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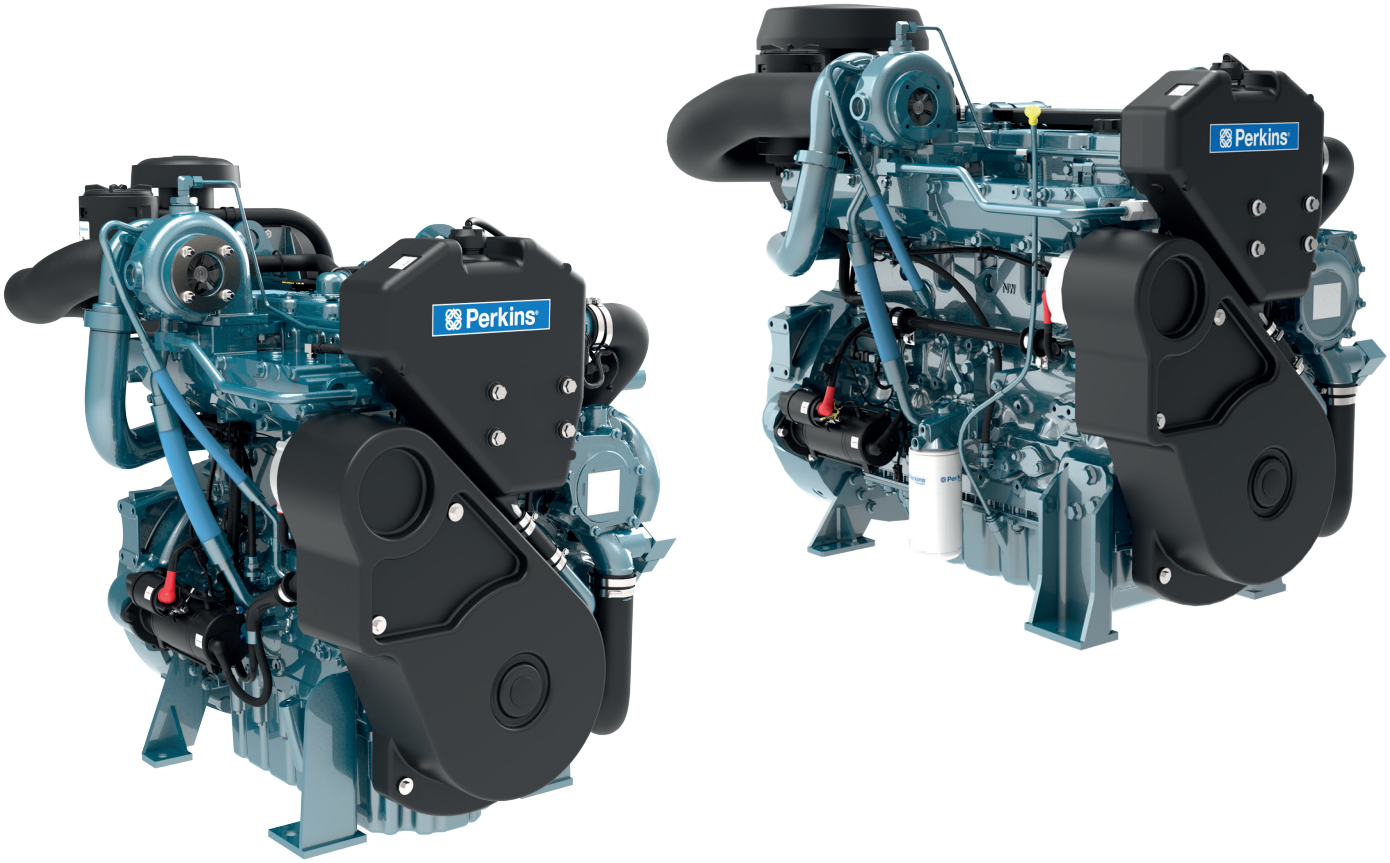
User's Handbook & Installation Information



E44 & E70B Marine Auxiliary Engine

Perkins®

Marine Power

Perkins E44 & E70B Marine Auxiliary Engine User's Handbook & Installation Information

4 & 6 cylinder, turbocharged, aftercooled, diesel engines for marine auxiliary applications

Publication 641-0971, Issue 1

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Foreword

Thank you for purchasing the Perkins E44 or E70B 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 “DANGER”, “WARNING” or “CAUTION”. 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 worksite. 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.

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.

NOTICE

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

Other parts may not meet certain original equipment specifications.

When replacement parts are installed, the machine owner/user should ensure that the machine remains in compliance with all applicable requirements.

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. Forword

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.

WARNING – This product can expose you to chemicals including ethylene glycol, which is known to the State of California to cause birth defects or other reproductive harm. For more information go to:

www.P65Warnings.ca.gov

Do not ingest this chemical. Wash hands after handling to avoid incidental ingestion.

WARNING – This product can expose you to chemicals including lead and lead compounds, which are known to the State of California to cause cancer, birth defects, or other reproductive harm. For more information go to:

www.P65Warnings.ca.gov

Wash hands after handling components that may contain lead.

Literature Information

This manual contains safety, operation instructions, lubrication, and maintenance information. This manual should be stored in or near the engine area in a literature holder or literature storage area. Read, study, and keep it with the literature and engine information.

English is the primary language for all Perkins publications. The English used facilitates translation and consistency in electronic media delivery.

Some photographs or illustrations in this manual show details or attachments that may be different from your engine. Guards and covers may have been removed for illustrative purposes. Continuing improvement and advancement of product design may have caused changes to your engine which are not included in this manual Whenever a question arises regarding your engine, or this manual, please consult with your Perkins dealer for the latest available information.

Safety

This safety section lists basic safety precautions. In addition, this section identifies hazardous, warning situations. Read and understand the basic precautions

listed in the safety section before operating or performing lubrication, maintenance, and repair on this product.

Operation

Operating techniques outlined in this manual are basic. They assist with developing the skills and techniques required to operate the engine more efficiently and economically. Skill and techniques develop as the operator gains knowledge of the engine and its capabilities.

The operation section is a reference for operators. Photographs and illustrations guide the operator through procedures of inspecting, starting, operating, and stopping the engine. This section also includes a discussion of electronic diagnostic information.

Maintenance

The maintenance section is a guide to engine care. The illustrated, step-by-step instructions are grouped by fuel consumption, service hours and/or calendar time maintenance intervals. Items in the maintenance schedule are referenced to detailed instructions that follow.

Use fuel consumption or service hours to determine intervals. Calendar intervals shown (daily, annually, etc.) may be used instead of service meter intervals if they provide more convenient schedules and approximate the indicated service meter reading.

Recommended service should be performed at the appropriate intervals as indicated in the Maintenance Interval Schedule. The actual operating environment of the engine also governs the Maintenance Interval Schedule. Therefore, under severe, dusty, wet, or freezing cold operating conditions, more frequent lubrication, and maintenance than is specified in the Maintenance Interval Schedule may be necessary.

The maintenance schedule items are organized for a preventive maintenance management program. If the preventive maintenance program is followed, a periodic tune-up is not required. The implementation of a preventive maintenance management program should minimize operating costs through cost avoidances resulting from reductions in unscheduled downtime and failures.

Maintenance Intervals

Perform maintenance on items at multiples of the original requirement. Each level and/or individual items in each level should be shifted ahead or back depending upon your specific maintenance practices, operation, and application. We recommend that the maintenance schedules be reproduced and displayed near the engine as a convenient reminder. We also recommend that a maintenance record be maintained as part of the engine’s permanent record.

See the section in the Operation and Maintenance Manual, “Maintenance Records” for information regarding documents that are accepted as proof of maintenance or repair. Your authorized Perkins dealer can assist you in adjusting your maintenance schedule to meet the needs of your operating environment.

Overhaul

Major engine overhaul details are not covered in the Operation and Maintenance Manual except for the interval and the maintenance items in that interval. Major repairs are best left to trained personnel or an authorized Perkins dealer. Your Perkins dealer offers various options regarding overhaul programs. If you experience a major engine failure, there are also numerous after failure overhaul options available from your Perkins dealer. Consult with your dealer for information regarding these options.

