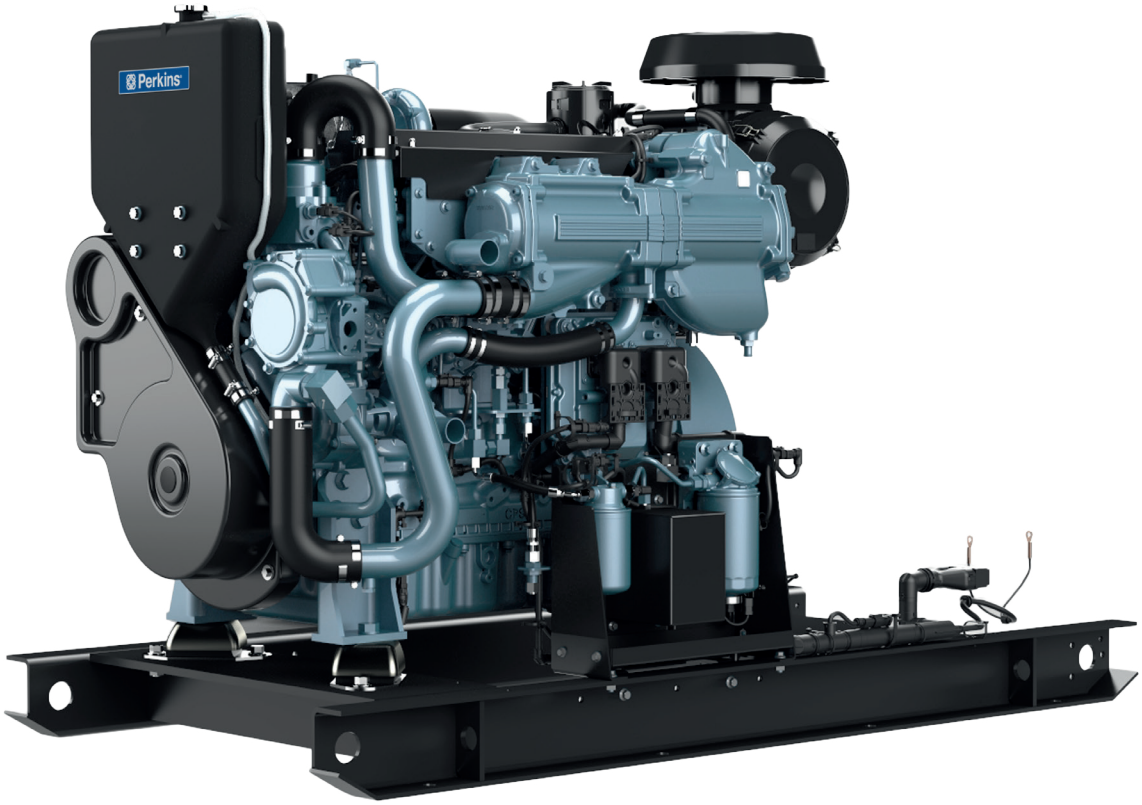
Part No 451-1172

GB

Perkins®

# User's Handbook & Installation Information




## E70M Marine Auxiliary Engine

Perkins®

THE HEART OF EVERY GREAT MACHINE

# Perkins E70M Marine Auxiliary Engine User's Handbook & Installation Information

## 6 cylinder, turbocharged, aftercooled, diesel engine for marine auxiliary applications

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# Foreword

Thank you for purchasing the Perkins E70M marine diesel engine. This manual contains information for the correct installation, operation and maintenance of your Perkins engine.

Information contained in this manual is correct at the time of printing. Perkins Marine reserves the right to make changes at any time. If there are any differences between this manual and your engine, please contact Perkins Marine.

## General safety precautions

These safety precautions are important. You must refer also to the local regulations in the country of use. Some items only refer to specific applications.

- Only use these engines in the type of application for which they have been designed.
- Do not run the engine with the top cover removed.
- Do not change the specification of the engine.
- It is important to maintain extreme cleanliness when working on the fuel system, since even tiny particles can cause engine or fuel system problems.
- Do not smoke when you put fuel in the tank.
- Clean away fuel which has been spilt. Material which has been contaminated by fuel must be moved to a safe place.
- Do not put fuel in the tank while the engine runs (unless it is absolutely necessary).
- Do not clean, add lubricating oil, or adjust the engine while it runs (unless you have had the correct training; even then extreme care must be used to prevent injury).
- Do not make adjustments that you do not understand.
- Ensure that the engine does not run in a location where it can cause a concentration of toxic emissions.
- Other persons must be kept at a safe distance while the engine, auxiliary equipment or boat is in operation.
- Do not permit loose clothing or long hair near moving parts.
- Keep away from moving parts during engine operation.

**⚠ WARNING**

**Some moving parts cannot be seen clearly while the engine runs.**

- Do not operate the engine if a safety guard has been removed.
- Do not remove the filler cap or any component of the cooling system while the engine is hot and while the coolant is under pressure, because dangerous hot coolant can be discharged.
- Do not use salt water or any other coolant which can cause corrosion in the closed circuit of the cooling system.
- Do not allow sparks or fire near the batteries (especially when the batteries are on charge) because the gases from the electrolyte are highly flammable. The battery fluid is dangerous to the skin and especially to the eyes.
- Disconnect the battery terminals before a repair is made to the electrical system.
- Ensure that the engine is operated only from the control panel or from the operators position.
- If your skin comes into contact with high-pressure fuel, obtain medical assistance immediately.
- Diesel fuel and lubricating oil (especially used lubricating oil) can damage the skin of certain persons. Protect your hands with gloves or a special solution to protect the skin.
- Do not wear clothing which is contaminated by lubricating oil. Do not put material which is contaminated with oil into the pockets of clothing.
- Discard used lubricating oil in accordance with local regulations to prevent contamination.
- Use extreme care if emergency repairs must be made at sea or in adverse conditions.
- The combustible material of some components of the engine (for example certain seals) can become extremely dangerous if it is burned. Never allow this burnt material to come into contact with the skin or with the eyes.
- Always close the seacock before the removal of any component of the auxiliary water circuit.
- Wear a face mask if the glass fibre cover of the turbocharger/dry exhaust system is to be removed or fitted.
- Always use a safety cage to protect the operator when a component is to be pressure tested in a container of water. Fit safety wires to secure the plugs which seal the hose connections of a component which is to be pressure tested.
- Do not allow compressed air to contact your skin. If compressed air enters your skin, obtain medical help immediately.

# Important Safety Information

Most accidents that involve product operation, maintenance and repair are caused by failure to observe basic safety rules or precautions. An accident can often be avoided by recognizing potentially hazardous situations before an accident occurs. A person must be alert to potential hazards, including human factors that can affect safety. This person should also have the necessary training, skills and tools to perform these functions properly.

**Improper operation, lubrication, maintenance or repair of this product can be dangerous and could result in injury or death.**

**Do not operate or perform any lubrication, maintenance or repair on this product, until you verify that you are authorized to perform this work, and have read and understood the operation, lubrication, maintenance and repair information.**

Safety precautions and warnings are provided in this manual and on the product. If these hazard warnings are not heeded, bodily injury or death could occur to you or to other persons.

The hazards are identified by the “Safety Alert Symbol” and followed by a “Signal Word” such as , “WARNING”, “Caution”, or ‘‘Note’’. The Safety Alert “WARNING” label is shown below.

**⚠ WARNING**

The meaning of this safety alert symbol is as follows:

**Attention! Become Alert! Your Safety is Involved.**

The message that appears under the warning explains the hazard and can be either written or pictorially presented.

A non-exhaustive list of operations that may cause product damage are identified by “NOTICE” labels on the product and in this publication.

**Perkins cannot anticipate every possible circumstance that might involve a potential hazard. The warnings in this publication and on the product are, therefore, not all inclusive. You must not use this product in any manner different from that considered by this manual without first satisfying yourself that you have considered all safety rules and precautions applicable to the operation of the product in the location of use, including site-specific rules and precautions applicable to the work site. If a tool, procedure, work method or operating technique that is not specifically recommended by Perkins is used, you must satisfy yourself that it is safe for you and for others. You should also ensure that you are authorized to perform this work, and that the product will not be damaged or become unsafe by the operation, lubrication, maintenance or repair procedures that you intend to use.**

**⚠ WARNING**

**When replacement parts are required for this product Perkins recommends using Perkins replacement parts.**

**Failure to follow this warning may lead to premature failures, product damage, personal injury or death.**

The information, specifications, and illustrations in this publication are on the basis of information that was available at the time that the publication was written. The specifications, torques, pressures, measurements, adjustments, illustrations, and other items can change at any time. These changes can affect the service that is given to the product. Obtain the complete and most current information before you start any job. Perkins dealers have the most current information available.

**In the United States, the maintenance, replacement, or repair of the emission control devices and systems may be performed by any repair establishment or individual of the owner’s choosing.**

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# User’s Information

# 1. Engine Views

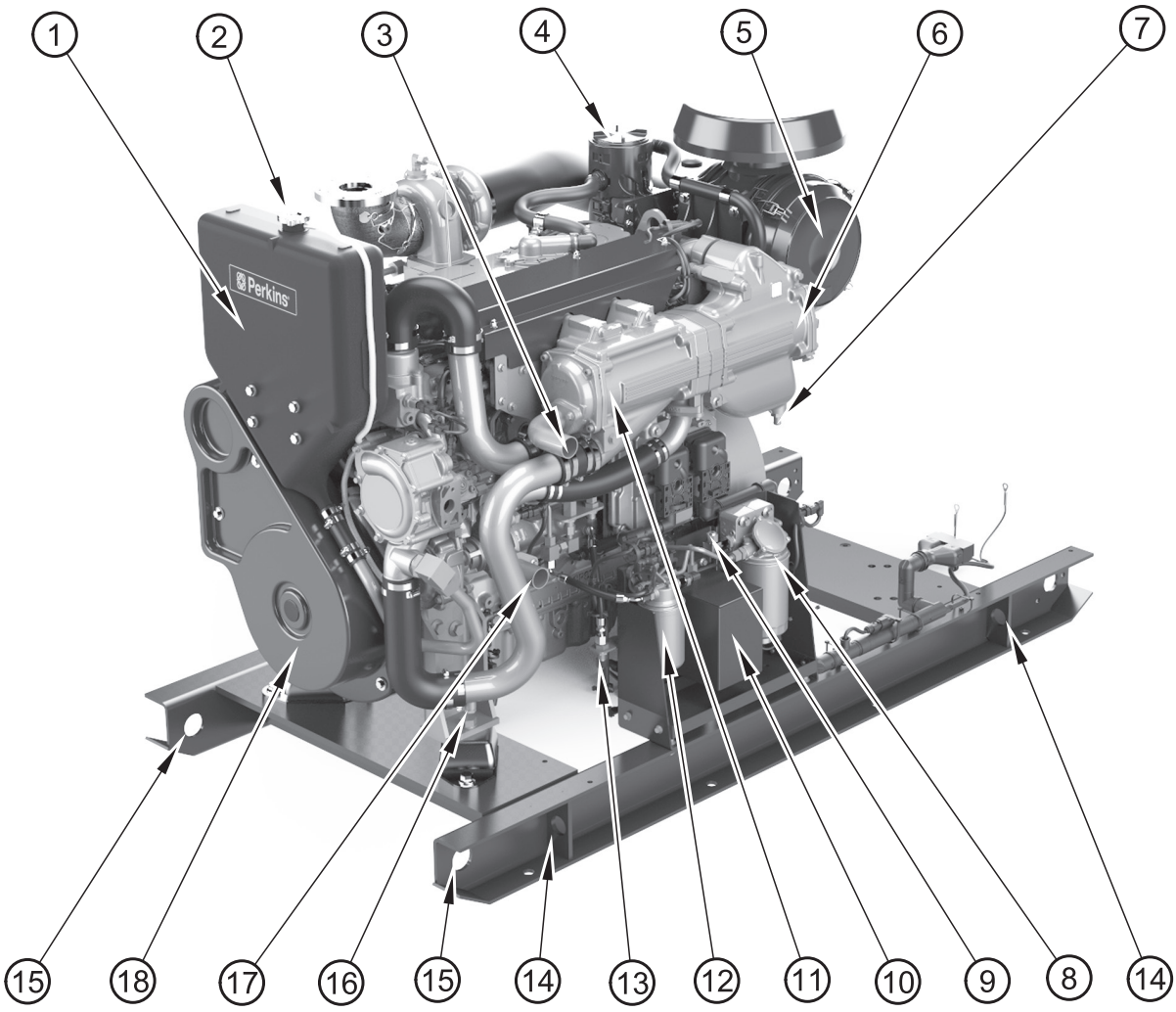
## Introduction

Perkins engines are built for specific applications and the views which follow may not necessarily match your engine specification.

## Location of engine parts

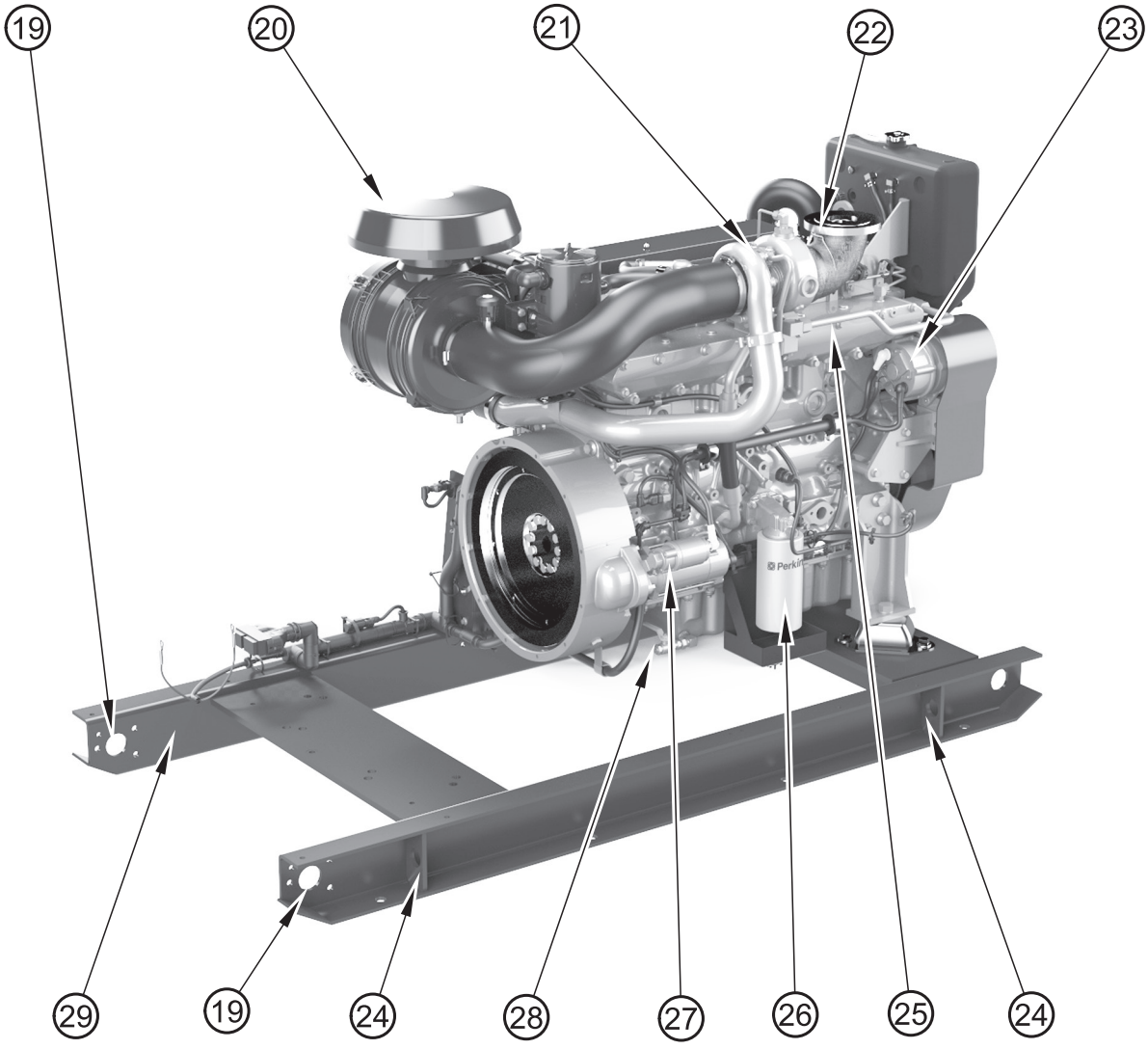
**Front and right side view**

1. Header tank
2. Coolant filler cap
3. Raw water outlet
4. Engine crankcase breather
5. Air cleaner canister
6. Aftercooler
7. Aftercooler condensation drain
8. Primary fuel filter
9. Fuel inlet
10. Fuel lift pump cover
11. Heat exchanger
12. Secondary fuel filters
13. Fuel outlet
14. Lifting point for entire auxiliary package
15. Drag holes only (not for lifting engine package)
16. Fresh water drain
17. Raw water intake
18. Belt cover

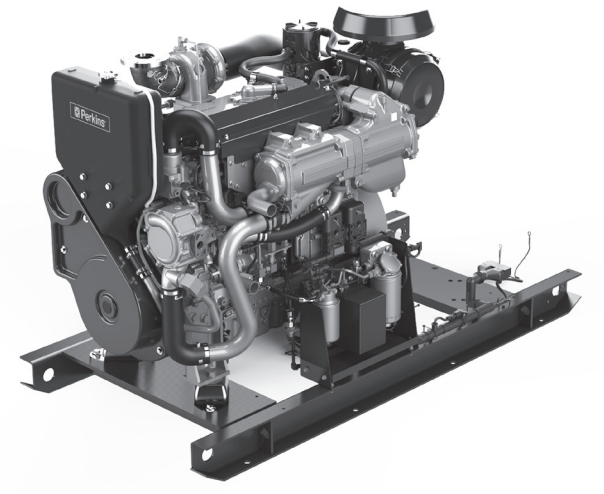


**Rear and left side view**

**19.** Drag holes only (not for lifting engine package)
**20.** Air cleaner inlet
**21.** Turbocharger
**22.** Exhaust flange
**23.** Alternator
**24.** Lifting point for entire auxiliary package
**25.** Exhaust manifold
**26.** Oil filter
**27.** Starter
**28.** Sump drain valve
**29.** Base frame



# 2. General Information



## Introduction

The Perkins range of marine engines are the latest developments from the Perkins Group of Companies together with Perkins Marine. These engines are designed for use in pleasure craft and for commercial craft.

Over sixty years of diesel production experience, together with the latest technology, have been applied to the manufacture of your engine to give you reliable and economic power.

### Safety notices

Safety advice is indicated in the text by the following methods:

**⚠ WARNING**

**This indicates that there is a possible danger to the person.**

**Caution: This indicates that there is a possible danger to the engine.**

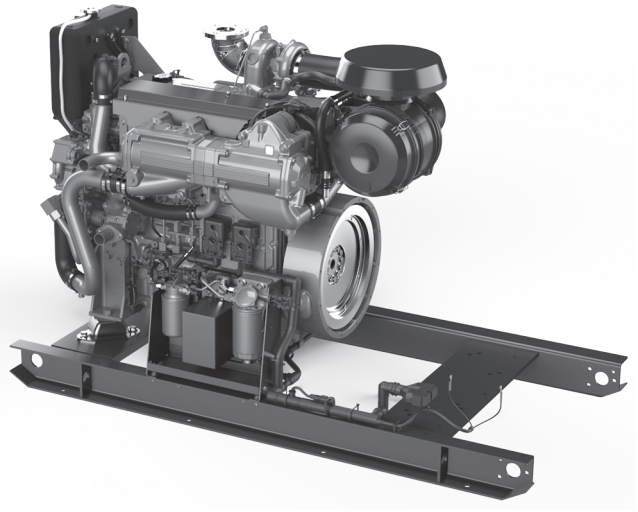
**Note:** Is used where the information is important, but there is no danger.

## How to care for your engine

**⚠ WARNING**

**Read the "Safety precautions" and remember them. They are given for your protection and must be applied at all times.**

**Caution: Do not clean an engine whilst it is running. If cold cleaning fluids are applied to a hot engine, certain components on the engine may be damaged.**



This handbook has been written to assist you to maintain and operate your engine correctly.

To obtain the best performance and the longest life from your engine, you must ensure that the maintenance operations are done at the correct intervals. If the engine works in a very dusty environment or other adverse conditions, certain maintenance intervals will have to be reduced. Renew the filter canisters and lubricating oil regularly in order to ensure that the inside of your engine remains clean.

Ensure that all adjustments and repairs are done by personnel who have had the correct training. Personnel with this training are available at your Perkins distributor. You can also obtain parts and service from your Perkins distributor. If you do not know the address of your nearest distributor, enquire at Perkins Marine.

When reference is made to the "left" or "right" side of the engine, this is as seen from the crankshaft damper end of the engine.

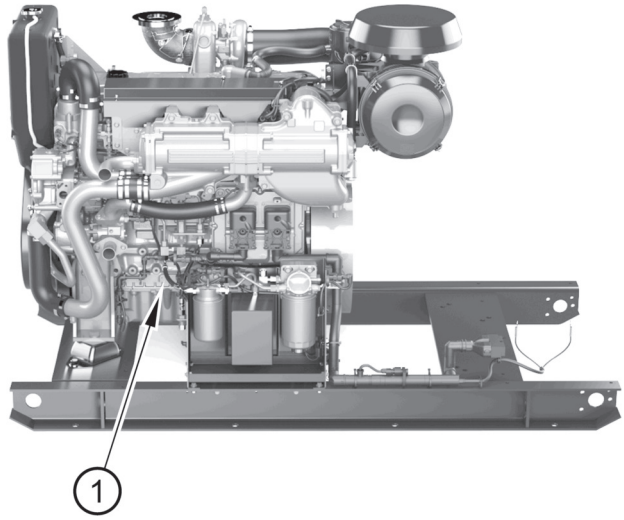



*Figure 1*

## Engine guarantee

If a claim under guarantee is necessary, the boat owner should make a guarantee claim on the nearest Perkins marine distributor or an approved dealer.

If it is difficult to find a Perkins distributor or an approved dealer, consult the Sales and Customer Support of Perkins Marine.

## Engine identification

Identification of the engine model is by a label fitted on top of the rocker cover.

If you need parts, service or information for your engine, you must give the complete engine number to your Perkins distributor.

The correct identification of the engine is by the full engine number.

The engine number and marine build number are stamped on a label which is fastened to the right side of the cylinder block (1) just above the sump. An example of the engine number is:

**BL51284U123456T**

## Contact details

**Perkins Marine**

Ferndown Industrial Estate
Wimborne
Dorset
BH21 7PW
England
Telephone: +44 (0)1202 796000
**www.Perkins.com/marine**

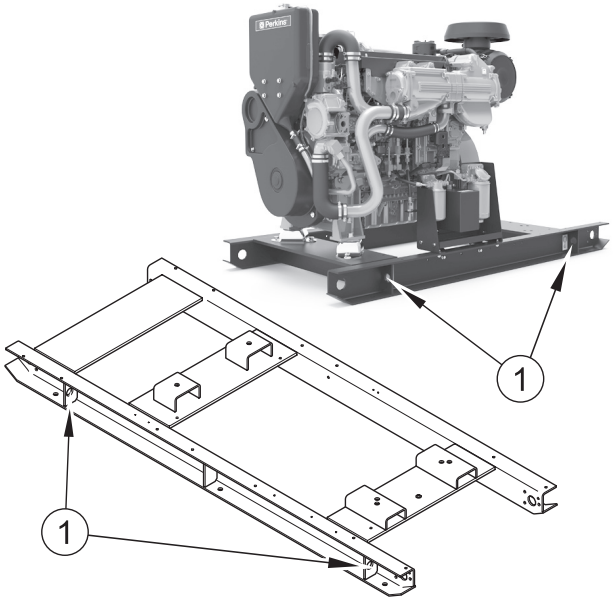



*Figure 2*

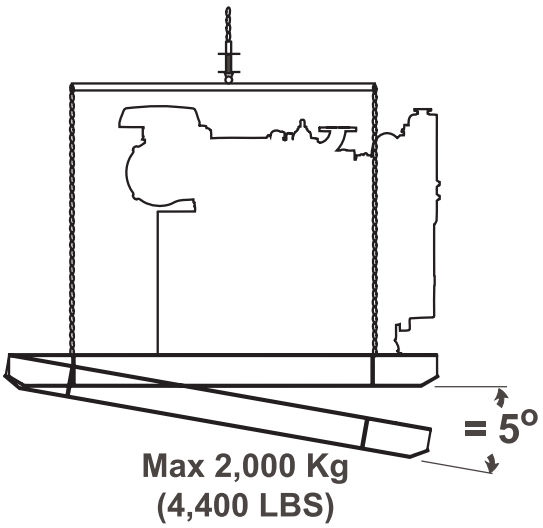



*Figure 3*

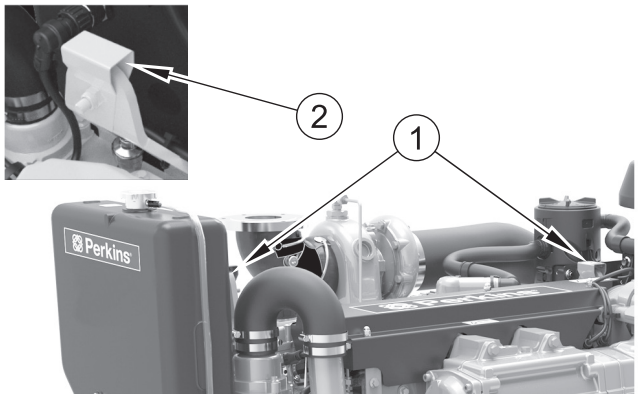



*Figure 4*

## Lifting the entire genset package

**Caution: Do not use the lifting eyes located on the engine to lift the whole assembly as damage may occur and invalidate warranty.**

**Caution: Only use the lifting eyes on the engine to lift the engine when separated from the auxiliary drive.**

**Caution: Care must be taken when lifting the auxiliary package when using strops as damage may occur if the pathway for the strops is too close to parts of the engine prone to damage.**

**Caution: Before lifting the entire auxiliary package, ensure that the total weight and the centre of gravity is known, this will depend on individual customer configuration.**

Lifting points have been provided on the base rails of the auxiliary set for lifting the entire package (figure 2 item 1).

Lifting the auxiliary set together requires special equipment and procedures.

Lifting strops and spreader bars must be used to lift the entire package using.

The arrangement must be capable of lifting a maximum of 2,000 Kg (4,400 lbs) and care must be taken not to let the package tilt anymore than 5$^{O}$ as shown in figure 3.

If in any doubt, please consult your Perkins dealer for information regarding fixtures for proper lifting of your complete package.

### Lifting the engine only

**Note:** Ensure that the auxiliary drive is adequately supported, when lifting the engine only.

To lift the **engine only**, once separated from the auxiliary drive, use the lifting eyes as shown in figure 4 item 1.

These lifting eyes have blanking plates fitted (item 2), which must first be removed. Reinstate these blanking plates after use.

# 3. Operation instructions

## Running-in

A gradual running-in of a new engine is not necessary. Prolonged operation at light loads during the early life of the engine can cause lubricating oil to enter the exhaust system. Maximum load can be applied to a new engine as soon as the engine is put into service and the coolant temperature has reached a minimum of 60$^{O}$ C (140$^{O}$ F).

**Cautions:**

- *The engine will benefit if the load is applied as soon as possible after the engine is put into service.*
- *Do not overload the engine.*

These ratings represent the performance capabilities to conditions specified in ISO 3046/1.

Test Conditions Air temperature 25$^{O}$ C (80$^{O}$ F) barometric pressure 100 kPa (29.5 in Hg), relative humidity 30%, maximum exhaust back pressure 15 kPa, maximum inlet restriction 5 kPa.

For operation outside of these conditions please consult your Perklns contact. Performance tolerance quoted by Perkins is ± 5%.

Electrical ratings assume a power factor of 0.8 and a generator efflciency of 93%.

## Preparations for an engine start

1. Ensure that there is more than enough fuel in the tank for the voyage.
2. Ensure that the fuel supply control (if fitted) is in the open position.
3. Check that the seacock strainer is clean.
4. Open the seacock.
5. Check the amount of coolant in the header tank.
6. Check the amount of lubricating oil in the sump.

Several factors affect engine start, for example:

- The power of the batteries
- The performance of the starter motor
- The viscosity of the lubricating oil
- The installation of a cold start system

## Operational angles

These engines are intended to be mounted so that the cylinders are vertical, when viewed from ahead or astern. The operational angles that are permissible in service are $20^{O}$ nose up, heel $25^{O}$ constant and $30^{O}$ intermittent.

# 4. Engine fluids

## Fuel system

| | |
|---|---|
| Fuel rate | 205 g/bkW-hr, 220 g/bkW-hr, 231 g/bkW-hr, 242 g/bkW-hr |
| Fuel rate | 26.4 kg/hr, 23.9 kg/hr, 18.8 kg/hr, 15.8 kg/hr |
| Fuel flow transfer pump | 4.0 L/min (63.3 gal/hr) |
| Fuel pressure static head | 2m (6.5 ft) |
| Fuel supply line restriction (max.) | 30 kPa (8.8 in Hg) (4.4 psi) |
| Fuel temperature transfer pump in (max.) | 60°C (140°F) |
| Fuel return line restriction (max.) | 20 kPa (5.9 in Hg) (2.9 psi) |
| Fuel supply/return connections | 11/16 in O ring face seal (ORFS) |
| Diesel fuel grade | ISO-F-DMX/ISO-F-DMA/ISO 8217: 1986 (E) Class F, EN590, D975, JIS class 1, 2, 3 |

## Lubricating oil specification

Use only good quality lubricating oil which is equivalent to or above the minimum specification shown in the table below.

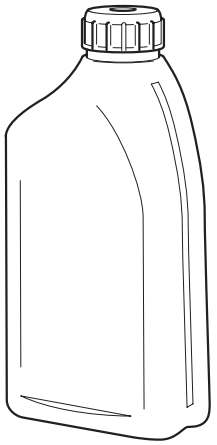
Target oil specifications are:

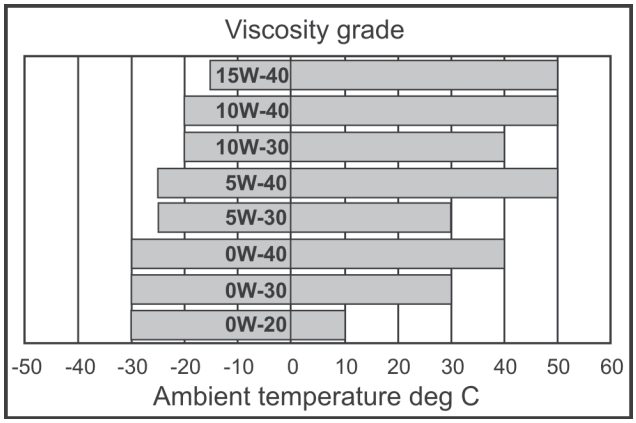
| Engine type | Specification |
|---|---|
| E70 TAGM | API-CJ4 |

Oil change period is 500 hrs.

**Caution: The type of lubricating oil to be used may be affected by the quality of the fuel which is available.**

**Caution:** A**lways ensure that the correct viscosity grade of lubricating oil is used for the ambient temperature range in which the engine will run as shown in the chart.**





## Coolant specification

The quality of the coolant which is used can have a great effect on the efficiency and life of the cooling system. The recommendations indicated below can help to maintain a good cooling system and to protect it against frost and/or corrosion.

If the correct procedures are not used, Perkins Marine cannot be held responsible for damage caused by frost or corrosion, or for loss of cooling efficiency.

