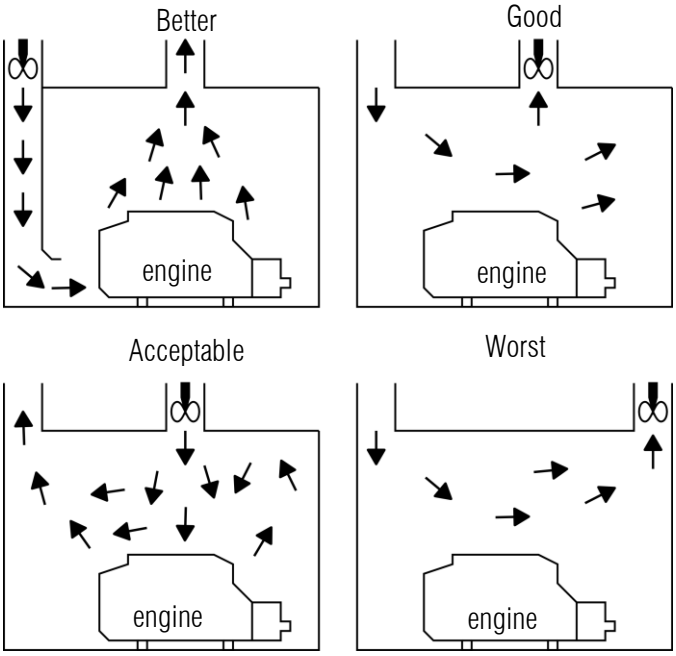


Figure 9 - Engine compartment ventilation diagrams

In the image of Figure 9, the fan represented is appropriate for adequate ventilation of the compartment in order to reduce the presence of moisture and condensation. It should be applied also in cases where the shape of the engine compartment does not favour a correct air passage around the entire engine.

3.5.2 Ventilation openings

In the engine compartment must always enter air at the lowest temperature possible; warm air must be discharged upwards. The vents must not allow access to rain water or to splashes of seawater during navigation.

The size of the ventilation openings must be multiplied by the number of engines installed.

The combustion air flow rate (for single engine) is shown in the following table:

Engine	Intake air flow rate	
	[m^3/min]	[ft^3/min]
1.3HPE	8	282
1.9/2.4HPE	10	353
3.0HPE	12.5	424

The best temperature of operation of the engine is between 30 and 40°C. This temperature must be checked after the installation, near the air inlet filter to the engine. For this purpose, the minimum diameter of the ventilation openings is indicated in the following table:

Engine	Dimension of the ventilation openings	
	Intake [cm^2]	Exhaust [cm^2]
1.3HPE	184 (28 in^2)	80 (12 in^2)
1.9/2.4HPE	230 (35 in^2)	100 (16 in^2)
3.0HPE	285 (45 in^2)	125 (20 in^2)

If it is not possible to reach an operating temperature within the indicated range, or to improve the air inflow to the engine, it is appropriate to increase the size of the ventilation apertures.

Even with the increase in the size of the ventilation openings it is not possible to return within the indicated range because of weather conditions or the shape of the engine compartment, it is necessary to check the difference between the outside temperature and the engine compartment: this should never be above 25°C.

Intake temperatures above 40°C can damage the engine.

Failure to follow the instructions regarding the dimensions of the openings and the operating temperature compromises the engine reliability and will void the warranty.

3.6 Installation angles

Refer to the table below for the maximum installation angles and use of the engine.

Engine	Maximum longitudinal angle of continuous operation (static + dynamic) [degrees /360]	Maximum transverse angle of continuous operation (static + dynamic) [degrees /360]	Longitudinal for checking the oil level with standard dipstick [degrees/360]
1.3HPE	± 20	± 25	0 ÷ +6
1.9/2.4/3.0 HPE	± 10	± 20	0 ÷ +6

Use the engine speed out of the ranges allowed may constitute a serious failure of the production unit because of the lack of oil in the pump and can lead to engine damage.

Always check the oil level when the engine is in a horizontal position, or within the limit indicated in the table above.

4 Engine alignment

The engine alignment with the transmission must be carried out carefully. Depending on the type of transmission to which the engine is coupled, it is necessary to follow different alignment methods.

The installer of the engine in the boat is responsible for the alignment of the engine to the transmission system. Once finished the alignment, these must always be checked again after the first set in motion and before delivery of the boat to the customer.

WARNING An improper alignment leads to vibrations of the propulsion unit that may damage parts of the engine and transmission, as well as to affect their operation.

One of the purposes of a correct alignment of the engine it is to eliminate all the vibrations of the propulsion system and thereby reducing the mechanical stresses and noise.

DANGER **The failure of parts of the engine and transmission due to a bad alignment may cause danger to the boat user.**

DANGER **All transmission parts with parts in motion must be suitably protected to prevent the user's contact with running engine.**

4.1 Anti-vibration mounts

Regardless of whether it is equipped with stern drive, inverter, water-jet propulsion unit or sail drive, the engine must rest on some anti-vibration mounts installed directly on the side members.

The anti-vibration mounts are made as in Figure 10:

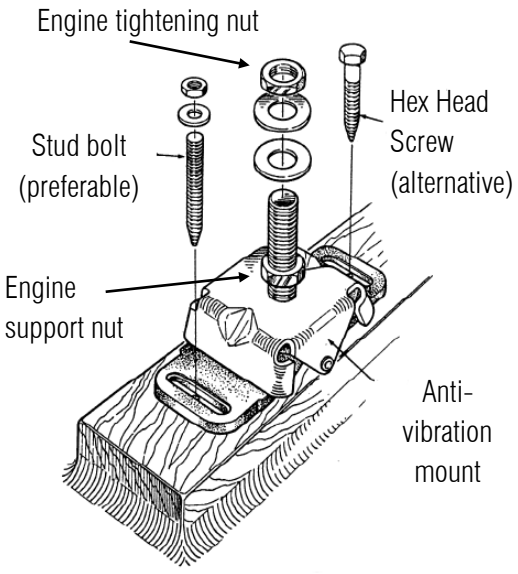


Figure 10 - Anti-vibration mounts

It is always better to use stud bolts rather than screws with hexagon head because it ensures a greater fixing duration: if you need to loosen the support in fact, the stud bolt remains stationary in the longitudinal member. Prevent that the screw is removed every time ensures durability of the bond between screw and nut.

The orientation and the number of mounts necessary to fix the engine are indicated in the following table:

Transmission	Orientation	Supports	
		Distribution side	Flywheel side
On-line inverter	stern flywheel	2	2
Angle inverter	stern flywheel	2	2
V inverter (V-drive)	bow flywheel	2	2
Water-jet propulsion unit	stern flywheel	2	2
Stern drive Mercruiser® (Z-drive)	stern flywheel	2	-
Sail drive	stern flywheel	2	-
Stern drive Volvo® (Z-drive)	stern flywheel	2	-

In some cases (stern drive engine) it is not necessary the use of supports on the flywheel side because the engine is connected integrally to the transmission which acts as a support for the engine.

The nuts for supporting and clamping the engine on the threaded pin of the anti-vibration mount must be carried out with a torque wrench at a torque of 150 Nm (110 lb-ft).

The selection of the correct hardness and type of anti-vibration mounts is made by the installer and it should be made taking into account the type of boat and the stresses that the hull will transmit to the propulsive assembly, in addition to the weight and arrangement of the latter inside of the boat.

WARNING The choice of mounts of incorrect size can cause engine damage and preclude its operation.

4.2 Engines with Mercruiser Bravo® stern drive

For the installation of the engine supplied with Mercruiser Bravo® I, II or III, stern drive, carefully follow the manufacturer's installation manual (Cummings Mercruiser Diesel®) supplied with the engine. Please also consider the following information.

NOTE

Carefully follow the instructions contained in the stern drive installation manuals of the manufacturer, or this may invalidate the warranty.

The transom positioning is not covered by this manual, and is available on the stern drive manufacturer's manual. The hull and engine compartment of the boat must be designed so as to allow the correct positioning of the transom - and consequently the engine - inside of them, without causing problems to the circuits connection (such as e.g. exhaust for a too high waterline related to the engine position).

4.2.1 Stern drive transom preparation

After positioning the transom and installing the piston to control the rudder and the rear exhaust, as described in the installation manual of the stern drive Mercruiser Bravo®, before installing the rest of the stern drive, it is necessary to position and install the engine. Follow the steps below:

1. Make sure that the engine bell contains the rubber bushes needed to couple with the transom supports. The bushings are shown in the image of Figure 11 with the letter a.

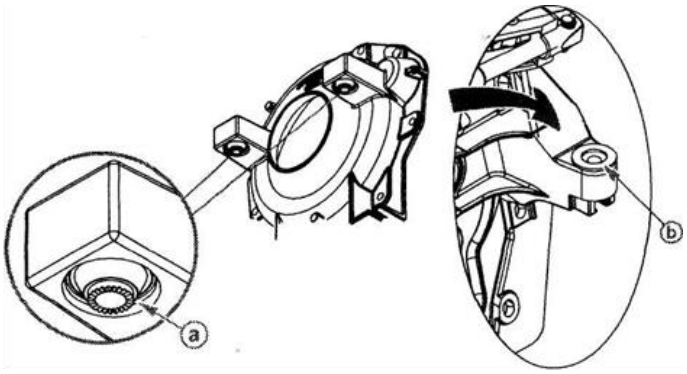


Figure 11 - Engine bell for Mercruiser Bravo® stern drive

2. Always use fibre washers (indicated by the letter b in Figure 11) between the engine bell and transom.

4.2.2 Engine positioning with Bravo Mercuiser stern drive

After preparing the transom, follow these steps:

3. Lift the engine and keep it suspended above the side members. Make sure the engine is level when suspended.

For the criteria for handling the engine, refer to the paragraph 3.2 - Engine Disassembling and Handling on page 7.

4. Lower the engine in the hull position making it go down slowly.
5. Install flexible mountings at the front of the engine (see paragraph 4.1 – Anti-vibration mounts on page 14). Do not tighten the nuts of the supports , or the supports to the side members.

NOTE

The supports tightening must be performed only at the end of this procedure.

6. Align the rear of the engine with the transom inner plate. At the same time align the upper exhaust pipe of the engine with the lower exhaust of the transom.

WARNING

A wrong coupling between the bell supports and the transom cause inaccurate alignment, which may lead to irreparable damage of the engine.

7. Insert and tighten both bolts as shown in Figure 12. Do not tighten the bolts, but leave a clearance.

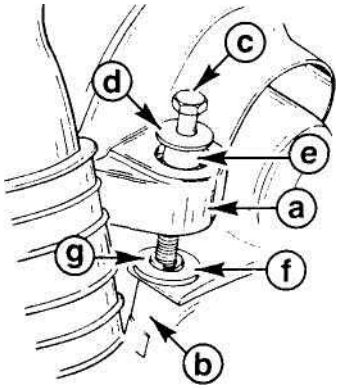


Figure 12 - Bolts tightening between the engine and transom supports. a) engine support; b) transom support; c) bolt; d) lock washer; e) spacer; f) spring washer; g) lock washer with double helix.

8. Adjust the front supports of the engine until the side members touch the hull. Do not tighten the supports to the side members.
9. Make sure the engine is on all four support points (the two front dampers and the rear transom supports).

4.2.3 Engine alignment with Mercruiser Bravo® stern drive

10. Remove the dust cover from the outboard part of the stern drive at the transom, indicated with the letter a in Figure 13.

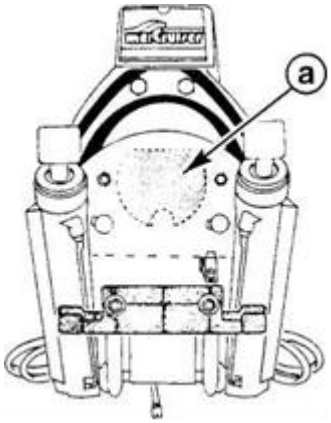


Figure 13 - Position of the dust cover on the outboard transom.

11. Check the position of the transom self-aligning bearing and make sure it is properly aligned with the engine flexible-coupling. If not, reposition the engine by repeating the steps of the paragraph 4.2.2 on page 15.
12. Grease the FNM® alignment bar.

WARNING

Do not use the alignment bar of another manufacturer, it may cause misalignment and engine damage.
Use only the alignment bar code produced by CMD code 2.018.381.1 supplied with the engine.

13. Place the alignment bar as shown in Figure 14 The bar must cross the stern drive, the grooved unit and the test centering (indicated by the letter n in Figure 15).

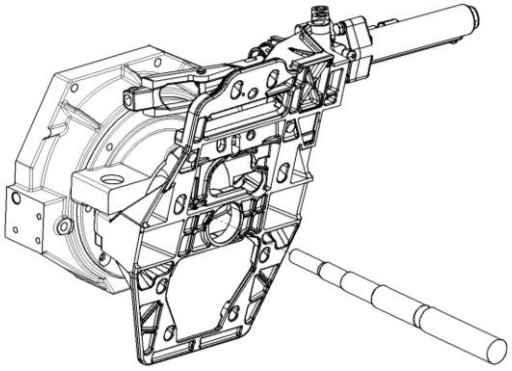


Figure 14- Inserting the alignment bar in the transom.

14. Make sure the bar arrives to the end of stroke and touches the screw (item 16 of Figure 15)
15. Turn the bar by hand checking the absence of friction or jamming.

WARNING

The engine is aligned correctly only if the bar slips easily in position. In case of rubbing it must be aligned again!

16. If the alignment is not correct, operate on the adjusting nuts of the anti-vibration mounts and realign the engine, and then repeat the steps from point 13.

NOTE

A small engine setting for perfect alignment can be performed exploiting the grooves of the engine support.

17. Remove tension from the lifting chain, resting the engine only on the anti-vibration mounts and the transom.
18. Tighten the supports to the side members.

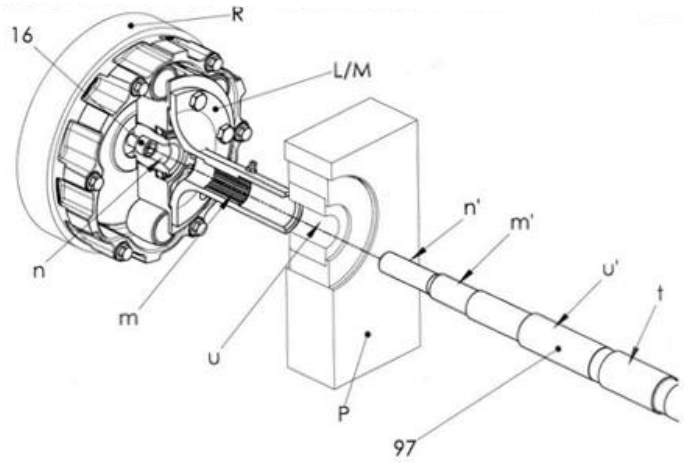


Figure 15- Elements of the engine alignment with Mercruiser Bravo® stern drive. 16) screw (terminal part of the flexible coupling); 97) alignment bar; m/l) flexible coupling; P) stern drive; R) engine; m) grooved flexible coupling; m ') counterpart of the grooved bar; n) centering on the flexible coupling; n ') counterpart centering on the bar; s) contact ends; t) handle; u) transom bearing; u ') bearing counterpart on the bar.