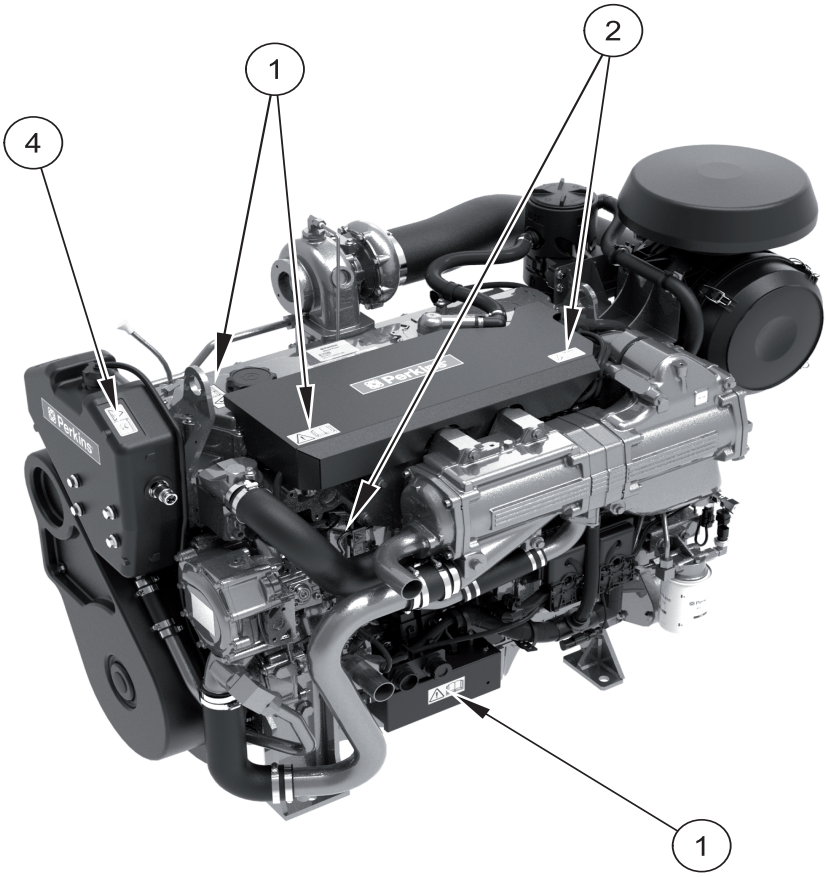
Safety

Safety Messages

There may be several specific safety messages on your engine. The exact location and a description of the safety messages are reviewed in this section. Please become familiar with all of the messages.

Ensure that all of the safety messages are legible. Clean the safety messages or replace the safety messages if the words cannot be read or if the illustrations are not visible. Use a cloth, water, and soap for cleaning the safety messages. Do not use solvents, gasoline, or other harsh chemicals. Solvents, gasoline, or harsh chemicals could loosen the adhesive that secures the safety messages. The safety messages that are loosened could drop off the engine.

Replace any safety message that is damaged or missing. If a safety message is attached to a part of the engine that is replaced, install a new safety message on the replacement part. Your Perkins dealer can provide new safety messages.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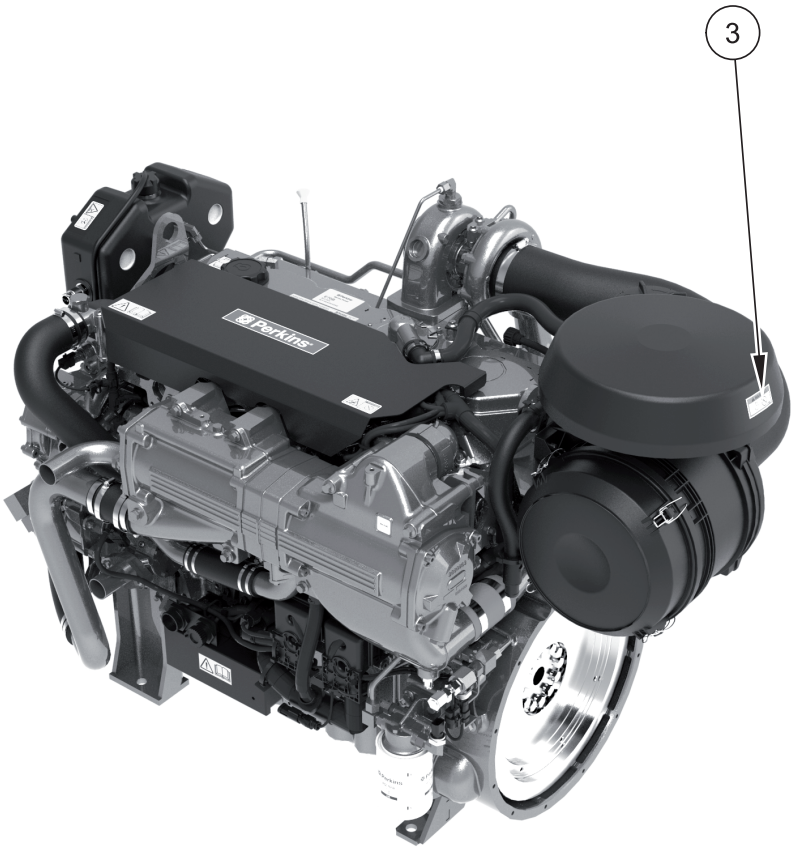
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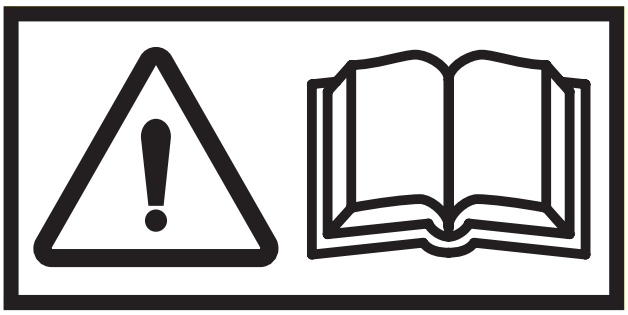


Universal Warning (1)

⚠ WARNING

Do not operate or work on this engine or generator set unless you have read and understand the instructions and warnings in the Operation and Maintenance Manuals.

Failure to follow the warnings and instructions could result in injury or death. Contact any Perkins dealer for replacement manuals. Proper care is your responsibility.

The universal warning label is located in three different positions. The top cover plate, the top of the valve mechanisms cover and the fuel pump housing.

Hand High Pressure (2)

⚠ WARNING

Contact with high pressure fuel may cause fluid penetration and burn hazards. High pressure fuel spray may cause a fire hazard. Failure to follow these inspection, maintenance and service instructions may cause personal injury or death.

The hand high-pressure warning label is installed on the top cover plate.

Do Not Use Ether (3)

⚠ WARNING

If equipped with an air inlet heater (AIH) for cold weather starting, do not use aerosol types of starting aids such as ether. Such use could result in an explosion and personal injury.

The do not use ether label is installed on the rain cap of the air cleaner.

Hot Fluid Under Pressure (4)

Pressurized system! Hot coolant can cause serious burns, injury or death. To open the cooling system filler cap, stop the engine and wait until the cooling system components are cool. Loosen the cooling system pressure cap slowly in order to relieve the pressure. Read and understand the Operation and Maintenance Manual before performing any cooling system maintenance.

The warning label of hot fluid under pressure is installed on the header tank.

General Hazard Information

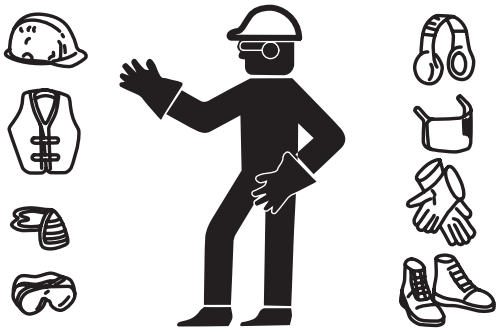
Attach a “Do Not Operate” warning tag to the start switch or controls before the engine is serviced or repaired. Attach the warning tags to the engine and to each operator control station. When appropriate, disconnect the starting controls.

Do not allow unauthorised personnel on the engine, or around the engine when the engine is being serviced.