The correct coolant/anti-freeze to use is Extended Life Coolant.

| Extended Life Coolant |
|---|
| Qty: 5 litres Part No 60061<br>Qty: 25 litres Part No 60062 |

**Heat exchanger.** The coolant mixture must be a 50/50 mix with clean water.

**Keel cooled, under normal conditions.** The coolant mixture must be a mix of 20% antifreeze and 80% clean water, down to minus 7$^{O}$ C.

'Extended Life Coolant' has a service life of 6000 service hours or 3 years which ever is sooner.

'Extended Life Coolant' should not be mixed with other products.

Unlike many protective coolants, 'Extended Life Coolant' does not coat components with a protective layer to prevent corrosion. Instead it uses virtually non-depleting corrosion inhibitors.

An alternative to 'Extend Life Coolant' is Havoline (XLC) Extended Life Coolant/Anti-freeze.

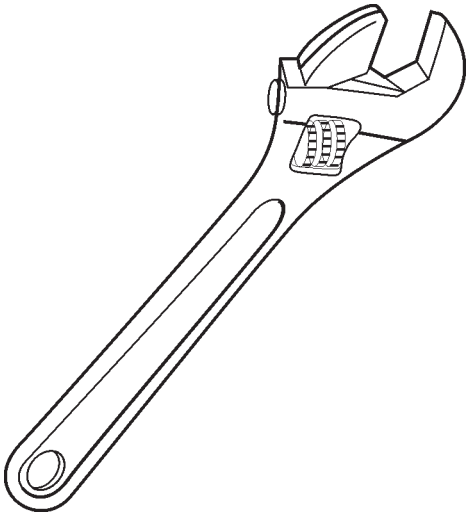
**Caution: Using a coolant/anti-freeze which coats components with a protective layer to prevent corrosion may impair the efficiency of the cooling system and lead to the engine overheating.**

An anti-freeze which contains the correct inhibitor must be used at all times to prevent damage to the engine by corrosion, because of the use of aluminium in the coolant circuit.

If frost protection is not necessary, it is still extremely important to use an approved anti-freeze mixture because this gives a protection against corrosion and also raises the boiling point of the coolant.

**Note:** If combustion gases are released into the coolant circuit, the coolant must be renewed.

# 5. Regular maintenance



## Maintenance periods

These preventive maintenance periods apply to average conditions of operation. Check the periods given by the manufacturer of the boat in which the engine is installed. If necessary, use the shorter periods. When the operation of the engine must conform to the local regulations these periods and procedures may need to be adapted to ensure correct operation of the engine.

It is good preventive maintenance to check for leakage and loose fasteners at each service.

These maintenance periods apply only to engines that are operated with fuel and lubricating oil which conform to the specifications given in this handbook.

Use the procedures in this chapter to maintain your engine in accordance with the regular maintenance schedule.

**Schedules**

The schedules which follow must be applied at the interval (hours or months) which occur first.

**When required**

- Battery - replace
- Battery or battery cable - disconnect
- Engine - clean
- Fuel system - prime
- Sea water strainer - clean/inspect

**Daily**

- Cooling system coolant level - check
- Electrical connections - check
- Engine oil level - check
- Fuel system primary filter/water separator - drain
- Fuel tank water and sediment - drain
- Walk-around inspection
- Oil leaks - check
- Engine air cleaner service indicator - inspect

**Every week**

- Hoses and clamps - inspect/replace/retorque
- Instrument panel - inspect
- Jacket water heater - check
- Engine mounts - check

**Initial 500 service hours**

- Engine oil and filter - change
- Fuel system primary filter (water separator) element - replace
- Fuel system secondary filter - replace

**Every 500 service hours or 1 year**

- Auxiliary water impeller - replace (heat exchanger model only)
- Battery electrolyte level - check
- Engine air cleaner element - clean/replace - check
- Sea water strainer - clean/inspect
- Audible warning devices - check
- Crankshaft damper - check
- External fastenings - check
- Auxiliary water strainer (if fitted) - check
- Heat exchanger seals - check

**Every 1000 service hours**

- Aftercooler condensate drain valve - inspect/clean
- Aftercooler core - inspect

- Belt tensioner - check
- Belt - inspect
- Water pump - inspect

**Every 1500 service hours**

- Engine crankcase breather - replace

**Every 2000 service hours**

- Engine mounts - inspect
- Heat exchanger - inspect
- Starting motor - inspect
- Turbocharger - inspect
- Coolant gravity - check
- Alternator - inspect

**Every 3000 service hours**

- Alternator and fan belts - replace

**Every 3000 service hours or 3 years**

- Engine protective devices - check

**Every 4000 service hours**

- Aftercooler core - clean/test

**Every 6000 service hours or 3 years**

- Cooling system coolant (ELC) - change

## How to fill the coolant circuit

**⚠ WARNING**

**If coolant is to be added to the circuit during service, allow the engine to cool before the coolant is added. Remove the filler cap slowly as dangerous coolant could be discharged if the coolant is still hot and the system under pressure. Do not put too much coolant in the coolant circuit. There is a relief valve in the filler cap which will open and release hot coolant if too much coolant is added.**

**Caution: If coolant is added to the circuit during service, it must consist of the same original mixture as used to fill the system.**

1. Remove the filler cap (figure 5 item 1) of the header tank and slowly fill the coolant system until the coolant level is just below the pipes inside the header tank.
2. Wait for five to ten minutes and check the coolant level, add coolant if necessary. Fit the filler cap.
3. Start the engine. When it has reached its normal temperature of operation, stop it and let it cool.
4. Remove the filler cap of the header tank and add coolant until the level of the coolant is between 25 mm (1.00 in) and 40 mm (1.50 in) below the bottom of the pipes. Fit the filler cap.

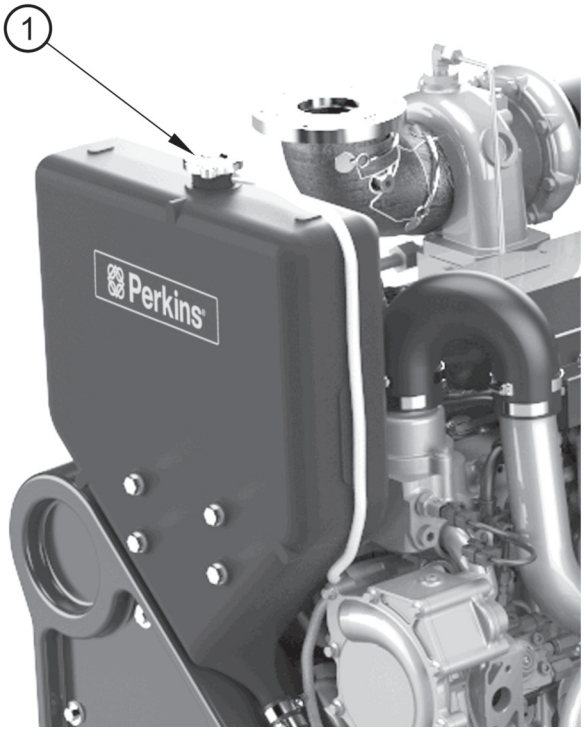



*Figure 5*

## How to drain the coolant circuit

**⚠ WARNING**

- *Discard the used coolant in a safe place and in accordance with local regulations.*
- *Do not drain the coolant while the engine is still hot and the system is under pressure because dangerous hot coolant can be discharged.*

1. Loosen the coolant filler cap on the header tank (figure 5 item 1).
2. Remove the drain plug (figure 6 item 1) from the heat exchanger pipe.
3. Remove the drain plug (figure 7 item 1) from the exhaust manifold and the sampling plug located on the left side of the cylinder block.
4. After the system has been drained, fit the filler cap and the drain plugs.
5. Fasten a label in a suitable place to indicate that the coolant system has been drained.

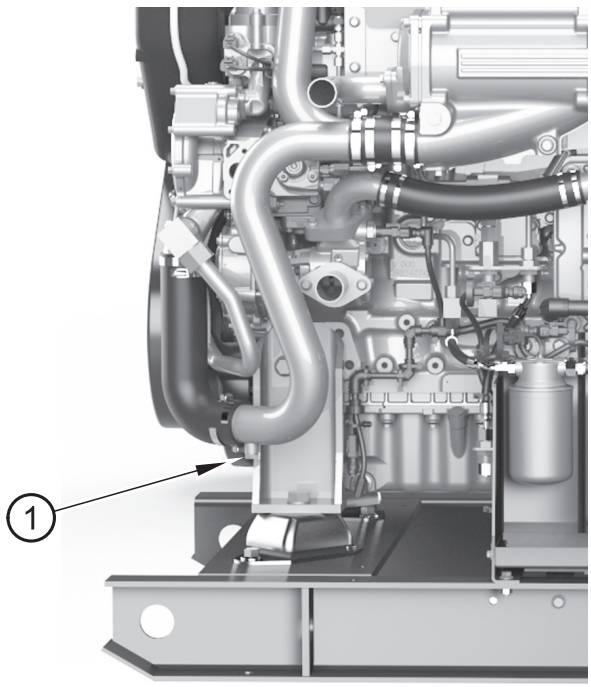



*Figure 6*

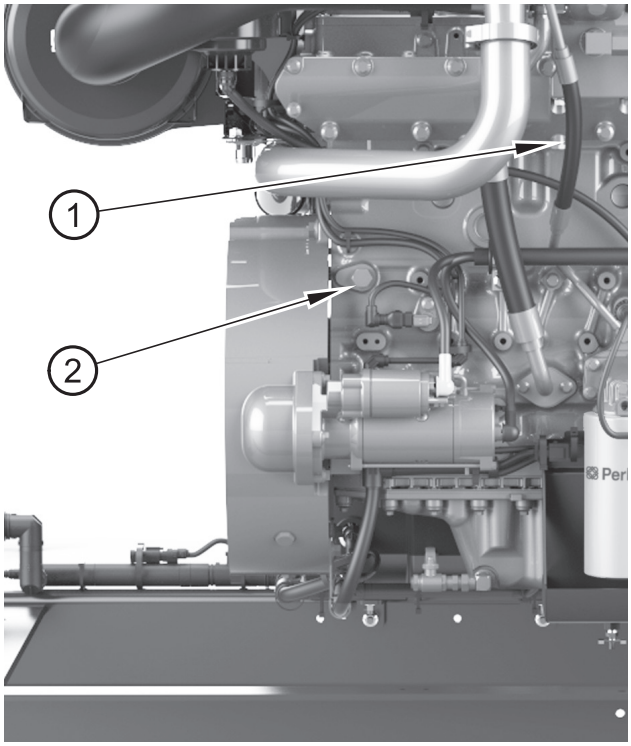



*Figure 7*

**Caution: The closed circuit system cannot be drained completely. If the coolant is drained for engine preservation purposes or for protection from frost, the coolant system must be filled again with an approved antifreeze mixture.**

**Engines fitted with keel coolers**

The coolant capacity and the method used to drain the coolant circuit of an engine connected to a keel cooler will vary in different applications.

Use the instructions given by the keel cooler manufacturer to drain and renew the engine coolant if a keel cooler is fitted.

## How to check the specific gravity of the coolant

For mixtures which contain inhibited ethylene glycol:

1. Operate the engine until it is warm enough to open the thermostat. Continue to run the engine until the coolant has circulated the cooling system.
2. Stop the engine.
3. Allow the engine to cool until the temperature of the coolant is below 60$^{O}$ C (140$^{O}$ F).

**⚠ WARNING**

**Do not drain the coolant while the engine is still hot and the system is under pressure because dangerous hot coolant can be discharged.**

Remove the filler cap of the cooling system.
Drain some coolant from the cooling system into a suitable container.

Use a special coolant hydrometer that will check the temperature and the specific gravity of the coolant, follow the manufacturer's instructions.

**Note:** If a special coolant hydrometer is not available, put a hydrometer and a separate thermometer into the antifreeze mixture and check the readings on both instruments. Compare the readings with the chart.

Adjust the strength of the mixture as necessary.

**Note:** If it is necessary to fill or replenish the coolant system in service, mix the coolant to the correct strength before it is added to the coolant system.

Perkins antifreeze with a concentration of 50% will give protection against frost to a temperature of -35$^{O}$ C (-31$^{O}$ F). It will also give protection against corrosion. This is especially important when there are aluminium components in the coolant circuit.

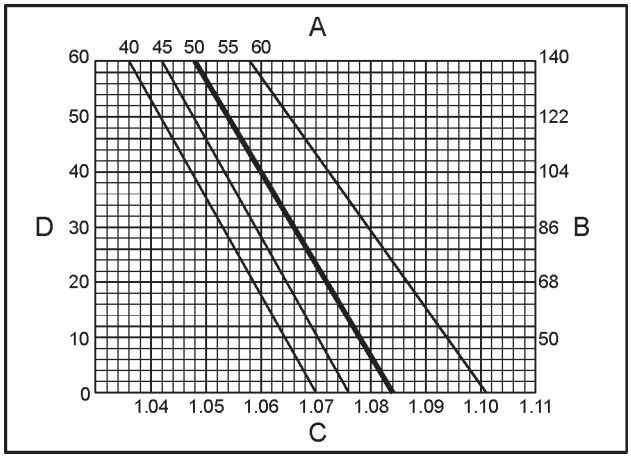
**Specific gravity chart**

**A** = Percentage antifreeze by volume

**B** = Mixture temperature in $^{O}F$

**C** = Specific gravity

**D** = Mixture temperature in $^{O}C$



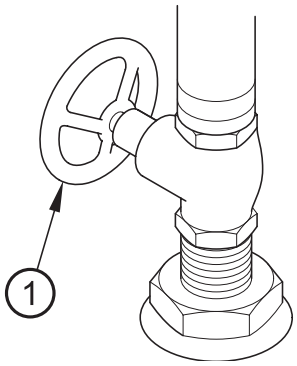



*Figure 8*

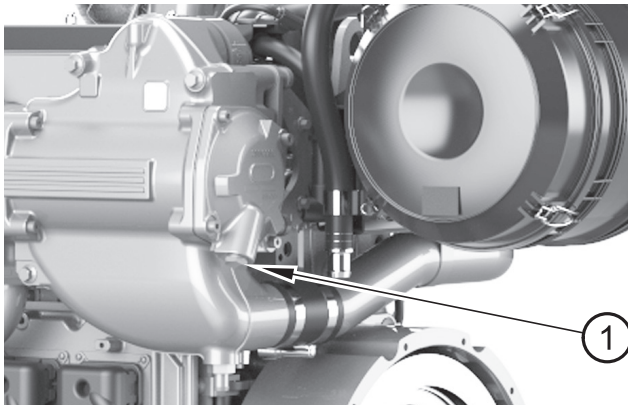



*Figure 9*

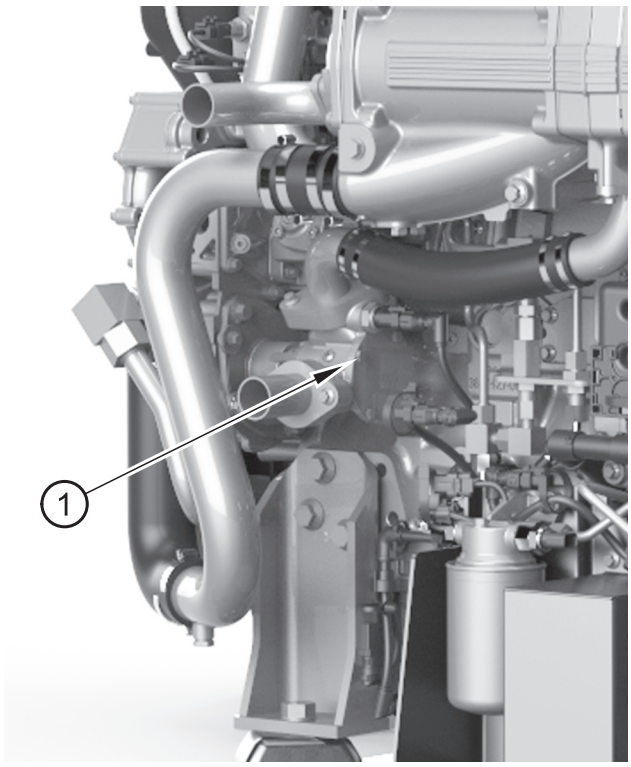



*Figure 10*

## How to drain the auxiliary water system

**Caution: The auxiliary water system cannot be drained completely. If the system is drained for engine preservation purposes or for protection from frost, the system must be filled again with an approved antifreeze mixture.**

1. Ensure that the seacock is closed (figure 8 item 1 shows a typical example).
2. Remove the drain plug (figure 9 item 1), from the aftercooler. Ensure that the drain hole is not restricted.
3. Remove the auxiliary pump endplate by unscrewing the 4 retaining bolts (figure 10 item 1) and allow the water to drain into a suitable container.
4. Turn the crankshaft to ensure that the auxiliary water pump is empty.
5. Refit the drain plug to the aftercooler and replace the auxiliary water pump endplate with the 4 retaining bolts.

**Caution: When the auxiliary water system is to be used again, ensure that the seacock is open.**

## How to check the impeller of the auxiliary water pump

**Caution: When the impeller is checked, the strainer in the outlet hose of the auxiliary water pump must also be checked.**

1. Ensure that the seacock is closed.
2. Release the four bolts (figure 11 items 1) which fasten the end plate of the auxiliary water pump and remove the plate. When the end plate of the auxiliary water pump is removed, some auxiliary water will flow from the pump.
3. Care should be taken with the sealing ‘O’ ring (figure 12 item 1).
4. Remove the rubber end cap (item 2) and then pull the impeller from the shaft (figure 13 item 1).
5. Clean the contact surfaces of the pump body and the end plate.
6. Inspect the rubber impeller for excessive wear or for damage and renew it, if necessary.
7. Apply Castrol Spheerol SX2 grease to the blades of the new impeller and fit the impeller into the housing with the blades bent clockwise. Refit the rubber end cap and sealing ‘O’ ring.
8. Fit the end plate and tighten the end plate bolts.
9. Open the seacock.

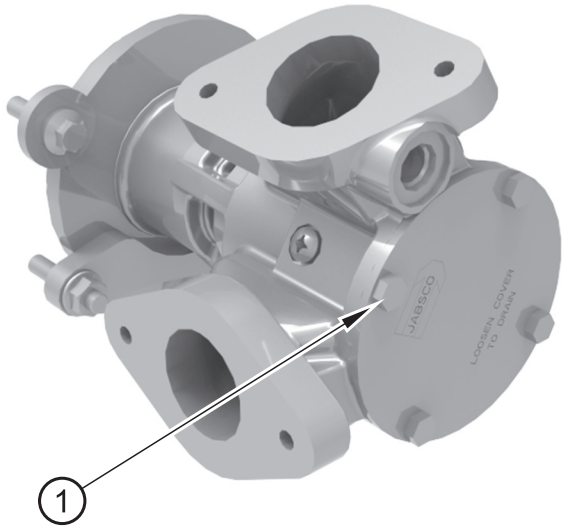



*Figure 11*

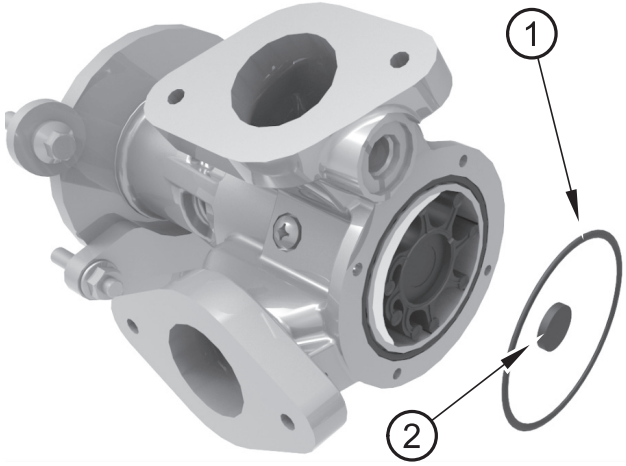



*Figure 12*

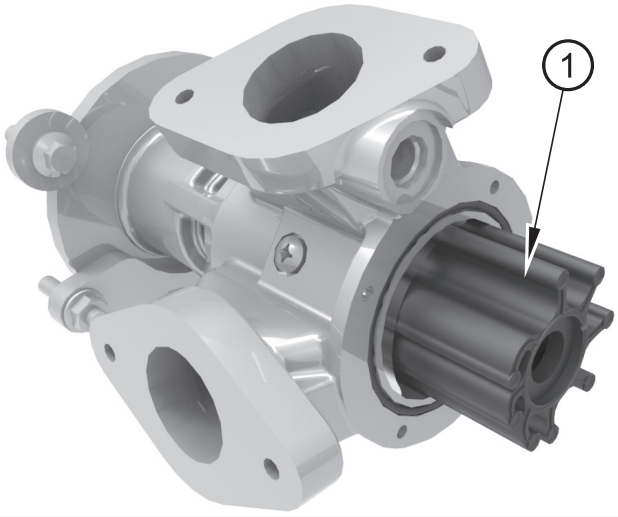



*Figure 13*

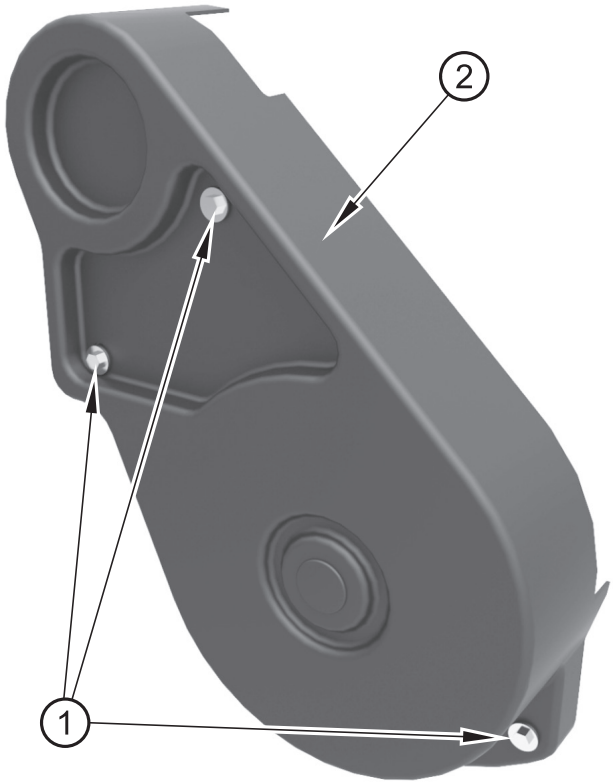



*Figure 14*

## How to check the drive belt of the alternator

**⚠ WARNING**

**The engines have a guard fitted to give protection from the alternator fan and the drive belt. Ensure that this guard is fitted before the engine is started.**

**Note:** The engine may have the ability to auto start. Ensure that the power supply is isolated before any service or repair is performed.

To maximize the engine performance, inspect the belt for wear and for cracking. Replace a belt that is worn or damaged.

If the belt is too loose, vibration causes unnecessary wear on the belt and the pulley.

1. Undo the bolts (figure 14 item 1) and remove the guard (item 2).
2. Inspect the belt for cracks, splits, glazing, grease, displacement of the cord and evidence of fluid contamination.

The belt must be replaced if the following conditions are present.

- The belt has a crack in more than one rib.
- More than one section of the belt is displaced in one rib of a maximum length of 50.8 mm (2 inches).

3. Align the guard to the engine. Install the bolts and tighten securely.

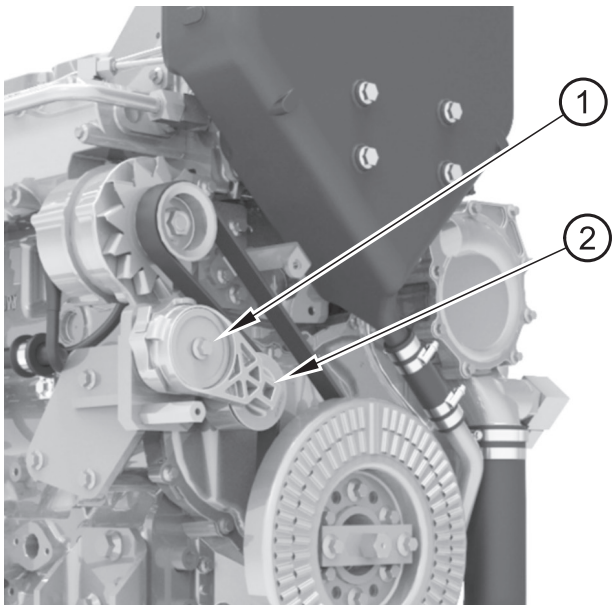



*Figure 15*

## How to check the belt tension of the alternator

**⚠ WARNING**

**The engines have a guard fitted to give protection from the alternator fan and the drive belt. Ensure that this guard is fitted before the engine is started.**

**Note:** The engine may have the ability to auto start. Ensure that the power supply is isolated before any service or repair is performed.

1. Undo the bolts (figure 14 item 1) and remove the guard (item 2).
2. Inspect the belt for cracks, splits, glazing, grease, displacement of the cord and evidence of fluid contamination.

3. Inspect the belt. Ensure that the belt tensioner is securely installed. Visually inspect the belt tensioner (item 1) for damage. Check that the pulley on the tensioner rotates freely and that the bearing is not loose. If necessary, replace damaged components.

## How to replace the drive belt of the alternator

**⚠ WARNING**

**The engines have a guard fitted to give protection from the alternator fan and the drive belt. Ensure that this guard is fitted before the engine is started.**

**Note:** The engine may have the ability to auto start. Ensure that the power supply is isolated before any service or repair is performed.

1. Undo the bolts (figure 14 item 1) and remove the guard (item 2).
2. Insert a square drive tool (figure 15 item 2) into the square hole in the belt tensioner (item 1). Rotate the belt tensioner clockwise in order to relieve tension on the drive belt. Remove the belt.
3. Install the new belt correctly, as shown in figure 16. Be sure that the belt is fully seated on the pulleys. The correct tension will automatically be applied when the ratchet is removed.
4. Replace the guard.

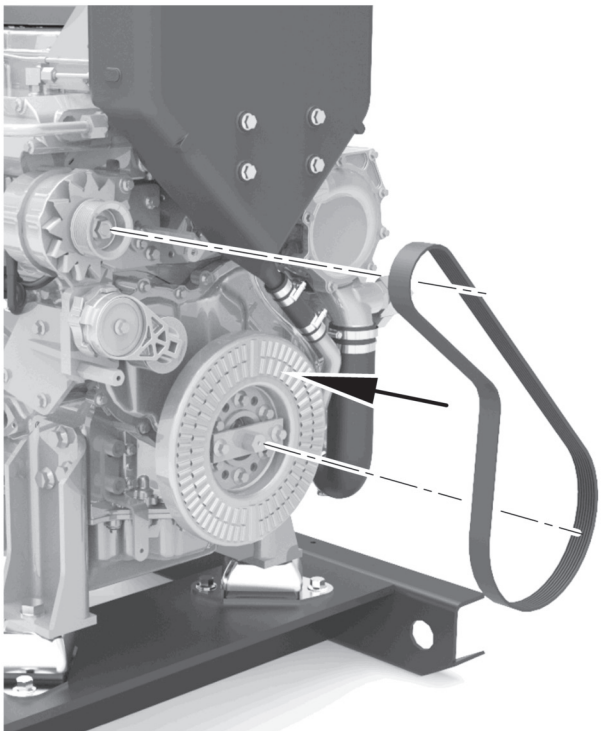


*Figure 16*

## How to check the condition of the heat exchanger/aftercooler

The interval for the maintenance of the tube type heat exchanger/aftercooler (figure 17 item 1) depends on the operating environment of the vessel and on the operating time. The sea water that is circulated through the heat exchanger and the amount of operating time of the vessel affects the following items:

- Cleanliness of the tubes for the heat exchanger
- Effectiveness of the heat exchanger system

Operating in water that contains silt, sediment, salt, algae, etc will adversely affect the heat exchanger system. In addition, intermittent use of the vessel will adversely affect the heat exchanger system.

The following items indicate that the heat exchanger may require cleaning:

- Increased coolant temperature
- Engine overheating

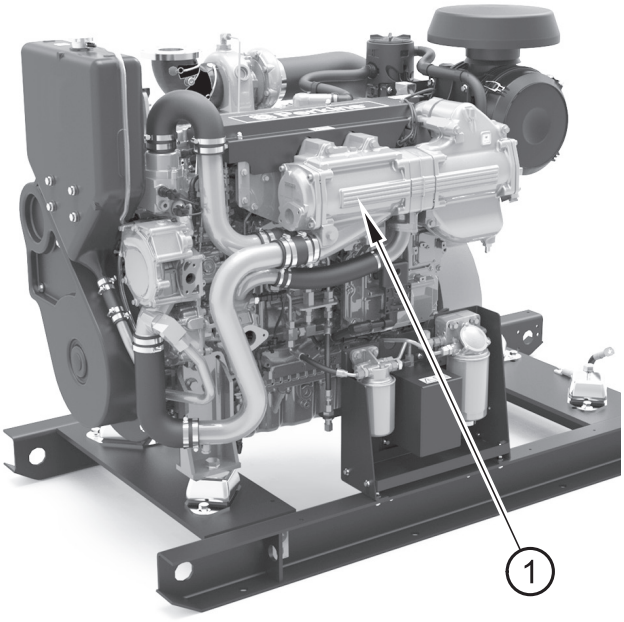



*Figure 17*

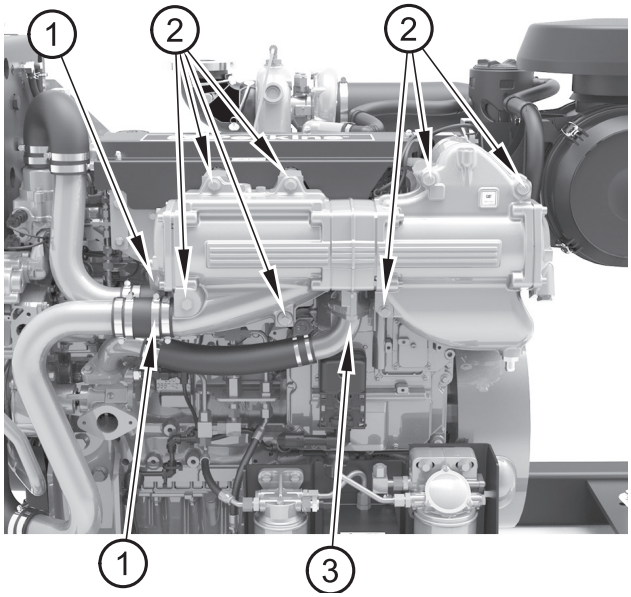



*Figure 18*

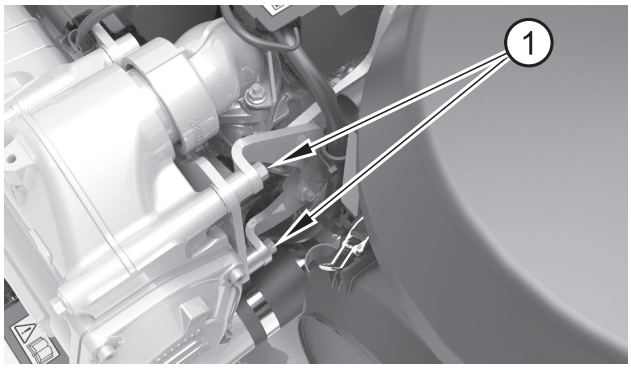



*Figure 19*

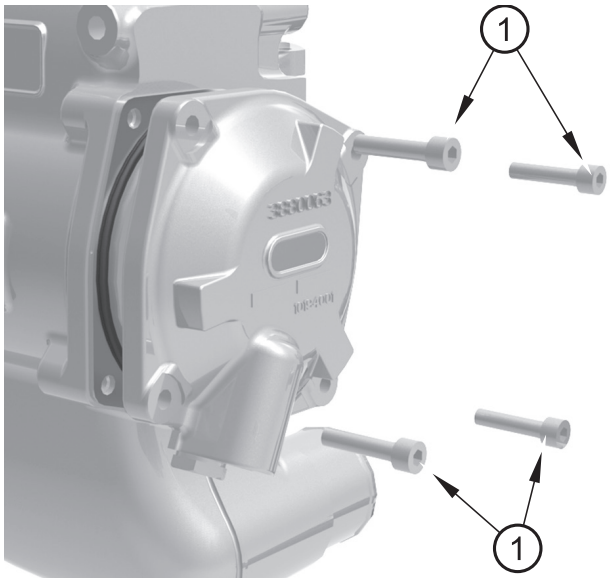



*Figure 20*

- Excessive pressure drop between the water inlet and the water outlet

An operator that is familiar with the normal operating temperature of the coolant can determine when the coolant temperature is out of the normal range. Inspection and maintenance of the heat exchanger are required if the engine is overheating.