19. Recheck the engine alignment by fitting again the alignment bar.
20. Tighten the rear bolts between the engine and rear transom to 50 Nm (38 lb-ft) and the front ones that stop the anti-vibration mounts to the engine, as described in paragraph 0 on page 14.
21. Remove the alignment bar.

It is necessary to recheck the engine alignment:

- at least 24 hours after installation, with the boat in the water, during the sea trial.
- after 30h during the first service.

After the procedure, it is possible to carry out the other operations of engine connection to the services, as described in chapter 5 - Services connection to the engine compartment on page 21 and as described in the stern drive manufacturer's installation manual, supplied with the engine.

4.3 Engines with inverter

For installation of the engines equipped with inverter, follow the steps below.

WARNING

If the engine is supplied without inverter or inverter disconnected, the latter must be connected to the engine before fitting it into the engine compartment.

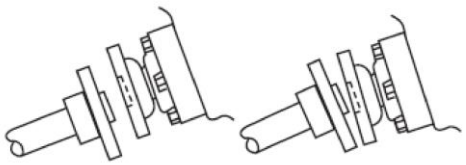
1. Lift the engine and keep it suspended above the side members. Make sure the engine is level when suspended.

WARNING

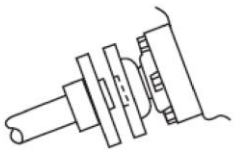
The weight of the inverter offsets the centre of gravity of the engine. Always make sure that during lifting the load is distributed and allows the engine to remain horizontal.

For the criteria for handling the engine, refer to the paragraph 3.2 - Engine Disassembling and Handling on page 7.

2. Lower the engine in the hull position making it go down slowly.
3. Install the front and rear anti-vibration mounts on the engine (see paragraph 4.1 – Anti-vibration mounts on page 14). Do not tighten the nuts of the supports , or the supports to the side members.
4. Place the engine on the side members and align it so that the flanges of the transmission shaft and are visually aligned, as in the image of Figure 16:



OFFSET ERROR ANGLE ERROR



FLANGES ARE PARALLEL WITH THE DISTANCE BETWEEN THE SIDES CONSTANT IN ALL POINTS

Figure 16- Alignment of the inverter flanges

5. Adjust the height of all supports acting on the engine support nut (see Figure 10 on page 14) in such a way that the alignment is as in the image above (perfect alignment).

NOTE

It is possible that in order to ensure a correct alignment the engine is not mounted perfectly horizontally. Check in the table of chapter 3.6 – Installation angles on page 13 the maximum angle at which the correct operation of the engine is ensured.

6. Disconnect the lifting chain, making sure that the engine rests properly on all its supports.
7. Tighten the supports to the side members.
8. Recheck the alignment of the flanges by checking that the maximum distance between the two faces is less than 0,05 mm (0.002 in) at intervals of 90 degrees.
9. If the alignment of the engine is not correct, loosen the supports on the side members and repeat the steps from point n. 3.
10. Tighten the engine to the supports as described in paragraph 4.1 – Anti-vibration mounts on page 14.

WARNING

It is necessary to recheck the engine alignment:

- at least 24 hours after installation, with the boat in the water, during the sea trial.
- after 30h during the first service.

In the engine assembly connection with inverter to the lineshaft, it is suggested to use a number of flexible joints specially dimensioned according to the torque to be transmitted, the length and angles of the lineshaft.

WARNING

The design and construction of the lineshaft is not covered by this manual. The installer is responsible for the appropriate sizing of a lineshaft able to ensure the correct operation of the engine-transmission assembly.

After the procedure, it is possible to carry out other operations of engine connection to the devices, as described in chapter 5, Services connection to the engine compartment, on page 21.

4.4 Engines with Twindisc Seaprop® sail drive

For the installation of the engine supplied with Seaprop® sail drive, carefully follow the manufacturer's installation manual supplied with the drive. Please also consider the following information.

The engine installation to the drive must only be performed after connecting the drive in position inside the boat. For the drive mounting information refer to the manufacturer's manual.

Proceed as follows:

1. Lift the engine and keep it suspended above the side members. Make sure the engine is level when suspended.

For the criteria for handling the engine, refer to the paragraph 3.2 - Engine Disassembling and Handling on page 7.

2. Lower the engine in the hull position making it go down slowly.
3. Install flexible mountings at the front of the engine (see paragraph 4.1 – Anti-vibration mounts on page 14). Do not tighten the nuts of the supports , or the supports to the side members.

NOTE

The supports tightening must be performed only at the end of this procedure.

4. Move the engine and adjust the supports to align the engine bell with the drive bell, as in the figure below. Make sure that the drive grooves fit properly within the flexible coupling mounted on the flywheel.

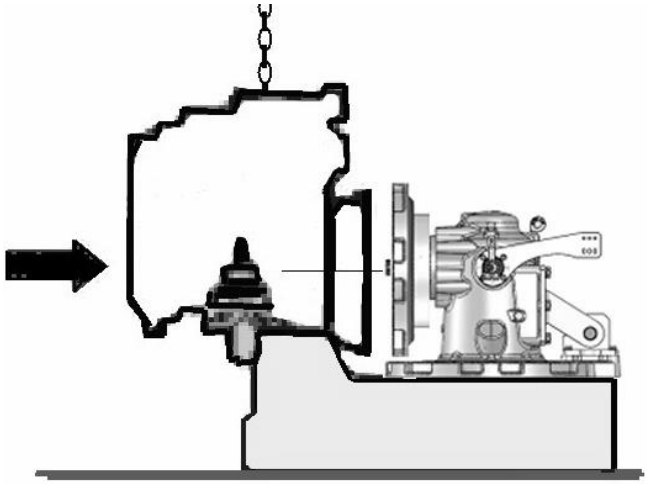


Figure 17 - Approaching the engine to the sail drive already installed

5. Bring the two bells into contact, then tighten the screws loosely, so that it is possible to make further adjustments.
6. Adjust the front anti-vibration mounts bringing them into contact with the side members .
7. After the alignment, tighten the screws that connect the two bells. Only after tightening the supports to the engine and to the side members.

WARNING

It is necessary to recheck the engine alignment:

- at least 24 hours after installation, with the boat in the water, during the sea trial.
- after 30h during the first service.

Continue the installation of the drive as explained in the installation manual of the manufacturer.

4.5 Engines with Alamarin® water-jet propulsion unit

For the installation of the engine supplied with Alamarin® water-jet propulsion unit carefully follow the manufacturer's installation manual supplied with the water-jet Please also consider the following information.

The engines of the HPE range can be connected to the water-jet propulsion unit in two modes, depending on the size of the engine:

Engine	Coupling type	Jet Alamarin® models
1.3 HPE	Direct	160 / 180 / 185
	Flange with bearings	
1.9/2.4 HPE	Flange with bearings	230
3.0 HPE	Flange with bearings	245 / 288

In both cases, the installation provides the connection between the engine and water-jet propulsion unit through a lineshaft that rotates at the same speed of the crankshaft.

DANGER

Apply a cover to the lineshaft to prevent operator access to the moving parts during operation. Failure to follow this warning can result in a hazard to the health of the boat users.

4.5.1 Direct connection

The direct connection is made by connecting the flange of the water-jet propulsion unit directly on the flywheel with the lineshaft, as in the following image:

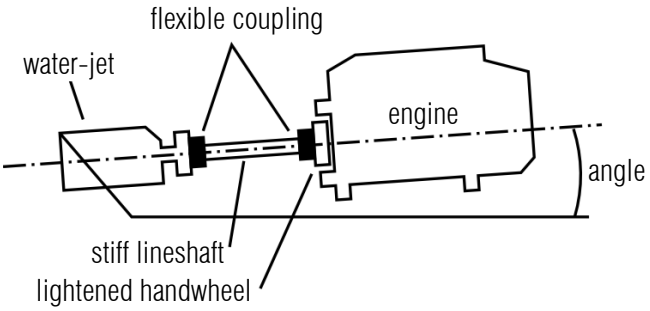


Figure 18 - Direct connection between engine and water-jet propulsion unit

This configuration is known as "lightweight ".

The direct connection must be performed only in cases in which the flywheel of the engine is set for this application. It is mandatory to use a flexible coupling to each of the two ends of the shaft.

Engine connection to the water-jet propulsion unit without two flexible couplings can cause breakage of the engine and water-jet propulsion unit lineshaft.

It is necessary to recheck the engine alignment:

- at least 24 hours after installation, with the boat in the water, during the sea trial.
- after 30h during the first service.

The engine must be perfectly aligned with the flange of the water-jet propulsion unit. To align the engine, follow the principles described in paragraph 4.3 – Engines with inverter on page 18.

4.5.2 Connection to the flange with bearings

The connection to the flange with bearings involves the use of a constant velocity transmission, as in the following image:

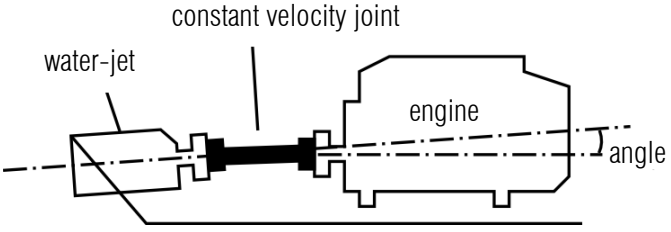


Figure 19 - Connection between engine and water-jet propulsion unit with flange with bearing

The flange with bearings is an integral part of the engine. The coupling is made by means of a constant velocity transmission, which must be suitably dimensioned according to the engine power.

For the coupling installation refer to the installation manual of the coupling manufacturer. **Some constant velocity joints are designed to work only at an angle and never in straight alignment.** In this case the positioning and alignment of the engine can be carried out by checking only the engine and water-jet propulsion unit angles of installation.

The selection and sizing of the model of constant velocity joint is the responsibility of the engine in the boat.

In the case of use of joints that require precise alignment, follow the principles described in paragraph 4.3 – Engines with inverter on page 18.

4.5.3 Installation angle of the water-jet engines

The installation angle of the engine must not exceed those maximum permitted in the installation drawings of the engine, and in any case depends on the type of water-jet propulsion unit, the shape of the hull and desired performance.

The engine angle installation is not permitted as it involves the malfunction of the engine and can lead to its breakage.

Refer to the installation manual of the manufacturer of the water-jet propulsion unit for more information on the proper selection of the angle and the position of the water-jet propulsion unit with respect to the keel line.

4.5.4 Other connection methods

Other connection methods between engine and water-jet propulsion unit (e.g. with inverter interposed) do not fall in the solutions provided by CMD and are not covered by this manual.

The responsibility for the choice and selection of different components in the connection between engine and water-jet engine is the exclusive responsibility of the engine installer in the boat.

4.6 Engines with Volvo® stern drive prearrangement

Compatibility with the Volvo® stern drive transmission is given only in case of new engines. CMD is not in any way connected to the Volvo brand or its products.

The installation of HPE engines on Volvo® stern drives is the exclusive responsibility of the engine installer in the boat.

5 Services connection to the engine compartment

5.1 Services connection points

The marine engines of the FNM® HPE range are provided of yellow tags that indicate the connection points of the various circuits of the engine to the devices and to the services of the boat.

The tags also indicate particular situations of danger as well as useful information to the installer, such as the absence of oil or coolant in the engine.

After installing the engine remove all the tags that signal the circuits.

5.2 Fuel circuit

WARNING

When installing the fuel circuit, always respect the laws in the country where the boat will be used, as well as the rules of common sense necessary to prevent the occurrence of accidents.

The fuel circuit must ensure safety and be equipped with a control system that promptly alerts the boat driver of loss or faults.

WARNING

Use diesel fuel complying with the EN590 specifications. The use of fuels with different formula may irreparably damage the engine.

5.2.1 Tank

The tank is a component that is not supplied with the engine that requires accurate procedures and maintenance. Always refer to the manufacturer's instructions.

Follow the instructions below for connecting the tank (Figure):

- All connections must be positioned on the upper side of the tank.
- The drain plug must be in the lowest point of the tank and allow the emptying of residues and sediment.
- The diameter of the fill tube (or refilling) must be equal to or greater than 50 mm (2 in).
- The vent pipe of the tank must have a minimum internal diameter of 13 mm (1/2 in) and prevent the entry of water in the tank.

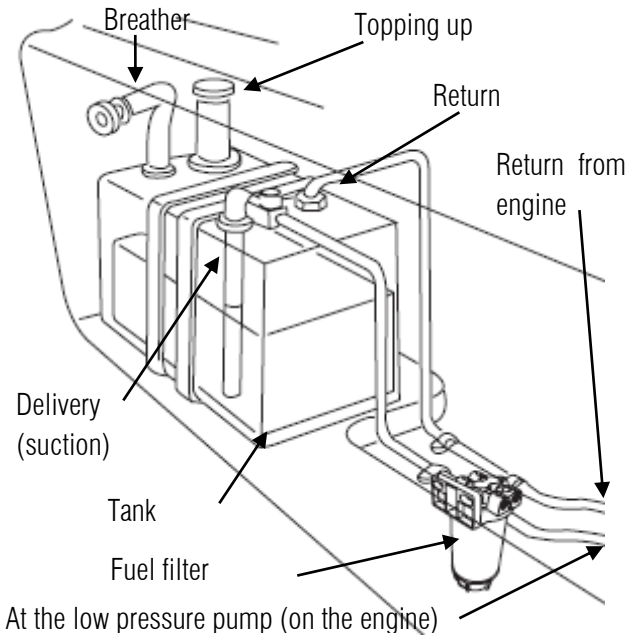


Figure 20 - Tank configuration

All fuel pipes must be securely fastened with cable gland. The holes through which the pipes enter in bulkheads must be rounded and protected with rubber seals to prevent abrasion and the consequent tubes breakage.

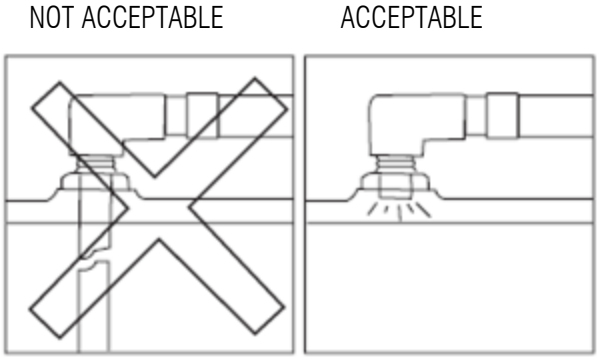


Figure 21 - Diesel return pipe position

Pay attention to the connection of the diesel fuel return pipe. The return pipe must end in the highest part possible of the tank (as shown in Figure 21).