Cautiously remove the following parts. To help prevent spraying or splashing of pressurized fluids, hold a rag over the part that is being removed.

- Filler caps
- Grease fittings
- Pressure taps
- Breathers
- Drain plugs

Use caution when cover plates are removed. Gradually loosen, but do not remove the last two bolts or nuts that are at opposite ends of the cover plate or the device. Before removing the last two bolts or nuts, pry the cover loose to relieve any spring pressure or other pressure.



- Wear a hard hat, protective glasses, and other protective equipment, as required.
- When work is performed around an engine that is operating, wear protective devices for ears to help prevent damage to hearing.
- Do not wear loose clothing or jewelry that can snag on controls or on other parts of the engine.
- Ensure that all protective guards and all covers are secured in place on the engine.
- Never put maintenance fluids into glass containers. Glass containers can break.
- Use all cleaning solutions with care.
- Report all necessary repairs.

Unless other instructions are provided, perform the maintenance under the following conditions:

- **Th**e engine is stopped. Ensure that the engine cannot be started.
- The protective locks or the controls are in the applied position.
- Disconnect the batteries when maintenance is performed or when the electrical system is serviced. Disconnect the battery ground leads. Tape the leads to help prevent sparks.
- When starting a new engine, make provisions

to stop the engine if an overspeed occurs. If an engine has not been started since service has been performed, make provisions to stop the engine if an overspeed occurs. Shutting down the engine may be accomplished by shutting off the fuel supply and/or the air supply to the engine.

• Do not attempt any repairs that are not understood. Use the proper tools. Replace any equipment that is damaged or repair the equipment.

• Start the engine with the operator controls. Never short across the starting motor terminals or the batteries. This method of starting the engine could bypass the engine neutral start system and/or the electrical system could be damaged.

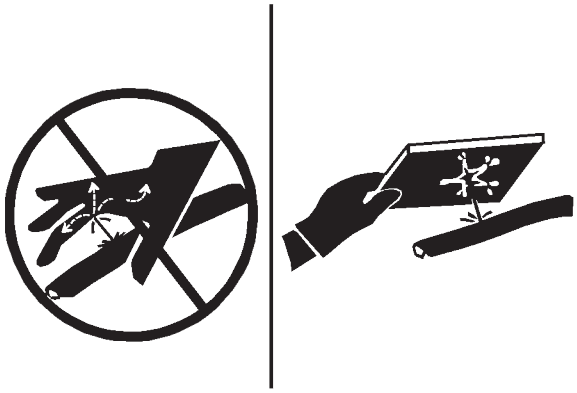
Pressurized Air and Water

Pressurized air and/or water can cause debris and/or hot water to be blown out which could result in personal injury.

The maximum air pressure for cleaning purposes must be reduced to 205 kPa (30 psi) when the air nozzle is deadheaded and used with effective chip guarding (if applicable) and personal protective equipment. The maximum water pressure for cleaning purposes must be below 275 kPa (40 psi).

When pressurized air and/or pressurized water is used for cleaning, wear protective clothing, protective shoes, and eye protection. Eye protection includes goggles or a protective face shield. Always wear eye protection for cleaning the cooling system.

Avoid direct spraying of water on electrical connectors, connections, and components. When using air for cleaning, allow the machine to cool to reduce the possibility of fine debris igniting when redeposited on hot surfaces.



Fluid Penetration

Always use a board or cardboard when you check for a leak. Leaking fluid that is under pressure can penetrate body tissue. Fluid penetration can cause serious injury and possible death. A pin hole leak can cause severe injury. If fluid is injected into your skin, you must get treatment immediately. Seek treatment from a doctor that is familiar with this type of injury.

Containing Fluid Spillage

NOTICE

Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting, and repair of the product. Be

prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids.

Dispose of all fluids according to local regulations and mandates.

Static Electricity Hazard when Fueling with Ultra-low Sulphur Diesel Fuel

The removal of sulphur and other compounds in ultra-low sulphur diesel fuel (ULSD fuel) decreases the conductivity of ULSD and increases the ability of ULSD to store static charge. Refineries may have treated the fuel with a static dissipating additive. Many factors can reduce the effectiveness of the additive over time. Static charges can build up in ULSD fuel while the fuel is flowing through fuel delivery systems. Static electricity discharge when combustible vapours are present could result in a fire or explosion. Ensure that the entire system used to refuel your machine (fuel supply tank, transfer pump, transfer hose, nozzle, and others) is properly grounded and bonded. Consult with your fuel or fuel system supplier to ensure that the delivery system complies with fuelling standards for proper grounding and bonding.

⚠ WARNING

Avoid static electricity risk when fueling. Ultra-low sulphur diesel fuel (ULSD fuel) poses a greater static ignition hazard than earlier diesel formulations with a higher sulfur contents. Avoid death or serious injury from fire or explosion. Consult with your fuel or fuel system supplier to ensure the delivery system is in compliance with fuelling standards for proper grounding and bonding practices.

Lines, Tubes, and Hoses

Do not bend or strike high-pressure lines. Do not install lines, tubes, or hoses that are damaged.

Repair any fuel lines, oil lines, tubes, or hoses that are loose or damaged. Leaks can cause fires.

Inspect all lines, tubes, and hoses carefully. Do not use bare hands to check for leaks. Always use a board or cardboard for checking engine components for leaks. Tighten all connections to the recommended torque.

Check for the following conditions:

- End fittings that are damaged or leaking
- Outer covering that is chafed or cut
- Wire that is exposed in reinforced hose
- Outer covering that is ballooning locally

- Flexible part of the hose that is kinked or crushed
- Armouring that is embedded in the outer covering

Ensure that all the clamps, the guards, and the heat shields are installed correctly. Correct installation of these components will help to prevent these effects: vibration, rubbing against other parts and excessive heat during operation.

Inhalation

Exhaust

Use caution. Exhaust fumes can be hazardous to your health. If you operate the equipment in an enclosed area, adequate ventilation is necessary. Ensure that the crankcase exhaust is routed outside of the vessel.

Hexavalent Chromium

Perkins equipment and replacement parts comply with applicable regulations and requirements where originally sold. Perkins recommends the use of only genuine Perkins replacement parts.

Hexavalent chromium has occasionally been detected on exhaust and heat shield systems on Perkins engines. Although lab testing is the only accurate way to know if hexavalent chromium is, in fact, present, the presence of a yellow deposit in areas of high heat (for example, exhaust system components or exhaust insulation) may be an indication of the presence of hexavalent chromium.

Use caution if you suspect the presence of hexavalent chromium. Avoid skin contact when handling items that you suspect may contain hexavalent chromium, and avoid inhalation of any dust in the suspect area. Inhalation of, or skin contact with, hexavalent chromium dust may be hazardous to your health.

If such yellow deposits are found on the engine, engine component parts, or associated equipment or packages, Perkins recommends following local health and safety regulations and guidelines, utilizing good hygiene, and adhering to safe work practices when handling the equipment or parts. Perkins also recommends the following:

- Wear appropriate personal protective equipment (PPE).
- Wash your hands and face with soap and water prior to eating, drinking, or smoking, and also during rest room breaks, to prevent ingestion of any yellow powder.
- Never use compressed air for cleaning areas suspected of containing hexavalent chromium.
- Avoid brushing, grinding, or cutting materials

suspected of containing hexavalent chromium.

• Obey environmental regulations for the disposal of all materials that may contain or have come into contact with hexavalent chromium.

• Stay away from areas that might have hexavalent chromium particles in the air.

Asbestos Information

Perkins equipment and replacement parts that are shipped from Perkins are asbestos free. Perkins recommends the use of only genuine Perkins replacement parts. Use the following guidelines when you handle any replacement parts that contain asbestos or when you handle asbestos debris.

Use caution. Avoid inhaling dust that might be generated when you handle components that contain asbestos fibers. Inhaling this dust can be hazardous to your health. The components that may contain asbestos fibers are brake pads, brake bands, lining material, clutch plates, and some gaskets. The asbestos that is used in these components is bound in a resin or sealed in some way. Normal handling is not hazardous unless airborne dust that contains asbestos is generated.

If dust that may contain asbestos is present, there are several guidelines that should be followed:

• Never use compressed air for cleaning.

• Avoid brushing materials that contain asbestos.