## Cleaning the heat exchanger/aftercooler

1. Drain the fresh water and auxiliary water circuits.
2. Slacken the hose clips (figure 18 item 1).
3. Remove bolts (item 3) and remove hose assembly.
4. Remove bolts (item 2).
5. Remove the bolts that secure the assembly at the rear (figure 19 item 1).
6. Remove the heat exchanger assembly.
7. Remove the endcap by undoing the bolts (figure 20 item 1).
8. Turn the heat exchanger core upside-down in order to remove debris.

**Note:** Do not use a high concentration of caustic cleaner to clean the core. A high concentration of caustic cleaner can attack the internal metals of the core and cause leakage. Only use the recommended concentration of cleaner.

**If tubestack is greasy**

1. Degrease using solvent or by washing with warm alkaline detergent that is compatible with aluminium.
2. Rinse with water and air dry.

**If tubestack is not greasy.**

1. Wash with warm alkaline detergent that is compatible with aluminium.

**Note:** Do not use Acids on aluminium.

2. Rinse with water and air dry.
3. Inspect the core in order to ensure cleanliness. Pressure test the core. Many shops that service radiators are equipped to perform pressure tests. If necessary, repair the core.

**Disassembly**

Follow the steps 1 to 8 under 'Cleaning the Heat Exchanger/aftercooler'.

1. Remove O ring seal (figure 21 item 1) and tubestack (item 2).
2. Undo the bolts (figure 22 item 3) and remove the heat exchanger body (item 1). Withdraw the O ring seal (item 2).
3. The aftercooler assembly can be broken down as per figure 23.
    1. O ring seal.
    2. Spacer.
    3. Adaptor.
    4. Spacer.
    5. Tubestack.
    6. Aftercooler body.
4. Back flush with the tubestack with cleaner.
5. Steam clean the tubestack in order to remove any residue. Flush the fins of the aftercooler core. Remove any trapped debris.

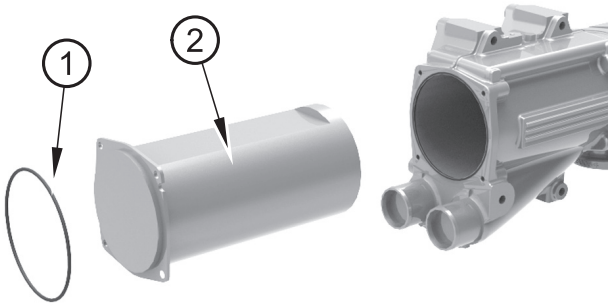



*Figure 21*

**⚠ WARNING**

**Personal injury can result from air pressure.**

**When using air pressure, proper protective equipment should be worn.**

**Maximum air pressure at the nozzle must not exceed 205 kPa (30 psi) for cleaning purposes.**

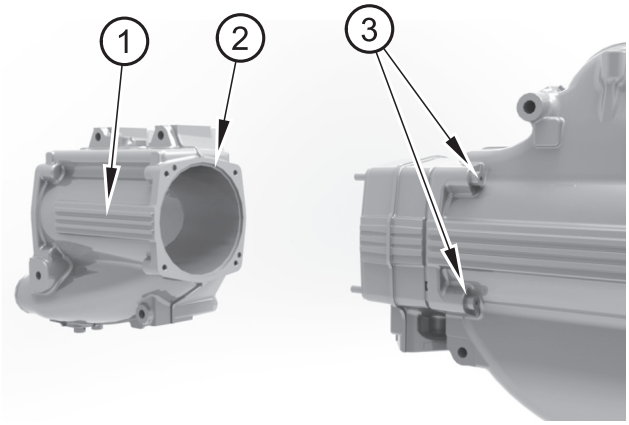



*Figure 22*

6. Dry the tubestack with with compressed air in the reverse direction of the normal flow.
7. Inspect the core in order to ensure cleanliness. Pressure test the core. Many shops that service radiators are equipped to perform pressure tests. Repair the tubestack if necessary.

**Assembly**

1. Assembly is the reversal of the disassembly procedure, however replacement O ring seals should be used.
2. Refill the system with the correct coolant, run the engine and inspect for leaks.

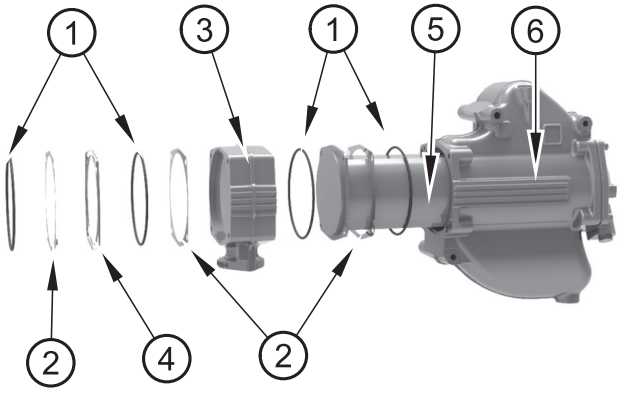



*Figure 23*

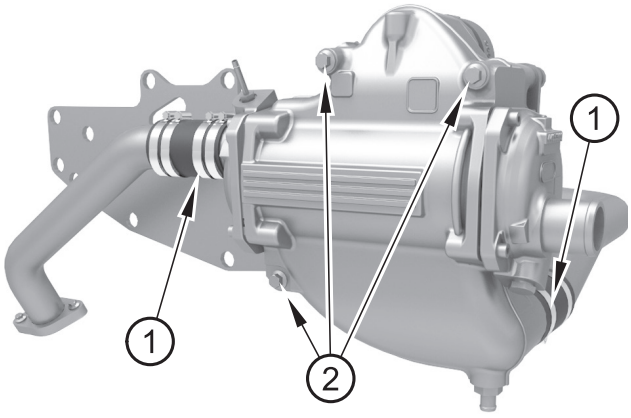



*Figure 24*

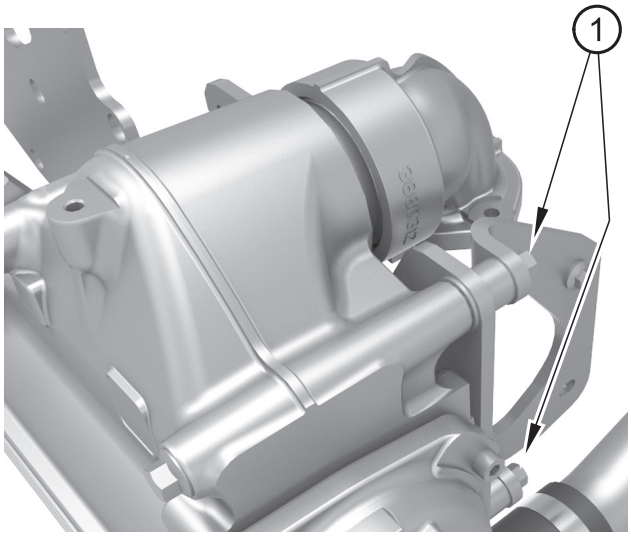



*Figure 25*

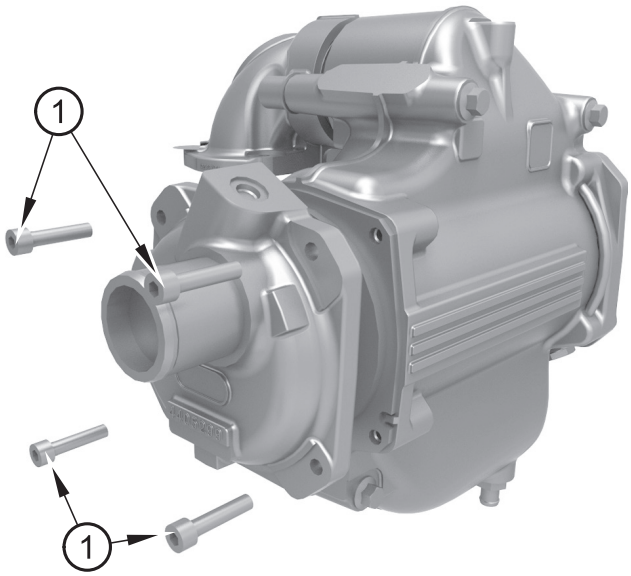



*Figure 26*

## How to check the condition of the keel cooled aftercooler

The interval for the maintenance of the tube type heat keel cooled aftercooler depends on the operating environment of the vessel and on the operating time. The sea water that is circulated through the heat exchanger and the amount of operating time of the vessel affects the following items:

- Cleanliness of the tubes for the heat exchanger
- Effectiveness of the heat exchanger system

Operating in water that contains silt, sediment, salt, algae, etc will adversely affect the heat exchanger system. In addition, intermittent use of the vessel will adversely affect the heat exchanger system.

The following items indicate that the heat exchanger may require cleaning:

- Increased coolant temperature
- Engine overheating
- Excessive pressure drop between the water inlet and the water outlet

An operator that is familiar with the normal operating temperature of the coolant can determine when the coolant temperature is out of the normal range. Inspection and maintenance of the heat exchanger are required if the engine is overheating.

## Cleaning the aftercooler

1. Drain the fresh water and auxiliary water circuits.
2. Slacken the hose clips (figure 24 item 1).
3. Remove bolts (item 2) and remove hose assemblies.
4. Remove the bolts that secure the assembly at the rear (figure 25 item 1).
5. Remove the heat exchanger assembly.
6. Remove the endcap by undoing the bolts (figure 26 item 1).
7. Turn the heat exchanger core upside-down in order to remove debris.

**Note:** Do not use a high concentration of caustic cleaner to clean the core. A high concentration of caustic cleaner can attack the internal metals of the core and cause leakage. Only use the recommended concentration of cleaner.

**If tubestack is greasy**

1. Degrease using solvent or by washing with warm alkaline detergent that is compatible with aluminium.

2. Rinse with water and air dry.

**If tubestack is not greasy.**

1. Wash with warm alkaline detergent that is compatible with aluminium.

**Note:** Do not use Acids on aluminium.

2. Rinse with water and air dry.
3. Inspect the core in order to ensure cleanliness. Pressure test the core. Many shops that service radiators are equipped to perform pressure tests. If necessary, repair the core.

**Disassembly**

Follow the steps 1 to 8 under 'Cleaning the Heat Exchanger/aftercooler'.

1. Remove O ring seal (figure 27 item 1) and tubestack (item 2).
2. Back flush with the tubestack with cleaner.
3. Steam clean the tubestack in order to remove any residue. Flush the fins of the aftercooler core. Remove any trapped debris.

**⚠ WARNING**

**Personal injury can result from air pressure.**

**When using air pressure, proper protective equipment should be worn.**

**Maximum air pressure at the nozzle must not exceed 205 kPa (30 psi) for cleaning purposes.**

4. Dry the tubestack with with compressed air in the reverse direction of the normal flow.
5. Inspect the core in order to ensure cleanliness. Pressure test the core. Many shops that service radiators are equipped to perform pressure tests. Repair the tubestack if necessary.

**Assembly**

1. Assembly is the reversal of the disassembly procedure, however replacement O ring seals should be used.
2. Refill the system with the correct coolant, run the engine and inspect for leaks.

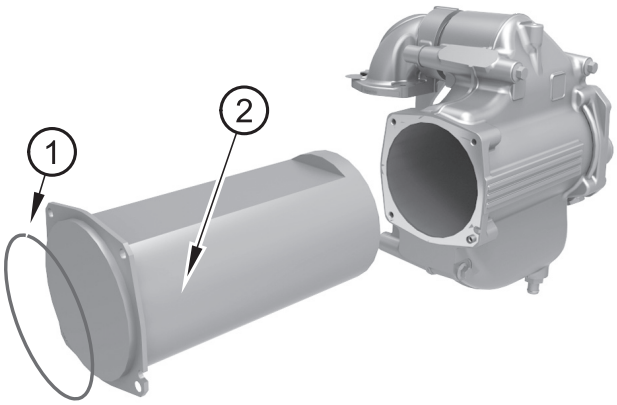



*Figure 27*

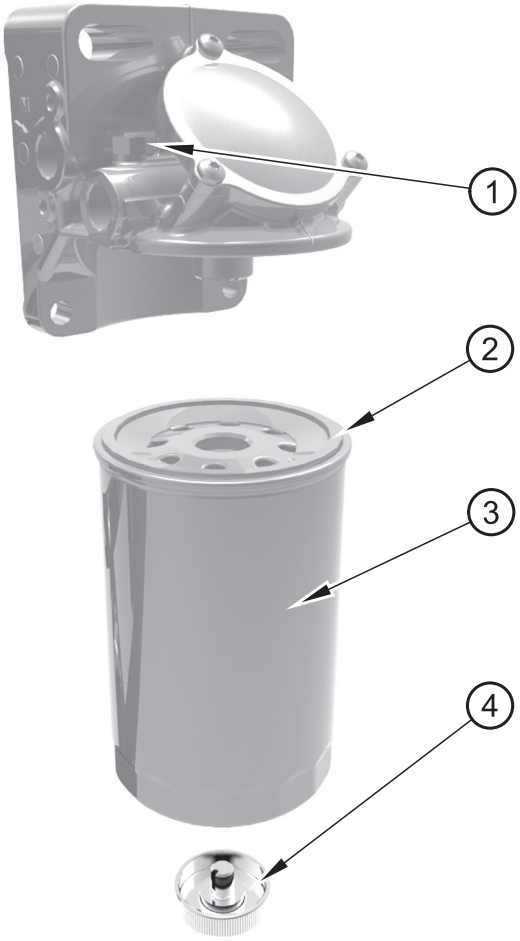



*Figure 28*

## How to renew the element on the primary fuel filter (simplex)

**⚠ WARNING**

**Fuel leaked or spilled onto hot surfaces or electrical components can cause a fire. To help prevent possible injury, turn the start switch off when changing fuel filters or water separator elements. Clean up fuel spills immediately.**

**Note:** Refer to, “Cleanliness of Fuel System Components” in the Installation Manual for detailed information on the standards of cleanliness that must be observed during ALL work on the fuel system. It is important to maintain extreme cleanliness when working on the fuel system, since even tiny particles can cause engine or fuel system problems.

**Note:** Ensure that the engine is stopped before any servicing or repair is performed.

After the engine has stopped, you must wait for 60 seconds in order to allow the fuel pressure to be purged from the high pressure fuel lines before any service or repair is performed on the engine fuel lines. If necessary, perform minor adjustments. Repair any leaks from the low pressure fuel system and from the cooling, lubrication or air systems. Replace any high pressure fuel line that has leaked.

**Caution: Do not open high pressure fuel lines to bleed the fuel system as it is self bleeding**

Ensure that all adjustments, maintenance and repairs are performed by authorized personnel that have the correct training.

1. The engine can have the ability to auto start. Ensure that the power supply is isolated before any service or repair is performed.
2. Turn the fuel supply valve to the OFF position before performing this maintenance.
3. Place a soft cloth over the vent screw (figure 28 item 1) on the filter. Open the vent screw in order to relieve the pressure that may be within the fuel system.
4. Open the drain valve (item 4). Allow the fluid to drain into the catching tray. Tighten the drain valve by hand pressure only. Then, tighten the vent screw securely.

**Note:** Retain the drain valve and fit into the new filter.

5. If necessary, use a chain wrench to remove the canister (item 3).

**Note:** Do not prefill the new filter.

6. Spin on the new canister until the O'ring seal (item 2) contacts the sealing surface. Then rotate the canister an extra 3/4's of a turn. Do not use a tool in order to install the canister.
7. Open the fuel supply and drain any fuel in the catch tray with the tap and collect in a suitable container.

**Note:** The secondary filter should be replaced at the same time as the primary, followed by the priming procedure.

## How to renew the element on the secondary fuel filter

**⚠ WARNING**

**Fuel leaked or spilled onto hot surfaces or electrical components can cause a fire. To help prevent possible injury, turn the start switch off when changing fuel filters or water separator elements. Clean up fuel spills immediately.**

**Note:** Refer to, "Cleanliness of Fuel System Components" in the Installation Manual for detailed information on the standards of cleanliness that must be observed during ALL work on the fuel system. It is important to maintain extreme cleanliness when working on the fuel system, since even tiny particles can cause engine or fuel system problems.

It is important to maintain extreme cleanliness when working on the fuel system, since even tiny particles can cause engine or fuel system problems.

**Note:** Ensure that the engine is stopped before any servicing or repair is performed.

After the engine has stopped, you must wait for 60 seconds in order to allow the fuel pressure to be purged from the high pressure fuel lines before any service or repair is performed on the engine fuel lines. If necessary, perform minor adjustments. Repair any leaks from the low pressure fuel system and from the cooling, lubrication or air systems. Replace any high pressure fuel line that has leaked.

Ensure that all adjustments, maintenance and repairs are performed by authorized personnel that have the correct training.

Typical example

1. The engine can have the ability to auto start. Ensure that the power supply is isolated before any service or repair is performed.

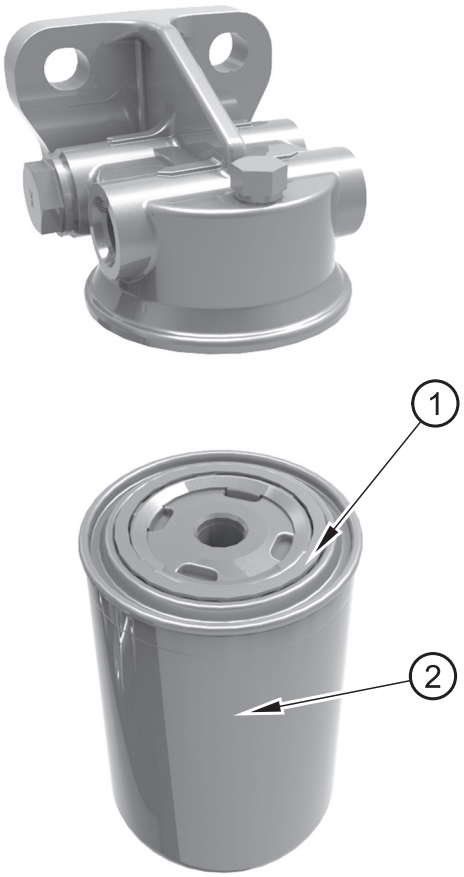



*Figure 29*

2. Turn the fuel supply valve to the OFF position before performing this maintenance.
3. Use a chain wrench in order to remove old canister (figure 29 item 2).
4. Lubricate the 'O' ring seal (item 1) with clean engine oil on the new canister. Install the new canister.

**Caution: Do not use filter where the wrapping is damaged. Do not prefill.**

5. Spin on the canister until the 'O' ring seal contacts the sealing surface. Then rotate the canister one full turn. Do not use a tool in order to install the canister.
6. Open the fuel supply valve. Remove the container and dispose of the fluid in a safe place.

## How to renew the lubricating oil of the engine

**⚠ WARNING**

**Hot oil and components can cause personal injury. Do not allow hot oil or hot components to contact the skin.**

**⚠ WARNING**

**Discard the used lubricating oil in a safe place and in accordance with local regulations.**

**Caution: Use a suitable container to drain the old oil into and dispose of the contents according to the local regulations.**

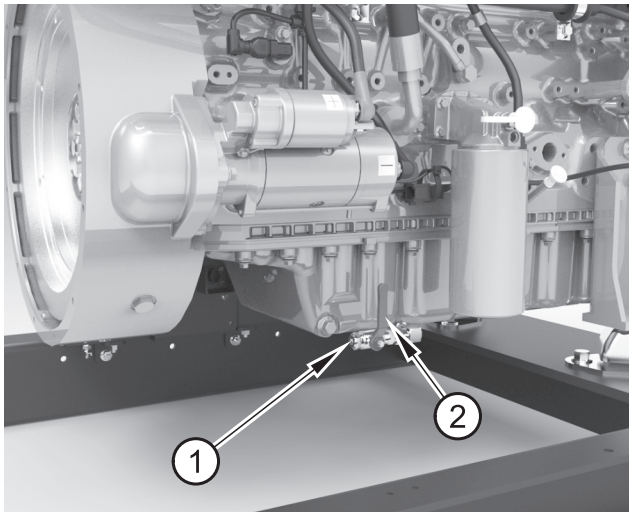



*Figure 30*

Drain the oil when it is warm as this will ensure that any waste particles are removed at the same time.

1. Remove the drain plug (figure 30 item 1).
2. Attach a suitable length of hose to the drain and place a suitable container with a capacity of at least 21 litres at the other end.
3. Open the drain tap (item 2).
4. Close the drain tap when there is no more oil left in the sump.

**Caution: Do not fill the sump past the maximum notch (mark) on the dipstick as this can have an adverse affect on the performance of the engine or damage the engine. Excess lubricating oil must be drained from the sump.**

5. Clean the area around the filler cap on top of the rocker cover.
6. Remove the oil filler cap (figure 31 item 1).
7. Fill the oil sump with the correct amount of new engine lubricating oil. Allow the oil enough time to pass to the sump. Remove the dipstick (figure 32 item 1) and ensure that the lubricating oil is to the full mark. Do not exceed the full mark on the dipstick. Ensure that the dipstick is fitted correctly in the dipstick tube.
8. Replace the oil filler cap.
9. Start the engine and operate in a no load condition for 2 minutes and check for leaks.
10. Recheck the oil level and top up if necessary.

**Note:** Renew the filter canister when the lubricating oil is renewed.

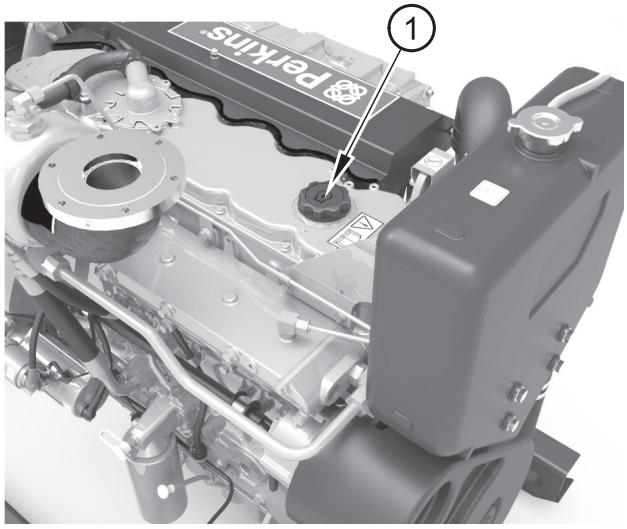



*Figure 31*

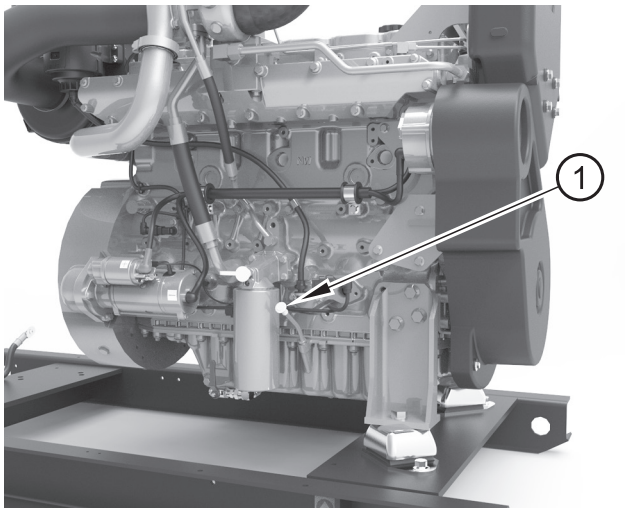



*Figure 32*

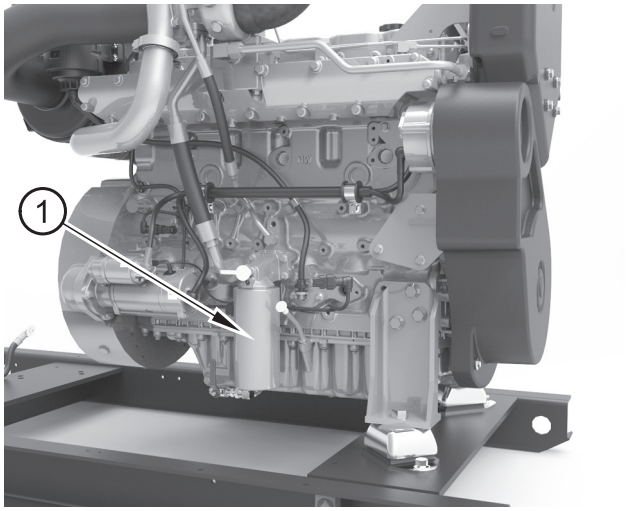



*Figure 33*

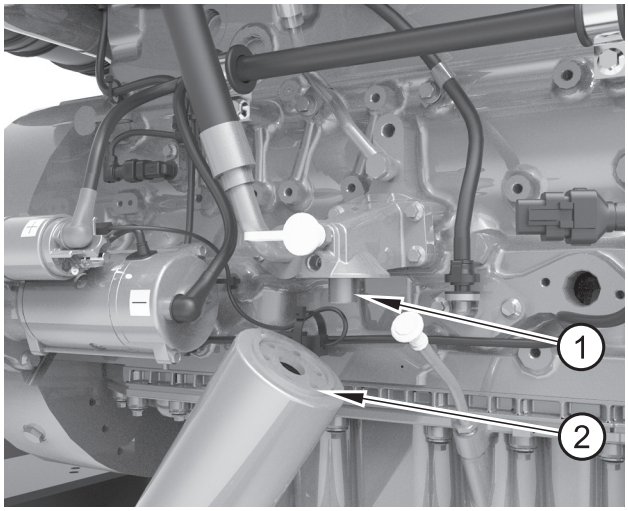



*Figure 34*

## How to renew the canister of the lubricating oil filter

**⚠ WARNING**

**Discard the used canister and lubricating oil in a safe place and in accordance with local regulations.**

1. Put a tray or plastic bag under or around the filter to retain spilt lubricating oil.
2. Remove the filter canister (figure 33 item 1) with a strap wrench or similar tool. Ensure that the adaptor (figure 34 item 1) is secure in the filter head. Then discard the canister.
3. Clean the filter head.
4. Lubricate the top of the new canister seal (item 2) with clean engine lubricating oil.

**Caution: Do not prefill with oil.**

5. Fit the new canister until the surfaces make contact, then tighten it by hand an extra 3/4's of a turn only. Do not use a strap wrench.
6. Ensure that there is lubricating oil in the sump. Operate the starter motor until the oil pressure warning light is extinguished or there is a reading on the gauge. The oil pressure should be greatest after a cold engine is started. The typical engine oil pressure with SAE10W40 is 350 to 450 kPa (50 to 65 psi) at rated rpm.
7. Operate the engine for 2 minutes and check for leakage from the filter. When the engine has cooled, check the oil level on the dipstick and put more oil into the sump, if necessary.

**Caution: The canister contains a valve and special tube to ensure that lubricating oil does not drain from the filter. Therefore, ensure that the correct canister is used.**

## How to renew the engine breather canister

1. Rotate the breather cap (figure 35 item 1) anti -clockwise and pull away from the main body
2. Remove the filter canister (figure 36 item 1) and discard.
3. Insert new filter canister.
4. Replace breather cap and re attach hose

## Oil breather

The breather hose (figure 37 item 1) helps to vent the vapours created in the engine.

The breather hose from the breather canister must be piped to a position, either overboard via a suitable oil trap,or as an option, to under the air cleaner cap depending on installation suitability and access.

Care should be taken to ensure that no excessive loops are created in any additional lengths of pipework.

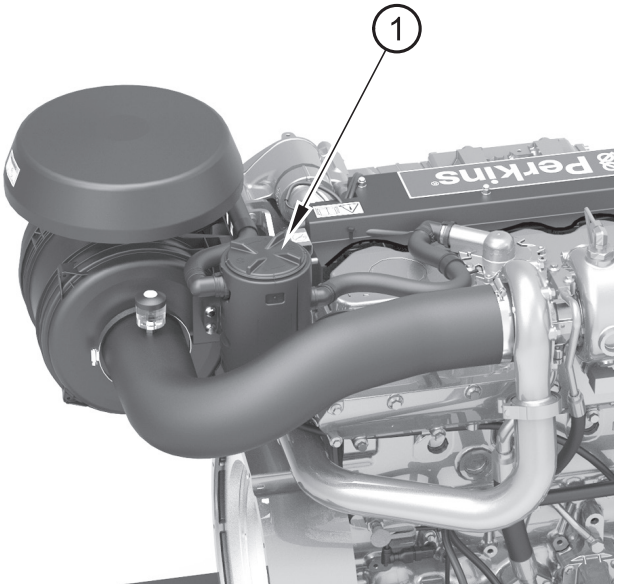



*Figure 35*

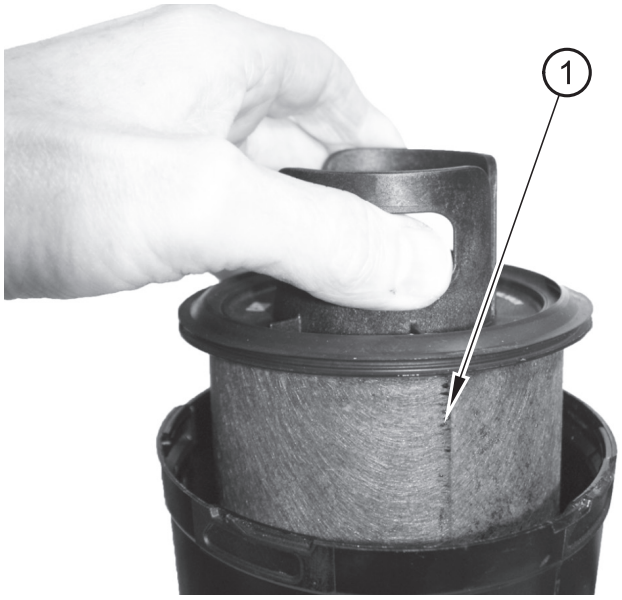



*Figure 36*

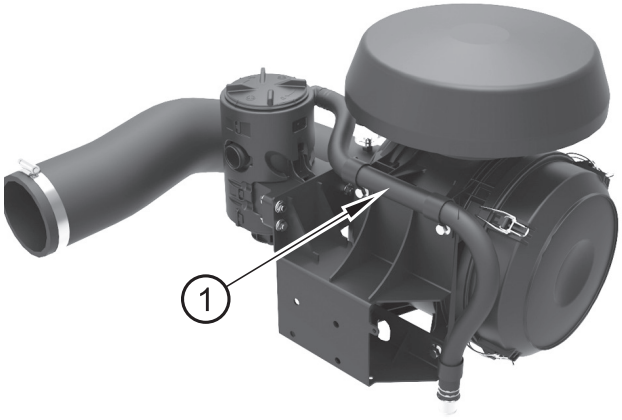



*Figure 37*


*Figure 38*

## How to inspect and renew the air filter

The service indicator (figure 38) will show when the air cleaner element will require changing.

Throughout the service life of the filter the sprung indicator, in the clear body, will move towards the red service area. When it reaches this red area the filter will need renewing.

1. Release the 4 catches and lift the cover (figure 39 item 1) to one side.
2. Remove the filter element (item 2).
3. Fit the new element.
4. Refit the cover and relocate the clips
5. Reset the service indicator by pressing the yellow button on top.