The fuel must be extracted from at least 25 mm (1 in) in height from the bottom of the tank to prevent suction of impurities.

The delivery (suction) and return pipes of the diesel fuel must have a minimum internal diameter of 8 mm (5/16 in). The outlet is connected to the fuel filter before reaching the low pressure pump.

Do not use pipes or fittings with a passage diameter less than 8 mm (5/16 in). The engine can be damaged.

It is good practice to use pipes with a larger diameter in the case of long distances between the tank and the engine to remedy the reduction in flow rate due to deposit of impurities along the tube.

It is recommended to use hoses to the fuel circuit to prevent breakage of the tubes during operation. Avoid stopping the tubes with solutions that can result in damage cause by cutting or rubbing profiles and sharp edges. Avoid sharp bends (excessive angle).

In case of twinned installations (two engines) use separate tubes both for delivery and for the return of fuel from each of the engines up to the tank.

All components of the circuit must be properly tested and manufactured for use with diesel fuel complying with EN590.

Do not use components of the fuel circuit which are not suitable for the passage of fuel type EN590. The breakage of one of these can lead to fuel losses in the circuit and potential risks for the safety and health of users of the boat, as well as to damage to the engine.

5.2.2 Fuel filter

The fuel filter (see Figure 20 on page 21) is supplied with the engine and can be installed on the engine itself or on a bulkhead in the engine compartment.

The normal filter provided may be insufficient to stop the fuel contamination resulting from the growth of algae.

In this regard, it is recommended to install an additional fuel filter in series (e.g. Racor 500) with the following characteristics:

- Possibility of water discharge
- Filtering capacity: minimum 2 µm
- Fittings diameter; minimum 20 mm (¾ in)
- Maximum flow rate: minimum 4.5 l/min (1 gal/min)

The presence of the additional fuel filter is required in some areas of the world where the proliferation of algae in the tank is common.

Install the additional filter between the engine filter and the tank. The filter must be permanently attached, and must be easy to inspect.

It is also possible to use additives for diesel fuel that contrast the growth of algae, especially in very hot climates. Since the chemical composition and the method of use of these additives can vary, CMD cannot guarantee that it does not affect the performance of the engine or cause damage to its operation.

The use of fuels or additives that do not meet the specifications for which the engine is designed involve the engine failure and it will void the warranty.

5.2.3 Connecting the engine to the fuel circuit

Connect the fuel delivery from the tank to the engine directly to the low-pressure electric pump mounted on the engine. The pump position varies from engine to engine and is identified by the following table (or refer to paragraph 3.3 - Engine elements on page 8).

Engine	Position of the fuel low pressure electric pump
1.3/1.9/2.4HPE	On the bell housing, left side.
3.0HPE	The lower end of the intercooler, near the bell (left side)

Connect the fuel return pipe from the engine to the tank directly on the return fitting which is located on the high pressure pump or near the rail (diesel fuel high pressure distributor).

5.3 Sea water circuit

The system of sea water intakes and pipes must be sufficient to ensure a correct supply of sea water to the engine. Water is necessary for the proper operation of the engine.

The absence of a proper sea water intake to the engine causes the immediate heating of the propulsion unit. Operating the engine without sea water in the circuit will irreparably damage the pump impeller, as well as the whole engine, and may void the engine warranty.

The minimum flow rate of sea water to the engine and the minimum diameter of the pipes are indicated in the following table:

Engine	Sea water minimum flow rate		Minimum diameter of sea water pipes	
	[l/min]	[gal/min]	[mm]	[in]
1.3HPE	90	24	25	1
1.9/2.4HPE	100	26	32	1 ¼
3.0HPE	100	26	32	1 ¼

The location of the flange or the sea water intake connector is available in the following table:

Engine	Position of the sea water intake flange position
1.3HPE	On the sea water pump
1.9HPE	At the diesel fuel or diesel fuel/steering oil
2.4HPE	On the sea water pump
3.0HPE with exception of the Volvo® stern drive prearrangement	On the sea water pump
3.0HPE Volvo® stern drive prearrangement	At the diesel fuel or diesel fuel/steering oil

The sea water intake circuit connection must be made as in Figure 22 below:

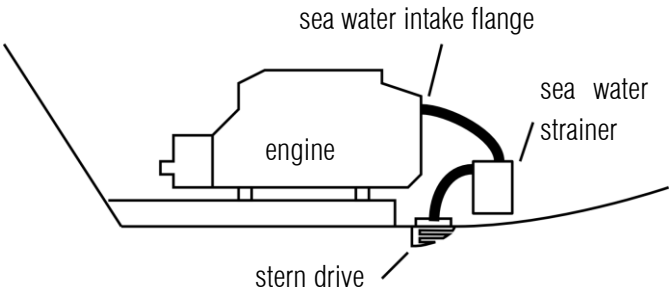


Figure 22 - Sea water intake connection

The intake pipe must go from the sea water intake to the filter (not supplied as standard), then to the engine intake flange. Use only rubber hoses of suitable thickness to prevent breakage. Ensure that the pipe touches the moving parts of the engine. Fasten the pipe with metal clamps.

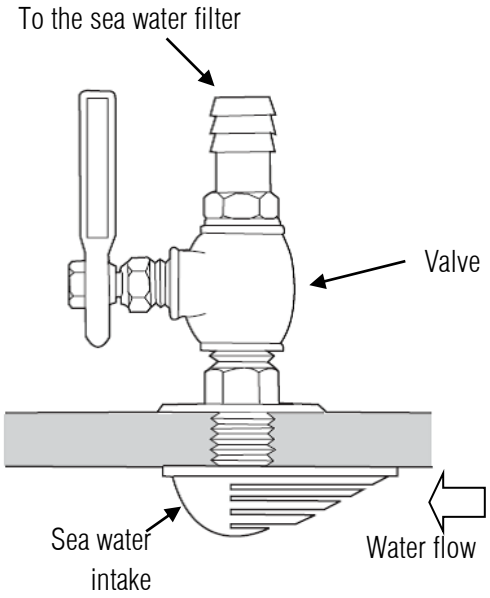


Figure 23 - Sea water intake

Make sure that between the sea water intake and the sea water filter there is a shut-off valve of the pipe and that no point of the circuit is less than the minimum diameter indicated in the tables above.

The water filter and the size of all the pipes of the sea water system must ensure the minimum flow rate required for operation of the engine.

WARNING

Failure to comply with the requirements of this chapter involves damage to the engine and will void the engine warranty.

In the case of stern drive installations, it is mandatory to install an additional sea water intake: the sea water intake on the transom of the stern drive can easily become clogged leading to a lack of engine cooling.

NOTE

The absence of double sea water intake in case of stern drive installation may void the warranty.

Refer to the diagram in the following figure to connect the double sea water intake in case of stern drive installations. In the junction of two circuits, use a T shape fitting.

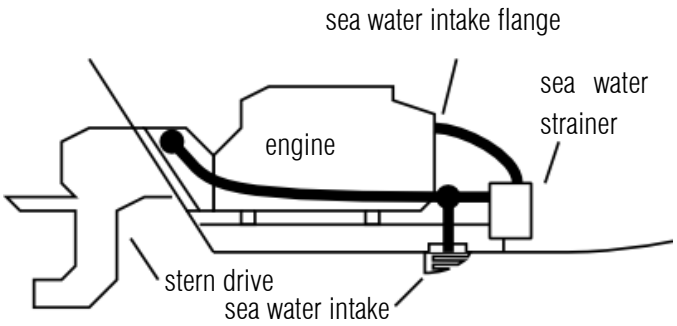


Figure 24 - Connection diagram of the double water intake (stern drive installations)

In the case of twin installations (two engines), each engine must have its own sea water circuit separate and independent of the other engine.

5.4 Exhaust system

The installation of the exhaust system depends on the position of the engine with respect to the waterline of the boat.

Failure to follow the rules contained in this paragraph may lead to the infiltration of water into the engine, resulting in damage. Comply with the instructions.

NOTE

Correct positioning of the engine inside of the boat is the responsibility of the installer who must respect the waterline position.

5.4.1 Engine in stern drive configuration

In case of stern drive installations the correct positioning of the engine depends on the specifications of the stern drive installed.

Refer to paragraph 4.2 –

waterline (worst case)

stern drive

Engines with Mercruiser Bravo® stern drive on page 14 to see the correct positioning of the stern drive assembly and the engine inside the engine compartment.

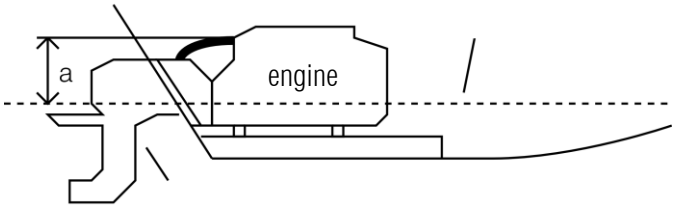


Figure 25 - Engine exhaust in stern drive configuration

In case of stern drive installations the upper exhaust elbow (on the engine) must be fixed with a sleeve of appropriate diameter to the discharge lower elbow (on the stern drive), as shown in Figure 26. Use two clamps to each end of the sleeve to ensure the appropriate seal.

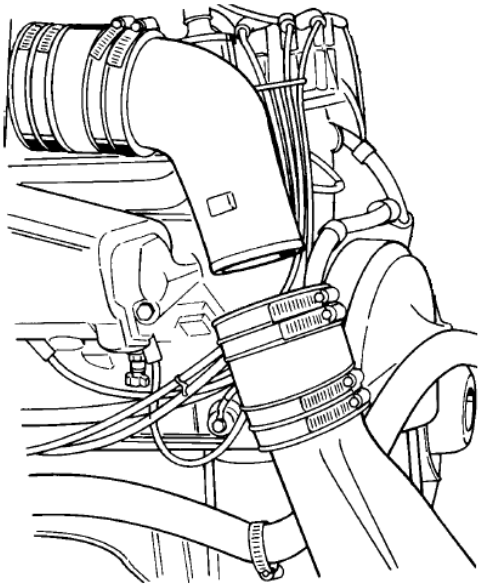


Figure 26 - Exhaust sleeve in Stern drive version

The minimum height *a* in Figure 25 between the waterline and the highest point of the upper exhaust elbow (on the engine) is shown in the following table:

Engine	Distance *a* between the waterline and the highest point of the exhaust [mm]	Exhaust riser [mm]
1.9HPE	min 470	80 (3 3⁄16 in)
2.4HPE	min 470	80 (3 3⁄16 in)
3.0HPE	min 550	100 (3 15⁄16 in)

5.4.2 Engine in Inverter / JetDrive / Saildrive configuration

In case of inverter, JetDrive or Saildrive installations the upper discharge elbow must be connected to the exhaust outlet on

the transom, as in the following figures. Depending on the configuration of the engine compartment, the point of emission of the engine exhaust gas (elbow) may be located:

1. Case A, discharge at more than 15 cm from the waterline – Figure 27 below. In this case it is advisable to install a silencer suitably sized to prevent the return of waste water into the engine and draw the exhaust line with a gooseneck shape:

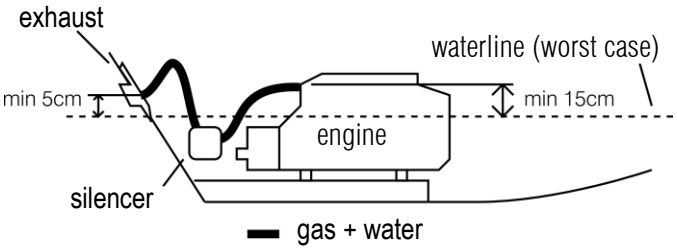


Figure 27 - Engine exhaust in configuration A

2. Case B, discharge subjected or less than 15 cm above the waterline – Figure 28 sotto. In this case it is necessary to remove the sea water supply sleeve between the manifold and the exhaust elbow on the engine and install an anti-siphon at the minimum height of 40cm from the waterline, so as to avoid the risk of return of water to the exhaust when the engine is stopped. The two circuits (water and gas) to be joined again in a lower point of the discharge line before the silencer. Use a gooseneck exhaust geometry with the highest point at a minimum height of 45cm from the waterline. Check with the manufacturer of the silencer the correct installation position.

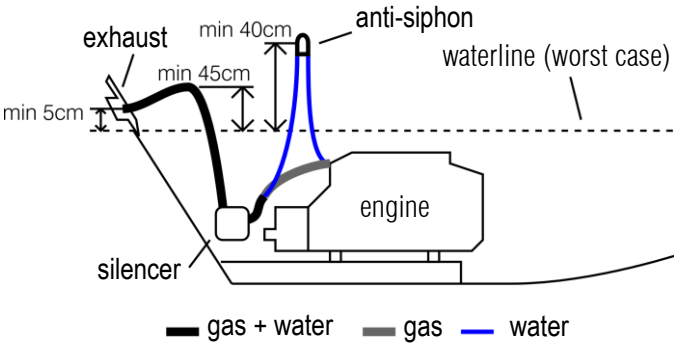


Figure 28 - Engine exhaust in configuration B

The filler on the transom must always be above (min 5 cm) the waterline.

The silencer must always be below the engine exhaust elbow .

In the installation of flexible sleeves, always guarantee that the bending angles are not narrow and that the inner tube is not directed directly against the sleeve, as in Figure 29.

The inner tube of the discharge elbow contains the exhaust gas at high temperatures that could damage the sleeve, leading to a loss of water in the engine compartment.

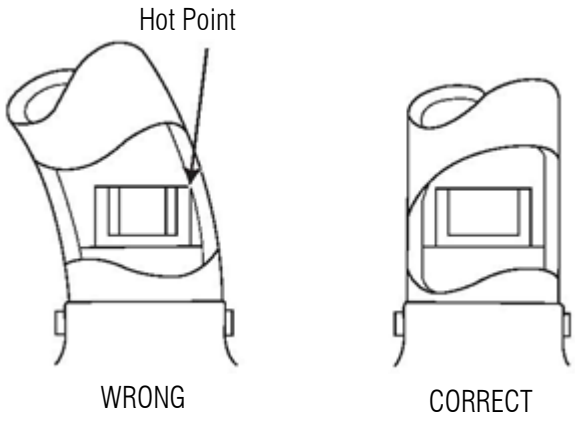


Figure 29 - Installation sleeve on the exhaust elbow

The diameter of the exhaust pipe (gas + water) is shown in the following table

Engine	Exhaust riser diameter [mm]
1.3HPE	60 (2 3/8 in)
1.9/2.4HPE	90 (3 9/16 in)
3.0HPE	100 (3 15/16 in)

5.5 Hydraulic fluid circuit (if present)

In the case of engines equipped with power steering pump (or hydraulic pump or power steering), it is necessary to connect the pump to driving device, usually the hydraulic actuator of the stern drive. To connect the circuit properly, follow the steps below:

1. Connect the delivery from the power steering pump to the device using a hose of suitable diameter.
2. Connect the return from the device to the power steering tank, placed on one of the sides of the engine, using a hose of smaller diameter.
3. Tighten the hoses to the tank and to the power steering pump making sure there is no leakage of fluid.
4. Fasten the tubes with suitable clamps or cable gland to the bulkheads or to the engine in such a way that they are not free to move. Avoid too tight bends.