• Avoid grinding materials that contain asbestos.

• Use a wet method to clean up asbestos materials.

• A vacuum cleaner that is equipped with a high efficiency particulate air filter (HEPA) can also be used.

• Use exhaust ventilation on permanent machining jobs.

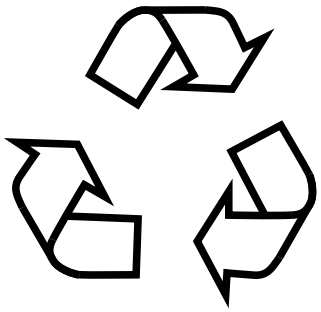
• Wear an approved respirator if there is no other way to control the dust.

• Comply with applicable rules and regulations for the work place. In the United States, use Occupational Safety and Health Administration (OSHA) requirements. These OSHA requirements can be found in “29 CFR 1910.1001”.

• Obey environmental regulations for the disposal of asbestos.

• Stay away from areas that might have asbestos particles in the air.

Softwrap



Keep the engine room ventilation operating at full capacity. Wear a particulate respirator that has been approved by the National Institute of Occupational Safety and Health (NIOSH). Wear appropriate protective clothing to minimize direct contact. Use good hygiene practices and wash hands thoroughly after handling Softwrap material. Do not smoke until washing hands thoroughly after handling Softwrap material. Clean up debris with a vacuum or by wet sweeping. Do not use pressurized air to clean up debris.

Dispose of Waste Properly

Improperly disposing of waste can threaten the environment. Potentially harmful fluids should be disposed of according to local regulations.

Always use leakproof containers when you drain fluids. Do not pour waste onto the ground, down a drain, or into any source of water.

Burn Prevention

Do not touch any part of an operating engine. Allow the engine to cool before any maintenance is performed on the engine.

⚠ WARNING

Contact with high pressure fuel may cause fluid penetration and burn hazards. High pressure fuel spray may cause a fire hazard. Failure to follow these inspection, maintenance and service instructions may cause personal injury or death.

After the engine has stopped, wait for 10 minutes 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.

Allow the pressure to be purged in the air system, in the hydraulic system, in the lubrication system, or in the cooling system before any lines, fittings, or related items are disconnected.

Coolant

When the engine is at operating temperature, the engine coolant is hot. The coolant is also under pressure. The radiator and all lines to the heaters or to the engine contain hot coolant.

Any contact with hot coolant or with steam can cause severe burns. Allow cooling system components to cool before the cooling system is drained.

Check that the coolant level after the engine has stopped and the engine has been allowed to cool.

Ensure that the filler cap is cool before removing the filler cap. The filler cap must be cool enough to touch

with a bare hand. Remove the filler cap slowly in order to relieve pressure.

Cooling system conditioner contains alkali. Alkali can cause personal injury. Do not allow alkali to contact the skin, the eyes, or the mouth.

Oils

Skin may be irritated following repeated or prolonged exposure to mineral and synthetic base oils. Refer to your suppliers Material Safety Data Sheets for detailed information. Hot oil and lubricating components can cause personal injury. Do not allow hot oil to contact the skin. Appropriate personal protective equipment should be used.

Diesel Fuel

Diesel may be irritating to the eyes, respiratory system, and skin. Prolonged exposure to diesel may cause various skin conditions. Appropriate personal protective equipment should be used. Refer to supplier Material safety Data sheets for detailed information.

Batteries

Electrolyte is an acid. Electrolyte can cause personal injury. Do not allow electrolyte to contact the skin or the eyes. Always wear protective glasses for servicing batteries. Wash hands after touching the batteries and connectors. Use of gloves is recommended.

Fire Prevention and Explosion Prevention

Use of personal protection equipment (PPE) may be needed.

All fuels, most lubricants, and some coolant mixtures are flammable.

Always perform a Walk-Around Inspection, which may help you identify a fire hazard. Do not operate a product when a fire hazard exists. Contact your Perkins dealer for service.

Flammable fluids that are leaking or spilled onto hot surfaces or onto electrical components can cause a fire. Fire may cause personal injury and property damage.

A flash fire may result if the covers for the engine crankcase are removed within 15 minutes after an emergency shutdown.

Determine whether the engine will be operated in an environment that allows combustible gases to be drawn into the air inlet system. These gases could cause the engine to overspeed. Personal injury, property damage, or engine damage could result.

If the application involves the presence of combustible gases, consult your Perkins dealer for additional information about suitable protection devices.

Remove all flammable materials such as fuel, oil, and debris from the engine. Do not allow any flammable materials to accumulate on the engine.

All fluids that are captured in the fluid spill containment basin should be cleaned up immediately. Failure to clean up spilled fluids can cause a fire. Fire may cause personal injury and property damage.

Store fuels and lubricants in properly marked containers away from unauthorized persons. Store oily rags and any flammable materials in protective containers. Do not smoke in areas that are used for storing flammable materials.

Do not expose the engine to any flame.

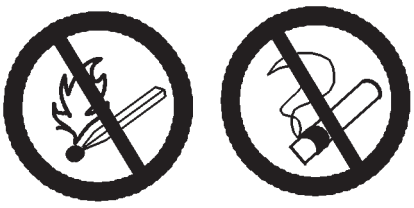
Exhaust shields (if equipped) protect hot exhaust components from oil or fuel spray in a line, a tube, or a seal failure. Exhaust shields must be installed correctly.

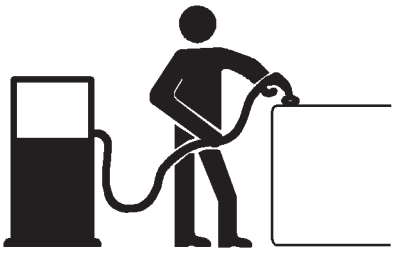
Do not weld on lines or tanks that contain flammable fluids. Do not flame cut lines or tanks that contain flammable fluid. Clean any such lines or tanks thoroughly with a nonflammable solvent prior to welding or flame cutting.

Wiring must be kept in good condition. Properly route and attach all electrical wires. Check all electrical wires daily. Repair any wires that are loose or frayed before you operate the engine. Clean all electrical connections and tighten all electrical connections.

Eliminate all wiring that is unattached or unnecessary. Do not use any wires or cables that are smaller than the recommended gauge. Do not bypass any fuses and/or circuit breakers.

Arcing or sparking could cause a fire. Secure connections, recommended wiring, and properly maintained battery cables will help to prevent arcing or sparking.





Inspect all lines and hoses for wear or for deterioration. Properly route all hoses. The lines and hoses must have adequate support and secure clamps. Tighten all connections to the recommended torque. Leaks can cause fires.

Properly install all oil filters and fuel filters. The filter housings must be tightened to the proper torque.

Use caution when you are refuelling an engine. Do not smoke while you are refuelling an engine. Do not refuel an engine near open flames or sparks. Always stop the engine before refuelling.

Avoid static electricity risk when fuelling. Ultra low sulphur diesel (ULSD) poses a greater static ignition

hazard that earlier diesel formulation with a higher sulphur content. Avoid death or serious injury from the fire or explosion. Consult with your fuel or fuel system supplier to ensure that the delivery system is in compliance with fuelling standards for proper grounding and bonding practices.

Gases from a battery can explode. Keep any open flames or sparks away from the top of a battery. Do not smoke in battery charging areas.

Never check the battery charge by placing a metal object across the terminal posts. Use a voltmeter or a hydrometer.

Improper jumper cable connections can cause an explosion that can result in injury. Refer to the Operation Section of this manual for specific instructions.

Do not charge a frozen battery. Charging a frozen battery may result in an explosion.

The batteries must be kept clean. The covers (if equipped) must be kept on the cells. Use the recommended cables, connections, and battery box covers when the engine is operated.

Fire Extinguisher

Make sure that a fire extinguisher is available. Be familiar with the operation of the fire extinguisher. Inspect the fire extinguisher and service the fire extinguisher regularly. Obey the recommendations on the instruction plate.

Lines, Tubes, and Hoses

After the engine has stopped, you must wait for 10 minutes 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.

Do not bend high-pressure lines. Do not strike high-pressure lines. Do not install any lines that are bent or damaged.