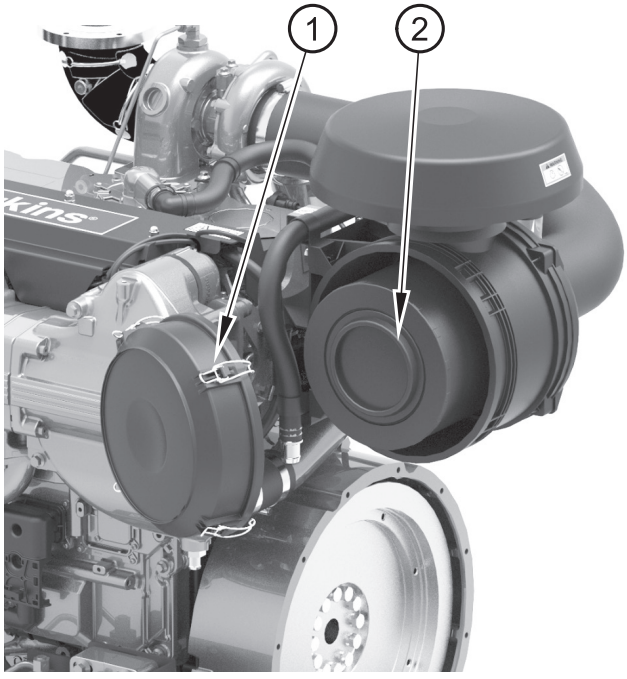



*Figure 39*

## How to check the condition of the vibration damper

**Caution: A vibration damper should be renewed if there is impact damage to the outer casing or if there is leakage of the viscous fluid from the cover plate.**

To gain access to the vibration damper (figure 40 item 1), remove the 4 bolts (item 2) holding the belt cover in place.

Check the area around the holes for the damper bolts for cracks and general wear if the damper has become loose in service.

Check that the six bolts (figure 41 item 2) for the viscous damper are tightened correctly:

Tighten the six M12 bolts to 115 Nm (85 lb ft).

If it is necessary to renew the vibration damper refer to the workshop manual.

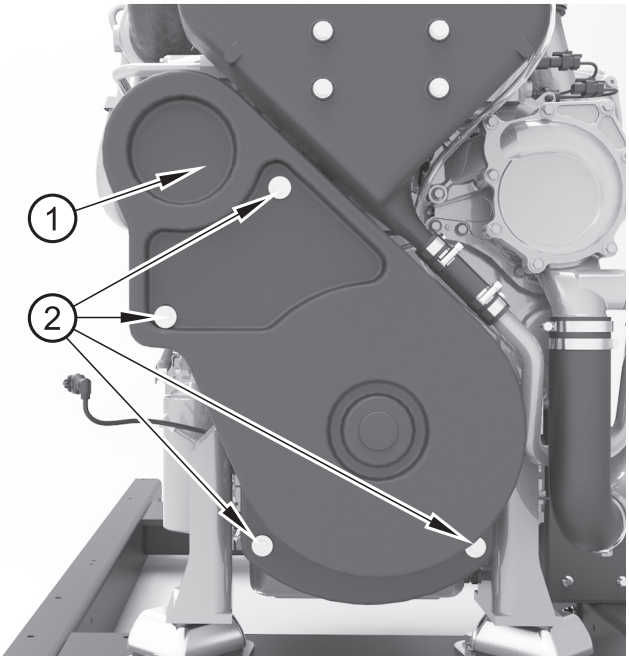



*Figure 40*

## Corrosion

This can occur when two different metals are in contact near to, or in, sea water. For example, a brass or bronze pipe fitted into aluminium can cause rapid corrosion. For this reason, special precautions are necessary when an engine is installed. In this situation, some components will be connected to a sacrificial anode fitted to the hull. Specialist manufacturers will advise on the maintenance of these anodes.

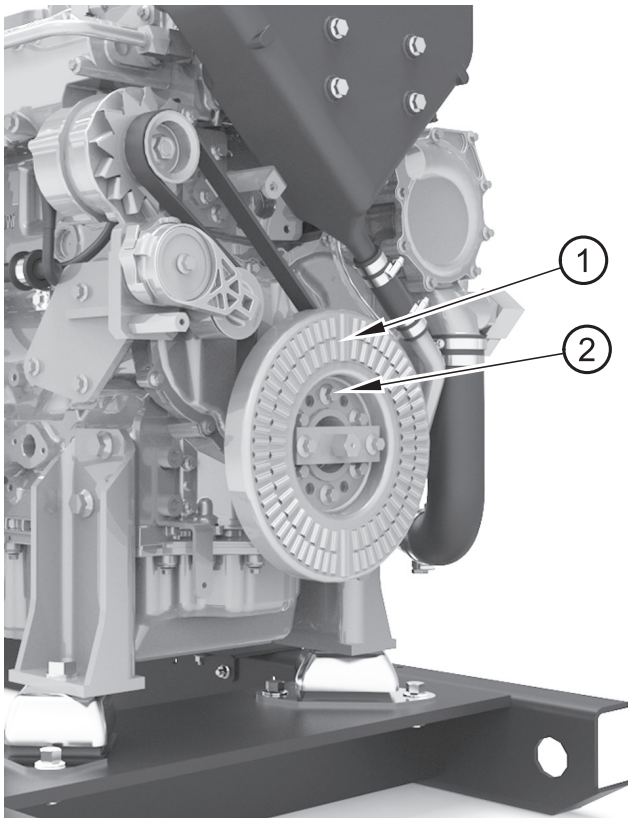



*Figure 41*

# 6. Engine preservation

## Introduction

The recommendations indicated below are designed to prevent damage to the engine when it is withdrawn from service for a prolonged period, 3 months or more. Use these procedures if the engine is to be withdrawn from service. The instructions for the use of POWERPART products are given on the outside of each container.

## Procedure

1. Completely clean the outside of the engine.
2. When a preservative fuel is to be used, drain the fuel system and fill it with the preservative fuel. POWERPART Lay-Up 1 can be added to the normal fuel to change it to a preservative fuel. If preservative fuel is not used, the system can be completely filled with normal fuel but the fuel must be drained and discarded at the end of the storage period together with the fuel filter canister.
3. Operate the engine until it is warm. Then correct leakages of fuel, lubricating oil or air. Stop the engine and drain the lubricating oil from the sump.
4. Renew the canister of the lubricating oil filter.
5. Fill the sump to the full mark with new and clean lubricating oil and add POWERPART Lay-up 2 to the oil to protect the engine against corrosion. If POWERPART Lay-Up 2 is not available, use a correct preservative fluid instead of the lubricating oil. If a preservative fluid is used, this must be drained and the lubricating oil sump must be filled to the correct level with normal lubricating oil at the end of the storage period.
6. Drain the coolant circuit. In order to protect the cooling system against corrosion, fill it with an approved antifreeze mixture because this gives protection against corrosion.

**Caution: If protection against frost is not necessary and a corrosion inhibitor is to be used, it is recommended that you consult the Service Department, Perkins Marine.**

7. Operate the engine for a short period in order to circulate the lubricating oil and the coolant in the engine.
8. Close the seacock and drain the auxiliary water cooling system.

**Caution: The auxiliary water system cannot be drained completely. If the system is drained for engine preservation purposes or for protection from frost, the system must be filled again with an approved antifreeze mixture.**

9. Remove the impeller from the auxiliary water pump and put the impeller in a dark place for storage. Before the impeller is fitted at the end of the storage period, lubricate lightly the blades and each end of the impeller and the inside of the pump with Spheerol SX2 grease or glycerine.

**Caution: The auxiliary water pump must never run in a dry condition because this can damage the impeller blades.**

10. Spray POWERPART Lay-Up 2 into the induction manifold. Seal the manifold and breather outlet with waterproof tape.
11. Remove the exhaust pipe. Spray POWERPART Lay-Up 2 into the exhaust manifold. Seal the manifold with waterproof tape.
12. Disconnect the battery. Then put the battery into safe storage in a fully charged condition. Before the battery is put into storage, protect its terminals against corrosion. POWERPART Lay-Up 3 can be used on the terminals.
13. Seal the vent pipe of the fuel tank or the fuel filler cap with waterproof tape.
14. Remove the alternator drive belt and put it into storage.

15. In order to prevent corrosion, spray the engine with POWERPART Lay-Up 3. Do not spray the area inside the alternator cooling fan.

**Caution: After a period in storage, but before the engine is started, operate the starter motor with the stop switch held in the "STOP" position until oil pressure is indicated. Oil pressure is indicated when the low pressure warning light is extinguished. If a solenoid stop control is used on the fuel injection pump, it must be disconnected for this operation.**

If the engine protection is done correctly according to the above recommendations, no corrosion damage will normally occur. Perkins Marine are not responsible for damage which may occur when an engine is in storage after a period in service.

**How to add antifreeze to the auxiliary water system for engine preservation purposes**

Before antifreeze is added to the auxiliary water system the system should be flushed out with fresh water. To do this operate the engine for one to two minutes with the seacock closed and with a supply of fresh water through the open top of the auxiliary water strainer.

1. Obtain two empty, clean containers each with a capacity of approximately 9,0 litres (2 UK gallons) 9.6 US quarts. Also obtain 4,5 litre (1 UK gallon) 5 US quarts of POWERPART antifreeze.
2. Remove the outlet from the connection on the heat exchanger and put the end of the hose into one of the containers.
3. Remove the cover from the top of the auxiliary water strainer, and with the seacock closed, add some antifreeze through the open top of the auxiliary water strainer. Start the engine and run the engine at idle speed, then continue to add the remainder of the antifreeze through the open top of the strainer.
4. Operate the engine for several minutes. During this period, change the containers around, pour the antifreeze/water solution from the container at the outlet (hose end) into the strainer.
5. When the antifreeze is mixed thoroughly and has been circulated through the auxiliary water system, stop the engine. Fit the top of the auxiliary water strainer.

# 7. Parts and service

## Introduction

If problems occur with your engine or with the components fitted onto it, your Perkins distributor can make the necessary repairs and will ensure that only the correct parts are fitted and that the work is done correctly.

## Service literature

Workshop manuals, Installation drawings and other service publications are available from your Perkins distributor at a nominal cost.

## Training

Local training for the correct operation, service and overhaul of engines is available at Perkins distributor. If special training is necessary, your Perkins distributor can advise you how to obtain it at Perkins Marine or the Perkins Customer Training Department, Peterborough, or other main centres.

## POWERPART recommended consumable products

Perkins have made available the products recommended below in order to assist in the correct operation, service and maintenance of your engine and your machine. The instructions for the use of each product are given on the outside of each container. These products are available from your Perkins distributor or Perkins Marine.

**POWERPART Antifreeze**

Protects the cooling system against frost and corrosion.

**POWERPART Easy Flush**

Cleans the cooling system.

**POWERPART Gasket and flange sealant**

To seal flat faces of components where no joint is used. Especially suitable for aluminium components.

**POWERPART Gasket remover**

An aerosol for the removal of sealants and adhesives.

**POWERPART Griptite**

To improve the grip of worn tools and fasteners.

**POWERPART Hydraulic threadseal**

To retain and seal pipe connections with fine threads. Especially suitable for hydraulic and pneumatic systems.

**POWERPART Industrial grade super glue**

Instant adhesive designed for metals, plastics and rubbers.

**POWERPART Lay-Up 1**

A diesel fuel additive for protection against corrosion.

**POWERPART Lay-Up 2**

Protects the inside of the engine and of other closed systems.

**POWERPART Lay-Up 3**

Protects outside metal parts.

**POWERPART Metal repair putty**

Designed for external repair of metal and plastic.

**POWERPART Pipe sealant and sealant primer**

To retain and seal pipe connections with coarse threads. Pressure systems can be used immediately.

**POWERPART Retainer (high strength)**

To retain components which have an interference fit. Currently Loctite 638.

**POWERPART Safety cleaner**

General cleaner in an aerosol container

**POWERPART Silicone adhesive**

An RTV silicone adhesive for application where low pressure tests occur before the adhesive sets. Used for sealing flange where oil resistance is needed and movement of the joint occurs.

**POWERPART Silicone RTV sealing and jointing compound**

Silicone rubber sealant which prevents leakage through gaps. Currently Hylosil.

**POWERPART Stud and bearing lock**

To provide a heavy duty seal to components that have a light interference fit.

**POWERPART Threadlock and nutlock**

To retain small fasteners where easy removal is necessary.

**POWERPART Universal jointing compound**

Universal jointing compound which seals joints. Currently Hylomar.

# 8. General data

### Basic Technical Data

| | |
|---|---|
| Number of Cylinders | 6 |
| Cylinder Arrangement | Vertical in-line |
| Cycle | 4 stroke |
| Induction System | Turbo after cooled |
| Combustion System | Direct injection |
| Bore | 105 mm |
| Stroke | 135 mm |
| Compression Ratio | 16.5:1 |
| Cubic Capacity | 7.01 litres |
| Direction of Rotation | Anti-clockwise view from flywheel |
| Firing Order | 1, 5, 3, 6, 2, 4, |
| Total Weight (wet) | 1212 kg |
| Total Weight (dry) | 1157 kg |
| Overall Dimensions | Height = 1260 mm<br>Length = 1928 mm<br>Width = 956 mm |

### Performance

**Typical Average Sound Pressure Level at 1 Metre**

1500 rev/min = 86.5 dBA ( Complete with a Typical Alternator)
1800 rev/min = 88.9 dBA ( Complete with a Typical Alternator)

Note

All data based on operation under ISO/TR14396, ISO 3046/1 standard reference conditions

**Test Conditions**

Air temperature 25$^{O}$C (77$^{O}$F) barometric pressure 100 kPa (29.5 in Hg), relative humidity 30%, all ratings certified within ± 5%

If the engine is to operate in ambient conditions other than the test conditions then suitable adjustments must be made for any change in inlet air temperature, barometric pressure or humidity.

**Diesel Fuel**

ISO-F-DMX/ISO-F-DMA/ISO 8217:1986 (E) Class F, EN590, D975, JIS class 1,2,3

**Lubricating Oil**

A multrigrade lubricating oil must be used which conforms to specification API-CJ4

**Start/Load Delay**

90% of prime power can be applied 10 seconds after the starter motor is energized. The remaining 10% can be applied 30 seconds after start if the ambient temperature is not less than 15$^{O}$C. If the ambient temperature is less than 15$^{O}$C, an immersion heater is recommended.

### General Installation Data - Typical Installation Conditions

| Item | Units | Type of Operation and Application | | | | | |
|---|---|---|---|---|---|---|---|
| | | Prime Power | | | 110% | | |
| | | Tag1 | Tag2 | Tag3 | Tag1 | Tag2 | Tag3 |
| Engine Speed | rev/min | 1500 | | | | | |
| Net Engine Power | kW | 109.3 | 129.0 | 163.9 | 120.2 | 141.9 | 180.3 |
| Brake Mean Effective Pressure | bar | 12.47 | 14.71 | 18.7 | 13.71 | 16.19 | 20.57 |
| Piston Speed | m/s | 6.8 | 6.8 | 6.8 | 6.8 | 6.8 | 6.8 |
| Engine Coolant Flow (FW) Max | litre/min | 240 | 240 | 240 | 240 | 240 | 240 |
| Raw Water Flow Max | litre/min | 138.5 | 138.5 | 138.5 | 138.5 | 138.5 | 138.5 |
| Combustion Air Flow | $m^3$/min | 9.48 | 10.47 | 11.78 | 9.77 | 10.55 | 11.81 |
| Exhaust Gas Flow | $m^3$/min | 19.86 | 22.25 | 25.32 | 20.6 | 22.55 | 25.51 |
| Exhaust Gas Temperature | $^{O}$C | 418.0 | 433.0 | 443.4 | 428.0 | 438.0 | 446.3 |
| Total Heat From Fuel | kW | 304.4 | 353.5 | 426.2 | 326.7 | 372.5 | 448.4 |
| Gross Heat to Power | kW | 109.3 | 129.0 | 163.9 | 120.2 | 141.9 | 180.3 |
| Net Heat to Power | kW | 109.3 | 129.0 | 163.9 | 120.2 | 141.9 | 180.3 |
| Heat to Water and Lubricating Oil | kW | 89.4 | 101.5 | 117.8 | 94.3 | 104.9 | 121.4 |
| Heat to Exhaust | kW | 82.1 | 94.9 | 110.0 | 87.2 | 97.1 | 111.7 |
| Heat to Radiation | kW | 8.2 | 8.1 | 8.3 | 8.2 | 8.2 | 8.3 |
| Heat to Aftercooler | kW | 15.4 | 19.9 | 26.2 | 16.8 | 20.5 | 26.7 |

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| Item | Units | Type of Operation and Application | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Prime Power | | | | 110% | | | |
| | | Tag1 | Tag2 | Tag3 | Tag4 | Tag1 | Tag2 | Tag3 | Tag4 |
| Engine Speed | rev/min | 1800 | | | | | | | |
| Net Engine Power | kW | 129.0 | 164.0 | 191.3 | 218.6 | 141.3 | 180.4 | 210.4 | 240.5 |
| Brake Mean Effective Pressure | bar | 12.26 | 15.58 | 18.18 | 20.78 | 13.48 | 17.14 | 20.0 | 22.86 |
| Piston Speed | m/s | 8.1 | 8.1 | 8.1 | 8.1 | 8.1 | 8.1 | 8.1 | 8.1 |
| Engine Coolant Flow (FW) Max | litre/min | 340 | 340 | 340 | 340 | 340 | 340 | 340 | 340 |
| Raw Water Flow Max | litre/min | 139 | 139 | 139 | 139 | 139 | 139 | 139 | 139 |
| Combustion Air Flow | $m^3$/min | 13.8 | 15.18 | 16.41 | 17.04 | 14.17 | 15.61 | 16.63 | 17.42 |
| Exhaust Gas Flow | $m^3$/min | 25.65 | 29.14 | 32.53 | 34.94 | 26.48 | 30.26 | 33.37 | 36.46 |
| Exhaust Gas Temperature | $^O$C | 349.8 | 365.2 | 380.9 | 403.4 | 356.8 | 375.2 | 396.0 | 423.6 |
| Total Heat From Fuel | kW | 365.0 | 439.8 | 506.9 | 571.6 | 390.3 | 473.7 | 546.8 | 620.0 |
| Gross Heat to Power | kW | 129.0 | 164.0 | 191.3 | 218.6 | 141.3 | 180.4 | 210.4 | 240.5 |
| Net Heat to Power | kW | 129.0 | 164.0 | 191.3 | 218.6 | 141.3 | 180.4 | 210.4 | 240.5 |
| Heat to Water and Lubricating Oil | kW | 101.3 | 118.2 | 135.4 | 153.0 | 106.5 | 125.8 | 145.4 | 164.1 |
| Heat to Exhaust | kW | 96.6 | 111.8 | 127.1 | 142.0 | 101.7 | 119.0 | 135.6 | 154.2 |
| Heat to Radiation | kW | 8.7 | 8.7 | 8.8 | 8.8 | 8.8 | 8.7 | 8.9 | 8.8 |
| Heat to Aftercooler | kW | 29.4 | 37.1 | 44.3 | 49.2 | 31.4 | 39.8 | 46.5 | 52.4 |

**Cooling System**

Minimum seacock diameter (full flow) 39mm
Maximum lift of seawater pump 2m
Maximum seawater inlet temperature 38 $^o$C

Pressure cap setting 50kPa
Maximum Engine intake Temperature 50 $^o$C

**Coolant**

Extended Life Coolant 50% Mix (Heat Exchanger)
Extended Life Coolant 20% Mix (Keel Cooled, normal conditions)
Maximum raw water pump inlet pressure 50/60 Hz 15Kpa

Total system coolant capacity 38 litres
Drain down capacity 38.5 litres
Maximum temperature to engine 70 $^0$C

**Thermostat**

Operating range 83-94 $^0$C

**Electrical System**

**Battery Charging System:**

Type: Insulated return
Alternator: 100 amp- 12 volt
55 amp- 24 volt

Starter 4.2 kW 12 volt
4.0 kW 24 volt

**Cold start recommendations**

Minimum cranking speed 100 rpm

| Batteries for Temperatures down to - 5 Deg.C (23 Deg. F) | |
|---|---|
| 12 Volt | 24 Volt |
| One battery - 520 Amps BS3911 or 800 Amps SAE J537 (CCA) | Two 12 Volt batteries in series - each 315 Amps BS3911 or 535 Amps SAE J537 (CCA) |
| **Batteries for Temperatures down to - 15 Deg.C (5 Deg. F)** | |
| Two 12 Volt batteries in parallel, each 520 Amps BS3911 or 800 Amps SAE J537 (CCA) | Two 12 Volt batteries in parallel, each 520 Amps BS3911 or 800 Amps SAE J537 (CCA) |

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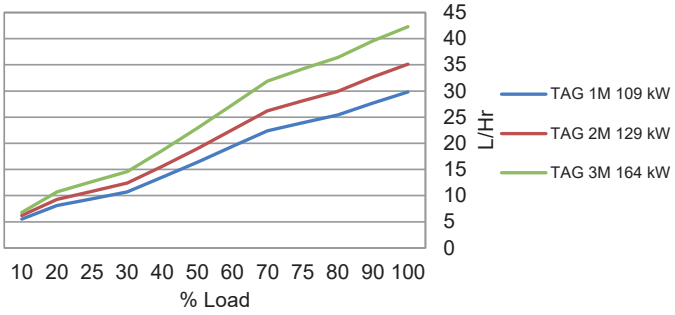
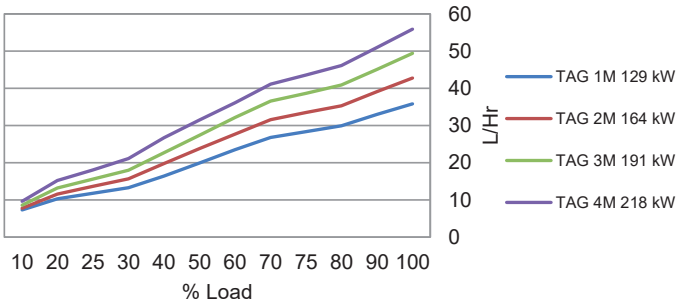
**Fuel consumption**

**Fuel Consumption Prime Power Rating 1500 RPM (50 Hz)**




**Fuel Consumption Prime Power Rating 1800 RPM (60 Hz)**




**Fuel Lift Pump**

| | |
|---|---|
| Flow/hour | 4 Ltr/min(240 Ltrs/Hr) |
| Maximum suction head | 2m |
| Maximum supply line restriction | 30 kPa |
| Maximum returnline restriction | 20 kPa |

| | |
|---|---|
| **Governor Type** | ECM |
| Speed control to | ISO 8528, G2 |

**Exhaust system**

| | |
|---|---|
| Max allowable back pressure | 15 kPa |
| Exhaust connection | 68 bore 6x9.8 holes on 145mm PCD |

**Induction system**

**Maximum air intake restriction**

| | |
|---|---|
| Clean filter | 5 kPa |
| Dirty filter | 8 kPa |
| Air filter type | 2 stage cyclonic/paper element |

**Lubrication system**

**Lubricating oil capacity:**

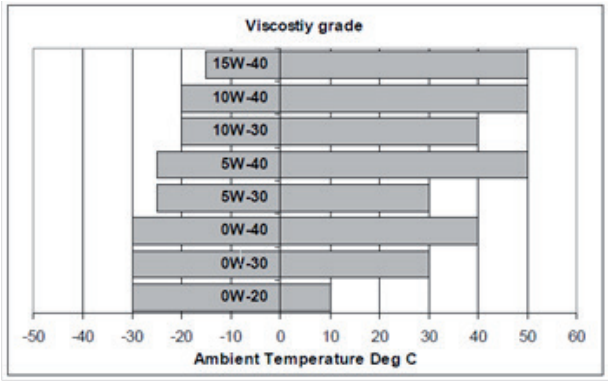
| | |
|---|---|
| Total system | 21 litres |
| Minimum | 17.5 litres |
| Maximum engine operating angle intermittent | 30°C |

**Lubricating oil pressure**

| | |
|---|---|
| Relief valve opens | 415-470 kPa |
| At maximum rated speed | 500+/-100 kPa |
| Normal oil temperature | 110°C |
| Max continuous oil temperature | 125°C |
| Oil consumption at full load as a % of fuel consumption | 0.01 % |

**Recommended SAE viscosity**

Multigrade oil must be used which conforms to API-CJ4.
See illustration below:



## Warranty information

Perkins warrants to the ultimate purchaser and each subsequent purchaser that new Marine Diesel Engines up to 18.5 L (1129 cubic inch) per cylinder (excluding Tier 1 and Tier 2 Marine Engines less than 50 kW) operated and serviced in the United States, including all parts of the emission control systems (emission-related components), are:

- Designed, built, and equipped to conform, at the time of sale, with applicable emission standards. These standards are prescribed by the United States Environmental Protection Agency (EPA) regulations.
- Free from defects in materials and workmanship in emission-related components that can cause the engine to fail to conform to applicable emission standards for the warranty period.

A detailed explanation of the Emission Control Warranty that is applicable to new marine diesel engines, including the components covered and the warranty period, is found in Supplement, SELF9002, “Federal Emissions Control Warranty”. Consult your Perkins dealer to determine if your engine is subject to an Emission Control Warranty.

# Installation Information

# 9. Location of engine installation points

## Front and right side

**1** Coolant filler cap.

**2** Header tank.

**3** Raw water inlet.

**4** Fresh water drain point.

**5** Fuel return.

**6** Lifting point, entire package.

**7** Secondary fuel filter.

**8** Primary fuel filter.

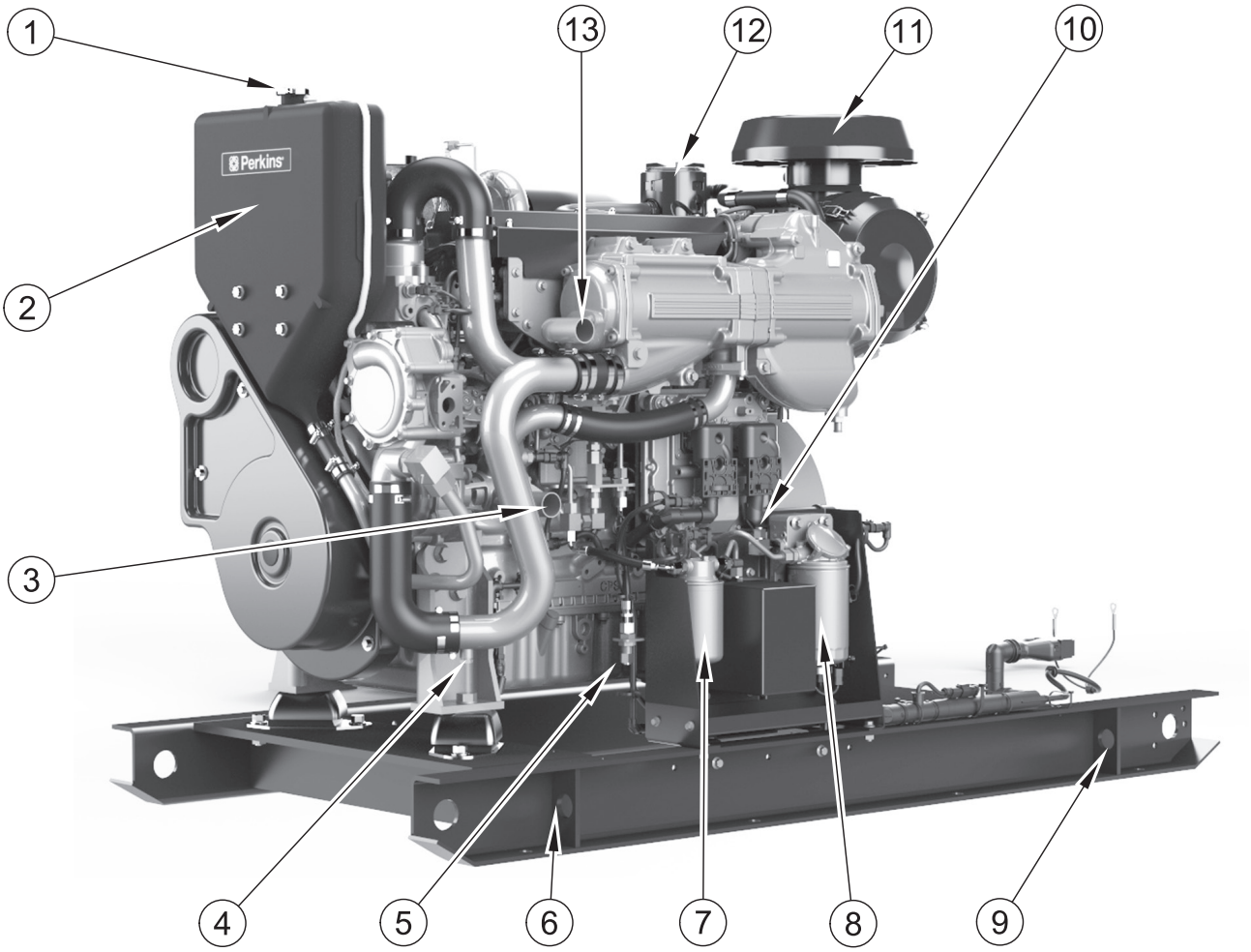
**9** Lifting point, entire package.

**10** Fuel inlet.

**11** Air intake

**12** Crankcase breather.

**13** Raw water outlet.



## Rear and left side

**14** Lifting point, entire package.

**15** Starter.

**16** Engine oil drain.

**17** Oil filter.

**18** Lifting point, entire package.

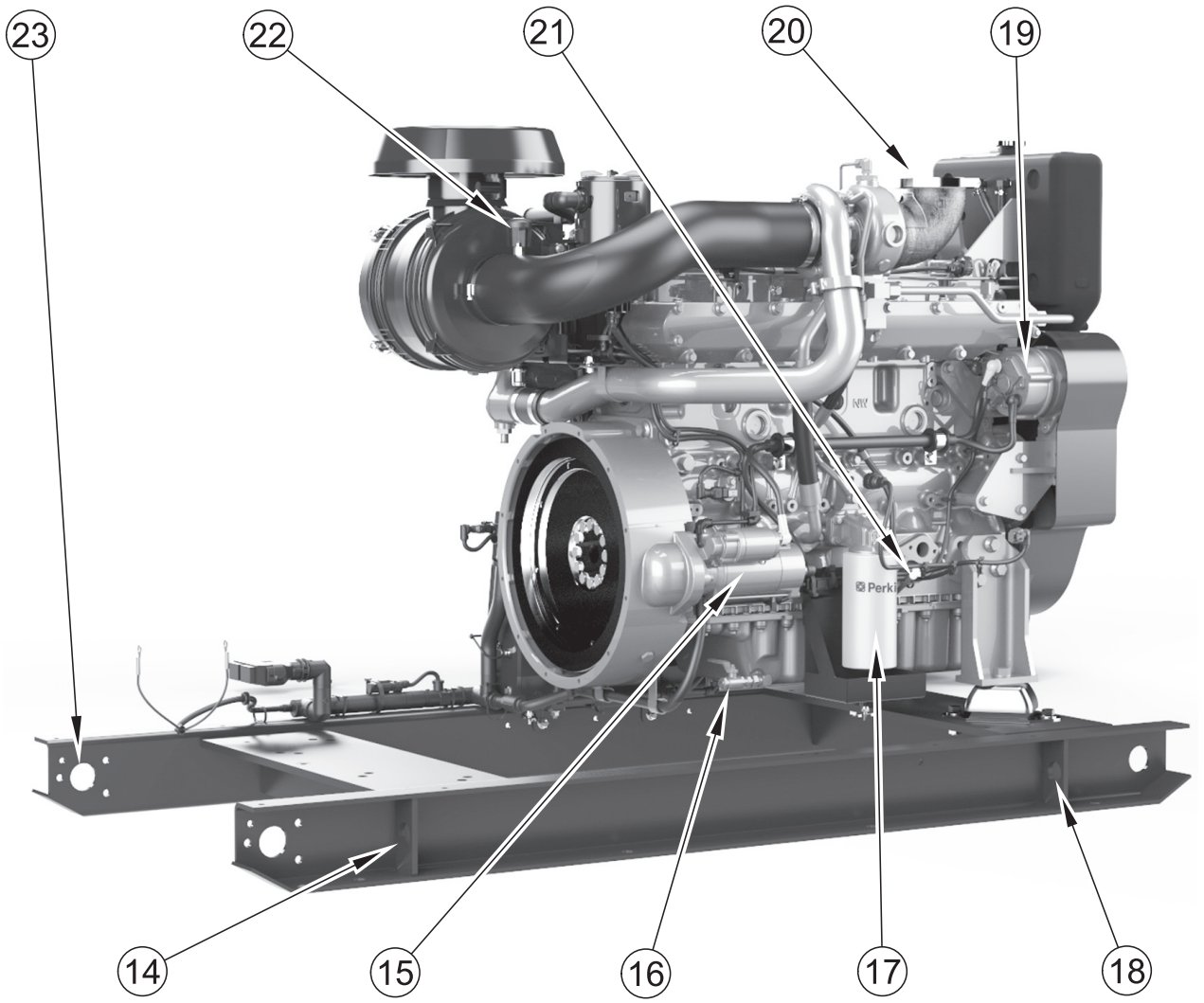
**19** Alternator.