The hoses must never come into contact with the moving components of the wheelhouse, with the coupling or with the transmission shaft.

5. In the case of engines with Mercruiser Bravo® stern drive, the delivery (a) and return (b) pipes are shown in the image of the figure below. Tighten both fittings on the transom to 30 Nm (23 lb-ft):

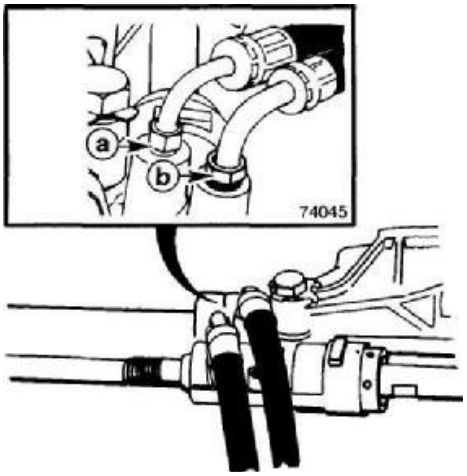


Figure 30 - Delivery (a) and return (b) of the power steering tube for Mercruiser Bravo® stern drives

The engines of the HPE range are provided with two different types of high-pressure tubes for the hydraulic circuit. The connectors at the end of the two tubes are the following:

Type Pipe	Delivery fitting	Return fitting
A (suitable for Mercruiser® stern drive hydraulic steering)	Threaded M16x1.5 (Male)	Threaded M14x1.25 (Male)
B (suitable for Volvo® stern drive hydraulic steering)	Threaded ISO228 G 3/8 "(Female)	Sleeve Ø10mm

After the connection process, top up the hydraulic fluid on the power steering tank using only oil type ATF.

The original oil for Mercruiser® "Power Trim & Tilt Fluid" stern drive order code Mercruiser® 92 – 858074K01, exceeds the ATF specifications and is recommended for installations with this type of stern drive.

5.6 Throttle

The engines of HPE range are provided with electronic control unit. The engine control is made by an electrical signal that represents the percentage of throttle (or pedal) load. The signal is provided directly from a control system or by a potentiometer mechanically connected to a mechanical throttle. There are 3 control modes:

1. **Mechanical throttle**: this prearrangement is provided as standard with the engine, which is equipped with mechanical "potentiometer".
2. **Flexball® electronic throttle**: supplied on request with the engine. In this case a the potentiometer is provided for compatibility with the mechanical systems.
3. **Electronic throttle connection kit**: supplied on request with the engine (in this case it has a potentiometer) or as

an option to ensure compatibility with other control systems.

The throttle, especially if mechanical or provided by third parties is not part of the engine supply. CMD is not responsible in any way for damage or danger caused by incorrect use or by a malfunction of the throttle systems.

When installing the throttle lever, always check that it is not possible to start the engine, or accelerate the engine during the gear engagement Also check that the throttle always allows the propulsion unit control, also in dangerous conditions.

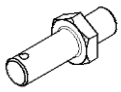
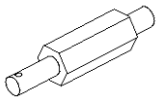
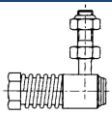
The engine start up with gear engaged, or the ability to accelerate the engine during the gear engagement can cause engine or transmission failure .

The conditions of use described above represent a danger to the occupants or to swimmers passing near the propeller.

5.6.1 Mechanical throttle

For boats with mechanical system control prearrangement (with tie rods), the engine is provided with potentiometer already installed on it. The position of the potentiometer varies according to the type of engine.

The potentiometer is equipped with a pivot around which the throttle lever rotates. A return spring brings the cable on the zero position. The useful stroke length is about 80mm. On the lever there are two types of fastener depending on the application for which the engine is provided:

Appl.Type	Cable Type	Sheath fixing point	Cable end	Stop-sheath
Mercruiser® stern drive	C5/C36	Fixed	 Pin with split pin	 Pin with split pin
Other	C2/C8	Adjustable	 L7 (spherical joint)	 L14 (U bolt)

Check with the diagnostic tool (or with the digital speedometer - LOAD/UNLOAD function) that the potentiometer makes the full stroke.

5.6.2 Flexball® electronic throttle

For information on the Flexball® electronic throttle installation and use consult the manufacturer's manual. The configuration of the throttle also varies depending on engine level and transmission selected.

Once installed the throttle, for the electrical connection see chapter 6.15 – Electronic throttles electrical connection on page 39, it is necessary to:

1. Adjust the stroke of the actuator (or actuators for twin installations) gear engagement. This is carried out by following the requirement in chapters11 and 12 of the throttle installation manual . The strokes adjustment must necessarily be carried out in two times (three for water-jet propulsion unit installations). The setting is made by changing only the parameters 0L, 0F, 0H (single engine) or 0L, 0F, 0H, 1L, 1F, 1H (twin engine) inside the control unit:
    a. DRY: A person on board and one on the ground are required to check the exact engagement point of the gear.
    b. IN THE WATER: Only one person on board for the setting, which must be carried out strictly with the engine running and with calm seas. The engagement of the gear results in a slight displacement of the boat in the front and rear direction due to the rotation of the engine in idle.
    c. NEUTRAL GEAR BALANCE IN THE WATER (WATER-JET):the neutral point corresponds to the condition in which the water-jet propulsion unit paddle thrusts are perfectly balanced. For this reason, this setting must be made with the engine running and calm sea. Only one person on board is required to make the setting.
2. A verification of the throttle operation electrical parameters. During the configuration of parameters in the control unit of the control system, it may happen to change other parameters not related to the setting of specific strokes. The parameters are of two types:
    a. Specific of the throttle system (as described in chapter 14.2 of the installation manual of the control system). These parameters are related to the throttle system and must not be modified.
    b. Specific of the engine (as described in chapter 14.2.2.1 of the installation manual of the control system). These parameters are related to the management of the engine throttle and must not be modified. Changing these parameters can lead to serious risks to the safety of persons and in any case will void the warranty.

Make sure that the parameters are set correctly with the numerical value shown in the installation manual of the control system.

Failure or bad configuration of gear engagement strokes and changing the throttle control parameters with other values can be critical to the propulsion system, resulting in malfunction or breakage and void the engine warranty.

5.6.3 Electronic throttle connection kit

For compatibility with other types of electronic control systems, there is a universal kit:

Type Engine	Order Code	Description
HPE	3.900.379.1	Electronic throttle connection kit

For the correct use of the kit, it is necessary to connect the following pins of the 6 way connector:

PIN	Destination
1	GROUND
3	THROTTLE

The ground node used must correspond to the ground connected to the engine; choose adequate cable diameter and lengths to transmit this type of signal. Use rubber plugs from the kit to close the missing pins and ensure that all connections are watertight.

The throttle signal is a voltage signal that meets the requirements of the curve in Figure 31 sotto:

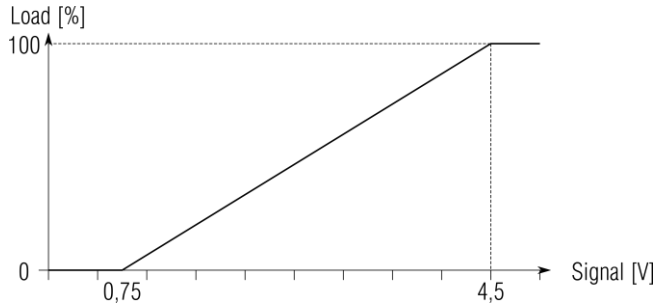


Figure 31 - Curve of the throttle signal expected by the engine

The engine load varies in direct proportion with the voltage between the pins 1 and 3. The maximum and minimum points are the following:

ΔV_{1-3}	Destination
≤0,75V	0% load
≥4,5V	100% load

The use of electrical signals that do not meet the requirements described above can damage the engine control unit and cause a malfunction of the whole engine unit, including transmission, and voids the guarantee.

5.6.4 Transmission control

The transmission control in its clutches gear, or in other operations, depends on the type of transmission and is not covered by this manual.

For information on the transmission control, refer to the transmission manufacturer's manual.

5.7 Propeller selection and torque engines installation drawings

The boat manufacturer and engine installer are responsible to select an appropriate propeller.

The right selection allows the driver of the boat to obtain the maximum speed of the boat in correspondence of the highest crankshaft speed of rotation, with a normal load and with the throttle in the full throttle position.

The following operating conditions can cause a loss of speed. If this happens, consider the selection of a propeller with minor step:

Use mainly in warm and humid seasons.

Use at high altitudes.

- Use with high loads (e.g.. high number of passengers).
- Use for boats where high accelerations are required (e.g. sports).

Select the propeller considering that its use at full load (throttle to stroke end) for long periods with a propeller with extremely low ratio can damage the engine.

An appropriate propeller will allow the engine to reach the maximum rotational speed when the throttle is fully open.

In case of paired installations (two engines), comply with the propellers rotation diagram shown in: Figure 32: the direction of rotation must be for both outboard, looking the boat from the stern..

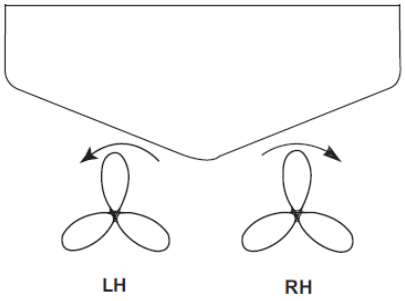


Figure 32 - Scheme of propellers rotation for twin installations

6 Wiring installation

6.1 Electrical system and system specifications

Proper installation of the engine to the electric system of the boat is the responsibility of the installer. Carefully read the instructions in this chapter.

In principle, it is appropriate to make sure that all the metallic components inside the boat have their frame connected to the ground continuity.

Check that each electrical connection is made in a solid way and isolated from the outside.

6.2 Battery and power supply

Each engine installed on the boat needs a separate battery. In the case of twin installations (two engines), make sure you have a battery for each engine.

The specifications of the batteries are as follows:

Characteristics	Value
Typology	Suitable for marine use, excellent resistance to load and unload cycles
Rated Voltage [V]	12
Capacity [Ah]	>110
Minimum pick-up current [A]	>850
Connectors	Conical Clamps

Do not use batteries with threaded, nut ,or wings connector.

To comply with the needs of correct operation of the engines it is necessary to use an auxiliary battery prepared exclusively for such services and dimensioned in accordance with the number and the maximum load of the devices.

Do not use the battery engine to connect services. The current absorption can cause malfunction of the engine.

6.2.1 Cables diameter and length

it is necessary to place the battery as close as possible to the engine to use short battery cables.

The diameter of the battery cables must be selected according to their length. Follow the table below:

Cable length [m]	Class	Minimum thickness [mm²]
up to 0.9	2	35
from 0.9 to 1.4	0	50
from 1.4 to 1.8	00	70
from 1.8 to 2.4	000	95
from 2.4 to 3.1	0000	120
from 3.1 to 3.6	2* x 00	2 x 70
from 3.6 to 4.8	2* x 000	2 x 95
from 4.8 to 6.1	2* x 0000	2 x 120

* use two cables for each pole

It is recommended to tin solder the wires to the battery to ensure the durability of the electrical contact.

Battery wear reduces the starting current, it is necessary to strictly comply with specifications to avoid starting problems and engine operation.

6.2.2 Connection to the battery

The power cables from the battery must be connected as described below, as applicable:

Failure to comply with the instructions for connecting the battery can lead to failure of electric parts of the engine. Always follow the instructions provided.

1. **Single-engine installation, single battery**: connect the battery terminals to the engine:
   - **Positive** (marked with +): to the pole B+ of the starter engine of the engine (see paragraph3.3 – Engine elements on page 8).
   - **Negative** (marked with -): to the ground point on the engine wiring (see paragraph 3.3 – Engine elements on page 8). Be sure to remove the paint to ensure adequate electrical contact between the cable and the engine.

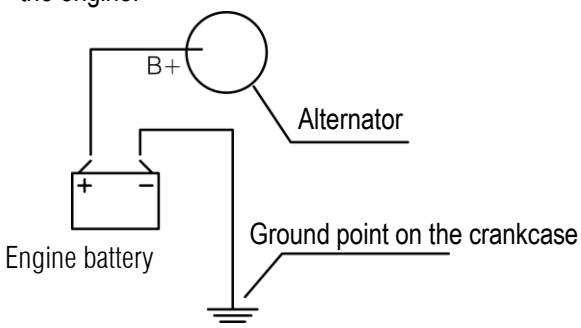


Figure 33 - Wiring diagram for single-engine, single battery installation.

2. **Single engine, two batteries installation with load dispatcher**, see diagram below:

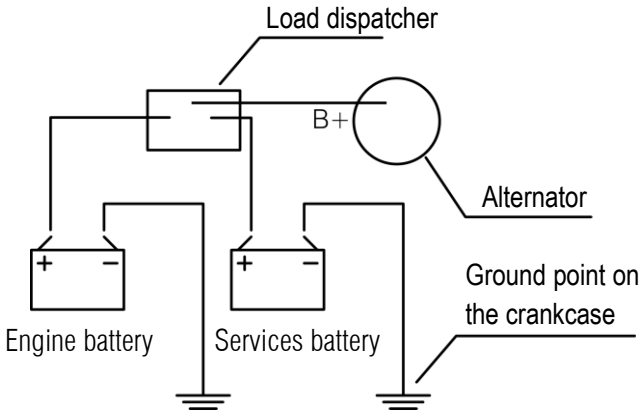


Figure 34 - Wiring diagram for single-engine, double battery installation.

NOTE Some load dispatchers do not allow the energizing of the alternator to charge the battery.

In the presence of load dispatcher, depending on the model and type of dispatcher, it can happen that the alternator is not energized and the battery is not recharged. In this case it is necessary to use a timed relay connected as in Figure 35 sotto to temporarily energize the alternator and allow the batteries charging.

WARNING Use only relays that match the codes: Writtin Electronic® 600 100; Wehrle® 51 233 016; Imel: I18086.