Repair any lines that are loose or damaged. Leaks can cause fires. Consult your Perkins dealer for repair or for replacement parts.

Check lines, tubes, and hoses carefully. Do not use your bare hand to check for leaks. Use a board or cardboard to check for leaks. Tighten all connections to the recommended torque.

Replace the parts if any of the following conditions are present:

- End fittings are damaged or leaking.
- Outer coverings are chafed or cut.
- Wires are exposed.
- Outer coverings are ballooning.

- Flexible parts of the hoses are kinked.
- Outer covers have embedded armoring.
- End fittings are displaced.

Make sure that all clamps, guards, and heat shields are installed correctly in order to prevent vibration, rubbing against other parts, and excessive heat.

Crushing Prevention and Cutting Prevention

Support the component properly when work beneath the component is performed.

Unless other maintenance instructions are provided, never attempt adjustments while the engine is running.

Stay clear of all rotating parts and of all moving parts. Leave the guards in place until maintenance is performed. After the maintenance is performed, reinstall the guards.

Keep objects away from moving fan blades. The fan blades will throw objects or cut objects.

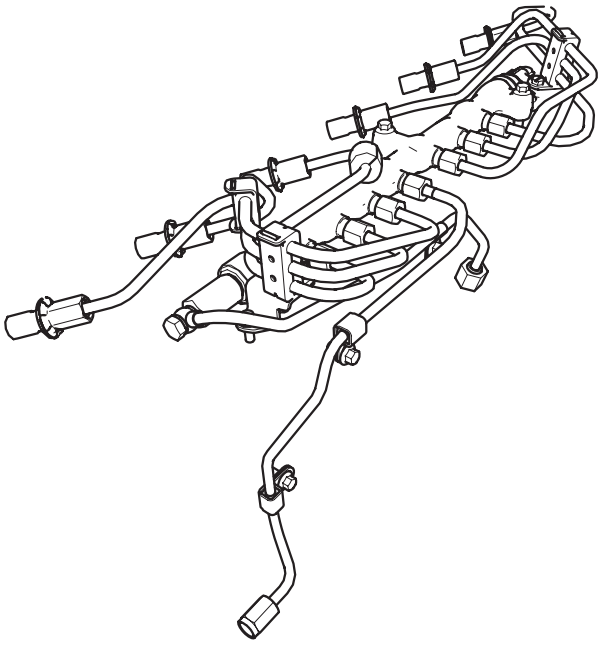
When objects are struck, wear protective glasses to avoid injury to the eyes.

Chips or other debris may fly off objects when objects are struck. Before objects are struck, ensure that no one will be injured by flying debris.

High Pressure Fuel Lines

⚠ WARNING

Contact with high pressure fuel may cause fluid penetration and burn hazards. High pressure fuel spray may cause a fire hazard. Failure to follow these inspection, maintenance and service instructions may cause personal injury or death.



Typical example

These fuel lines are different from fuel lines on other fuel systems because of the following items:

- The high-pressure fuel lines are constantly charged with high pressure.
- The internal pressures of the high-pressure fuel lines are higher than other types of fuel system.
- The high-pressure fuel lines are formed to shape and then strengthened by a special process.

Do not step on the high-pressure fuel lines. Do not deflect the high-pressure fuel lines. Do not bend or strike the high-pressure fuel lines. Deformation or damage of the high-pressure fuel lines may cause a point of weakness and potential failure.

Do not check the high-pressure fuel lines with the engine or the starting motor in operation. After the engine has stopped, allow 60 seconds to pass for the pressure to be purged before any service or repair is performed on the engine fuel lines.

Do not loosen the high-pressure fuel lines in order to remove air from the fuel system. This procedure is not required.

Visually inspect the high-pressure fuel lines before the engine is started. This inspection should be each day.

If you inspect the engine in operation, always use the proper inspection procedure in order to avoid a fluid penetration hazard. Refer to this Operation and Maintenance Manual, “General Hazard Information”.

- Inspect the high-pressure fuel lines for damage, deformation, a nick, a cut, a crease, or a dent.
- Do not operate the engine with a fuel leak. If there is a leak, do not tighten the connection in order to stop the leak. The connection must only be tightened to the recommended torque. Refer to Disassembly and Assembly, “Fuel Injection Lines -Remove and Install”.
- If the high-pressure fuel lines are torqued correctly and the high-pressure fuel lines are leaking, the high-pressure fuel lines must be replaced.
- Ensure that all clips on the high-pressure fuel lines are in place. Do not operate the engine with clips that are damaged, missing, or loose.
- Do not attach any other item to the high-pressure fuel lines.
- Loosened high-pressure fuel lines must be replaced. Also removed high-pressure fuel lines must be replaced. Refer to Disassembly and Assembly manual, “Fuel Injection Lines - Remove and Install”.

Before Starting Engine

NOTICE

For initial start-up of a new or rebuilt engine, and for start-up of an engine that has been serviced, make provision to shut the engine off should an overspeed occur. This may be accomplished by shutting off the air and/or fuel supply to the engine.

⚠ WARNING

Engine exhaust contains products of combustion which may be harmful to your health. Always start

and operate the engine in a well ventilated area and, if in an enclosed area, vent the exhaust to the outside.

Inspect the engine for potential hazards.

Do not start the engine if there is a “DO NOT OPERATE” warning tag or similar warning tag attached to the start switch. Do not move any of the controls if there is a “DO NOT OPERATE” warning tag or similar warning tag attached to the controls.

Before starting the engine, ensure that no one is on, underneath, or close to the engine. Ensure that the area is free of personnel.

If equipped, ensure that the lighting system for the engine is suitable for the conditions. Ensure that all lights work properly, if equipped.

All protective guards and all protective covers must be installed if the engine must be started to perform service procedures. To help prevent an accident that is caused by parts in rotation, work around the parts carefully.

Do not bypass the automatic shutoff circuits. Do not disable the automatic shutoff circuits. The circuits are provided to help prevent personal injury. The circuits are also provided to help prevent engine damage.

See the Service Manual for repairs and for adjustments.

Engine Starting

⚠ WARNING

Do not use aerosol types of starting aids such as ether. Such use could result in an explosion and personal injury.

If a warning tag is attached to the engine start switch or to the controls, do not start the engine or move the controls. Consult with the person that attached the warning tag before the engine is started.

All protective guards and all protective covers must be installed if the engine must be started in order to perform service procedures. To help prevent an accident that is caused by parts in rotation, work around the parts carefully.

Start the engine from the operator compartment or from the engine start switch.

Note: Do not overcrank the engine. Overcranking the engine may cause water from the exhaust system to enter into the cylinders.

Always start the engine according to the procedure that is described in the Operation and Maintenance Manual, “Engine Starting” topic in the Operation

Section. Knowing the correct procedure will help to prevent major damage to the engine components. Knowing the procedure will also help to prevent personal injury.

Engine exhaust contains products of combustion which can be harmful to your health. Always start the engine and operate the engine in a well ventilated area. If the engine is started in an enclosed area, vent the engine exhaust to the outside.

Note: The engine is equipped with a device for cold starting. If the engine will be operated in very cold conditions, then an extra cold starting aid may be required. Normally, the engine will be equipped with the correct type of starting aid for your region of operation.

These engines are equipped with a glow plug starting aid in each individual cylinder that heats the intake air in order to improve starting.

Engine Stopping

Never disconnect any charging unit circuit or battery circuit cable from the battery when the charging unit is operating. A spark can cause the combustible gases that are produced by some batteries to ignite.

To help prevent sparks from igniting combustible gases that are produced by some batteries, the negative “−” jump-start cable should be connected last from the external power source to the negative “−” terminal of the starting motor. If the starting motor is not equipped with a negative “−” terminal, connect the jump-start cable to the engine block.

Check the electrical wires daily for wires that are loose or frayed. Tighten all loose electrical wires before the engine is started. Repair all frayed electrical wires before the engine is started. See the Operation and Maintenance Manual for specific starting instructions

Electrical System

Never disconnect any charging unit circuit or battery circuit cable from the battery when the charging unit is operating. A spark can cause the combustible gases that are produced by some batteries to ignite.