**20** Exhaust connection.

**21** Dipstick.

**22** Air cleaner indicator.

**23** 4 drag holes, (not for lifting the entire package).



# 10. Introduction

## Ratings

The most fundamental factor governing the correct sizing of an auxiliary unit is the power rating required. By considering of the electrical load likely to be applied to the a.c. generator, the user can estimate the required power rating. This is usually done by adding together the kW ratings of the individual parts of the load to arrive at a total kW power rating ‘figure.

Initially every possible load should be included. In addition an allowance for future growth typically between 15% and 20% is common practice. This total kW power rating can now be checked with standard published output for the standard range of auxiliary unit packages. For standby or emergency service, only the essential loads need to be included.

Having established the power requirement and possible auxiliary unit size we need now to look at the specific supply details, environmental conditions and performance criteria required when supplying this particular load. This next stage is the ‘fine tuning’ to ensure that exactly the right size of machine is chosen for the application.

It should be noted that standard published output lists usually quote a kVA rating as well as a kW power rating, and is relating these a power factor of 0.8 lagging is assumed:

i.e., kW = 0.8 x kVA

| Rating | Rated speed | Mechanical power | |
|---|---|---|---|
| | | Prime | Stand-by |
| | RPM | mkW | mkW |
| 1 | 1500 | 109.3 | 120.2 |
| 2 | 1500 | 129.0 | 141.9 |
| 3 | 1500 | 164.0 | 180.4 |
| 4 | 1800 | 129.0 | 141.9 |
| 5 | 1800 | 163.9 | 180.4 |
| 6 | 1800 | 191.3 | 210.4 |
| 7 | 1800 | 218.6 | 240.5 |

## Engine

The engine ratings are determined at the ISO 3046-1 standard reference conditions, 25$^{O}$ C (77$^{O}$ F) air temperature, barometric pressure 100 kPa (29.5 in Hg), and 30% relative humidity. If the engine is

to operate in ambient conditions other than the test conditions then suitable adjustments must be made for any change in inlet temperature. This is more noticeable for naturally aspirated and turbocharged engines, a 6% engine de-rate at an ambient of $50^{O}$ C, than for engines that are turbocharged and aftercooled.

## General comments on load conditions

The majority of a.c. generator applications are in supplying electricity to standard loads such as lighting, heating, ventilation, and an infinite variety of motor drives.

In arriving at a total load figure it is always wise to select the standard rating larger than that estimated. This is despite the fact that it is unlikely that all the loads will not be operating at the same time and hence a smaller machine may be considered. However, future operating conditions and future growth are very difficult to estimate. An allowance of 15% to 20% excess capacity designed into a set is a small price to pay compared with the cost of a completely new larger unit that may be required to drive additional loads in a few years' time. The exceptions are sets solely for emergency service, when only the essential loads need be included.

There are two basic conditions to check when sizing auxiliary units. The steady state condition, which is mainly concerned with normal operation of the generator within temperature rise limits; and the transient condition, which examines voltage deviations when suddenly applying high current loads (e.g. during motor starting). It is essential that both these conditions be checked, as a rating sufficient for the steady state condition is often not large enough to meet motor starting or voltage dip requirements.

It is the nature of the applied load that dictates the system power factor. Loads that operate at or very close to unity (1.0) power factory include most forms of lighting, rectifier and thyristor type loads; in fact any load which does not include an induction coil (motor). Generally, all domestic loads can be considered as unity power factor since any motors (washing machine, refrigerator, etc. represent only a small part of the load, being normally fractional horsepower motors.

For all remaining load types, some knowledge of operating power factor is required, which for motors depends a great deal on their size and power rating. When considering motor loads, design data should be sought from the motor manufacturer.

In order for a motor to start to rotate, the magnetic field of the motor must be built up to create sufficient torque. During the starting period a very large current is demanded form the power source. This is known as starting or locked rotor current. The level of starting current can vary greatly depending upon the motor design. Six times motor full load current can be considered a usual starting current for most three phase motors. In applying this level of load to an a.c. generator, the output voltage disruption may be quite severe. Momentary transient voltage dips in excess of 40% are possible. Consequent effects of this on other connected loads may be experienced. For example, lighting may dim or even go out altogether; other motors may stop due to insufficient holding voltage on the control contactor coils or release of under voltage protection relays. Therefore, for most applications a maximum voltage dip ought to be specified. Generally the maximum voltage dip should not exceed 30%; and in the absence of any prescribed limit this is the figure normally assumed.

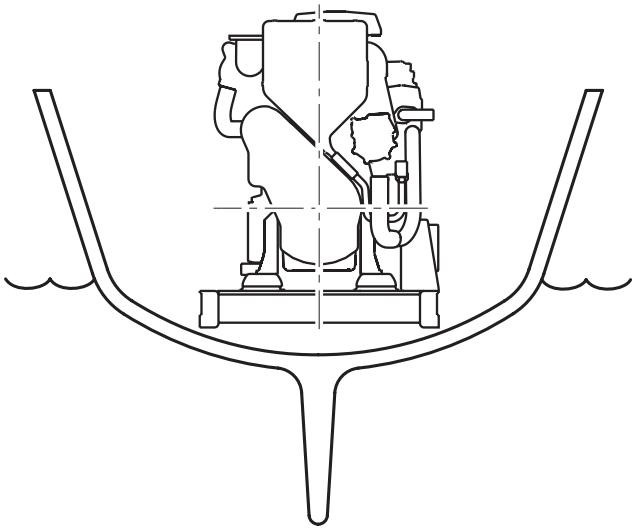


*Figure 1*

# 11. Engine mounting

**Caution: There must be sufficient space around the engine to avoid any contact with any surrounding vessel structure to avoid damage.**

**Caution: Do not exceed the minimum and maximum installation angles quoted in this installation guide.**

**Caution: Any mounts supplied by the end user must comply with the manufacturers specifications.**

**Caution: Where the auxiliary unit is mounted must be of sound and strong construction so as not to put additional stress and vibration on the unit and vessel.**

## Installation angles

These engines are intended to be mounted so that the cylinders are vertical, when viewed from ahead or astern as in (figure 1). Maximum continuous angle of operation is 25$^{o}$ and 30$^{o}$ intermittent in any direction (figure 2).

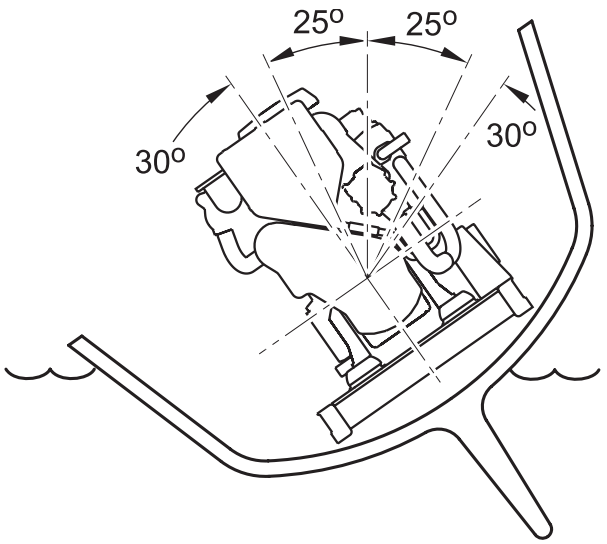



*Figure 2*

## Engine base

**1** 509 mm.

**2** 896 mm.

**3** 212 mm.

**4** 22 mm diameter.

The engine base should be securely mounted to the surface using appropriate hardware in such a way that it is safe from vibration. Typically this would be on rails or on a secured structural base.

Figure 3 shows the base for the after cooled and keel cooled units. with the dimensions for the securing hardware.

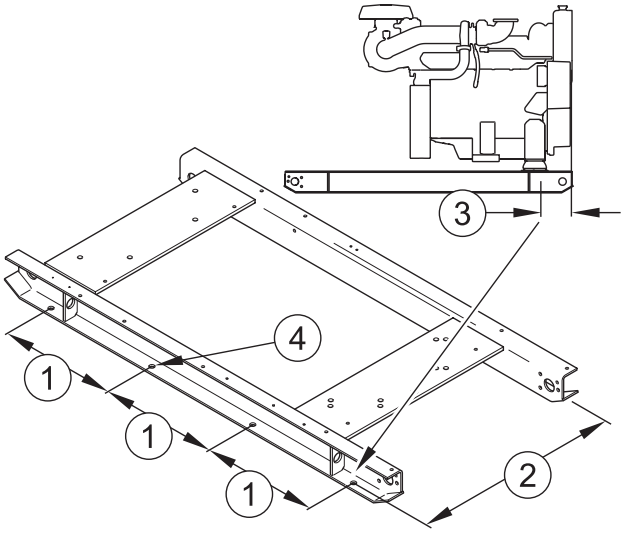



*Figure 3*

# Lifting the entire auxiliary package

**Caution: Only use the lifting eyes on the engine to lift the engine when separated from the auxiliary drive.**

**Caution: Care must be taken when lifting the auxiliary package when using strops as damage may occur if the pathway for the strops is too close to parts of the engine prone to damage.**

**Caution: Before lifting, ensure the weight and the centre of gravity of the entire package is known. Ensure the unit cannot tilt anymore than 5° as shown.**

Lifting points have been provided (figure 4 item 1) on the base rails of the auxiliary unit for lifting the entire package.

Lifting the entire auxiliary unit requires special equipment and procedures.

Lifting strops and spreader bars must be used to lift the entire package using lifting points (figure 4 item 1).

The arrangement must be capable of lifting 2,000 Kg (4,400 lbs) and care must be taken not to let the package tilt anymore than 5° as shown in (figure 5).

If in any doubt, please consult your Perkins dealer for information regarding fixtures for proper lifting of your complete package.

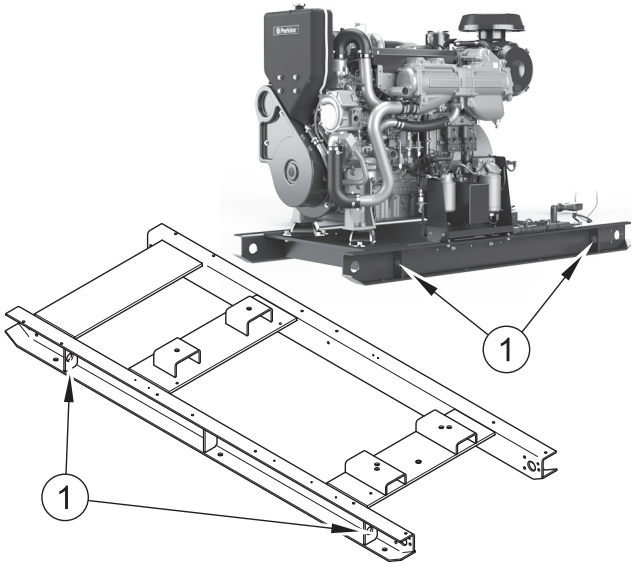



*Figure 4*

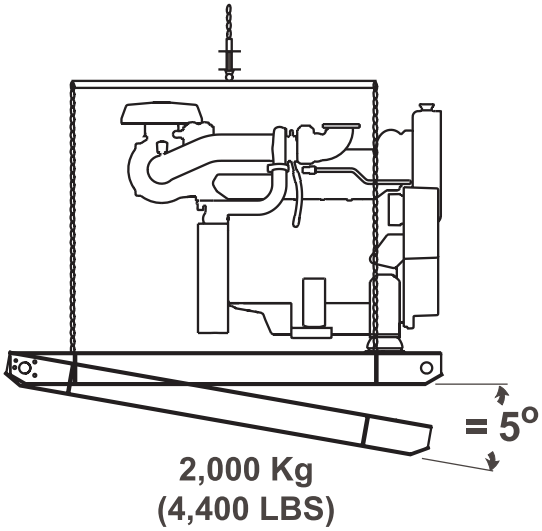



*Figure 5*

# Lifting the engine only

**Caution: Ensure that the auxiliary unit is adequately supported, when lifting th engine only.**

To lift the engine only, use the lifting eyes as shown in figure 6, item 1.

These lifting eyes have blanking plates fitted (figure 6 item 2), which must first be removed. Reinstate these blanking plates after use.

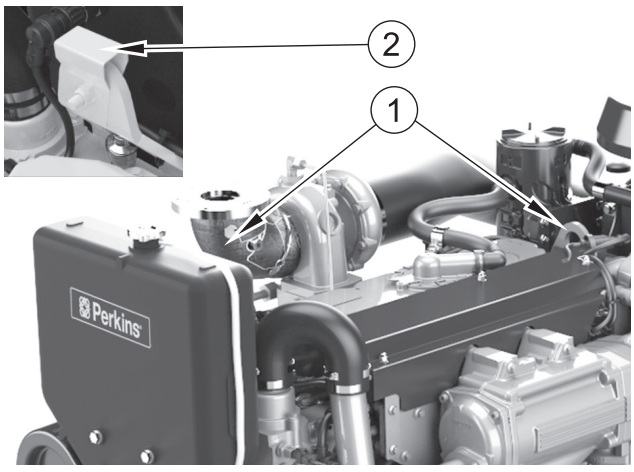



*Figure 6*

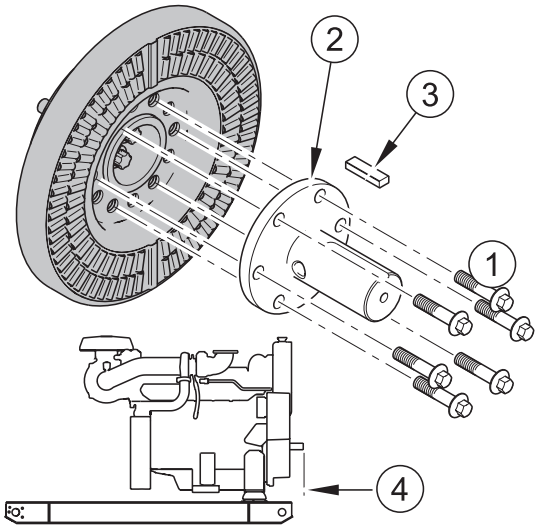



*Figure 7*

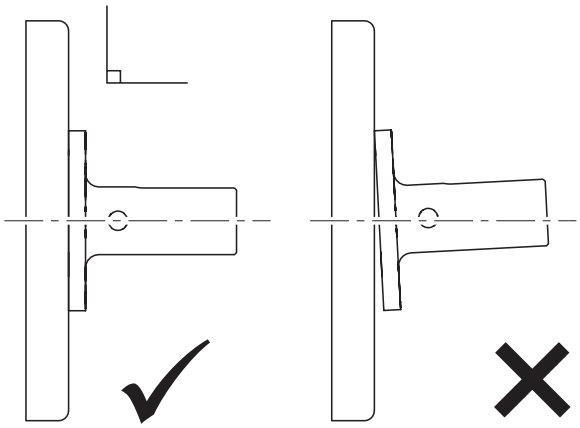


*Figure 8*

# Power take-off (optional)

## PTO fitting instructions

**⚠ WARNING**

**For safety reasons, all moving parts should be shielded by a guard.**

**Caution: Load should be applied gradually, not suddenly. Maximum load is 100%.**

**Note:** Fitting the PTO should be undertaken by a qualified marine engineer.

**Note:** Remove all traces of paint from the mating faces before assembly.

**Note:** It is recommended that a TVA (Torsional Vibration Analysis) is carried out on all equipment that is expected to run on the PTO.

Figure 7 shows the PTO assembly.

**1** M12 bolts, tighten to 115 Nm

**2** PTO shaft.

**3** Key.

**4** Rear face of the engine block to the end of the PTO is 1135 mm.

Ensure that the PTO shaft is correctly fitted as shown in figure 8.

## Provision for power take-off

**Caution: Care must be taken when mounting additional machinery to avoid stress and vibration.**

**Caution: Suitable material must be used to make a support frame bearing in mind the weight and type of equipment to be utilised.**

**Caution: It is strongly recommended that crankshaft axial and belt driven loads are analysed, and it is advisable to carry out a full TVA (Torsional Vibration Analysis) on any additional driven loads.**

PTO's are used predominately to drive auxiliary equipment such as refrigerators, water makers, additional alternators, hydraulic winch motors for example.

The way in which the additional machinery is mounted is important to avoid stress to the auxiliary unit and vessel.

## Belt driven

**Caution: Additional inertia must not be added to the PTO shaft without specialist advice. Consult your distributor if you need advice about non-standard drive arrangements.**

**Note:** Maximum recommended offtake 2 kW per belt.

**Note:** Multiple belt driven accessories should as far as possible be distributed evenly on either side of the engine to minimise side loads

**Note:** If you are in any doubt, please contact your distributor.

**Note:** The frame shown is not a factory option.

Figure 9 shows how mounting the machinery to the hull will create excessive vibration which could lead to damage of the genset or vessel.

The arrangement shown in figure 10 should be adopted with a suitable frame mounted on the engine and not to the base to support the additional equipment.

Figure 11 shows a taper lock drive for belt driven PTO arrangements.

Five inch 'A' section pulley with 3 grooves (figure 11 item 2) and five inch 'B' section pulley with 2 grooves (item 1) are recommended, secured in place by taper locks (item 3).

In this case, the maximum power which can be taken will be limited by the belts and it will be necessary to calculate for marginal applications.

A suggested frame is shown in figure 12, which shows a typical arrangement which is not a factory option.

The frame has been bolted between the engine and mounts in place of the engine feet with a platform to secure the equipment.

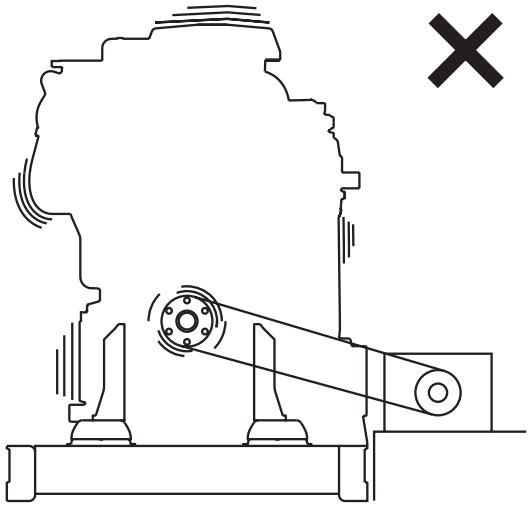


*Figure 9*

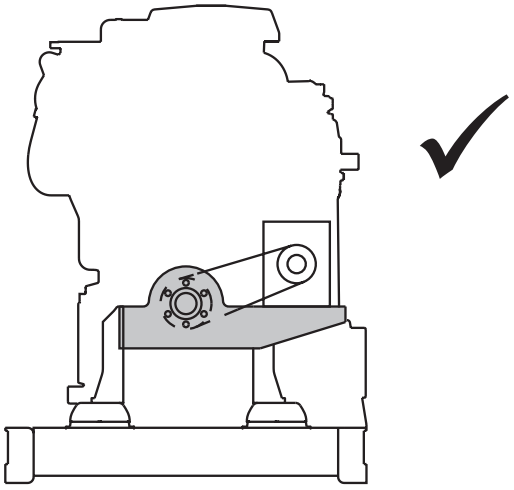


*Figure 10*

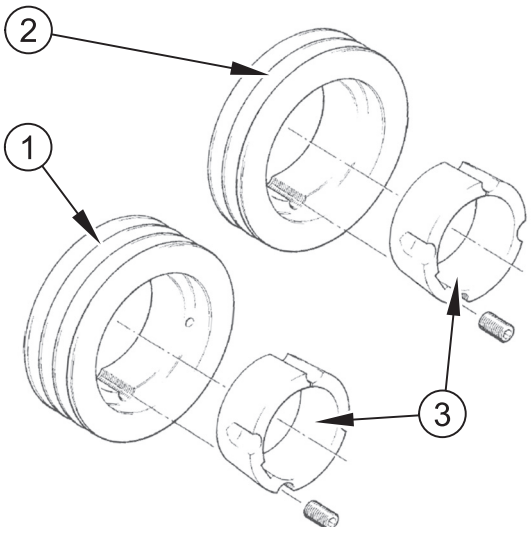



*Figure 11*

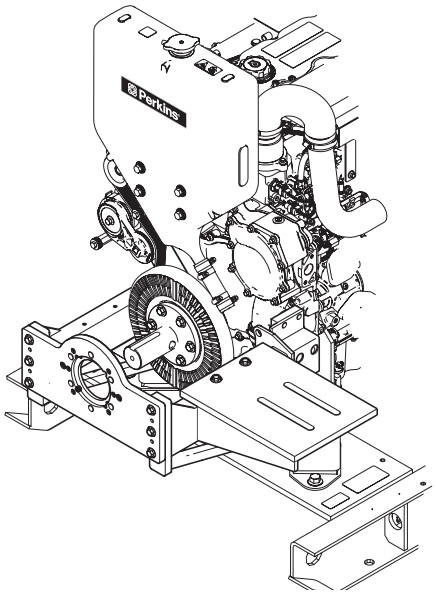



*Figure 12*

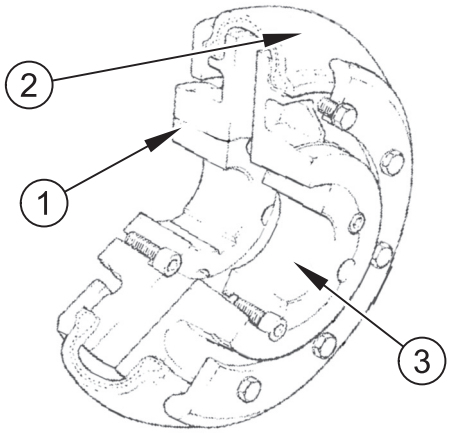



*Figure 13*

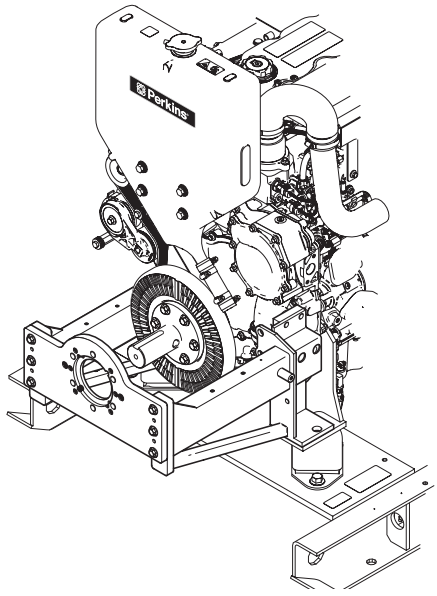



*Figure 14*

## Axial driven

**Caution: Additional inertia must not be added to the PTO shaft without specialist advice. Consult your distributor if you need advice about non-standard drive arrangements.**

**Caution: If the unit utilises flexible mounts, careful attention is required to prevent strain on the crankshaft nose.**

**Note:** The frame shown is not a factory option.

A tyre type coupling should be used as shown in figure 13 and this prevents strain on the crankshaft nose.

**1** Taper lock flanges.

**2** Flexible tyre.

**3** Taper lock.

A suggested frame is shown in figure 14, which has been bolted between the engine and mounts in place of the engine feet. This illustration shows a typical arrangement and is not a factory option.

# Polar diagram

This diagram shows the loading capability of the front of the crankshaft.

The load angle, when viewed from the front of the engine, is measured clockwise, with 0° aligned to TDC.

Overhung load (Newtons) is directed radially outwards from the centre of the diagram.

It is possible to take power from the front crankshaft pulley via belts, chains, etc. This type of PTO generates a bending moment on the front of the crankshaft. Excessive bending moments can cause issues excessive stresses on the crankshaft.

The diagram shows the maximum radial load that can be applied to the crankshaft by a belt driven device (viewed from the front of the engine). The radial load is taken at the main crankshaft pulley location (103 mm from front face of cylinder block) and is measured in N. Loads taken from an auxiliary pulley (mounted forwards of the standard crankshaft pulley) should be scaled using moments taken from the front face of the cylinder block.

A standard 8 rib belt drive arrangement (powering a fan, alternator, etc) applies a maximum load of 2 kN in a vertical (0°) direction onto the crankshaft pulley (103 mm from front face of cylinder block).

A heavy duty 12 rib belt drive arrangement (powering a fan, alternator, etc) applies a maximum load of 4 kN in a vertical (0°) direction onto the crankshaft pulley (110 mm from front face of cylinder block).

The load needs to be taken into consideration if the engine takes a belt drive arrangement.

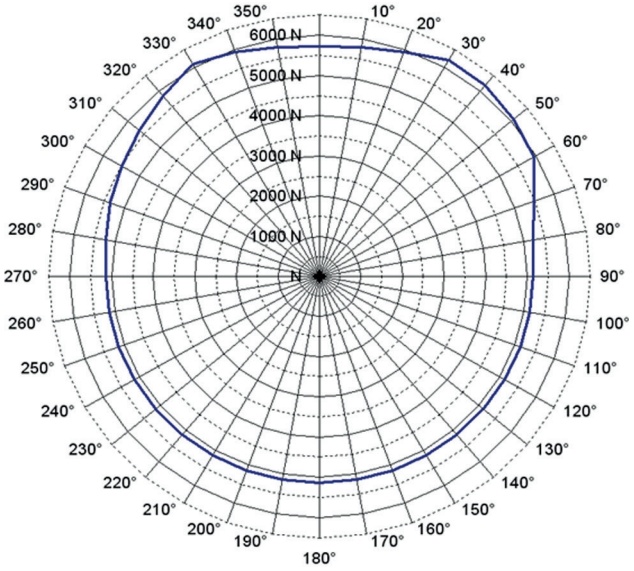



*Figure 15*

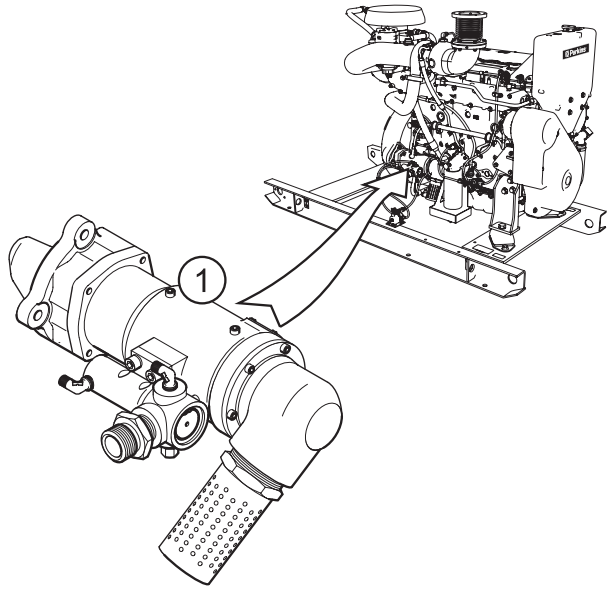



*Figure 16*

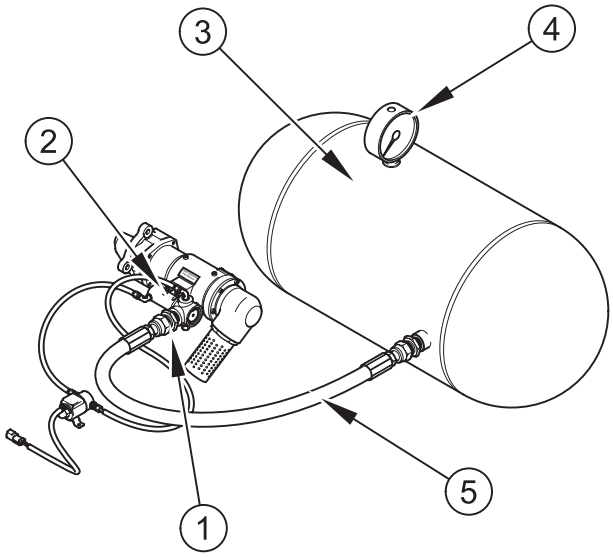
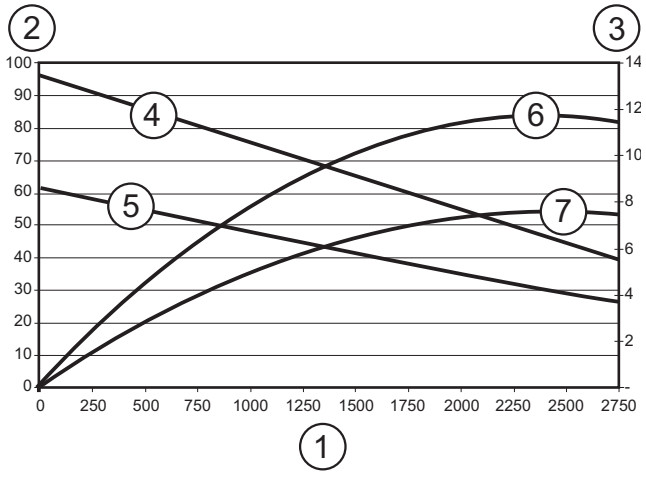



*Figure 17*




# Air starter (optional)

**Caution: Turbine air starters are sensitive to flow restrictions and require unrestricted pipe work. Ensure that all hoses and fittings have a bore of at least 25 mm (1”) diameter and that one size is maintained throughout the installation.**

Figure 16 shows the optional air starter (item 1).

Figure 17 shows the main elements and connections.

**1** 1” BSP fitting.

**2** Electronic relay valve.

**3** Air reservoir.

**4** Pressure gauge.

**5** Supply line, 25 mm (1”) minimum bore.

The air supply to the starter needs to be 1” BSP (P1) to connect to the air feed which has a maximum pressure of 8 bar and a minimum of 5.5 bar.

| Flow Rates/Consumption | |
|---|---|
| @ 5.5 bar | 0.2 $m^3/s$ |
| @ 8.0 bar | 0.29 $m^3/s$ |

The working pressure rating of the hoses and fittings must match the starter working pressure and be rated above the maximum possible pressure that the system can achieve. The use of elbows should be kept to a minimum.

The graph shows the power and torque curves for the air starter.