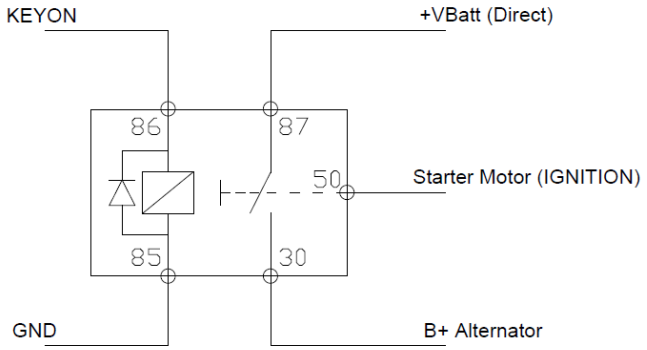


Figure 35- Wiring diagram of timed relay connection for load dispatcher

Connect the pins using the minimum cross sections shown in the table:

PIN	Service	Cable diameter [mm²]
1(86)	Key-ON	0.5
2(85)	Ground	0.5
3(30)	B+ (Alternator)	2.5
5(87)	+VBatt (Direct power)	1
9(50)	Starter Motor (consent)	1

3. **Twin installation, two batteries**: connect the batteries to the two engines as in case 1, keeping the two circuits separate.

4. **Twin installation, three batteries**: recommended connection in case of twin installations and the need for redundancy for selective charging of multiple batteries. Follow the wiring diagram below. Two battery exchangers provide the possibility of using and charging the various batteries individually or in parallel connection by means of manual selection.

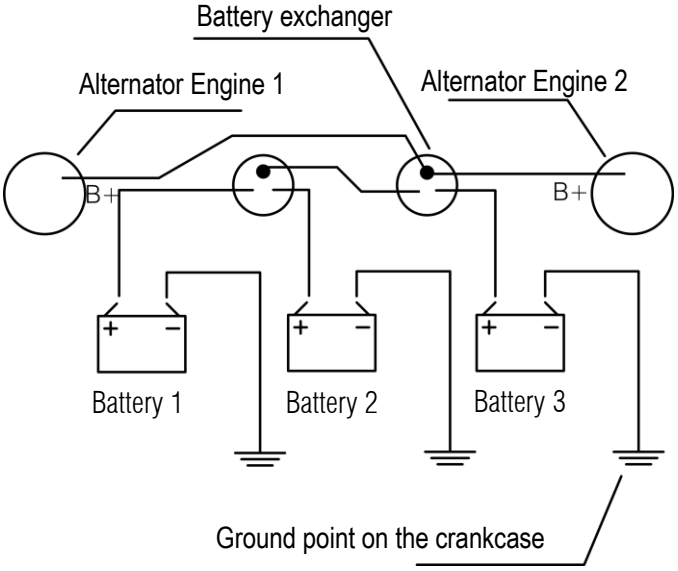


Figure 36 - Wiring diagram of three batteries in twin installation.

6.2.3 Ground circuit

Make sure that the frames of all metallic elements (including transom, inverters, etc ...) in the engine compartment are electrically connected to each other and to ground with cable of suitable diameter (see table in paragraph 6.2.1 – Cables diameter and length – on page 29).

NOTE The galvanic currents generated between different metals can, in some instances, lead to premature corrosion of the metal elements in contact with the sea water.

WARNING For engine installations on metal hulls, it is necessary to study an appropriate electrical insulation system between the engine and transmission, and use a insulated pole engine control system (see chapter 8.4 – Insulated Pole Kit on page 45).

6.3 Control Unit

The engine control unit (hereafter ECU - Electronic Control Unit) is a complex electronic assembly that manages the operation of the engine in all its aspects.

The ECU is enclosed in a metal box with IP67 protection against external agents.

It is equipped with an inspector for the service fuses of and two watertight connectors. Also it has an emergency button to press to immediately stop the operation of the engine.

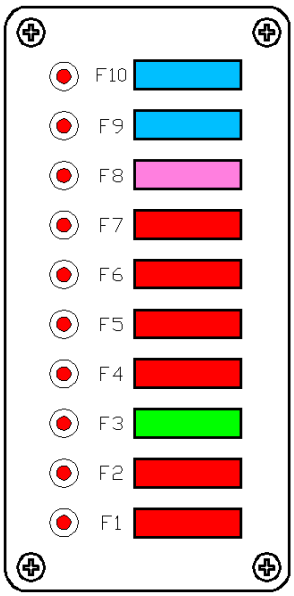
The ECU must be fixed inside the engine compartment on a wall or by designing appropriate supports. It is appropriate to the use anti-vibration mounts in order to avoid vibrations that may damage components inside the control unit, causing the engine malfunction.

The selection of a correct fixing system that avoids excessive stress on the ECU is provided by the installer, and depends on the type of boat. Excessive vibration can cause malfunction of the ECU and consequently of the engine.

6.4 Fuses and relays

The box of the control unit contains10 fuses that indicate the presence of power supply of the services associated to the engine. Each fuse is equipped with a light that, when on, indicates that the corresponding service is working properly.

In the engine normal mode of operation make sure that the lamps of all the fuses are lit and the fuses intact.

Orientation	Name	Rated Current [A]	Service
	F10	15	Diesel fuel pre-heating
	F9	15	Diesel fuel pump - low pressure circuit
	F8	3	Glow plugs
	F7	10	PIN 4 ECU + diesel fuel pump relay
	F6	10	PIN 5 ECU + diesel fuel pre-heating relay
	F5	10	Key-ON
	F4	10	EOBD diagnosis
	F3	30	Engine starter
	F2	10	Alternator lamp
	F1	10	Not Used

6.5 Control panel

The engines of the HPE range are supplied with digital panel to control the engine.

6.5.1 Types of control panels

Depending on the equipment of the engine, the control panel can be completed with master tool, key lock, indicators and warning lights in the assembled version (or full, as in the following figure):

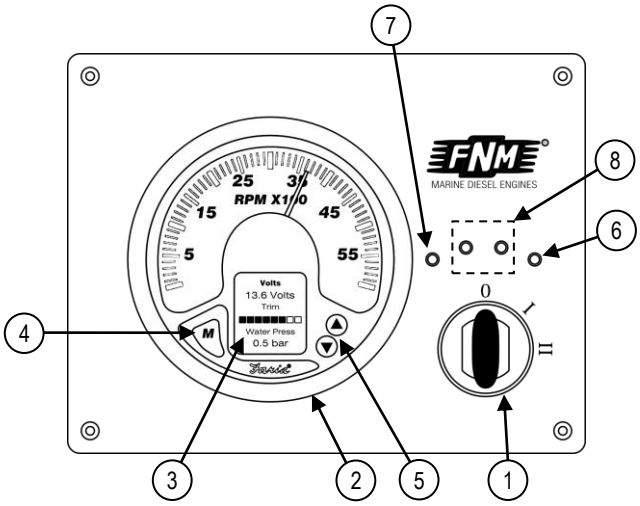


Figure 37- Complete digital instrument panel

Or provide only the key lock and warning lights, as in the following figure. In this case the master tool is still supplied and must be installed separately.

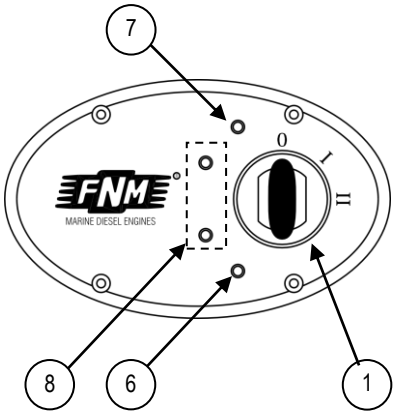


Figure 38 - Digital instrument panel in separate configuration

The panel elements are:

Table of contents	Name	Description
1	Three-position key lock	It allows to start and stop the engine.
2	Rpm counter (Master Tool)	It measures the engine crankshaft speed rotation in RPM (revolutions per minute).
3	CANBUS universal instrument	It allows to display all the engine operating parameters and alarms.
4	MODE button	To change the operating mode of the CANBUS Universal Instrument.
5	Direction buttons	They allow you to scroll through the CANBUS Universal Tool menu
6	Glows plugs pilot lamp	It lights on during the glow plugs preheating phase, with the key lock in position I and engine off.
7	Transmission oil anomaly pilot lamp	It lights up in case of problems with the transmission lubrication. It requires the sensor connection.
8	Other pilot lamps	Optional

Size and dimensions of the panels are shown in the following table:

Panel	Fastening	Fastening Holes Position [mm]	Panel Overall Dimensions [mm]	Perforation template
Assembled	4 M4 screws	200 x 150	219 x 169	Attached to the manual
Separate	4 M4 screws	80 x 70	160 x 99	Attached to the manual

The CANBUS Universal Tool allows to display all the engine operating parameters.

- **Volts**: is the operating voltage of the battery in volts.
- **Trim**: is the position proportional to the trim inclination angle.

NOTE

The Trim location information is only available in applications that require the adjustment of the trim, such as the stern drive.

- **Oil Press**: is the engine oil pressure in bar or PSI.
- **Engine Hour**: is the total number of running hours of your marine engine.
- **Fuel Level e Fuel Left**: is the indication of the fuel level in the tank (it requires an additional sensor).
- **Water Press**: is the engine coolant pressure.
- **Fuel Used**: is the amount of fuel used since last reset of the instrument (it requires an additional sensor).
- **Trans Gear**: shows the current gear engaged in the transmission (it requires an additional sensor).
- **Trans Temp**: indicates the current oil temperature in the transmission (it requires an additional sensor).
- **Trans Press**: indicates the current oil pressure in the transmission (it requires an additional sensor).
- **Boost Press**: shows the current engine boost pressure (turbocharger boost pressure).
- **Throttle o Engine Load**: show the percentage relative to the position of the throttle.
- **Coolant Tmp**: shows the engine coolant temperature.
- **Water Level/Temp**: shows the level or the temperature of water in the optional tank (e.g.. household users, requires an additional sensor, and the speedometer tool).
- **Rudder Angle**: shows the rudder angle (it requires an additional sensor).
- **Speed**: shows the boat speed in knots or km/h (it requires an additional sensor, and the speedometer tool). Not compatible with the Air Temp measurement).
- **Air temp**: shows the air external temperature (it requires an additional sensor, and the speedometer tool). Not compatible with the speed measurement).

It is possible to add to the standard supply also one or more additional tools that allow you to view the following information with a needle:

Tool	Connection	Dimensions (in)	Hole diameter [mm]	Function shown	Order code
Master Speedometer	Master	5”	111.3 (4 3/8 in)	Engine revs (rpm)	4.049.086.1
		4”	85 (2 3/8 in)		4.049.082.1
Master Speedometer	-	4”	85 (2 3/8 in)	Speed (knots)	4.049.084.1
Trim	Slave	2”	52.4 (2 1/16 in)	angle	4.049.079.1
Battery	Slave	2”	52.4 (2 1/16 in)	voltage (volts)	4.049.078.1
Fuel level	Slave	2”	52.4 (2 1/16 in)	volume (litres)	4.049.076.1
Engine temperature	Slave	2”	52.4 (2 1/16 in)	temperature (°C)	4.049.075.1
Oil pressure	Slave	2”	52.4 (2 1/16 in)	pressure (bar)	4.049.077.1
Water level	Slave	2”	52.4 (2 1/16 in)	volume (litres)	4.049.080.1
Rudder angle	Slave	2”	52.4 (2 1/16 in)	angle	4.049.081.1

WARNING

For each instrument with slave connection in addition to the first, a Master-Slave connection cable code 1.010.117.1 (l = 30cm/12in) or code 1.010.119.1 (l = 100cm/39in) is required.

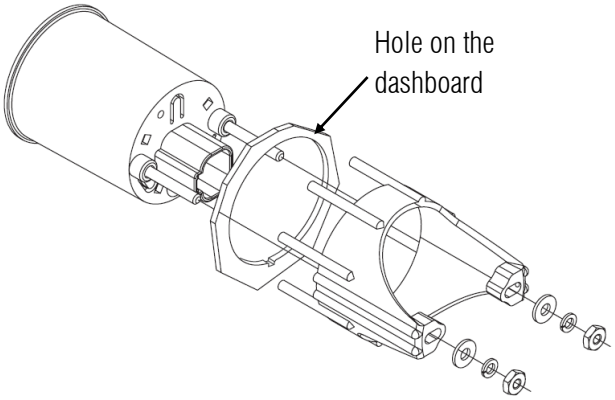


Figure 39- Instruments installation on the dashboard

Additional instruments are installed on the dashboard as in the image Figure 39. Refer to the table above for the hole size required for the installation of each instrument.

6.5.2 Panel wiring connectors

The CANBUS panel wiring is equipped with the following connectors:

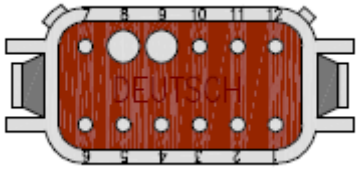


Figure 40 - Master Tachometer Connector (Tachometer - 9 pins connected)

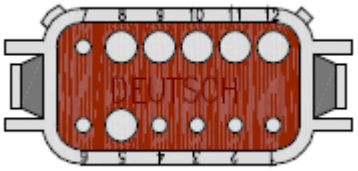


Figure 41 - Speedometer Connector (Speedometer - 6 pins connected)

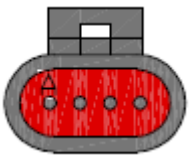


Figure 42 - First Slave Tool Connector (5 pins)

There is also a round connector (5 pin) that provides a direct connection to the engine control unit for monitoring the sensors detected through the standard J-1939:

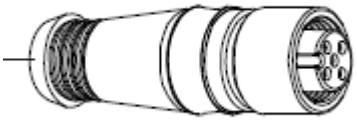


Figure 43 - MOLEX connector for NMEA2000 (5pin)

It is possible to use an optional adapter to convert this signal in the standard NMEA2000 to interface the engine with devices using this standard. See paragraph 8.5 – Maretron® NMEA2000 Control Unit on page 45.