To help prevent sparks from igniting combustible gases that are produced by some batteries, the negative “−” jump-start cable should be connected last from the external power source to the negative “−” terminal of the starting motor. If the starting motor is not equipped with a negative “−” terminal, connect the jump-start cable to the engine block.

Check the electrical wires daily for wires that are loose or frayed. Tighten all loose electrical wires before the engine is started. Repair all frayed electrical wires before the engine is started. See the Operation and

Maintenance Manual for specific starting instructions.

Grounding Practices

Properly ground the electrical system for the vessel and the engine. Proper grounding is necessary for optimum engine performance and reliability. Improper grounding will result in uncontrolled or unreliable electrical circuit paths.

Uncontrolled or unreliable electrical circuit paths may result in damage to main bearings, crankshaft bearing journal surfaces, and aluminum components. Uncontrolled electrical circuit paths may also cause electrical noise. Electrical noise may degrade the performance of the vessel and of the radio.

Connect the starting motor directly to the negative "-" battery terminal. Connect the alternator to the negative "-" battery or negative "-" terminal for the starting motor. The alternator and the starting motor must meet marine isolation requirements.

Note: All electrical connections must meet or exceed the American Boat and Yacht Council Standard E-11.

Use a bus bar with a direct path to the negative "-" battery terminal for low current components that require a negative "-" battery connection. Connect the bus bar directly to the negative "-" battery terminal.

Note: All return paths to the negative "-" battery must be able to carry fault currents.

The use of a bus bar ensures that the electronic control module (ECM) and the components connected to the ECM have a common reference point.

Note: If multiple bus bars are used to connect components to the negative "-" battery, a common reference should be provided. All bus bars must be wired together for proper engine synchronization for multiple engine operations.

Engine Electronics

⚠ WARNING

Tampering with the electronic system installation or the OEM wiring installation can be dangerous and could result in personal injury or death and/or engine damage.

⚠ WARNING

Electrical Shock Hazard. The electronic unit injectors use DC voltage. The ECM sends this voltage to the electronic unit injectors. Do not come in contact with the harness connector for the electronic unit injectors while the engine is operating. Failure to follow this instruction could result in personal injury or death.

This engine has a comprehensive, programmable Engine Monitoring System. The Electronic Control Module (ECM) monitors the engine operating conditions. If any of the engine parameters extend outside an allowable range, the ECM will initiate an immediate action.

The following actions are available for engine monitoring control:

- Warning
- Shutdown
- Shutdown Controller

The following monitored engine operating conditions may limit engine speed:

- Engine Coolant Temperature
- Engine Oil Pressure
- Engine Speed
- Intake Manifold Air Temperature
- High exhaust Temperature
- High Fuel Rail Temperature
- Low Coolant Level
- Engine Sensors

The Engine Monitoring package can vary for different engine models and different engine applications. However, the monitoring system and the engine monitoring control will be similar for all engines.

Note: Many of the engine control systems and display modules that are available for Perkins Engines will work in unison with the Engine Monitoring System. Together, the two controls will provide the engine monitoring function for the specific engine application. Refer to the Troubleshooting Guide for more information on the Engine Monitoring System.

Generator Isolating for Maintenance

When you service an electric power generation set or when you repair an electric power generation set, follow the procedure below:

1. Stop the engine.
2. Attach “DO NOT OPERATE” or similar warning tag to the engine prime mover starting circuit. Disconnect the engine starting circuit.
3. Disconnect the generator from the distribution system.
4. Lock out the circuit breaker. Attach “DO NOT OPERATE” or similar warning tag to the circuit breaker. Refer to the electrical diagram. Verify that all points of possible reverse power flow have been locked out.

5. Engine that the engine control system is not in “AUTO START” mode.
6. Attach “DO NOT OPERATE” or similar warning tag to the generator excitation controls.
7. Remove the terminal box cover of the generator.
8. Use an audio/visual proximity tester in order to verify that the generator is de-energized. This tester must be insulated for the proper voltage rating. Follow all guidelines in order to verify that the tester is operational.
9. Determine that the generator is in a de-energized condition. Add ground straps to the conductors or terminals. During the entire work period, these ground straps must remain connected to the conductors and to the terminals.