**1** Pinion speed (rpm).

**2** Torque (Nm).

**3** Power (kW).

**4** Torque at 8 bar.

**5** Torque at 5.5 bar.

**6** Power at 8 bar.

**7** Power at 5.5 bar.

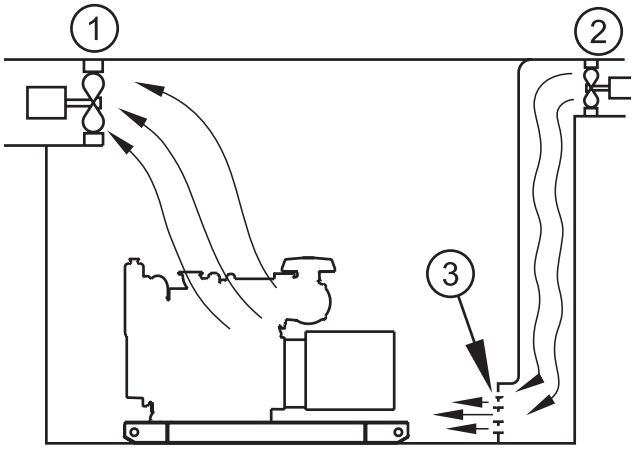



*Figure 18*

# 12. Genset room ventilation

**Note:** This is in addition to the ventilation needs of the main propulsion gensets. Operating in ambient temperatures above 50$^{O}$ C (122$^{O}$ F) there will be a noticeable reduction in power.

**Note:** Cross sectional area of air flow path must not be too small.

**Note:** Ensure that there is sufficient space at the front and rear of the enclosure for the inlet and outlet air ducts.

**Note:** maximum engine compartment depression is 5 kPa.

## General principles of air ventilation

Figure 18 shows a typical installation.

**1** Exhaust fan.

**2** Intake air.

**3** Intake louvres.

Correct ventilation air routing is vital for proper operation of Perkins engines and packaged units. Maintaining recommended air temperatures in the engine room is impossible without proper routing of the ventilation air. The following principles should be considered when designing an engine room ventilation system.

- Fresh air inlets should be located as far from the sources of heat as practical and as low as possible.
- Ventilation air should be exhausted from the engine room at the highest point possible, preferably directly over the engine.
- Ventilation air inlets and outlets should be positioned to prevent exhaust air from being drawn into the ventilation inlets (recirculation).
- Ventilation air inlets and outlets should be positioned to prevent pockets of stagnant or re circulating air, especially in the vicinity of the generator air inlet.
- Where possible, individual exhaust suction

points should be located directly above the primary heat sources. This will remove heat before it has a chance to mix with engine room air and raise the average temperature. It must be noted that this practice will also require that ventilation supply air be properly distributed around the primary heat sources.

- Avoid ventilation air supply ducts that blow cool air directly toward hot engine components. This mixes the hottest air in the engine room with incoming cool air, raising the average engine room temperature. This also leaves areas of the engine room with no appreciable ventilation.
- For installations where engines draw combustion air from inside the engine room, the routing should provide the coolest possible combustion air to the turbocharger inlets.
- For marine and offshore applications, the potential exists for seawater to be drawn into the ventilation air supply; systems for these applications must be designed to prevent seawater from being drawn into the air intake filters and ingested by the turbocharger. Generator cooling air must also be filtered to minimize the ingestion of salt.

These general routing principles, while driven by the same basic principles of heat transfer, will vary with the specific application. This section discusses the general considerations relating to single and dual engine applications, multiple engine (3+) applications, and several special applications.

The genset room must be ventilated for two reasons:

- To supply the genset with air for combustion.
- To provide a flow of air through the genset room to prevent an excessive temperature build up, which may cause components such as the alternator to overheat.

With an effective ventilation system the genset air intake temperature will be no more than $10^{O}$ C higher than the outside air temperature.

## Ventilation airflow

Required ventilation airflow depends on the desired engine room air temperature as well as the cooling air and combustion air requirements. While it is understood that total engine room ventilation air flow must take all equipment and machinery into account, the following sections provide a means for estimating the air flow required for successful operation.

For generator sets the combined heat radiated from the engine and heat rejected by the alternator must be used to correctly calculate the ventilation requirements. For engine and alternator heat rejections data, please refer to Perkins Technical Information. Engine radiated heat does not include any heat radiated from the exhaust system. In practice additional radiated heat may present in the engine room from the exhaust system and other equipment. This should be accounted for when designing the ventilation system.

## Calculating required ventilation airflow

Engine room ventilation air required for Perkins engines and packages can be estimated by the following formula:

$$V = \left[ \frac{H}{D \times Cp \times \Delta T} + \text{Combustion Air} \right]$$

Where:

V = Ventilating air ($m^3$/min), (cfm)

H = Heat radiation i.e. engine, driven equipment, and exhaust system (kW), (Btu/min)

D = Density of air at air temperature 38° C (100° F). The density is equal to 1.099 kg/$m^3$ (0.071 lb/$ft^3$)

Cp = Specific heat of air (0.017 kW x min/kg x $^{O}$C), (0.24 Btu/LBS/$^{O}$F)

$\Delta$T = Permissible temperature rise in engine room ($^{O}$C), ($^{O}$F) Typically 10$^{O}$C is permissible (Ensure however that the maximum engine room temperature is not exceeded in high temperature climates).

The air entry vents should be situated where spray is not likely to enter them and some form of water trap is desirable. Preferably the air ducts should reach the genset compartment at the sides of the hull so that water will fall into the bilge.

When the units are shut down after a run at high output in high ambient temperature conditions, it will be found that very high air temperatures will build up in the genset compartment. In boats with open cockpits this is usually of no real consequence but if the auxiliary units are mounted below a wheel house, then unpleasantly warm conditions may result. In these circumstances, ventilation fans are beneficial, preferably arranged to exhaust air from over the units.

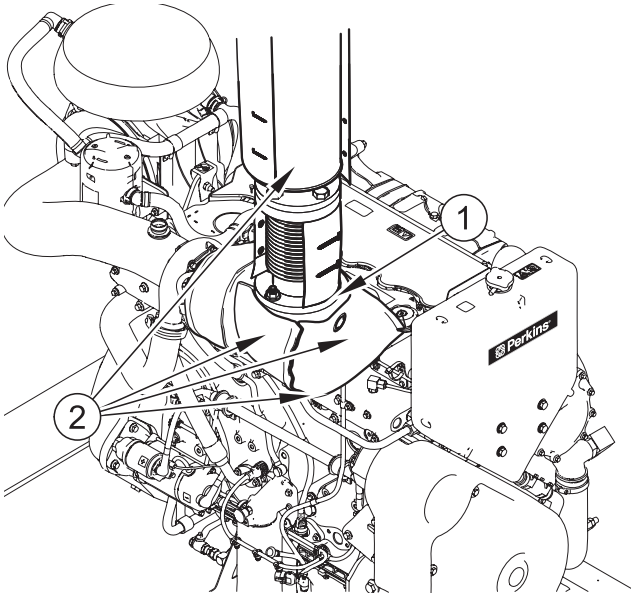



*Figure 19*

# 13. Exhaust systems

The exhaust system should conduct exhaust gases from the engine to the atmosphere with acceptable back pressure at the same time reducing exhaust noise to the minimum, avoiding gas leaks and excessive surface temperatures while accommodating engine movement on flexible mounts.

## Dry systems

**Caution: The remainder of the exhaust system should be well insulated to avoid fire risk.**

**Caution : Bellows should be in an unstrained condition when installed, so that the full bellows movement is available to absorb expansion and engine movement.**

Dry exhaust systems are most commonly used with engines which are keel cooled and are used for environmental reasons in some areas. This arrangement is particularly useful for commercial or pleasure craft operating in heavily silted water with debris and with radiator cooled engines.

Dry exhaust systems for marine installations need careful design to minimise the disadvantages of enclosing components that are at a high temperature in confined spaces. A typical system is shown in figure 19.

The first part of a dry system should include flexible connections (item 1) to permit movement between the engine and the fixed part of the exhaust. Connections of the stainless steel bellows type are suitable, but care must be taken to ensure that they are only required to accommodate movements that do not involve twisting the ends of the bellows relative to each other. Fitting a second bellows 90 degrees to the other one will achieve this. The bellows and elbows should be covered with fire blankets (item 2).

If there is a long exhaust run which gains height as it leaves the exhaust manifold, it may be necessary to incorporate a trap to collect condensate and allow it to be drained.

| Minimum internal bore diameter of the exhaust pipe |
|---|
| 102 mm (4 ins) |

# Exhaust support

**Caution: Rigid brackets should not be used**

The weight of the exhaust system should be supported by brackets and not carried by the bellows, as shown in figure 20.

**1** Bracket with link to allow movement due to expansion in the exhaust system (horizontal exhaust systems should be suspended from the deck head using similar brackets).

**2** Insulating lagging.

**3** Rigid bracket to support the weight of the vertical exhaust system.

**4** Heat blanket.

**5** Twin stainless steel bellows fitted to avoid torsional load on bellows unit - it is strongly recommended that twin bellows are used.

**6** $90^{O}$ elbow.

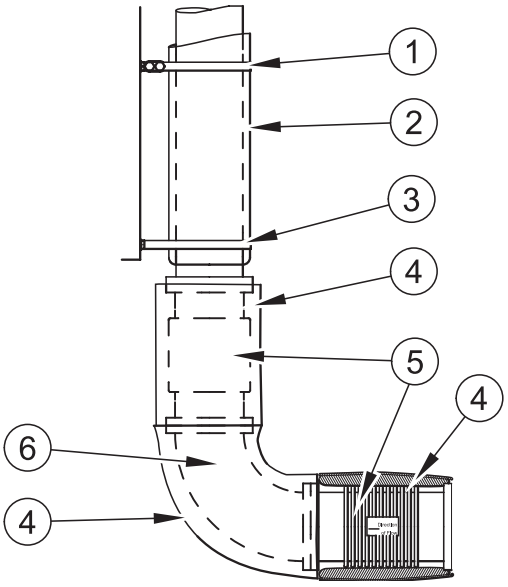



*Figure 20*

## Exhaust support limits

| Installation limits of flexible exhaust fittings - Bellows type | | | | |
|---|---|---|---|---|
| Bellows diameter | Maximum offset between flanges | | Maximum extension from free length | |
| | mm | inches | mm | inches |
| 5 & 6 in. | 1.00 | 0.04 | 2.00 | 0.08 |
| 8 & 12 in. | 19.05 | 0.75 | 25.40 | 1.00 |

# Silencer

Exhaust noise is one of the principal noise sources of any engine installation. The purpose of the silencer is to reduce the noise of the exhaust before it is released to the atmosphere.

Exhaust noise arises from the intermittent release of high pressure exhaust gas from the engine cylinders, causing strong gas pressure fluctuations in the exhaust system. This leads not only to discharge noise at the exhaust outlet, but also to noise radiation from exhaust pipe and silencer surfaces. A well designed and matched exhaust system will significantly reduce noise from these sources. The silencer makes a major contribution to exhaust noise reduction.

Excessive noise is objectionable in most applications. The required degree of silencing depends on factors such as the application type, whether it is stationary

or mobile and whether there are any legal regulations regarding noise emission. For example, excessive noise is objectionable in a hospital or residential area but may well be acceptable at an isolated pumping station.

## Silencer selection

The silencer is generally the largest single contributor to exhaust back-pressure. Therefore, required noise reduction and permissible back-pressure must be considered when selecting a silencer. Application type, available space, cost and appearance may also need to be taken into account.

Exhaust outlets should be arranged to keep water from entering the piping system. Rain caps forced open by exhaust pressure will accomplish this; however, they will also introduce additional back pressure into the system and should be carefully evaluated.

# Exhaust system back pressure

Excessive exhaust restriction can adversely affect performance, resulting in reduced power and increased fuel consumption, exhaust temperatures and emissions. It will also reduce exhaust valve and turbocharger life.

It is imperative that exhaust back pressure is kept within specified limits for those engines subject to emissions legislation. When designing an exhaust system, the design target for back pressure should be half the maximum allowable system back pressure. To ensure compliance, exhaust system back pressure must be verified to be within the Perkins EPA declared maximum value for the engine configuration and rating. Values can be found in the “Systems Data” listed in the Perkins Technical Marketing Information (PTMI) system.

Back pressure includes restrictions due to pipe size, silencer, system configuration, rain cap and other exhaust-related components. Excessive back pressure is commonly caused by one or more of the following factors:

- Exhaust pipe diameter too small.
- Excessive number of sharp bends in the system.
- Exhaust pipe too long.
- Silencer resistance too high.

1/8” BSP x M14 x 1.5 tappings are located in the dry exhaust outlet elbow for measuring exhaust back pressure.

# Exhaust Emissions Sampling

If required exhaust emissions can be sampled without risk of dilution with air using the 1/8” BSP or M14 x 1.5 tappings provided in the dry and wet exhaust elbow options. In addition, these tappings can be used to measure exhaust back pressure as previously described above. If other exhaust components are used for the engine installation, then a suitable port must be provided as close to the outlet of the turbocharger as possible, to ensure that exhaust gas sampling can be carried out without risk of air dilution. The exhaust outlet to atmosphere should be at least 1m (3’ 4”) downstream of the sample tapping to prevent dilution with air at the sample point.

# 14. Fuel systems

## Fuel connections

**Caution: Ensure that flexible fuel hose routing avoids coming into contact with parts of the engine which can lead to abrasion of the hose.**

A common reason for service problems with fuel systems is the use of poor or incompatible connectors, where the pressure tightness depends upon the use of sealing compounds, hose clamps, fibre washers trapped between inadequate and unmachined faces, or compression fittings which have been over-tightened to the point where they no longer seal.

Cleanliness during initial assembly is also of vital importance, particularly when fuel tanks are installed, as glass fibres and other rubbish may enter tanks through uncovered apertures.

It is strongly recommended that the flexible fuel pipes available as an option with the engine are used, which are as follows:

## Fuel feed and return

**Standard Fuel Feed**

- 11/16” ‘O’ Ring Faced Seal (ORFS).

**Standard Fuel Return**

- 11/16” ‘O’ Ring Faced Seal (ORFS).

**Optional Fuel Feed**

- 11/16” ‘O’ Ring Faced Seal (ORFS), straight female swivel connector.

**Optional Fuel Return**

- 11/16” ‘O’ Ring Faced Seal (ORFS), straight female swivel connector.

## Low pressure fuel system

The fuel lift pump should be no more than 2 metres above the minimum fuel level in the tank or 2 metres below the maximum fuel level in the tank.

## Fuel tanks

The more simple the fuel system, the better it will perform in service.

- The filler neck should be raised so that water will not enter when filling.

- The filler cap should seal effectively to prevent water entering when under way.
- A vent pipe should be fitted, again in such a way as to avoid the entry of water.
- The tank should have a sump or angled bottom with a drain tap so that water and sediment can be removed. (This is not always possible).
- Stop cocks can be fitted where necessary.
- Internal baffles may be required to prevent fuel surge.
- The tank should have a removable panel to simplify cleaning.
- The fuel pipe work should be as simple as possible with the minimum of valves and cross connections, so that obscure fuel feed problems are minimised.
- A fuel sedimenter (water separator) is required in the fuel system between the fuel tank and the engine mounted lift pump. To avoid problems when venting air after draining the sedimenter, it should preferably be installed below the normal minimum level of fuel in the fuel tank. (This is not always possible!).
- The tank should have at least two connections; a fuel feed connection, and a fuel return connection. Whenever possible a tank should only supply one engine, but in any case each engine should have its own fuel pipes, from tank to engine.

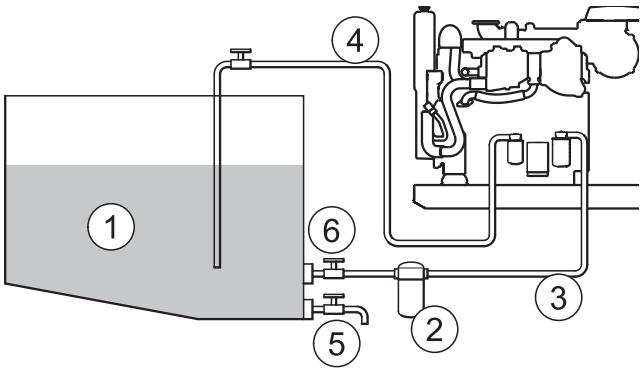



*Figure 21*

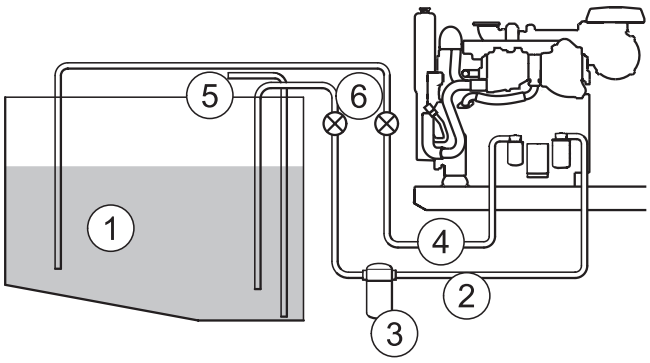



*Figure 22*

# Typical fuel systems

Figure 21

**1** Fuel tank.

**2** Water separator/pre filter.

**3** Main fuel feed.

**4** Fuel return.

**5** Drain point.

**6** Stop cock.

Figure 22

**1** Fuel tank.

**2** Main fuel feed.

**3** Water separator/pre filter.

**4** Fuel return.

**5** Drain tube.

**6** Stop cocks.

The more simple the fuel system, the better it will perform in service. Figure 21 shows an ideal system. In some applications there may be legislation that requires that fuel lines draw from, and return to, the top of the tank. Figure 22 shows an acceptable arrangement.

The fuel tank may be steel, aluminium, or G.R.P. (Glass Reinforced Plastic) or, alternatively, a rubber bag tank may be used.

The main fuel connection is taken from the rear of the tank (figure 22 item 1) so that all the fuel is available for use when under way when the hull will be at an angle.

The fuel return (item 4) is extended within the tank to near the bottom in order to prevent air locks which can arise due to siphoning of the fuel when the engines are stopped

The fuel returned to the tank should be kept away from the main fuel feed, to avoid recirculation.

A drain tube (figure 22 item 5) should be fitted to aid servicing and cleaning.

From the tank the main engine feed line (item 2) goes first to a water separator (item 3), preferably one fitted with a thick clear plastic bottom and a drain cock (use only if allowed by local regulations).

The fuel lines may be of metal, either copper or

seamless steel tubing used either with compression fittings or preferably soldered nipples, with a flexible armoured rubber hose to connect to the fuel lift pump.

Stop cocks (item 6) may also be fitted where necessary.

This simple fuel system is satisfactory when one or more engines are run from a single fuel tank, and it may also be used when there are two tanks each supplying one engine. In the latter case the system may include a cross connection, between the tanks by means of a balancing pipe, with a valve, at each end. In some installations cross connecting pipes between the two engine feed pipes and the two engine return pipes have been used, but valves are necessary in every line so that the appropriate system may be selected, and the complexity of installation and operation is such that the advantages in operating flexibility are out-weighed by the possibility of obscure problems due to component malfunctions, incorrect operation or engine interaction.

## Fuel systems with day tanks

**Note:** Fuel lines should have bends as wide as possible to minimise restriction.

**Note:** The size of the day tank should be such that warm fuel returning to the tank should not raise the temperature of the collected fuel too much or fuel coolers may be required.

**Note:** Day tanks are used in some installations to reduce vacuum or pressure within the fuel system.

**1** Main fuel tank.

**2** Water separator/pre-filter.

**3** Valve.

**4** Pump.

**5** Day tank.

**6** Overflow.

**7** Vent.

**8** Fuel return.

**9** Fuel feed.

Figure 23 shows a fuel system with a day tank situated above the main fuel tank, requiring a pump to transfer fuel into it.

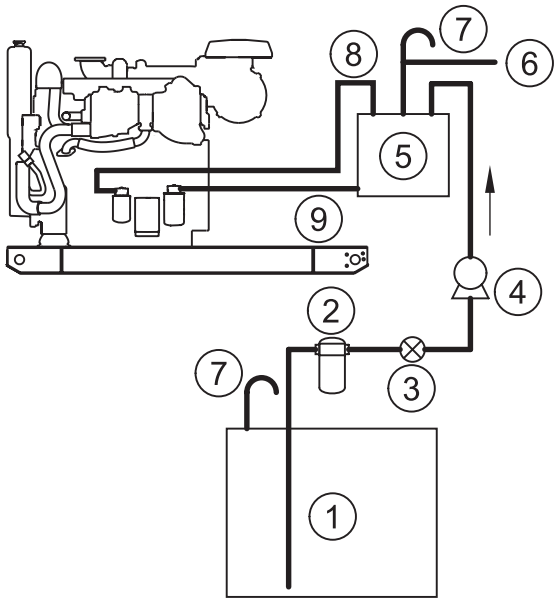


*Figure 23*

Excessive fuel return line pressure can cause fuel

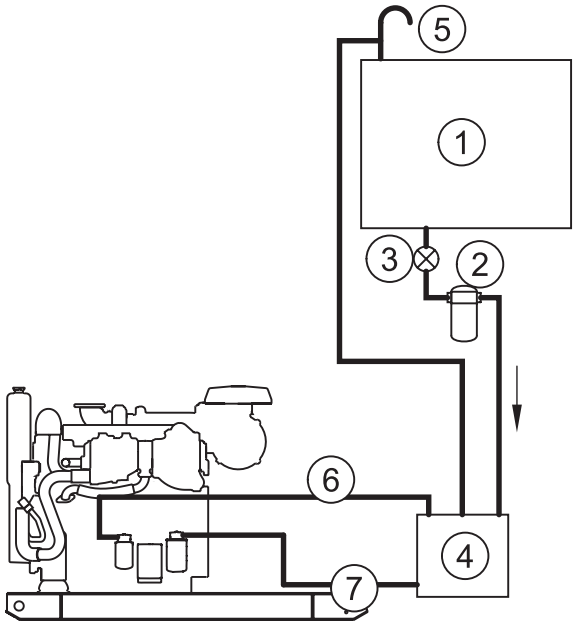



*Figure 24*

system issues and as such, when the engine is running at rated speed no load, the fuel return pressure measured at the connection point on the generator package must not exceed a gauge pressure of 40 kPa (11.8 inches Hg).

Practically, this means the height of the fuel return into the day tank must not be greater than 2.8 metres (9.2 feet) above the engine crankshaft.

**1** Main fuel tank.

**2** Water separator/pre-filter.

**3** Valve.

**4** Day tank.

**5** Vent.

**6** Fuel return.

**7** Fuel feed.

Figure 24 shows a system where the day tank is below the main fuel tank and therefore uses gravity to supply fuel to the day tank.

## Multiple fuel tanks

In some cases it is necessary to have a number of fuel tanks in order to achieve the required operating range. In such cases, where possible, one tank should be regarded as the main tank for each engine and the other tanks should be arranged so that they will drain into the main tank by gravity. If a gravity system is not possible, then the system shown in figure 24 should be used.

Figure 24 shows a collector tank (item1), fed by all the storage tanks and connected to the engine feed and return systems, but with a vent pipe (item 5) taken to any convenient tank and connected to it at the highest point. The fuel feeds (item 7) should be taken from the bottom of the collector tank and the fuel returns (item 6) at the top.

A water separator (item 2) should be installed which should suit the total flow for all the installed engines.

There is no doubt however, that a simple fuel system as illustrated in figure 23 or 24 should be used wherever possible, as having a completely separate tank and supply to each engine guarantees that if an engine stops, due to running out of fuel or to water or foreign matter in the fuel, the other engine will not be affected simultaneously. This will give some time for appropriate manoeuvring action to be taken. The simple system will also require the minimum number of valves and fittings, which ensures maximum reliability in service.

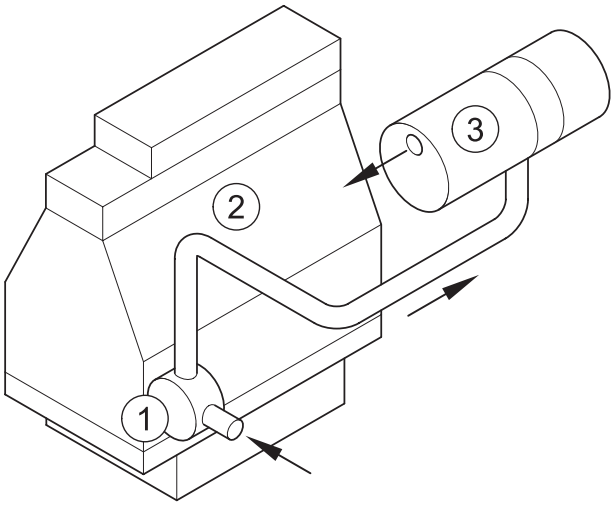



*Figure 25*

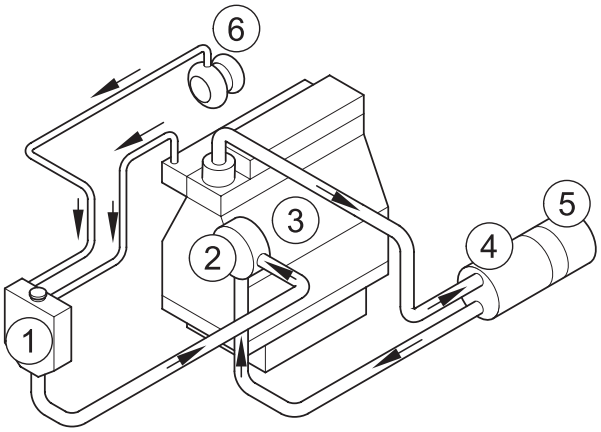



*Figure 26*

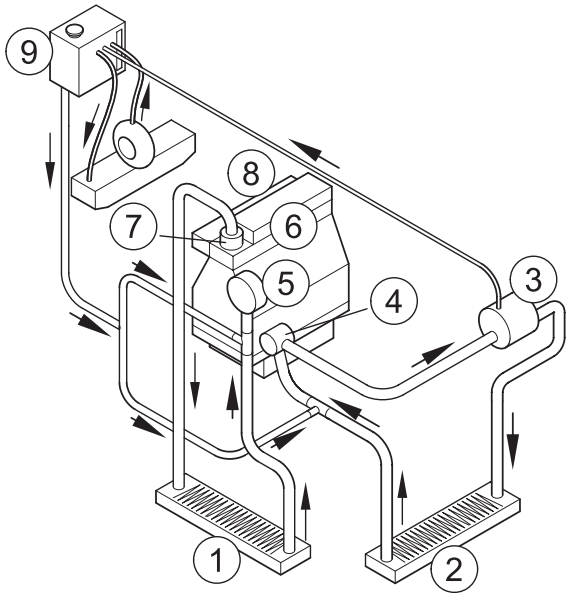



*Figure 27*

# 15. Engine cooling system

## Engine cooling

Heat exchanger cooling is when a ‘fresh’ to ‘auxiliary’ water heat exchanger is mounted on the engine. The fresh water in the closed circuit, is thermostatically controlled which, when closed, a permanent bleed by-passes the heat exchanger minimising the engines warm-up time but maintains sufficient flow through the cylinder block and exhaust manifold. When the engine has reached the correct working temperature the thermostat opens allowing the coolant over the heat exchanger tubestack which is cooled by sea water.

## Schematics

Figure 25 shows the auxiliary water cooling.

**1** Auxiliary water pump.

**2** Engine.

**3** Heat exchanger.

Figure 26 shows the fresh water cooling.

**1** Header tank.

**2** Fresh water pump.

**3** Engine.

**4** Heat exchanger.

**5** Aftercooler.

**6** Turbocharger.

Figure 27 shows the keel cooling.

**1** Jacket grid cooler.

**2** Aftercooler grid cooler.

**3** Aftercooler.

**4** Auxiliary water pump

**5** Fresh water pump.

**6** Engine.

**7** Thermostat.

**8** Exhaust manifold.

**9** Remote tank.

Figure 28 shows the air cooling

**1** Engine.

**2** Turbocharger.

**3** Charge air cooler.

**4** Radiator.

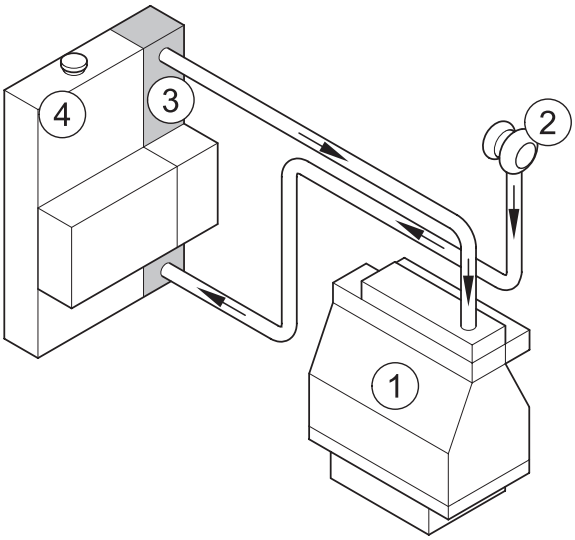



*Figure 28*

## Raw water systems

**Caution: The maximum pressure into the sea water pump should not exceed 15 kPa.**

**Note:** Ensure a separate feed for each engine. A shared supply is not recommended.

**Note:** Where possible mount the strainer so that the top is just above the waterline to facilitate cleaning.

A completely separate sea water system should be provided for each engine to prevent a blockage resulting in the need to shut down more than one engine.

A typical system is shown in figure 29.

The water intake fitting (item 4), situated below the water line, should not project appreciably below the bottom of the hull and it should be situated well clear of other components such as shafts, logs, rudders to prevent flow problems at high speeds.

The intake fittings and pipe work should have a minimum bore of 39 mm (1.5”) (item 2). Inboard of the intake fitting a sea cock must be provided (item 4). This should be of the full flow type giving unobstructed passage to the water in the open position, with a minimum bore of 39 mm (1.5”).

Between the intake fitting and the sea water pump (item 3) on the engine, there should be a strainer (item 5) which should be easily accessible for routine examination, and should be easily removable.

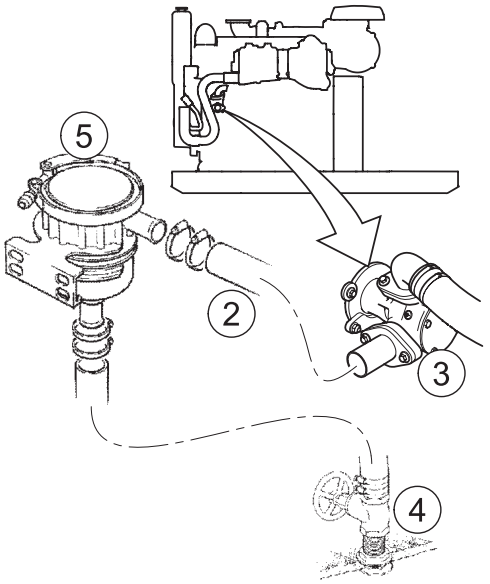



*Figure 29*

## Seawater Strainers

Strainers are required in order to protect the seawater pump, aftercooler, heat exchanger and other cooling system components from foreign material in the seawater. The foreign material can plug and/or coat heat transfer surfaces, causing overheating of the engine and shortened life of components. If the foreign material is abrasive, it will erode pump impellers and soft metal parts, reducing their effectiveness.

Full-flow strainers are desirable. The strainer screens

should be sized no larger than 1.6 mm (0.063 in) mesh for use in closed sea water circuits. The strainer connections should be no smaller than the recommended line size. The use of a differential pressure gauge across the strainers will indicate the pressure drop, and enables the operator to determine when the strainers need servicing.

From the sea water strainer a pipe should be run to the sea water pump inlet connection on the engine. The pipe may either be mainly rigid, of for example copper or cupro-nickel, or flexible, but only flexible hose which is reinforced to prevent collapse should be used. The system must be sufficiently flexible to permit the engine to move on its flexible mountings. The sea water pump connection is for a hose with a 42 mm (1.65”) bore, (optional flange connections).

Care should be taken to use compatible materials in the sea water systems, to prevent excessive galvanic corrosion. Systems incorporating copper, cupro-nickel, stainless steel Type 316, gun-metal, silver solder, and aluminium brass will generally be satisfactory. Components made from lead, iron, steel, aluminium or its alloys, zinc or magnesium, should be generally avoided.

## Keel cooling or skin cooling

**Caution: Twin grid coolers are required for the engine.**

**Caution: If the auxiliary engine is a replacement package and the original cooling system, keel cooler and expansion tank, is to be reused, then it is essential that the system thoroughly flushed to remove sludge that may be in the system. Failure to remove sludge could block air bleeds leading to the engine overheating.**

Keel cooling or skin cooling is a closed circuit method of cooling that in normal conditions uses a 20% antifreeze mix, 50% in extreme conditions.