All the wires of the panel start from the extension connector, that carries the electrical signals to and from the engine compartment:

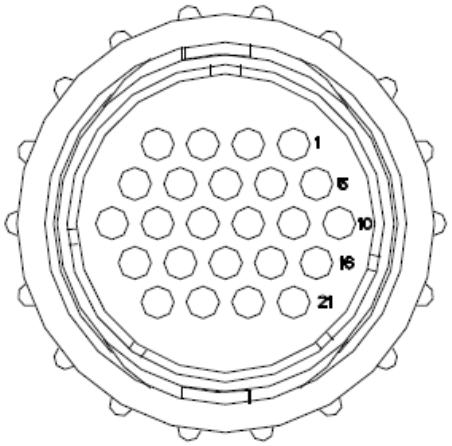


Figure 44 - TE® extension connector (24-pin) - Front View

The Pin map of the panel connector and extension cable is as follows:

Pin	Function	Colour	Connections	
			Instrument Panel Side	extension cable side
1	+ V Batt	Red	Pin 30 Key Lock	ECU
2	Starting Consent	Orange/Black	Pin 50a Key Lock	ECU
3	Panel on	Blue/Black	Pin 15/54 Key Lock	ECU
4	Ground	Black	Instruments	ECU
6	Fuel level	Pink	Instruments	Male "FUEL" Fastom
7	Trim angle	Orange/Blue	Instruments	Male "TRIM" Fastom
9	Glows plugs kit	Grey/Yellow	Glows plugs kit	ECU
14	Stern drive oil level alarm	Yellow/Blue	Drive Alarm Light	Male "STERN DRIVE" Fastom
15	Rudder angle	Red-Yellow	Instruments	Free End
16	Sea Water Temperature	Yellow	Instruments	Free End
17	Temp. Air/Paddlewheel	Orange	Instruments	Free End
19	CAN-	White	Instruments	ECU
20	CAN+	Red	Instruments	ECU
24	Stop	White-Red	Fastom not connected	ECU

6.6 Basic electrical connections

The engine is connected to the control unit, to the extension cable and to the instrument panel must be made as follows:

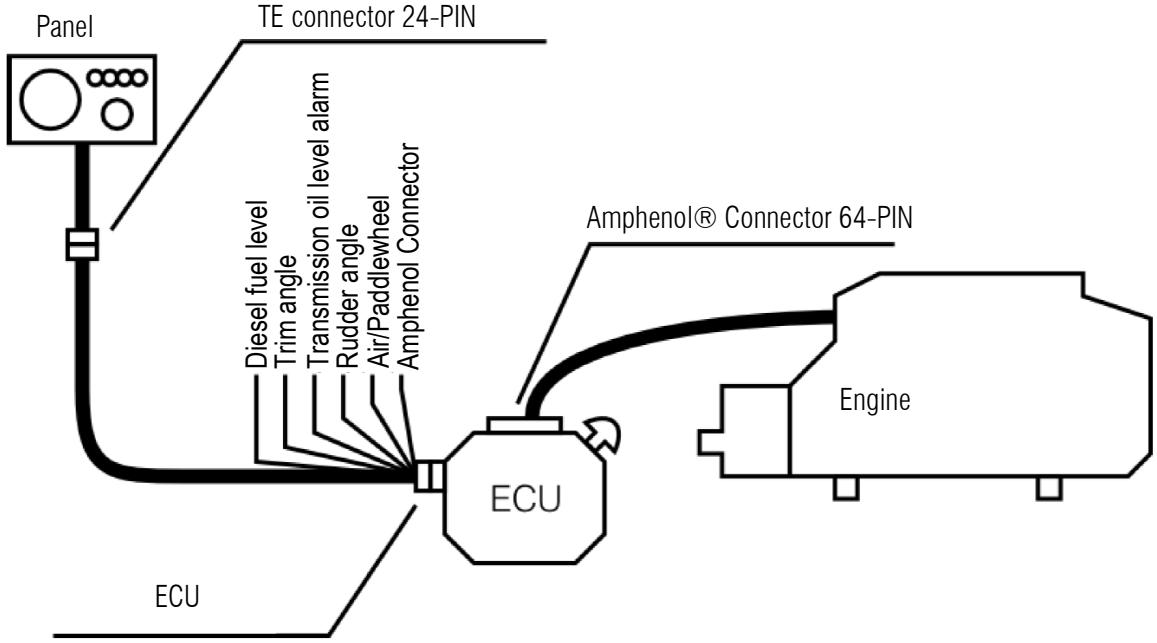


Figure 45- Basic electric connections wiring diagram for installations with single panel

1. Connect the Amphenol® rectangular 64-pin connector of the engine wiring to the control unit, ensuring that the locking clamps of the connector are in the locking position.
2. Connect the TE® round 24-pin connector of the extension cable from the control unit to the instrument panel. Make sure the lock nut is tightened. In the passage of the extension cable inside the boat, be careful to the direction of connection.
3. Connect the TE® round 24-pin connector of the extension cable to the control panel. Make sure the lock nut is tightened.
4. Use the extra wires near the extension cable connector inside the engine compartment to connect the related services, as described in the following paragraphs.

Do not use the lock key to take power signals in the vicinity of the instrument panel. The system cables are designed only for its intended use by CMD. Changes to the power supply system will void the warranty and can cause engine damage.

For the connection of electrical services not covered in this manual do not use the existing wires. Changes to the electrical wiring of any kind will void the warranty and can cause engine damage.

Changes to the electrical system may cause danger to users of the boat.

In the case of engines with fly-bridge system (double panel), carry out the elements connection as follows:

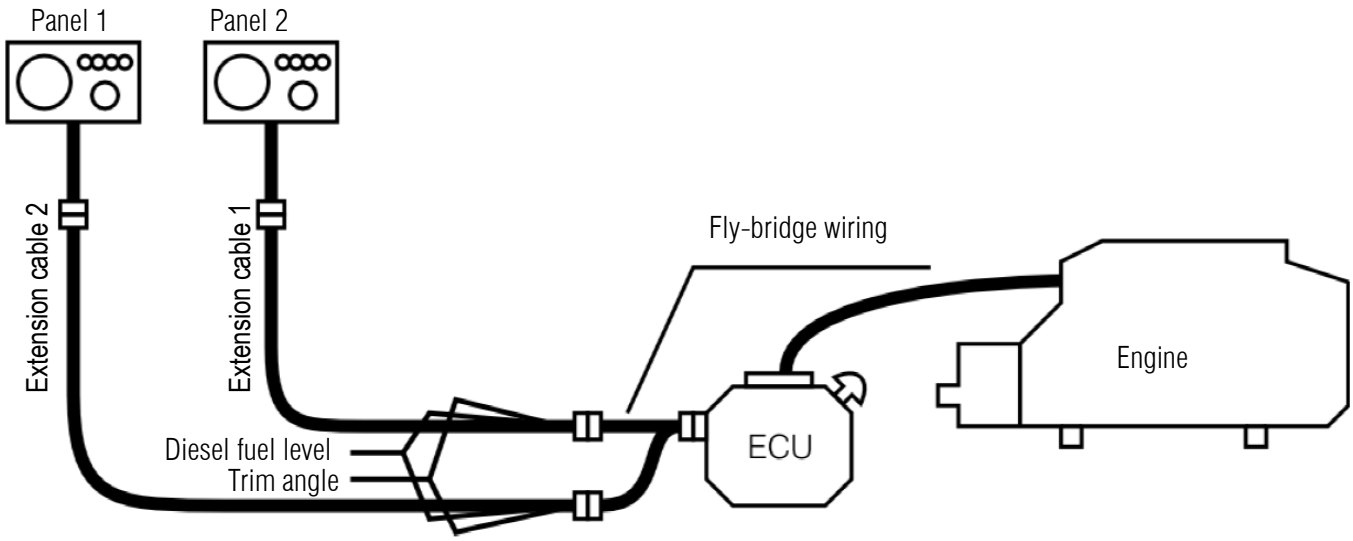


Figure 46- Basic electric connections wiring diagram for installations with double panel (flybridge)

In these cases, in addition to the connections specified above, it is necessary:

5. Connect the fly-bridge adapter (order code 1.010.079.1) immediately near the ECU and connect the two extensions on it using the TE® round 24pin connectors.
6. Combine with a junction every additional wire near the extension cable connectors for each device to be displayed on the two panels (e.g. fuel level or trim angle), as in figure sotto.

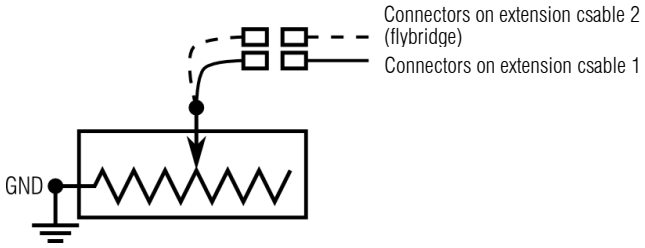


Figure 47- Connection of the device to the variable resistance (trim, fuel level) in fly-bridge systems.

The correct operation of the sensors, as well as the quality of the joints produced, also depends on the calibration of the instrument panels, as described in the following paragraphs.

6.7 Trim Circuit (if present)

The connections required to operate the trim are described below.

6.7.1 Trim angle sensor connection

The trim angle sensor must be connected:

1. Signal: connect the additional orange-blue wire labelled "TRIM SENDER" to the extension cable, near the ECU.
2. Ground: lead to a ground point of the electrical system, possibly near the battery.

In the case of Mercruiser Bravo® stern drive connect the sensor only to the instrument wiring, excluding other devices.

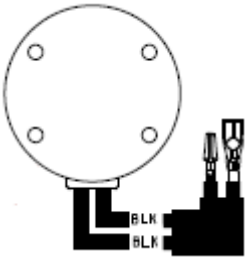


Figure 48 - "TRIM SENDER" Mercruiser Bravo® stern drive positioned to the right, equipped with a male and a female connector.

NOTE

Do not confuse the trim angle sensor, which shows on it the words "TRIM SENDER", with limit switches for the limit of the trim stroke, referred to as "LIMIT SWITCH"

Sensor Type	Order code
Trim+Limit Switch (for Mercruiser Bravo® stern drive)	4.024.001.1

For the proper operation of the trim sensor, perform all the operations indicated in chapter 6.9 – Calibration of trim and fuel level signals on the CANBUS instrument on page 37.

6.7.2 Connecting the trim/trailer control with Mercruiser® mechanical throttle

The connection of the trim/trailer control to the Mercruiser® mechanical throttle is not covered by this manual. For information on connecting, refer to the installation manuals of the drive and the Mercruiser® mechanical throttle.

The drive has a limit switch for the "LIMIT SWITCH" trim operation that must not be confused with the "TRIM SENDER" sensor. The limit switch, shoe in the following figure, is connected to the throttle to control the trim.

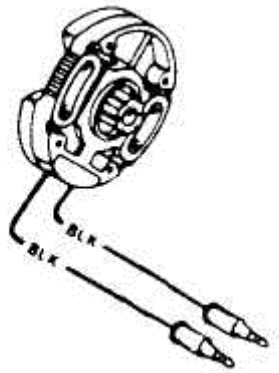


Figure 49 - Mercruiser Bravo® stern drive "LIMIT SWITCH" Trim positioned to the left, with two male connectors.

The order codes of the Mercruiser® throttle elements are the following:

Throttle type	Throttle order code	TRIM command electric cable
Single wall-mounted	2.018.308.1	2.018.311.1
Single on dashboard	2.018.341.1	
Double on dashboard	2.018.304.1	2.018.342.1
Only trim panel	-	1.049.017.1 (including panel)

6.7.3 Connecting the trim/trailer control with Flexball® electronic throttle

Use the prearranged cable contained in the box of the electronic throttle, and follow the guidelines on the Flexball® electronic throttle manufacturer's manual.

NOTE

In case of Mercruiser Bravo® stern drive, connect the LIMIT SWITCH of the drive, equipped with two round female fastom connectors to the throttle wiring.

6.8 Fuel level in the tank sensor (if present)

Connect the fuel level float as follows:

1. Signal: connect the additional pink wire labelled "FUEL LEVEL" on the extension cable, near the ECU.
2. Ground: lead to a ground point of the electrical system, possibly near the battery.

It is possible to use any type of resistive level sensor compatible with the EU (0 to 180Ω) or USA (240 ÷ 33Ω) standards.

Sensor Type	Order code	Sensor length
EU	4.049.029.1	Linear 404mm
EU	4.049.030.1	Linear 345mm
EU	4.049.031.1	With lever, adjustable
EU	4.049.033.1	Linear 498.5mm
EU	4.049.034.1	Linear 550mm

For proper calibration of the sensor follow the instructions in chapter 6.9 – Calibration of trim and fuel level signals on the CANBUS instrument .

6.9 Calibration of trim and fuel level signals on the CANBUS instrument

To obtain the correct functioning of the trim and fuel level sensor, it is necessary to follow these configuration guidelines for each instrument panel connected. To navigate the panel settings follow the information on the user manual of the instrument.

NOTE

Press the up and down arrows to move through the screens, press MENU quickly to cancel and hold MENU long to confirm.

1. Turn on the panel
2. Access the **MODIF MENU**, then select **ORIGIN. DATA**, **TANKS**, **T1:FUEL**.
3. Select the type of sensor: **US 240-33** or **EU 10-180**.
4. Select the analogue signal input on pin 3 of the connector 1: **AI#3 P1-8**
5. Exit the menu
6. Access the **MODIF MENU**, then select **ORIGIN. DATI**, **TRIM**, **SENSOR**.
7. Select **ANALOG.**
8. Turn off the panel.

At this point the two instruments are working properly.

WARNING

The selection of the fuel sensor settings is required for the proper operation of the trim even if no fuel sensor is connected.

Before setting the sensors with this procedure, and if some instrument configurations hinder the proper operation it is possible to make a **MASTER RESET** from the **SYSTEM** menu to return the instrument to the factory settings. In this case, at the engine selection request it is necessary to indicate **GENERIC**.

WARNING

The calibration procedure that follows is mandatory for fly-bridge installations. During the procedure make sure that systems are connected as in Figure 46 sopra and that on both panels the instruments are turned on.

For installations with double panel (fly-bridge) and junctions on the two extension cables, or if at the end of the procedure, even after a MASTER RESET, the sensors do not work, it is possible to make a detailed calibration of the trim and diesel sensors. Follow this procedure for the TRIM sensor:

9. Enter the ORIGIN menu. DATA, and then select TRIM and CAL SENDER.
10. Move your foot in the lowest position (ALL DOWN), then press MODE for more than 1 second.
11. Move your foot in the highest position (ALL UP), then press MODE for more than 1 second.
12. The system confirms with SETTINGS SAVED and a BEEP.

Follow this procedure for the fuel sensor:

13. Enter the SETUP FUEL menu , then select CAL SENDER.
14. Choose the calibration mode: 2, 3 or 5 points.
15. For each point on the mode selected (in 3 points every half tank is calibrated, in 5 points in every quarter), move the sensor to the desired position, then press MODE for more than one second.
16. The system confirms with SETTINGS SAVED and a BEEP.
17. For fly-bridge installations repeat the procedure on the second panel .

6.10 Transmission oil level alarm (if present)

Connect the transmission oil level alarm switch as follows:

1. Signal: connect the additional yellow-blue wire labelled "GEAR OIL" on the extension cable, near the ECU.
2. Ground: lead to a ground point of the electrical system, possibly near the battery.