1. Engine Views

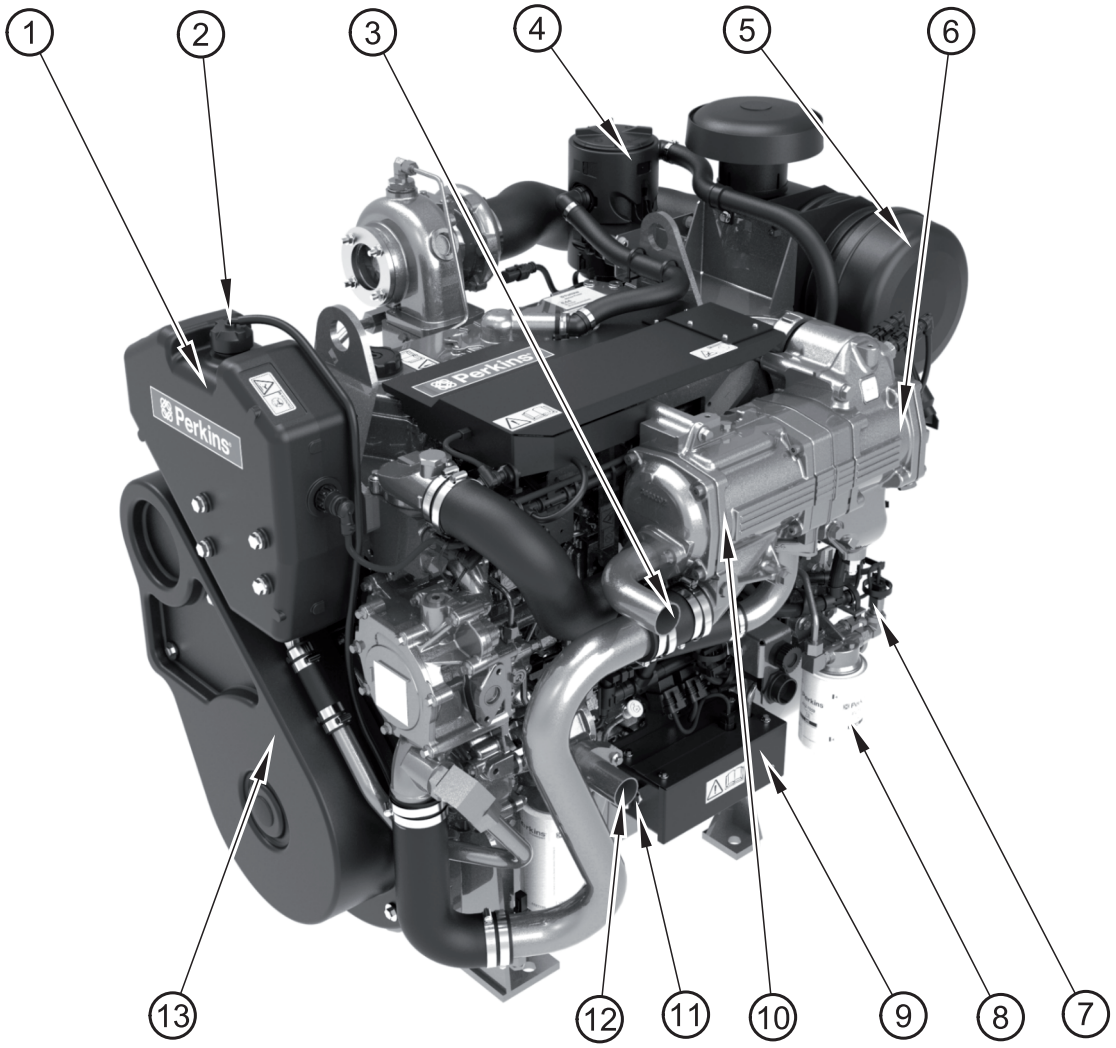
Introduction

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

Location of Engine Parts

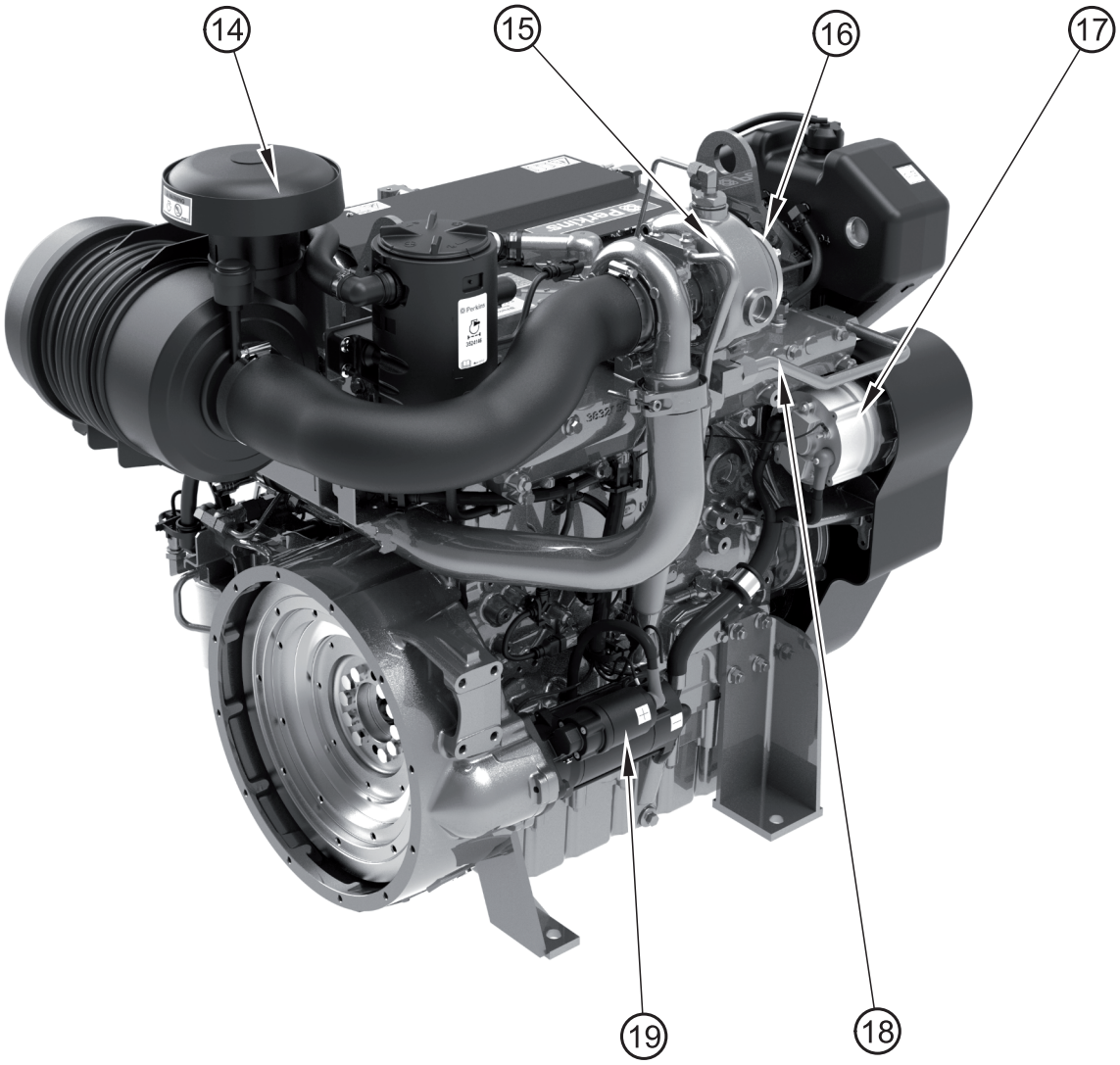
Front and Right Side View

1. Header tank
2. Coolant filler cap
3. Raw water outlet
4. Engine crankcase breather
5. Air cleaner canister
6. Aftercooler
7. Fuel outlet
8. Fuel filter
9. Fuel lift pump cover
10. Heat exchanger
11. Fuel inlet
12. Raw water intake
13. Belt cover

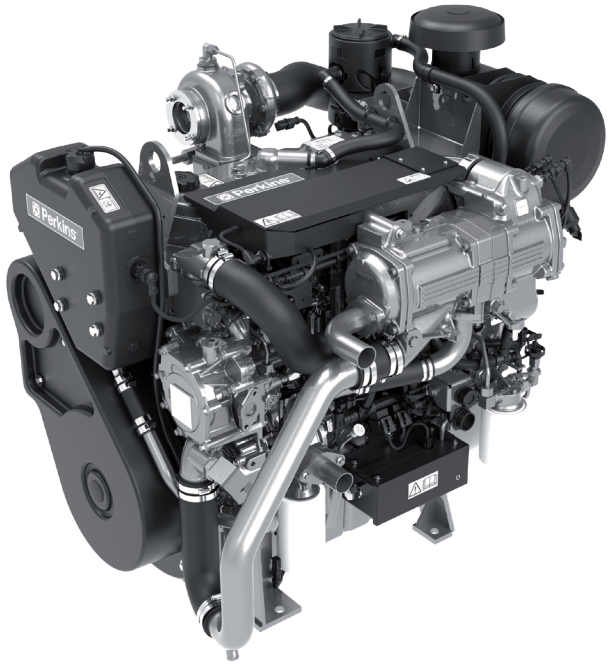


Rear and Left Side View

14. Air cleaner inlet
15. Turbocharger
16. Exhaust flange
17. Alternator
18. Exhaust manifold
19. Starter



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 eighty 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.

Note: This engine may optionally be certified to EU 2016/1628. The CO2 measurement results for the following engine families are:

Constant Speed CO2 Measurement Results for EU 2016/1628 Engine Families		
IWP2V4.4NZA	Constant Speed Turbo Aftercooled Ratings	710.26 g/kWh
IWP2V4.4NZB	Constant Speed Turbo Only Ratings	835.61 g/kWh
IWP2V07.0NNA	Variable Speed Turbo Aftercooled Rating	801.04 g/kWh
These CO2 measurement results are from testing over a fixed test cycle under laboratory conditions a parent engine representative of the engine family and shall not imply or express any guarantee of the performance of a particular engine.		

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.

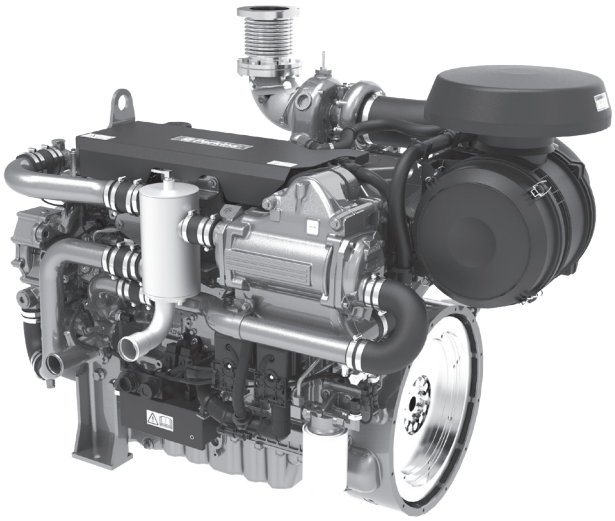
Note: Is used where the information is important, but there is no danger.

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.

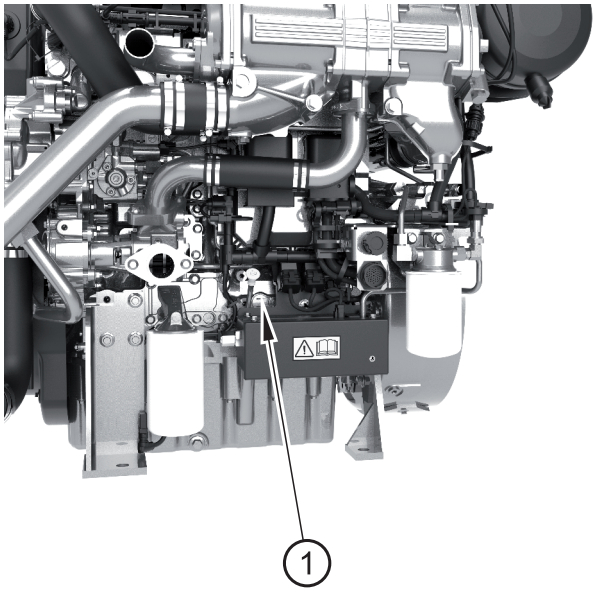


This handbook has been written to assist you to maintain and operate your engine correctly.