The coolant shown here is mandatory for use in all climates to ensure that adequate levels of corrosion inhibitor are present. The 20% antifreeze mix will give frost protection down to -7$^{O}$ C (19.4$^{O}$ F). For colder applications a 50% mix is mandatory which will give frost protection down to -37$^{O}$ C (-34.6$^{O}$ F).

A properly designed and installed cooling system is essential for satisfactory engine life and performance.

This system uses a group of tubes, pipes or channels attached to the outside of the hull below the waterline as a heat exchanger. Keel coolers are used in

preference to the standard raw water cooled engine mounted heat exchanger when operating in areas that have heavy silt and debris in the water that would erode the heat exchanger tubes or block them.

Keel cooling is used in Arctic conditions to avoid the problems of freezing that is experienced with the raw water circuit on the heat exchanger cooling system.

Keel coolers are available in standard designs from several manufacturers. These units are simple to install and are sized by the manufacturer for the engine model and boat application. Commercial coolers are made of erosion resistant materials and have a relatively high heat transfer efficiency.

The disadvantage of external keel coolers is that they are vulnerable to damage and must be guarded. An alternative to the commercially available coolers are fabricated keel coolers manufactured by the boat builder as part of the hull construction. These coolers are not as efficient and must be designed oversize to allow for a decrease in performance that follows the formation of rust, scale and marine growth on the keel cooler.

If the auxiliary engine is a replacement package and the original cooling system, keel cooler and expansion tank, is to be reused, then it is essential that the system thoroughly flushed to remove sludge that may be in the system. Failure to remove sludge could block air bleeds leading to the engine overheating.

## Sizing the coolers

Commercial keel coolers are manufactured in a variety of sizes and shapes. The keel cooler manufacturer will recommend a keel cooler when provided with the following data:-

- Engine model and rating
- Engine specification sheet.
- Heat Rejection.
- Engine coolant flow rates are at a system resistance of 15 kPa.
- Max. coolant temperatures from grid cooler
- Maximum raw water temperature.
- Pipe connections .
- Coolant - 20% antifreeze mix for normal conditions, 50% for extreme conditions.

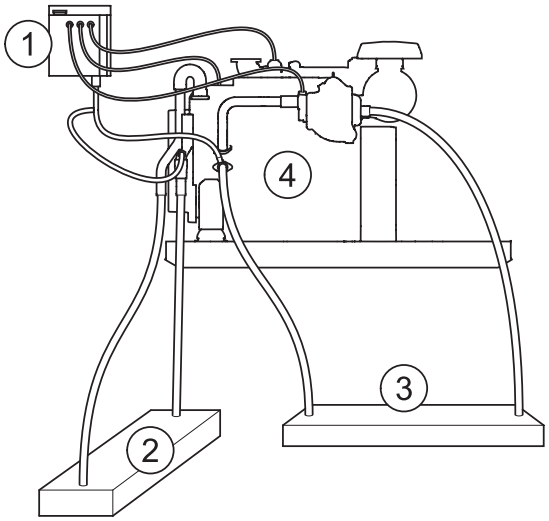



*Figure 30*

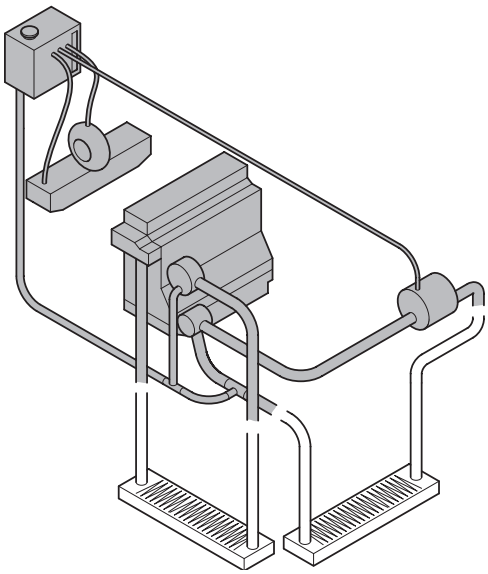


*Figure 31*

# Heat rejection data

As a general rule the pressure drop across the grid coolers should be between 14-28 kPa (2 to 4 psi) when operating with the thermostat fully open. Keeping the water velocity below 0.46 m/s (5 ft/s) will help to achieve this.

Great care should be taken during grid cooler selection to ensure that the highest sea water temperature the application will see is used to calculate the cooler size. In order to give the cooler sufficient size it is recommended that an engine outlet temperature of 86$^{O}$ C is achieved when operating in a sea of 25$^{O}$ C. Under these conditions the coolant returned to the engine will be close to, but not greater than 70$^{O}$ C. These guidelines should ensure that there is sufficient cooler capacity should the engine operate in seas hotter than 25$^{O}$ C.

The maximum coolant inlet temperature allowable to the aftercooler is 40$^{O}$ C when operating in a sea temperature of 27$^{O}$ C, with a 20% antifreeze mix. When operating with a 50% antifreeze mix (for cold environments only) the inlet temperature should not exceed 32$^{O}$ C.

# Keel cooling connections

Figure 30 shows the connections

**1** Remote tank.

**2** Fresh water circuit keel cooler.

**3** Aftercooler circuit keel cooler.

**4** Auxiliary engine.

Figure 31 shows the items not supplied with the engine as un-shaded.

Connections are both 50.8 mm (2 inches).

Keel coolers should be installed below the waterline far enough to avoid the aerated water close to the surface. Recessed and shielded coolers must allow for unobstructed flow around the coolers. The keel coolers should be installed so that air pockets are not present during the initial fill. Vents at all high points along the connecting pipes will be necessary.

Keel coolers should not be fitted where they would be exposed to pounding seas or hull flexing. The bow of the vessel is not considered to be a good location whereas adjacent to the keel, where it is the strongest area of the vessel, is the preferred location.

## De-aeration

**Caution: Air in the engine coolant can cause the following problems:**

- Air accelerates the corrosion within the engine water passages that can lead to high water temperatures as silt deposits on the surface of the cooler reducing the heat transfer. Premature failure of the engine can occur.
- Air expands more than coolant when heated and may cause loss of coolant from the engine system through the expansion tank overflow.
- In an extreme case, air will collect in one area and cause a loss of coolant flow around the cylinder block resulting in piston seizure and major engine damage.

**Caution: Care should be taken when filling the system and should be done slowly to avoid air pockets.**

**Caution: The boat builder should provide a secure and stable system.**

## Engine bleed (vents)

**Caution: Joining the bleed pipes into a common vent will reduce the total water flow and may result in aerated water flowing back into the engine resulting in the engine overheating and possible failure.**

The engine bleed system provides a continuous flow of water through the expansion tank as a method of removing air from the engine coolant. Depending on the model of the engine there can be up to three bleed pipes which need to be connected to the top of the expansion tank. Each bleed must be connected to the expansion tank without using tee's or other fittings that would join the bleed pipes together in a common vent.

## Expansion tank

The expansion volume in the tank must be large enough for the entire cooling system. Since the engine coolant expands about 5% between cold and hot engine operating temperatures, the expansion tank must have a volume equal to 5% of the entire cooling system volume.

When designing the larger expansion tank the

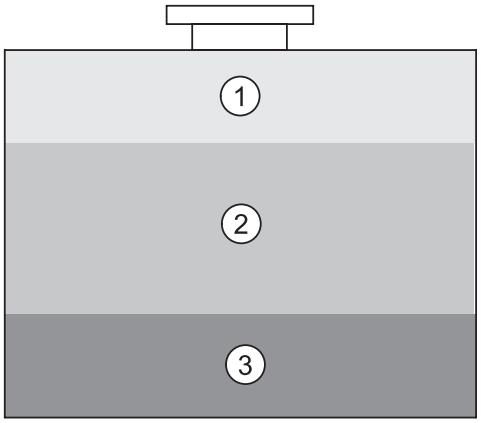



*Figure 32*

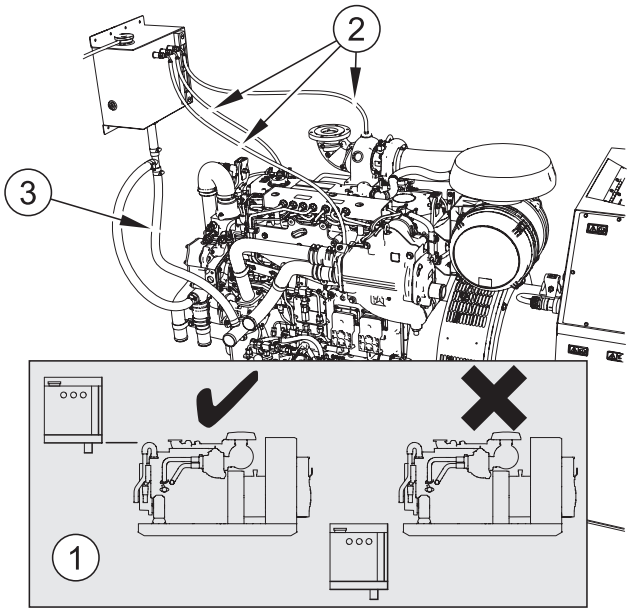



*Figure 33*

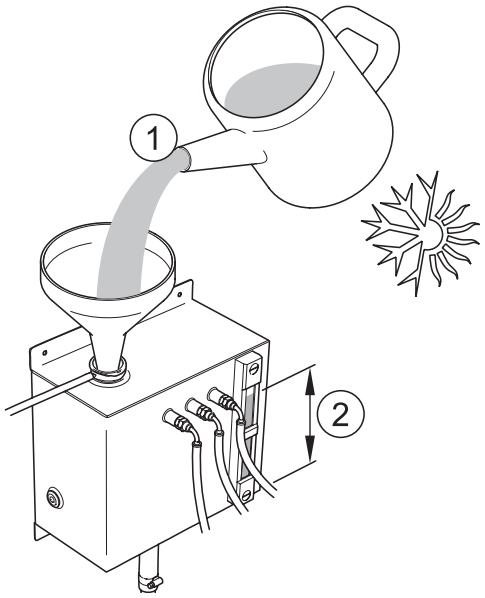



*Figure 34*

following allowance should be made:

- A 50 kPa pressure cap should be fitted to pressurise the system.
- 3% to 5% of total system capacity for expansion losses
- 10% of total system capacity for volume loss on hot shut down
- 5% of total system capacity for working volume

Figure 32 shows the allowances required when designing a larger expansion tank.

**1** 3% to 5% of total system capacity.

**2** 10% of total system capacity.

**3** 5% of total system capacity.

## Remote expansion tank

**⚠ WARNING**

**Hot coolant is under pressure and can cause severe burns when removing the pressure cap. First release the pressure in the system by loosening the pressure cap.**

A remotely mounted expansion tank is supplied as standard with a capacity of 19 litres. A remote cooler expansion tank kit can be fitted using the following procedure.

**1** Mount the remote expansion tank in a position where the bottom of the unit is as shown in figure 33.

**2** Connect the new bleed hoses (item 2) to the tank and the fittings on the engine.

**3** Connect the main inlet hose to the engine (item 3).

**4** Fill the remote expansion tank with 20% antifreeze solution (figure 34 item 1), for normal operation, (50% for extreme conditions), to the maximum position on the sight glass (item 2).

**5** Start the engine.

**6** Run the engine until normal working temperature is reached, between 82 to 88$^{O}$C.

**7** Stop engine.

**8** Check coolant level in the sight glass (figure 35).

**9** Top-up with 20% antifreeze solution , for normal operation, (50% for extreme conditions) to maximum level (figure 36).

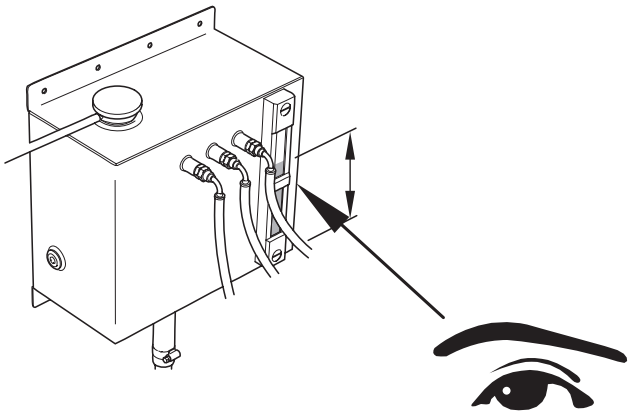


*Figure 35*

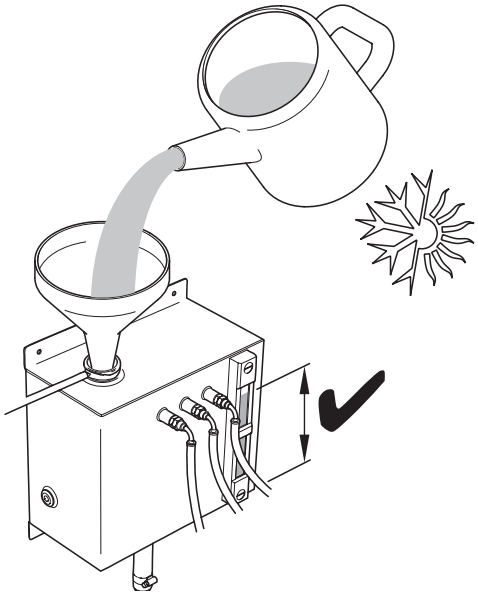


*Figure 36*

# 16. Electrical system

## Electrolytic corrosion

**⚠ WARNING**

**Electrical shock can cause severe personal injury or death. Great care should be taken when working on any electrical part of the auxiliary engine.**

**Caution: The engine may be damaged by electrolytic corrosion (stray current corrosion) if the correct bonding procedure is not adopted.**

**Caution: This section on bonding covers a typical system and has been included for guidance purposes only. It may not be appropriate for your boat. As installations vary, it is advised that specific recommendations from a specialist in the subject of electrolytic corrosion are obtained.**

## Definition of galvanic and electrolytic corrosion.

Galvanic corrosion is caused when two different metals are immersed in a conductive fluid such as seawater (called electrolyte), with a connection between them, an electric current is generated in the same way as a battery.

Electrolytic corrosion (stray current corrosion) is caused by a current from an external source such as the boats battery or shore supply.

## Avoiding electrolytic corrosion

A typical layout is shown in figure 34.

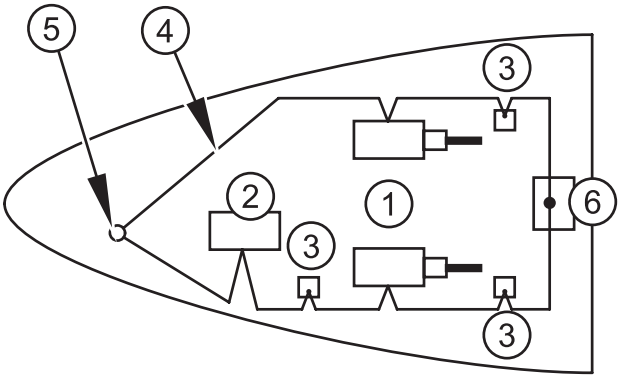



*Figure 34*

**1** Propulsion engines.

**2** Engine.

**3** Sea cock.

**4** Common bonding system wire in a ring as shown.

**5** Through the hull metal fittings.

**6** Zinc anode.

The current that causes electrolytic action is called ‘stray current’ which can emanate from two sources.

The first is the batteries on board the vessel where

the negative terminal is earthed to the hull at a central earth terminal. If other negative connections are made elsewhere on the vessel then the resulting small differences in voltage between the earth terminals can cause the same chemical action as in galvanic corrosion, but it must be stressed that this is not GALVANIC CORROSION but stray current known as electrolysis caused by an external electrical current.

The way to prevent electrolytic corrosion is to ensure a good electrical installation and to bond the engine to the bonding system in the boat which is providing a low resistance connection between all the metals in contact with the sea water. The bonding system should be connected to a zinc sacrificial anode that is fixed to the outside of the hull below sea level.

The bonding should consist of heavy stranded wire (not braiding or wire with fine strands). It is an advantage if the wire is tinned. Insulation is also an advantage and should preferably be green in colour. Although the current carried by the bonding system will not normally exceed 1 amp, the cable sizes should be generous as shown in the table below:

| Length of run to zinc anode | Suggested cable size |
|---|---|
| Up to 30 feet | 7 strand / 0.185 mm (4 $mm^2$) |
| 30 - 40 feet | 7 strand / 1.04 mm (6 $mm^2$) |

As many of the connections may be splashed with sea water they should be soldered wherever possible and clamped elsewhere, with the joint protected from corrosion by neoprene paint, or a similar material, to exclude water.

Bonding of aluminium boats is a special case as the various appliances on board should be earth free and therefore to avoid stray currents all appliances must be earthed to a single terminal.

Grounding is required on AC voltage for safety reasons if voltages are high, i.e. when there is a 240 volt generator on board or when a shore line is connected. Grounding (or earthing) must not be confused with the term ‘earth return’. Earth return carries current, whereas grounding (earthing) does not.

Figure 35 shows a typical example of how to ground the unit, using an earthing strap and bolt (item 1).

Another source of unplanned current giving raise to a form of stray current corrosion is an earth connection from a shore line. When a shore line is in use the boat system should be protected from earth leakage by an earth leakage switch on shore but as additional safety there should be a switch on board the boat.

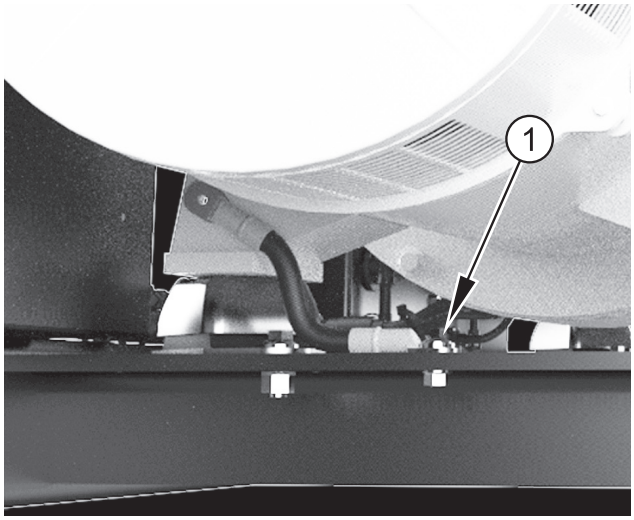



*Figure 35*

# Engine electrical system

**⚠ WARNING**

**Electrical shock can cause severe personal injury or death. Great care should be taken when working on any electrical part of the auxiliary engine.**

**Note:** Good communications principles should be adhered to, 120 ohms end resistors should be used to prevent interference from reflected signals.

The A5E2v2 ECM is an electronic control device that governs engine speed, torque output and manages the engines performance and emissions via a number of sensors and actuators. The device has two connection sockets, one for the engine wiring harness J2 and the other for the OEM machine wiring harness J1.

# Battery and starter cables

## Starter batteries

**⚠ WARNING**

**Only persons competent in electrical installations must carry out connections to the starter battery.**

**⚠ WARNING**

**The starter battery must be wired correctly otherwise a fire or personal electrocution could result causing injury or death**

**⚠ WARNING**

**Ensure that all wiring, connections, safety devices and associated materials conform to the local standards.**

**⚠ WARNING**

**Ensure that all wiring is checked prior to operating the alternator.**

**Caution: Main supply for starter and supply for control and start aid must be run separately from the battery.**

**Caution: Ensure that the wiring is arranged to take up any movement and vibration.**

**Caution: Ensure that all wiring is protected from any potential abrasion.**

**Note:** Long cable runs from the battery to the starter should, where possible, be avoided.

**Note:** Where starting at temperatures below freezing is an important requirement, a 24 volt system is the preferred choice

The performance of starter batteries is commonly expressed by the current in amperes that they will supply under specified conditions.

There are two standards by which battery performance is commonly stated:-

- BS3911 uses the current which can be maintained for 60 seconds, without the voltage of a nominal 12 V battery dropping below 8.4 volts, whilst at a temperature of -18$^{O}$ C.
- SAE J537 is similar except that the current is only maintained for 30 seconds and the voltage is allowed to fall to 7.2 volts.

| **Batteries for temperatures down to -5$^{O}$C (23$^{O}$F)** | |
|---|---|
| 12 Volt | 24 Volt |
| One battery - 520 Amps BS3911 or 800 Amps SAE J537 (CCA) | Two 12V batteries in series - each 315 Amps BS3911 or 535 Amps SAE J537(CCA) |
| **Batteries for temperatures down to -15$^{O}$C (5$^{O}$F)** | |
| Two 12V batteries in parallel, each 520 Amps BS3911 or 800 Amps SAE J537 (CCA) | Two 12V batteries in series, each 520 Amps BS3911 or 800 Amps SAE J537 (CCA) |

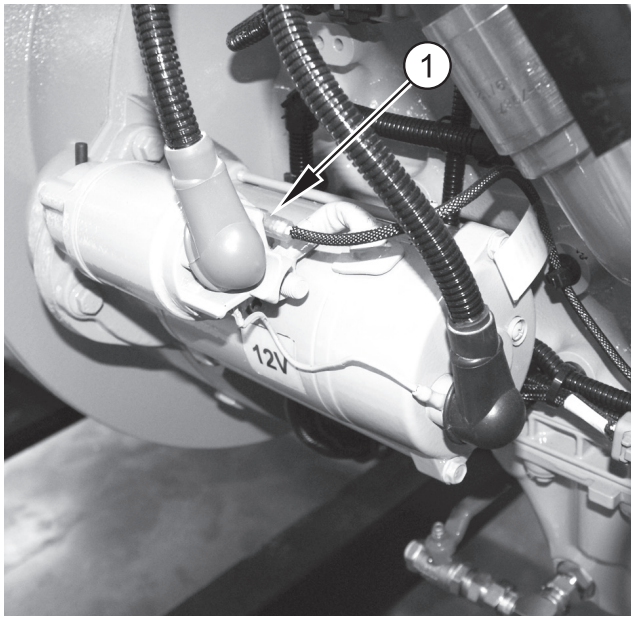



*Figure 36*

## Starter cables

### Starter motor and control system connection

The connection point for the starter motor is shown in figure 36.

## Battery isolator switches

A switch should be fitted in the positive lead to the starter, as close to the battery as is convenient. The switch should be suitable for a momentary current of at least 1000 Amps.

## Battery cables

The total resistance of the two leads from the battery to the engine should not exceed 0.0017 ohms. In practice, this means that the total length of the starter cables (positive and negative) should not exceed 6 metres if the commonly available 61/.044 cable is used. Longer cable runs, which should be avoided if possible, will require either double cables or a heavier cable, in order to comply with the total resistance of 0.0017 ohms.

Mounting the battery close to the starter is the preferred option.

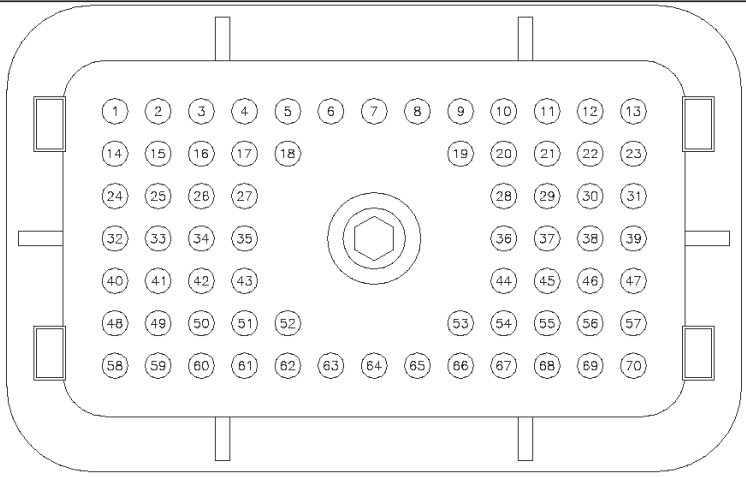
| **Starter cables for 12 or 24 volt systems** | | | | |
|---|---|---|---|---|
| *Maximum total length | | Cable size metric | Nominal C.S.A. | |
| Metres | Feet | | $mm^2$ | $in^2$ |
| 5.6 | 19.00 | 61/1,13 | 61 | 0.0948 |
| 9,0 | 28.30 | 19/2,52 | 95 | 0.1470 |

| Nominal resistance in ohms | | Approx. equivalent size | |
|---|---|---|---|
| Per metre | Per foot | English imperial | America B&S SAE |
| 0,000293 | 0.0000890 | 61/.044 | 00 |
| 0,000189 | 0.0000600 | 513/.018 | 000 |

*The length of all cables in the starter circuit (whether positive or negative), should be added together to give the ‘Total Length’.

# Customer connect

The following diagram shows the interface connector and the pin labels.




ECM CUSTOMER INTERFACE CONNECTOR
VIEWED FROM CABLE ENTRY SIDE
CONNECTOR 235-1081
COVER 343-1867
FEMALE INSERT 126-1766 QTY 54
BLANK INSERT 8T-8737 QTY 20

① Service toolcomms

② Engine fitted components

③ ECM power supply

④ Required for running

⑤ Input will change the engine state to OFF

⑥ Both parity inputs needed to change engine state to ON

All else optional

| Pin # | ECM F-C1 (J1 Customer Interface Harness) | |
|---|---|---|
| 1 | Analog throttle | |
| 2 | 5v sensor power | ② |
| 3 | 5v sensor return | ② |
| 4 | PWM Throttle power | |
| 5 | PWM Throttle return | |
| 6 | | |
| 7 | E-Stop -ve 0V input | ④ |
| 8 | CDL+ | ① |
| 9 | CDL - | ① |
| 10 | | |
| 11 | | |
| 12 | Glow plug -ve | |
| 13 | Overspeed lamp | |
| 14 | | |
| 15 | Fuel secondary prefilter pressure | |
| 16 | | |
| 17 | | |
| 18 | Switch signal return | |
| 19 | Coolant temperature lamp | |
| 20 | Glow plug +ve | |
| 21 | Lift pump -ve | ② |
| 22 | | |
| 23 | | |
| 24 | | |
| 25 | Fuel supply prefilter pressure | |
| 26 | Fuel supply postfilter pressure | |
| 27 | | |
| 28 | Shutdown / stop lamp | |
| 29 | warning / derate lamp | |
| 30 | | |
| 31 | Maintenance lamp | |
| 32 | | |
| 33 | | |
| 34 | J1939 Low | ① |
| 35 | | |

| Pin # | ECM F-C1 (J1 Customer Interface Harness) | |
|---|---|---|
| 36 | oil pressure lamp | |
| 37 | | |
| 38 | | |
| 39 | | |
| 40 | injection disable -ve 0V | ④⑤ |
| 41 | reset fault | |
| 42 | J1939 Shield | ① |
| 43 | Starter +ve | ④ |
| 44 | Maintenance reset | |
| 45 | Digital speed control enable | |
| 46 | Droop / Isochrenous | |
| 47 | Fuel secondary postfilter pressure | ② |
| 48 | ECM Power supply +ve 12/24V | ③ |
| 49 | coolant level sensor | |
| 50 | J1939 High | ① |
| 51 | starter -ve | ④ |
| 52 | ECM Power supply +ve 12/24V | ③ |
| 53 | ECM Power supply +ve 12/24V | ③ |
| 54 | | |
| 55 | ECM Power supply +ve 12/24V | ③ |
| 56 | Shutdown override -ve 0V input | |
| 57 | ECM Power supply +ve 12/24V | ③ |
| 58 | Digital speed raise | |
| 59 | Actuator driven return | |
| 60 | Digital speed lower | |
| 61 | ECM Power return -ve 0V | ③ |
| 62 | Run/Stop Parity +ve 12/24V | ④⑥ |
| 63 | ECM Power return -ve 0V | ③ |
| 64 | Run/Stop Parity +ve 12/24V | ④⑥ |
| 65 | ECM Power return -ve 0V | ③ |
| 66 | PWM Throttle signal | |
| 67 | ECM Power return -ve 0V | ③ |
| 68 | | |
| 69 | ECM Power return | ③ |
| 70 | Ignition Key +ve 12/24V | ④ |

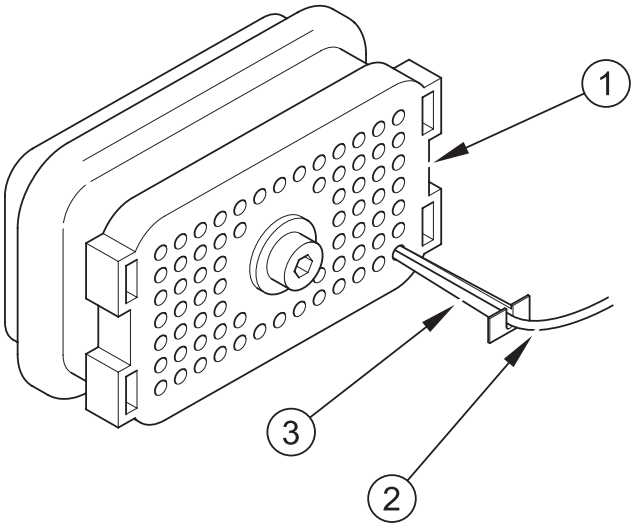



*Figure 37*

# Removal and installation of the harness connector terminals

Figure 37 shows the connector.

1. Remove the connector from the ECM.
2. Position Tooling (3) around wire (2).

**Note:** Make sure that the tool stays perpendicular to the face of connector (1).

3. Push the tool into the hole for the terminal. Gently pull the wire in order to remove the terminal from the rear of connector (1).
4. Remove the Tooling (3) from the wire

**Note:** If a terminal must be replaced, part number 9X-3402 must be used for 16 and 18 AWG wire. Part number 126-1768 must be used for 14 AWG wire.

## Terminal Insertion

1. Push the terminal into the rear of connector (1) until the terminal engages with the locking device.
2. Gently pull on wire (2) in order to make sure that the terminal is retained by the locking device.
3. Connect the connector to the ECM and then tighten the retaining screw to a torque of 6 N•m (53 lb in).

# ECM configuration

The Perkins Electronic Service Tool (EST) should be used in conjunction with the communications adapter to configure the ECM.

Sensors inputs can be enable/disabled to prevent unwanted fault diagnostic codes being broadcast.

# Electronic service tools

Perkins electronic service tools are designed to helpthe service technician:

- Retrieve diagnostic codes.
- Diagnose electrical problems.
- Read parameters.

- Program parameters.
- Install trim files.

## Required service tools

| Required Service Tools | |
|---|---|
| Part Number | Description |
| CH11155 | Crimp Tool (12-AWG TO 18-AWG) |
| 2900A019 | Wire Removal Tool |
| 27610285 | Removal Tool |
| - | Suitable Digital Multimeter |

Two short jumper wires are needed to check the continuity of some wiring harness circuits by shorting two adjacent terminals together in a connector. A long extension wire may also be needed to check the continuity of some wiring harness circuits.

## Optional service tools

The next table lists the optional service tools that can be used when the engine is serviced.

| Part Number | Description |
|---|---|
| U5MK1092 | Spoon Probe Kit(MULTIMETER) |
| or | Suitable Digital Pressure Indicator<br>or<br>Engine Pressure Group |
| | Suitable Battery Load Tester |
| | Suitable Temperature Adapter (MULTIMETER) |
| 28170107 | Bypass Harness As |
| 2900A038 | Harness As |

# Perkins electronic service tool

The Perkins Electronic Service Tool can display the following information:

- Status of all pressure sensors and temperature sensors
- Programmable parameter settings
- Active diagnostic codes and logged diagnostic codes
- Active events and Logged events
- Histograms

The Electronic Service Tool can also be used to perform the following functions:

- Diagnostic tests
- Programming of flash files
- Parameter programming
- Copy configuration function for ECM replacement
- Data logging
- Graphs (real time)

The following table lists the service tools that are required in order to use the Electronic Service Tool.

| **Service Tools for the use of the Electronic Service Tool** | |
|---|---|
| Part Number | Description |
| -(1) | Single Use Program License |
| -(1) | Data Subscription for All Engines |
| 27610251 | Communication Adapter (Electronic Service Tool to ECM interface) |
| 27610164 | Adapter Cable As |

(1) Refer to Perkins Engine Company Limited.