WARNING

The transmission oil level alarm is connected to the panel at a red signal LED and is powered at 12V. Test the alarm before proceeding with the installation. The alarm failure may cause malfunction of the transmission.

6.11 Rudder angle sensor (if present)

The rudder angle sensor must be connected as follows:

1. Signal: connect the additional red-yellow wire labelled "AUX" on the extension cable, near the ECU.
2. Ground: lead to a ground point of the electrical system, possibly near the battery.

For the selection of the sensor and the calibration procedure, refer to the CANBUS instrument manual .

6.12 GPS sensor (if present)

It is possible to connect a GPS sensor to digital signal, compliant with NMEA 0183, coming from a special antenna or a GPS cartographer, to measure the speed.

The sensor is connected using a 6-pin connector (DEUTSCH DT06-6S, not supplied) as shown in the figure sotto .

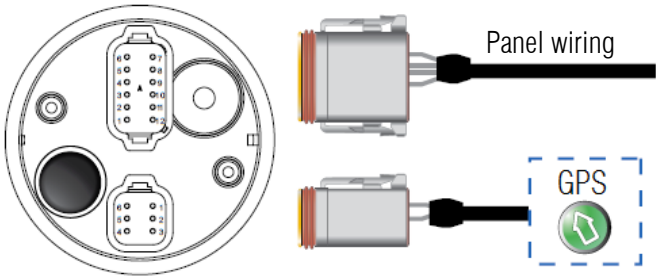


Figure 50 - GPS signal connection to the digital instrument.

Connect the sensor as follows:

1. Signal (NMEA 0183-A): connect to PIN 3 of the auxiliary connector behind the speedometer.
2. Ground (NMEA 0183-B): connect to PIN 4 of the auxiliary connector behind the speedometer. In addition lead this pin to a ground point of the panel wiring.

For the selection of the sensor and the calibration procedure, refer to the CANBUS instrument manual .

Sensor Type	Order code	Cable length
GPS antenna NMEA0183	4.049.088.1	15m

6.13 Other sensors and auxiliary cables

Connect the other sensors as follows:

6.13.1 Water temperature sensor (if present)

NOTE This additional sensor works only with the additional speedometer instrument installed on the panel.

Connect the sensor as follows:

1. Signal: connect the additional yellow wire labelled as "RAW WATER TEMP" on the extension cable, near the ECU.
2. Ground: lead to a ground point of the electrical system, possibly near the battery.

6.13.2 Air temperature or paddlewheel sensor (if present)

NOTE These additional sensors work only with the additional speedometer instrument.

NOTE It is not possible to install both sensors simultaneously, since they are using the same channel.

Connect one of the sensors as follows:

1. Signal: connect the additional orange wire labelled "AIR TEMP/PADDLE WHEEL" on the extension cable, near the ECU.
2. Ground: lead to a ground point of the electrical system, possibly near the battery.

6.13.3 Sensors not covered by this manual

The sensors not covered by this manual should not be connected using electric cables of the extension cable, of the panel or the engine.

DANGER **Changes to the electrical system may cause danger to users of the boat.**

For other connection options offered by the instruments, refer to the instrument manual supplied with the engine.

6.14 Emergency stop switch (if present)

The emergency switch is interposed between the pin 15/54 of the key lock and the positive connecting cable in the starter key (pin 3) as in the following image:

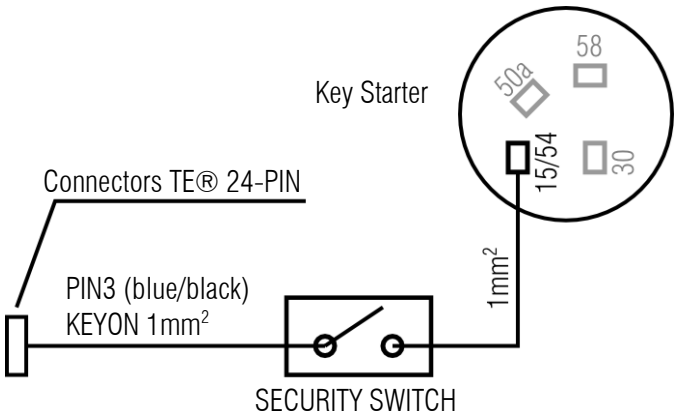


Figure 51- Installation diagram of single engine emergency switch

In the case of twin installations, follow the diagram below:

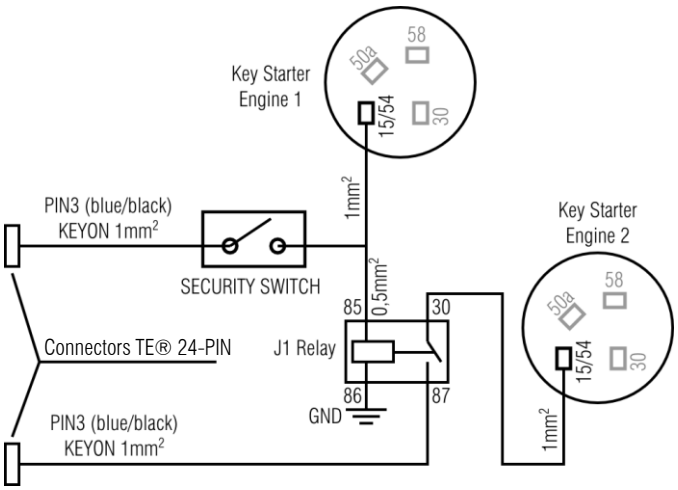


Figure 52- Installation diagram of twin engine emergency switch

Connect the switch to a relay 12V/10A (type: J1 Relay 12V/10A/NO) normally open, as in the diagram of the image above.

Check the proper operation of emergency switch: pressing the switch (or removing the plug for models with strap), the engine must shut down immediately.

DANGER

Always check the correct operation of the switch as its malfunction can cause harm to people.

6.15 Electronic throttles electrical connection

For the electrical connection of the electronic throttle, including Flexball®, check the following:

1. The ground of the electronic throttle system must match the ground of the electric engine. The HPE engines are electronic control engines whose control unit (ECU) reads the throttle signal as voltage signal referred to the engine ground.

DANGER

If the electronic control system does not correspond to the engine size it can lead to uncontrolled accelerations and not to the general operation of the throttle function, causing a serious hazard for the occupants of the boat.

2. The positive power supply cable of the throttle must never be directed to the battery or to the positive cable of the ignition key. It is always necessary to use a relay connected to the ignition key consent to power the electronic throttle. Failure to comply with this condition may cause the following conditions:

DANGER

With the ignition panel off and the gear lever set the gear could remain engaged. At the next power on there is the risk of starting the engine with gear engaged, creating serious danger to people's health.

WARNING

With the ignition panel off the lever remains active, consuming the engine battery power.

7 First power on and sea trial

After installation of the engine in the engine compartment it is necessary to make the first start up and the sea trial to check the operation of all the parameters.

The checks of this paragraph ensure the customer the engine safety and reliability. They must be made in good time before the delivery of the engine to the customer, so to have time to make the necessary adjustments or repairs.

Some of the checks to be made at this stage can be made dry; in this case it is necessary to remove the propeller from the lineshaft and make sure that the engine is able to intake and discharge water in the sea water circuit.

Do not run the engine dry at speeds exceeding 1500rpm. Be sure to monitor the refrigerant circuit temperature.

Remove the propeller during the engine dry ignition.

In the case of dry ignitions, ensure the inflow of water to the engine intake. Failure to comply with this warning may lead to malfunction and engine failure.

7.1 Preliminary checks

Before the first starting, make sure that:

1. The refrigerant circuit of the engine is full. In case of top-ups, only use mixtures of water and refrigerant additive as described in the Service Bulletin 01-2013 - Coolant liquid mixture maintenance.
2. The engine is filled with oil not beyond the maximum level allowed and not below the minimum level. The oil level check must be carried out within the angle specified in chapter 3.6 - Installation angles on page 13.
3. All sea water connections are connected correctly and that the valves are open.
4. The LEDs on the unit all work when the key is turned to position 1.
5. There are no leaks of any fluid inside the engine compartment.

7.2 Sea trial and Installation Form filling in

The sea trial and the Installation Form filling in is mandatory before the delivery of the boat to the customer.

Fill in the installation form **in its entirety**.

Once you have filled in all its parts, a copy of the form must be given to the customer and owner of the boat and sent to CMD, as indicated in chapter 1.3 - Warranty information on page 1.

Failure to complete in all its parts, or not sending the installation form will void the engine warranty.

Carry out the following operations:

1. Fill in the "Owner Information" section with the information on the installer and the owner of the engine in all its parts, including contact details.
2. Enter the technical data regarding the type of boat in the "Vessel" section.
3. Enter the technical data relating to the type of engine installed (specifying the side for twin installations). Pay special attention when entering the registration numbers of engine and transmission, the propeller data and the presence of loads on the additional pulley.
4. Fill out the "Engine compartment" section specifying how the alignment was performed, the type of vibration dampers installed and the engine installation angles. Indicate the number and size of the suction openings. Indicate that the throttle stroke has been verified.

Check with the diagnostic tool (or with the digital speedometer - LOAD/UNLOAD function) that the potentiometer makes the full stroke.

5. Fill out the "Services" section indicating the specifications of systems made, the presence of all the filters and fittings installed on them.
6. Carry out the sea trial. For the successful completion of the trial, it is necessary to use the EDR diagnostic tool.

Engines	EDR Diagnosis Tool Order Code
HPE	7.104.401.1

Prior to the sea trial eliminate the errors with the EDR.

When you first turn the engine control unit it can have inside stored errors due to the connection/disconnection of devices or sensors during installation. Always clear any errors before the first sea trial.

Save with the diagnosis software the following parameters: RPM, LOAD, ENGINE TEMPERATURE and COMPRESSOR PRESSURE. Record simultaneously with an external tool the INTAKE AIR and the DISCHARGE BACKPRESSURE .

While navigating, move the throttle load until reaching every point included in the list of the "Sea trial" section, then specify the parameters recorded by the EDR and by the other instruments.

Also indicate the maximum performance obtained during the trial.

7. Complete the "Conclusions and approval" part in its entirety, by inserting the comments in the "Notes" field. In this phase, it is necessary to:
    a. Show the customer all the contents of this handbook with the engine.
    b. Inform them of safety regulations.
    c. Explain the use of the engine.
    d. Inform the customer about the presence and operation of the emergency stop button.
    e. Inform the customer about the control unit fuses.
    f. Explain the Limited Warranty terms.
    g. Inform the customer about his responsibilities.
    h. Sign and make the customer sign the document. Place the installer stamp on the front part.

When the form is compiled, send it to CMD.

8 Accessories

8.1 Heating Kit (Boiler)

The kit boiler allows the extraction of a part of the cooling liquid to feed, with the heat produced by the engine, an external thermal device.

The kit varies depending on the engine model. Even the sampling points and the re-entry of the cooling liquid extracted depend on the model of the engine.

Engine	Heating Kit order code	Connection diagram
HPE 40S/80/80SD/ 110/110JD	3.900.319.1	Figure 53
HPE 40/150/150JD/170/ 170JD/190/190JD	3.900.180.1	Figure 56
HPE 225/225JD	3.900.131.1	Figure 56
HPE 100/250/250JD/250H	3.900.163.1	Figure 56
HPE 300	3.900.327.1	Figure 59
HPEL 45/80	3.900.319.1	Figure 53
HPEL 65/90	3.900.180.1	Figure 56

The diameter of the heating pipes is 16 mm (5/8 in). All elements of the heating circuit must withstand temperatures up to 130°C and pressures up to 3 bar.

WARNING

Follow the diagrams shown. Do not change the fittings size or location as this will damage the engine.

WARNING

Make sure that the heating fitting is with closed circuit and there is no leakage of coolant. Check the correct operation of the system.

In the heating kit installation it is always required to add two valves in correspondence of the sampling points (flow) and return (re-entry) in the circuit for isolating, where necessary, the heater and facilitate maintenance operations.

When connecting the heating kit it is necessary to restore the coolant level in the tank to compensate the volume of liquid which is absorbed by the heater circuit.

It is also necessary to bleed the circuit to ensure the absence of air.

After installation, check the correct operation of the kit and that the engine performance is maintained. Check the coolant level in the tank and check for leaks.

DANGER

The engine operation with low coolant level quickly leads to overheating, causing damage to the seals and internal parts of the engine.

Follow the instructions in the following paragraphs for the correct installation of the heating kit.

8.1.1 Engine family 1.3 HPE

To connect the kit follow the diagram below:

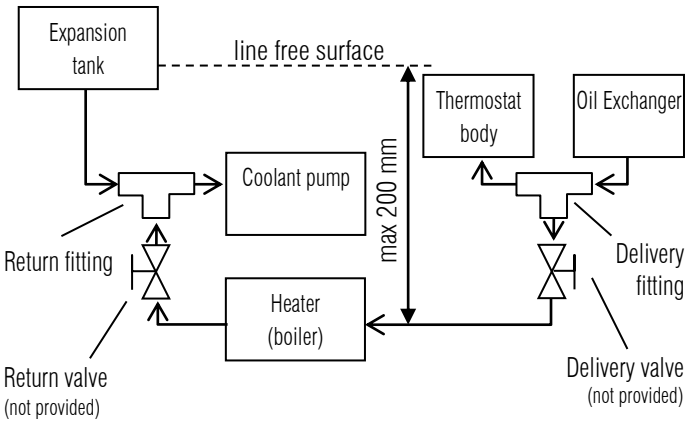


Figure 53 - Wiring diagram for heating kit on 1.3 HPE base engine

Insert the three-way delivery fitting cutting the sleeve between the thermostat and oil cooler in the point shown in the following image:

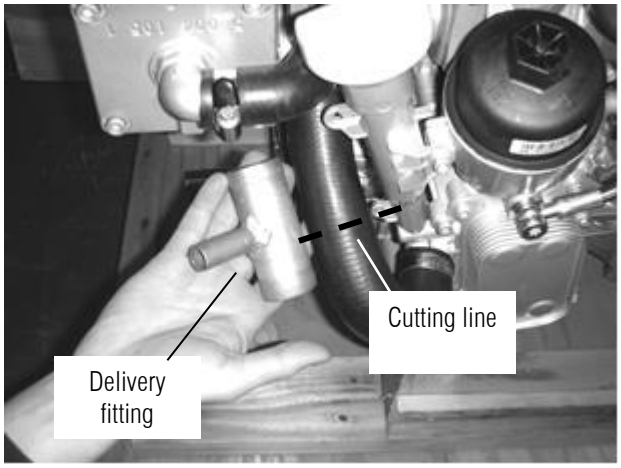


Figure 54- Sleeve to be cut to connect the boiler kit delivery connection on 1.3 HPE base engines.

Connect the two halves of the cut sleeve at the ends of the 32 mm (1 ¼ in) diameter fitting , and then connect the input of the heater circuit at the 16 mm (5/8 in) diameter end.

Insert the three-way return fitting cutting in half the sleeve between the expansion tank and the coolant pump as in the following figure:

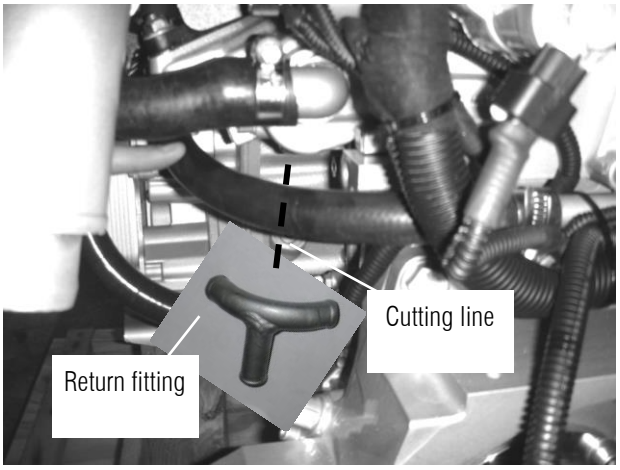


Figure 55 - Sleeve to be cut to connect the boiler kit return connection on 1.3 HPE base engines.

The return connection is oriented as in the Figure 55. Connect the 16 mm (8.5 in) diameter aligned ends to the cut sleeve. Connect the 16 mm (8.5 in) diameter free end to the output of the circuit heater.

Use cable clamps provided with the kit to attach the sleeves to the fittings.

8.1.2 Engine family 1.9 and 2.4 HPE

To connect the kit follow the diagram below:

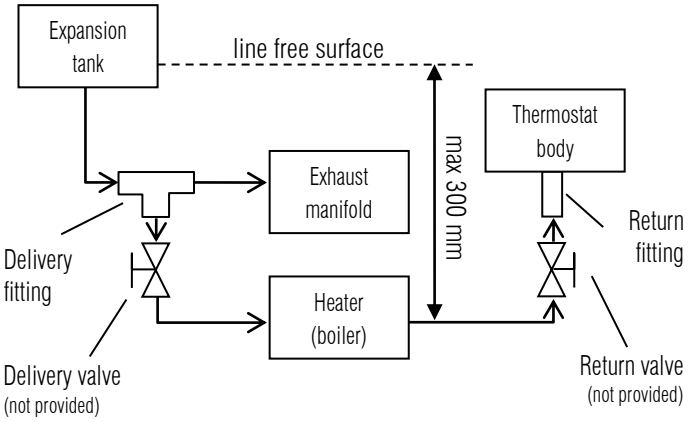


Figure 56- Wiring diagram for heating kit on 1.9 and 2.4 HPE base engine

Insert the three-way delivery fitting cutting the sleeve between the expansion tank and the exhaust manifold at the point indicated in the figure.

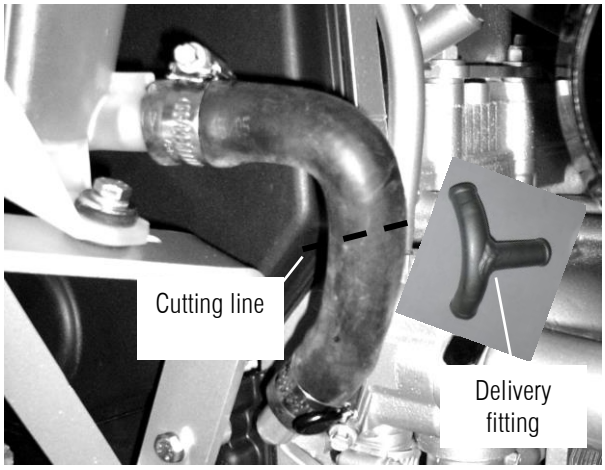


Figure 57 - Sleeve to be cut to connect the boiler kit return connection on 1.9 and 2.4 HPE base engines.

The delivery connection is oriented as in the image of Figure 57 . Connect the 16 mm (8.5 in) diameter aligned ends to the cut sleeve. Connect the 16 mm (8.5 in) diameter free end to the heater circuit input.

Screw the return fitting in place of the dowel M6x1.5 on the thermostat body, the point shown in the following image:

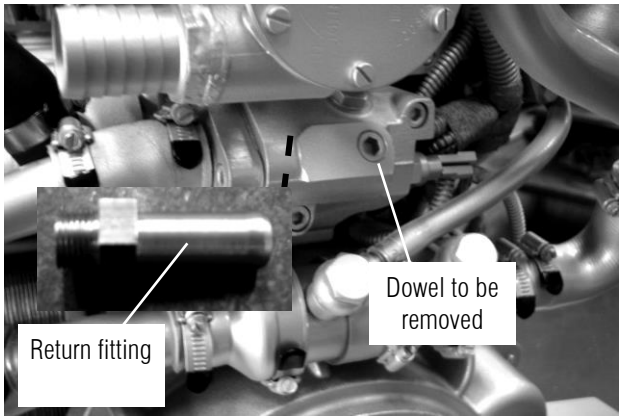


Figure 58- Installation point of the boiler kit return connection on 1.9 and 2.4 HPE base engines.

Connect the 16 mm (5/8 in) diameter fitting to the heater output circuit .

Use cable clamps provided with the kit to attach the sleeves to the fittings.

8.1.3 Engine family 3.0 HPE

To connect the kit follow the diagram below:

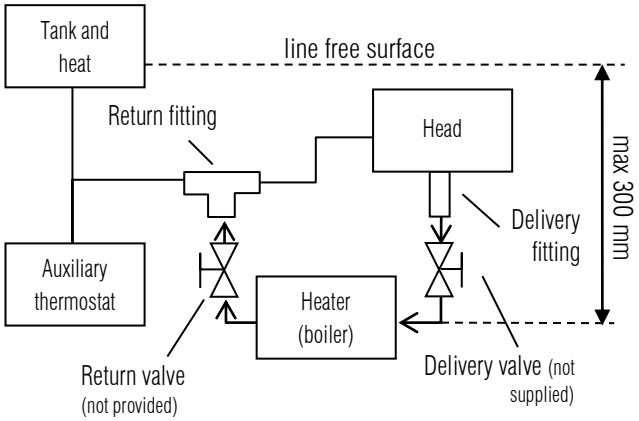


Figure 59 - Wiring diagram for heating kit on 3.0 HPE base engine

Screw the flow connection on the head, near the cooling water temperature sensor, removing the nut M16x1.25 in the point shown in the following image:

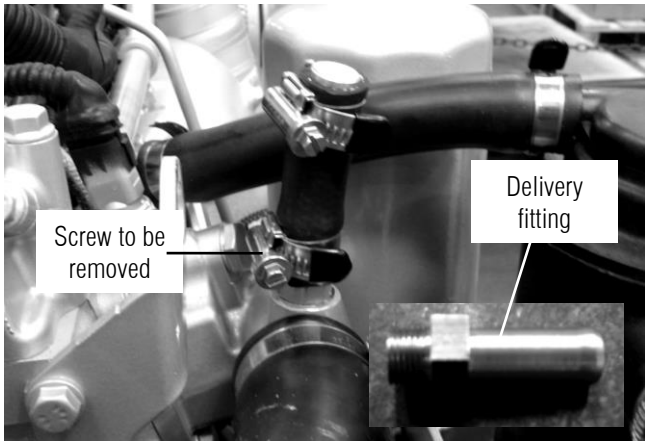


Figure 60 - Installation point of the boiler kit delivery connection on 3.0 HPE base engines.

Connect the 16 mm (5/8 in) diameter fitting to the heater input circuit .

Insert the three-way return fitting cutting the sleeve between the head and the connection pipe between the expansion tank and auxiliary thermostat as shown in the following image:

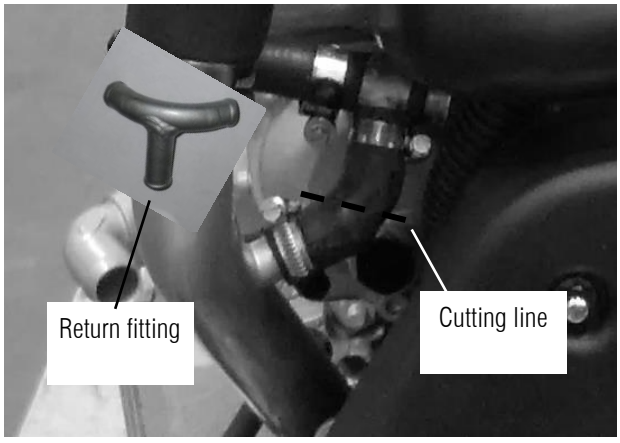


Figure 61 - Installation point of the boiler kit return connection on 3.0 HPE base engines.

Connect the two halves of the sleeve cut at the ends of the connector while preserving the orientation shown in Figure 61 Connect the free end of the16 mm (8.5 in) diameter fitting to the heating circuit output .

Use cable clamps provided with the kit to attach the sleeves to the fittings.

8.2 Accessories Additional Pulley (PTO)

The engines of the HPE range may be prearranged with an additional power take-off on the engine shaft. This possibility involves the installation of an additional pulley for trapezoidal toothed belts with one or more grooves.

Engine	Additional Pulley order code
1.3 HPE	already supplied with engine
1.9 HPE	3.017.016.1
2.4 HPE	with adapter 3.105.222.1
3.0 HPE	3.017.052.1

The pulley coupling with the accessory device must be correctly sized. The technical features of the additional pulley vary depending on the model of the engine and are expressed in the following table:

Engine	Number and Type of Additional Grooves	Rated diameter [mm]
1.3 HPE	1 x V-Belt Sect. SPB DIN 2211	125 (4 15/16 in)
1.9 HPE	2 x V-Belt Sect. A ISO R52-253	100 (3 15/16 in)
2.4 HPE		
3.0 HPE	1 x V-Belt Sect. Z/SPZ ISO 4183:95	80 (3 5/32 in)

During the installation it is necessary to check:

1. The maximum power which can be transmitted through the pulley

Engine	Maximum Power @1000 rpm	Maximum Power @ 2000 rpm	Maximum Power Anytime	Maximum radial force given by tensioning	Maximum tension force P	Maximum misalignment allowed
1.3 HPE	-	-	≤3 kw	-	15 N	α = 0.5° (β ~ 8mm/m*)
1.9 HPE	-	-	≤3 kw	-	15 N	
2.4 HPE	-	-	≤3 kw	-	15 N	
3.0 HPE	≤1 kw	≤1 kw	-	400 N	-	

*: mm of misalignment between the pulleys on the distance between the shafts:

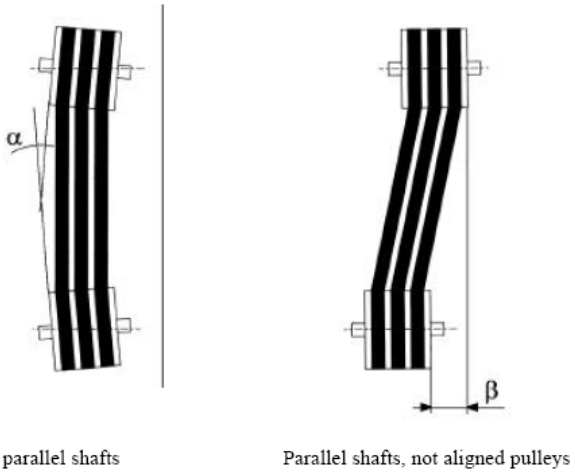


Figure 62 - Belt angles for auxiliary power take-off use

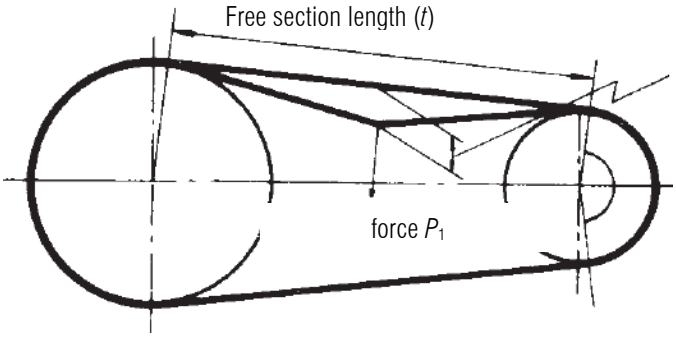


Figure 63 - Tensioning force P for the auxiliary belt

2. Transmission ratio
3. The alignment angles (Figure sopra) and the tensioning mode (Figure sopra).
4. The correct belt tensioning, according to the above table.

8.3 Additional Alternator

Is possible to combine an additional alternator to the engine that uses the use accessories additional pulley (see chapter 8.2 sopra).

Engine	Additional Alternator Order Code
1.3 HPE	3.900.316.1

For installation of the alternator follow the instructions in the accompanying manual.

8.4 Insulated Pole Kit

The insulated pole kit is a kit that allows the engine installation on metal-hulled vessels, separating the engine ground from the electrical system ground.

Engine	Isolated Pole Kit order code
1.3 HPE	3.900.378.1

To install the kit, follow the instructions in the attached manual.

WARNING

Install the engine as described in this manual, but do not connect the battery ground to the engine block, but to the isolated kit node.

WARNING

The ECU casing is grounded electrically, so it must be isolated from the boat during the installation.

8.5 Maretron® NMEA2000 Control Unit

The Maretron® NMEA2000 Control Unit is used to provide the signal to send the engine operating data to the integrated marine systems adopting the standard. The kit can be used on all engines in the HPE range.

Engine	NMEA Kit order code
Single Engine	3.900.392.1
Twin Engine	3.900.393.1

The kit contains all the necessary for connecting the NMEA control unit to the panel wiring , using the dedicated connector. To install the kit, follow the instructions in the attached manual.

8.6 Extension Kit

The extension kit is optional for engines connected to Mercruiser® and allows to remove the engine from the boat transom frame.

Engine	NMEA Kit order code
1.9/2.4/3.0HPE	3.900.369.1 (to be used in the engine order phase)

To install the kit, follow the instructions enclosed.

8.7 Mercathode® Control Unit

The Mercathode® control unit is not the subject of this manual.

Engine	Mercathode® Kit order code
1.9/2.4/3.0HPEP	3.900.264.1

The control unit can be installed on all Mercruiser® stern drives to mitigate galvanic corrosion.

To install the control unit follow the instructions in the attached manual.

9 Annexes

Annexes list (in electronic format):

1. Perforation template *1.049.067.1* – Assembled CANBUS Instrument Panel
2. Perforation template *1.049.068.1* – Separate 5” CANBUS Instrument Panel.
3. Perforation template *1.049.069.1* – Separate 4” CANBUS Instrument Panel.
4. *CMD Model 1408.02* – Installation Form

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