**Note:** For more information regarding the use of the Electronic Service Tool and the PC requirements for the Electronic Service Tool, refer to the documentation that accompanies your Perkins Electronic Service Tool software.

# Connecting the electronic service tool and the communication adapter II

Figure 38 shows the hard wire connections

**1** Personal Computer (PC)

**2** Adapter Cable (Computer Serial Port)

**3** Adapter Cable Assembly

**4** Communication Adapter II

**5** Adapter Cable Assembly

**Note:** Items (2), (3) and (4) are part of the Communication Adapter II kit.

Use the following procedure in order to connect the Electronic Service Tool and the Communication Adapter II.

**1** Turn the keyswitch to the OFF position.

**2** Connect cable (2) between the “COMPUTER” end of communication adapter (4) and the RS232 serial port of PC (1).

**Note:** The Adapter Cable Assembly (3) is required to connect to the USB port on computers that are not equipped with a RS232 serial port.

**3** Connect cable (5) between the “DATA LINK” end of communication adapter (4) and the diagnostic connector.

**4** Place the keyswitch in the ON position. If the Electronic Service Tool and the communication adapter do not communicate with the Electronic Control Module (ECM), refer to the diagnostic procedure Troubleshooting, “Electronic Service Tool Will Not Communicate With ECM”.

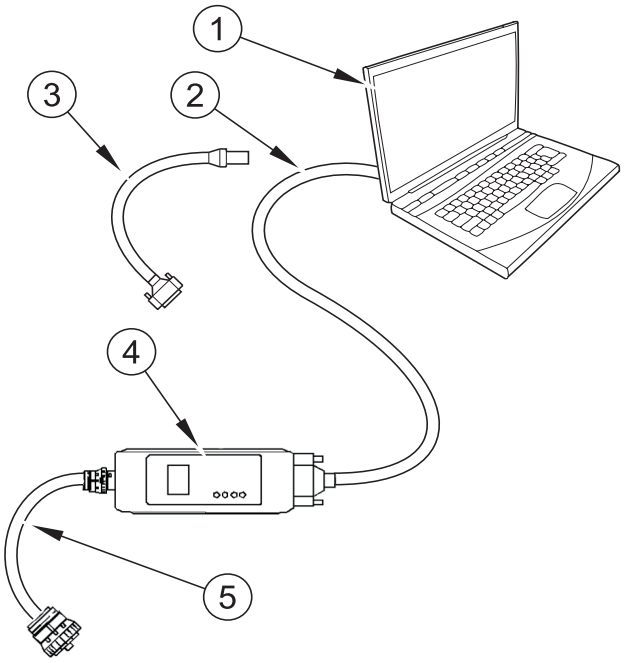



*Figure 38*

# Basic requirements for engine to function

### ECM Power Supply

Battery power must be supplied to the engine for the electronic control system. This is key to ensuring the engine operates correctly and reliably. The positive supply to the engine should be protected by a suitable fuse or breaker, with a rating of 30 Amp. The basic wiring diagram shows the suggesting positive and negative wiring. It is recommended that 1.5 mm² (16 AWG) wire is used to connect to the 70-way J1

ECM connector. There are five pins for the positive connection and five for the negative connection back to the battery. The total circuit resistance of the complete positive and negative wiring to the battery should NOT exceed 50 mΩ for a 12 volt engine or 100 mΩ for a 24 volt engine. This resistance should include the parallel combinations of the five positive wires and five negative wires, as shown below. This should be born in-mind when designing the cable routing. The table below can help when choosing wire size and length. The positive supply should be taken straight from the battery isolator and should NOT be taken from the starter motor positive. It is strongly recommended it is connected directly to the battery isolator, such that power is unlikely to be interrupted during use and such that the battery can be isolated during idle periods, to ensure the battery is not unnecessarily drained. The negative connections should also be taken straight back to the battery or negative busbar. They must NOT be connected to the start motor negative.

| Wire Gauge | | Typical Wire Resistance (mOhms) and Length(s) @ 20°C | | | | |
|---|---|---|---|---|---|---|
| AWG | mm² | 2m | 4m | 6m | 8m | 10m |
| 6 | 13.5 | 2.8 | 5.6 | 8.4 | 11.2 | 14 |
| 8 | 9 | 4 | 8 | 12 | 16 | 20 |
| 10 | 4.5 | 8 | 16 | 24 | 32 | 40 |
| 12 | 3 | 14 | 28 | 42 | 56 | 70 |
| 14 | 2 | 20 | 40 | 60 | 80 | 100 |

**Key Switch**

A key switch or ‘ignition’ switch should be used to control the engine. The basic wiring diagram shows the recommended connection for the key switch. The key switch positive supply should be protected by a suitable fuse or breaker with a rating of 5 Amp. The key switch must be on for the engine to run. If the key switch is turned off the engine will stop. The ‘Key Switch’ should also be used to provide power to the optional indicator lamps and Run/Start inputs (see section for Hardwired Start / Stop).

**Hardwired Start / Stop**

The engine maybe started and stopped using either hardwired signals or over J1939 using the GC1 message. If the hardwired start stop option is used the engine is started and runs by applying positive battery power to ECM Pins 62 and 64. The engine is stopped by removing power from ECM Pins 62 and 64. In addition apply negative battery to ECM Pin 40 will cause the engine to stop. The wiring diagram shows the suggested wiring, where the Run / Stop switch maybe either a switch or relay.

**Remote Stop**

A remote stop input is available on ECM Pin 7. Connecting pin 7 to battery negative will cause the engine to shut down. The engine will not start if this condition exists.

**Fuel Lift Pump**

The engine is equipped with an electric fuel lift pump which must run whilst the engine is running. The pump is ECM controlled and will also run following 'Key On' of the ECM for 2 minutes in order to prime the fuel system. The lift pump must be controlled by a suitable relay. The relay coil should have a maximum current draw of 300 mA and the lift pump must be protected with a suitable fuse or breaker with a rating of 30 Amps maximum.

The fuel lift pump maybe connected directly using the 2-pin connection on the pump body, in which case the positive terminal is pin 1. Alternatively, there may be an interconnecting harness, whereby the connection is a three-pin connector, in this case pin A is the positive terminal.

**Starter Relay**

The ECM has limited output current capability; therefore, a relay is required to provide power to the starter motor solenoid. The wiring diagram shows two configurations of the starter relay. The wiring to the relay coil depends on the ECM software installed. Software part number 501-3363 and earlier uses ECM Pins 43 and 51 to connect to the relay coil. In this configuration a relay must be selected which has a minimum hold-on current greater than 190 mA. Failure to select a relay which meets this requirement could cause the relay to stay energised, keeping the starter motor powered when not required. When using ECM software later than 501-3363, the relay coil positive is taken from ECM Pin 10, and the coil must not draw more than 2 Amps. The relay coil negative should be routed to battery negative. The switched power from the starter relay should be connected to Terminal '50-S' on the starter motor solenoid and must be protected by at least a 30 Amp fuse.

**Fuel Pressure Sensor**

For correct operation of the engine the fuel supply pressure must be measured. There are four fuel pressure sensors, however only the secondary filter outlet pressure is required for operation, the other three sensors are optional. The secondary filter outlet pressure sensor should be connected to the ECM as shown in wiring diagram. Power for the sensor is 5 Volts taken from ECM pin 2 and pin 3. The sensor signal is routed to the ECM on pin 47.

The optional fuel pressure sensors can be connected to the ECM to provide monitoring of differential pressure over the Primary and Secondary fuel filters if required. If fitted these sensors need to be enabled in the ECM using the service tool. These optional sensors share the same 5 Volt power supply as used for the mandatory sensor, ECM Pins 2 and 3. The sensor signals are routed to the ECM as follows:

| Fuel Pressure Sensor Location | ECM Input Pin |
|---|---|
| Primary Fuel Filter Inlet (Optional Fitment) | Pin 25 |
| Primary Fuel Filter Outlet (Optional Fitment) | Pin 26 |
| Secondary Fuel Filter Inlet (Optional Fitment) | Pin 15 |
| Secondary Fuel Filter Outlet (Mandatory Fitment) | Pin 47 |

**Engine Speed Control**

Although the engine is configured for fixed speed operation, a small amount of operating speed adjustment is provided, typically for the purpose of generator synchronisation and load control. There are four means of providing a speed control input to the ECM.

In order to control engine speed a throttle signal needs to be supplied to the engine. Typically, this is provided by a PWM or 5 V proportional signal provided to the primary throttle input. Alternatively, the engine speed can be controlled over the J1939 CANBus using the TSC1 message. The wiring diagram shows how a throttle sensor should be connected to the engine. Depending on the type of sensor used, it should take its power supply from either the ECM 8 V power provided on ECM Pins 4 and 5 or from the 5 V power provided on ECM Pins 2 and 3. The specification of the sensor should be checked to ensure the correct power source is chosen.

The PWM throttle signal should be provided by a sensor or controller with a sinking output driver, at a frequency of 500 Hz +/- 50 Hz. The sensor should give a valid output within 150 ms of power being applied to avoid diagnostics being raised due to a missing signal. 10% duty cycle equates to 0% throttle or request for low speed. 90% duty cycle equates to 100% throttle or request for high speed. Duty cycle lower than 5% or higher than 95% will result in diagnostics being raised to indicate throttle or wiring failure.

The 5 V proportional throttle signal should have a valid range of 0.5 – 4.5 volts. With 0.5 v equating to 0%

throttle or request for low speed. A voltage lower than 0.25 V or higher than 4.75 V will result in diagnostics being raised to indicate throttle or wiring failure.

In addition to the three throttle methods detailed above, there is also a digital throttle, which can be controlled using switches to raise and lower the speed in steps. Three switches are needed, an 'Enable' switch, a 'Raise' switch and a 'Lower' switch. The configuration of these switches is shown in wiring diagram.

The installed throttle input used must be selected in the ECM using the service tool.

**Note:** Should no throttle be required for the application, then in order to ensure no diagnostic faults are raised, the digital throttle enable input should be permanently connected to battery negative.

**Glow plugs**

The engine maybe equipped with glow plugs to improved starting capability in colder climates. The glow plugs should take their power from the application battery through a suitable fuse or breaker. For a 12 Volt system a 135 Amp breaker should be used, a 90 Amp breaker is acceptable for a 24 Volt system. Each glow plug has its negative connection to the cylinder block, and as such during the operation of the glow plugs, the cylinder block should be temporarily connected to battery negative using a relay. The ECM provides two outputs from the ECM drive the relays, ECM Pin 20 for the positive, and ECM Pin 12 for the negative relay. See the wiring diagram for the configuration of these relays.

Care should be taken when selecting wiring for the glow plugs to ensure it can handle the current drawn by all the glow plugs fitted to the engine. For a 12 Volt system each glow plug draws 18 Amps, with a minimum suggested wire size of 25 mm² or 4 AWG. For a 24 Volt system each glow plug draws 8 Amps, with a minimum suggested wire size of 16 mm² or 6 AWG. Ensure both the glow plug positive wiring and engine block negative wiring is of the same gauge.

**Note:** Wire size may need to be increased to avoid significant voltage drop if the circuit length is long.

The glow-plugs operate for a period when the 'Key Switch' is energised. The glow-plugs then re-energise during cranking and then remain energised for a period once the engine has started. The duration of each operation is dependent on both engine coolant temperature and intake manifold temperature. Note the glow plugs are unlikely to operate when the ambient temperature is above 10$^{O}$C (50$^{O}$F).

**Indicator Lamps**

The engine provides for a total of seven indication lamps. Out of these eight it is strongly recommended that as a minimum the stop and warning lamps are installed. These provide the operator with basic information regarding the engine's operation and any warnings or fault conditions. The wiring diagram shows how these lamps should be wired. They should take their power from the key switch signal. Each lamp should not exceed a current draw of 200 mA, this limits a lamp to using a maximum of a 2.2 watt bulb. Alternatively, LED indicators can be used. It is recommended the Stop lamp is RED and the warning lamp is AMBER. The following table shows possible lamp state combinations and there meaning. (LAMP TEST AT KEY ON)

| Red Stop Lamp | Amber Warning Lamp | Engine State |
|---|---|---|
| OFF | OFF | Normal engine operation with no faults, diagnostics or de-rates |
| OFF | ON | Warning – Engine has detected a problem, but continues to run without a de-rate. |
| OFF | SLOW FLASH | De-rate – Engine has detected a problem which is serious and has reduced available engine power to protect the engine. |
| ON | FAST FLASH | Shutdown – Engine has detected a problem which is serious and has shut down the engine to protect it and the operator. |

**Service / Diagnostic Connector**

A diagnostic connector must be provided to allow connection to the ECM for the purposes of diagnostics, service and engine configuration. The connector must be of the 9-Pin round Deutsch type, suppled with the engine. The connector must be wired as shown in the wiring diagram.

**Note:** The J1939 data link must be terminated with a 120 Ohm resistor close (within 300 mm) to the ECM connector.

**CANBus (J1939)**

A J1939 CANBus connection is provided on the ECM connector. This can be used for integrating instrumentation and controls to the engine. The wiring should conform to the SAE J1939-15 or J1939-11

standard, being a twisted pair with approximately 1 turn per inch. Whilst this twisted pair does not have to be shielded it is recommended that a shielded twisted pair cable is used, especially if the bus run is long. The shield should be grounded at one end only, preferably to the J1939 Shield connection on the ECM Pin 42. The end of the bus should be correctly terminated with a 120Ω resistor. The CANBus runs at 250kbit/s and broadcasts the following J1939 messages. In addition, it also accepts the TSC1 message for engine speed control if required (SPNs 695, 897 & 898) and the GC1 message for engine start / stop (SPN 3542). In order to TSC1 or GC1 to be used for speed control or start/stop it must be enabled via the service tool.

| PGN Name | PGN | SPN Name | SPN |
|---|---|---|---|
| DM1 | 65226 | *Active diagnostic codes & Lamp Status DM1 Message implemented as per J1939-73* | |
| AMB | 65269 | Barometric Pressure | 108 |
| DD | 65276 | Secondary Fuel Filter Differential Pressure | 95 |
| EAC | 65172 | Sea Water Pump Outlet Pressure | 2435 |
| EC1 | 65251 | Engine Speed At Idle - Point 1 | 188 |
| | | Engine Speed At High Idle - Point 6 | 532 |
| EEC1 | 61444 | Engine Speed | 190 |
| EEC2 | 61443 | Percent Load At Current Speed | 92 |
| | | Throttle Position | 91 |
| | | Throttle Position Low Idle Switch | 558 |
| EEC3 | 65247 | Exhaust Gas Mass Flow | 3236 |
| | | Desired Operating Speed | 515 |
| EFL_P1 | 65263 | Secondary Fuel Filter Inlet Pressure | 94 |
| | | Oil Pressure | 100 |
| | | Coolant Pressure | 101 |
| | | Coolant Level | 111 |
| EFL_P12 | 64735 | Secondary Fuel Filter Outlet Pressure | 5579 |
| EFL_P2 | 65243 | Injector Metering Rail Press | 157 |
| EFS | 65130 | Primary Fuel Filter Differential Pressure | 1382 |
| EI1 | 65170 | Pre Filter Oil Pressure | 1208 |

| | | | |
|---|---|---|---|
| EOI | 64914 | Engine Operating State | 3543 |
| ET1 | 65262 | Coolant Temperature | 110 |
| | | Fuel Temperature | 174 |
| | | Oil Temperature | 175 |
| FL | 65169 | Engine Fuel Leakage | 1239 |
| HOURS *(On Request)* | 65253 | Total Hours Of Operation | 247 |
| | | Total Revolutions | 249 |
| IC1 | 65270 | Intake Manifold 1 Gauge Pressure | 102 |
| | | Intake Manifold 1 Temperature | 105 |
| | | Air Intake Pressure | 106 |
| IC2 | 64976 | Intake Manifold 1 Absolute Pressure | 3563 |
| IMT1 | 65190 | Turbo Boost Pressure | 1127 |
| LFC1 | 65257 | Trip Fuel | 182 |
| | | Total Fuel Used | 250 |
| LFE1 | 65266 | Fuel Rate | 183 |
| LFI | 65203 | Trip Average Fuel Rate | 1029 |
| SEP1 | 64925 | Sensor Supply Voltage 1 | 3509 |
| | | Sensor Supply Voltage 2 | 3510 |
| VEP1 | 65271 | Battery Potential | 168 |
| | | Key-switch Battery Potential | 158 |

**Additional Features**

In addition to the basic engine wiring detailed above, required for the engine's basic operation, there are additional features which can be installed. The following sections details these features.

**Indicator Lamps**

There are five additional indicator lamps which can be connected to the ECM. Each lamp must be selected to ensure its current draw is no higher than 200 mA, typically limiting the lamp to a 2.2 watt bulb. Alternatively, LED indicators maybe used. Each lamp should take its power from the key switch signal.

| Lamp Function | ECM Pin | Description |
|---|---|---|
| Low Oil Pressure Lamp | J1-36 | Activates when low engine oil pressure is detected |

| | | |
|---|---|---|
| High Coolant Temperature Lamp | J1-19 | Activates when high engine coolant temperature is detected |
| Overspeed Lamp | J1-13 | Activates when engine overspeed is detected |
| Maintenance Lamp *(Also see Maintenance Reset Switch)* | J1-31 | Activates when engine is due routine maintenance |
| Flash Code Lamp | J1-30 | Provides flash-codes for active diagnostics and events |

**Digital Input Switches**

There are six additional digital inputs which can be connected to the ECM. A switch can be connected between each input and the shared digital input return on ECM Pin 18.

| Input Function | ECM Pin | Description |
|---|---|---|
| Maintenance Reset Switch | J1-44 | Allows the maintenance indicator to be reset following completion of maintenance. It is recommended the switch is a momentary type and is installed in a protected location to avoid it accidently being activated. |
| Droop / Isochronous Switch | J1-46 | Allows the selection of either fixed speed isochronous governing or droop governing. |
| Coolant Level Switch | J1-49 | Allows the ECM to monitor the coolant level. A coolant low level alarm can be triggered when low coolant level is detected. The configuration of the switch maybe either normally open or normally closed and is configured using the service tool. |

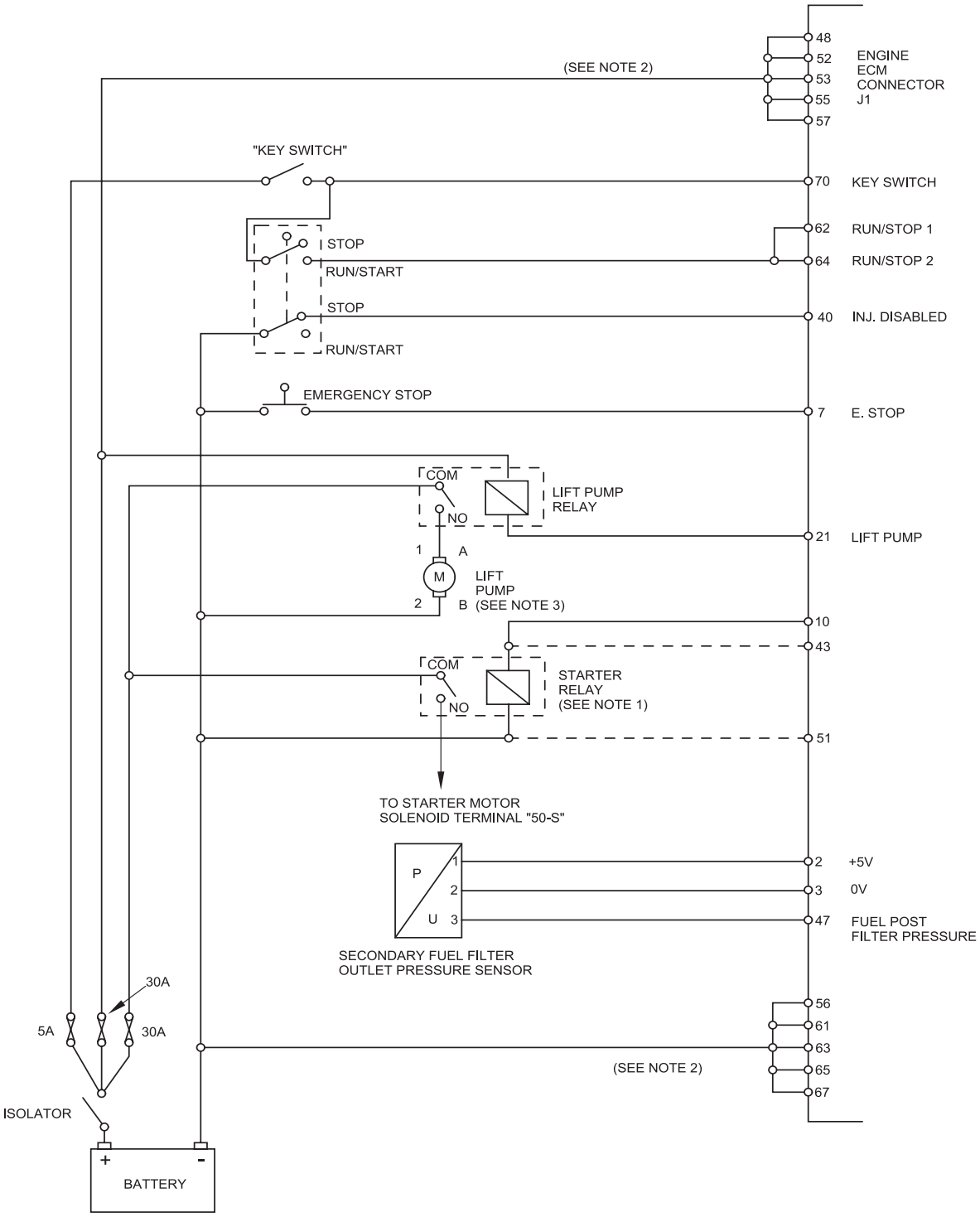
| | | |
|---|---|---|
| Shutdown Override Switch | J1-56 | Allows the engine monitoring system to be disabled such that shutdowns will not occur. Note the overspeed shutdown is permanently enabled and cannot be disabled using this feature. This feature must be enabled via the service tool. A Perkins dealer should be consulted prior to attempting to use this feature as its use can invalidate product warranty. |
| Fault Reset Switch | J1-41 | Allows the reset of specific ECM diagnostics and events. |
| Overspeed Verify Switch | J1-54 | Allows to operator to acknowledge an overspeed event to allow the engine to be restarted. |

## Wiring diagrams

These diagrams can be found on the following pages.

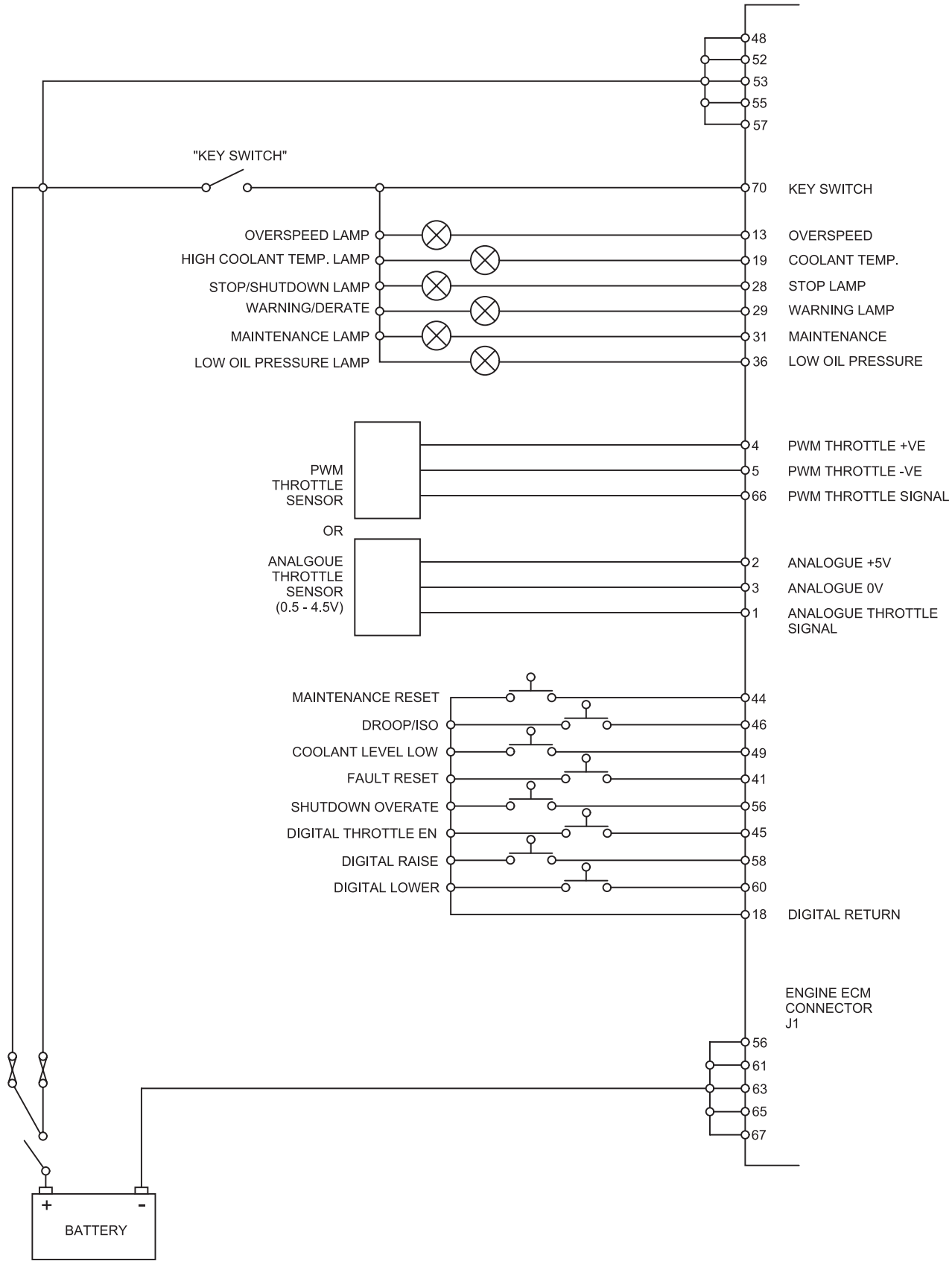
- Basic engine wiring.
- Throttle/lamps/inputs wiring.
- Diagnostics/glow plugs wiring.

# Basic Engine Wiring



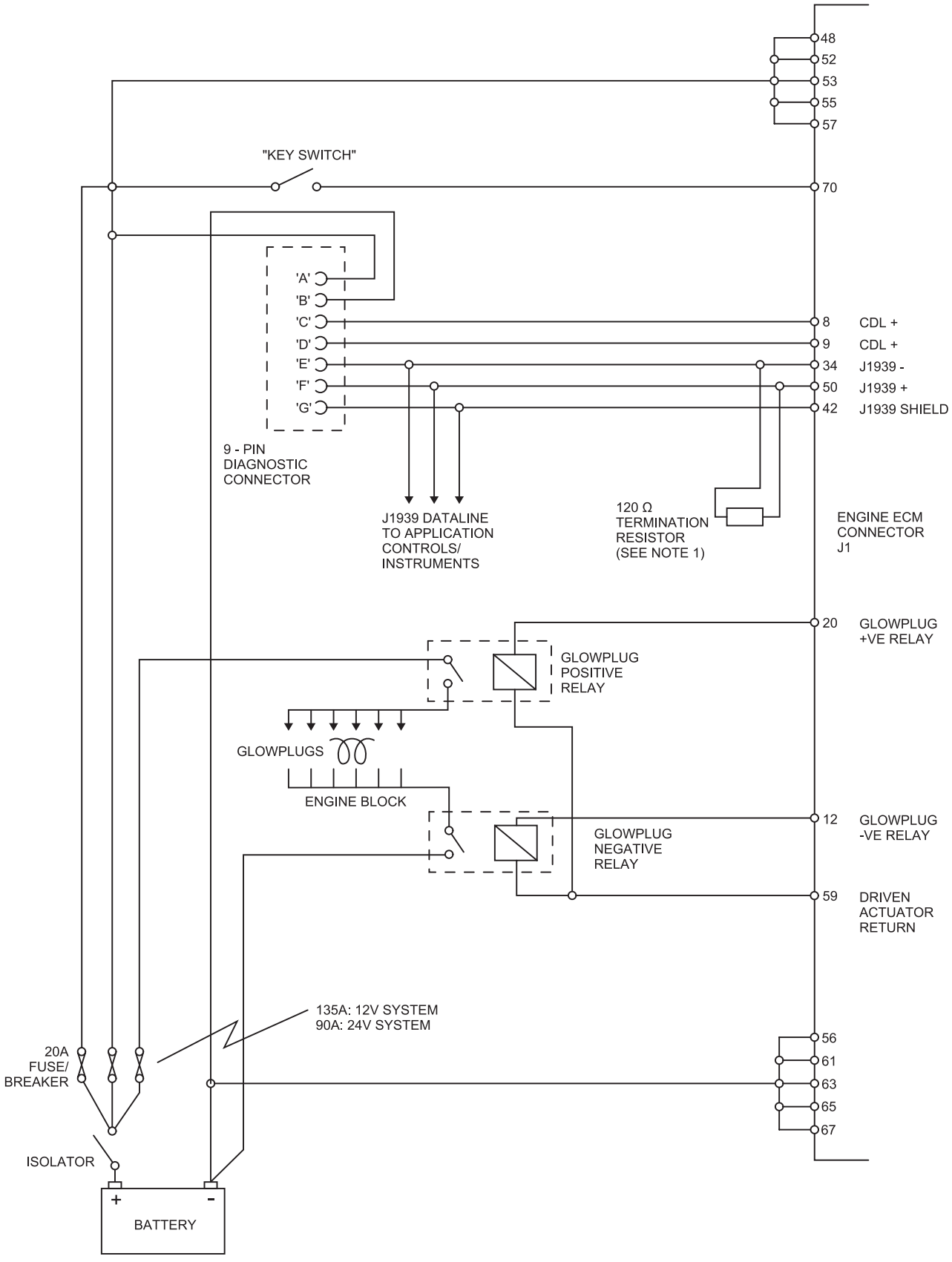

1. Starter relay has two wiring configurations to the ECM depending on ECM Software installed. ECM software up to and including part number 501-3363, should have the starter relay connected to ECM pins 43 and 51. Later ECM software requires the starter relay to be connected to ECM pin 10 and a battery negative connection. **NOTE** – Starter relays used on the older software (501-3363 and earlier) should have a minimum hold-on current greater than 190 mA. Relays W10728 (12 v) and W10041 (24 v) are suitable for this. This ensures the starter relay can correctly de-energise.
2. The main power supply wires to the ECM should be individually at least 1.5 mm² in size. The length of wiring between battery and ECM should also be kept as short as possible. These requirements apply to both ECM Battery Positive and ECM Battery Negative connections. See further section on ECM Power Supply.
3. The fuel lift pump maybe connected directly using the 2-pin connection on the pump body, in which case the positive terminal is pin 1. Alternatively, there may be an interconnecting harness, whereby the connection is a three-pin connector, in this case pin A is the positive terminal. The lift pump must be driven by a relay, and the relay coil should not draw any more than 300 mA.

# Throttle/Lamps/Inputs Wiring




1. A 120 Ohm termination resistor must be connected close, within 300 mm, to the ECM for correct functioning of the J1939 datalink.

# Diagnostics/Glow Plugs Wiring



**California**

Proposition 65 Warning

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

Perkins®

# Marine Power


Part No. 451-1172 issue 4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