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.



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:

MN85262U123456T

Contact Details

Perkins Marine

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

3. Operation Instructions

Note: The engine and emissions control system shall be operated, used, and maintained in accordance with the instructions provided. Failure to follow the instructions could result in emissions performance that does not meet the requirements applicable to the category of the engine. No deliberated tampering with, or misuse of the engine emissions control system should take place. Prompt action is critical to rectify any incorrect operation, use, or maintenance of the emissions control system.

Note: Engine operation when the engine or control system has a fault should be kept to the minimum required to move or operate the vessel or equipment to a safe position or condition. The fault should then be rectified prior to resuming operation of the engine. Operating the engine with a fault could render the engine exhaust emissions non-compliant.

Engine Diagnostics

The engine has built-in diagnostics in order to ensure that the engine systems are functioning correctly. The operator will be alerted to the condition by a “Stop or Warning” lamp. Under certain conditions, the engine horsepower and the vehicle speed may be limited. The electronic service tool may be used to display the diagnostic codes.

There are three types of diagnostic codes: active, logged and event.

Most of the diagnostic codes are logged and stored in the ECM. For additional information, refer to the Troubleshooting Guide.

The ECM provides an electronic governor that controls the injector output in order to maintain the desired engine rpm.

Note: In order to ensure maintained emission performance of the engine, scheduled maintenance must be followed. Failure to do so could rendered the exhaust emissions non-compliant.

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° C (80° 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

4. Engine Fluids

Fuel System

NOTICE

An engine certified to US Environmental Protection Agency (US EPA) Marine Tier 3 regulations which is installed in a US flagged vessel must use ultra-low sulfur diesel fuel (ULSD fuel) as defined by 40 CFR part 80.510(c). When an engine is not installed in a US flagged vessel, refer to applicable local or International Maritime Organization (IMO) regulations for fuel requirements.

NOTICE

In order to meet expected fuel system component life, 4 micron(c) absolute or less secondary fuel filtration is required for all Perkins Diesel Engines that are equipped with unit injected fuel systems. All current Perkins Diesel Engines are factory equipped with Perkins Advanced Efficiency 4 micron(c) absolute fuel filters.

Perkins does not warrant the quality or performance of non-Perkins fluids and filters.

NOTICE

An engine certified to EU 2017/654 which is installed in a vessel operating within EU inland waterways must use diesel fuel meeting standards EN590 or EN16709.

⚠ WARNING

Avoid static electricity risk when fueling. Ultra-low sulphur diesel fuel (ULSD fuel) poses a greater static ignition hazard than earlier diesel formulations with a higher sulphur contents. Avoid death or serious injury from fire or explosion. Consult with your fuel or fuel system supplier to ensure the delivery system is in compliance with fuelling standards for proper grounding and bonding practices.

Specifications for Distillate Diesel Fuel

Diesel fuel must meet the standards required for the engine emissions certification. Refer to table (Table of fuel specifications by fuel standard) for the fuel specifications required for each certification. Ensure the diesel fuel used when an applicable emissions standard is in-force meets the specifications detailed within this table.

Fuel Specifications by Fuel Standard					
Fuel Specification	**Fuel Standard**				
	ASTM D975	EN590	ISO 8217:2018 DMX	ISO 8217:2018 DMA	ISO 8217:2018 DFA
Cetane Number (Minimum)	40	51	45	40	40
Sulphur (Maximum)	15 ppm	10 ppm	10,000 ppm (1%)(1)		
FAME (Maximum)	0%	7%	0%		7%
Lubricity (Maximum Wear Scar) ISO 12156–1	520um	460um	520um		520um

(1) The purchaser shall define the maximum sulphur limit in accordance with relevant statutory regulations (Refer to IS ISO 8217:2018 for further information)

Table of fuel specification requirements by emissions certification lists the key fuel specifications of each distillate diesel fuel standard. Refer to this to ensure the correct fuel standard is selected for compliant engine operation. Failure to ensure the engine is operating on the correct fuel can render the exhaust emissions to be non-compliant.

Fuel Specification Requirements by Emissions Certification			
Emissions Certification	Cetane Number (Minimum)	Sulphur (Maximum)	FAME (Maximum)
US EPA Tier 3	40	15 ppm	7%
EU Stage V (EU 2017/654)	45	10 ppm	7%
IMO II	40	1000 ppm	20%

Practically this means engines operating in European Inland-Waterways should use diesel fuel meeting either EN590 or EN16709 standards. Engines installed in US flagged vessels require ULSD diesel fuel meeting the ASTM D975 fuel to be used. In most other cases, the engine can use Marine Distillate

Diesel Fuels as listed in this table, to the ISO 8217 standard if so required.

In all cases, refer to applicable local or International Maritime Organization (IMO) regulations for fuel requirements.

Lubricity (as tested to standard ISO 12156–1) should not exceed 520 um for any fuel used.

The fuels listed below are permissible for engines which are not certified to US Marine EPA Tier 3 regulations.

Engines which are not Certified to US Marine EPA Tier 3 Regulations

The fuels listed below are permissible for engines which are not certified to US Marine EPA Tier 3 Regulations:

Marine Distillate Diesel Fuels(1)
ISO 8217-DMA ISO 8217-DMX
ISO 8217-DMX

(1) Use only CIMAC specifications that are equivalent to the listed ISO specification. This specification is: CIMAC DA

Note: Vessels that are traveling internationally and that have on/off NOx controls must enable these controls prior to entering a NECA. For US flagged vessels, on/off controls are not allowed without an exemption during international travel. The controls must always be on. Foreign destinations should be reviewed for supply of ULSD fuel and DEF prior to departure. Exemptions for ULSD or DEF use by US flagged vessels may be requested from the US Environmental Protection Agency (EPA). The EPA can be contacted at the following address:

complianceinfo@epa.gov

Physical address:

Designated Compliance Officer
Heavy-Duty and Nonroad Engine Group 6403-J
U.S. AVE. NW
Washington, DC 20460

Biodiesel

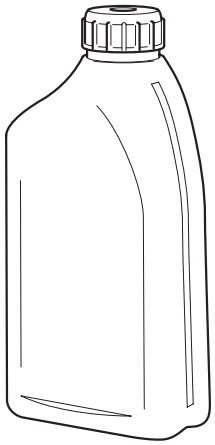
A biodiesel blend of up to 20 percent may be used in the engine when the fuel blend meets the recommendations in table below. A blend of greater than 20 percent biodiesel may be acceptable sometimes. See your Perkins dealer for more information.

Note: An oil analysis program is **recommended strongly** when using biodiesel blends above 5 percent.

Biodiesel Blends for Perkins Commercial Diesel Engines		
Biodiesel blend stock	Final blend	Distillate diesel fuel used for blend
“ASTM D6751” or “EN14214”	B20: “ASTM D7467” and “API” gravity 30-45	“ASTM D975” or “EN590”

Fuel Additives

Many types of fuel additives are available. Perkins does not generally recommend the use of fuel additives. For more information contact your Perkins dealer.



Lubricating Oil Specification

Engine oil		
	Litres	US gal
E44	11.5	3.1
E70B	17.5	4.6

The engines that have duplex oil filters installed will require additional oil.

Fluid Recommendations

Diesel Engine Oil

Due to significant variations in the quality and in the performance of commercially available oils, Perkins makes the following recommendations:

Note: Multigrade oils are the preferred oils for use in this Perkins Diesel Engine.

Commercial Lubricants	Viscosity Grade
Diesel Engine Oil-Ul-tra Low Sulfur (API CJ-4)(1)	SAE 15W-40
	SAE 10W-30
	SAE 5W-40
	SAE 0W-40
Diesel Engine Oil (API CI-4/CI-4 PLUS and API CH-4)	SAE 15W-40
	SAE 10W-30

(1) ACEA E9 oils are validated using some but not all API CJ-4 standard performance tests. ACEA E9 oils may be used if oil meeting the API CJ-4 specifications is not available.

Engines which are Certified to US Marine Environmental Protection Agency (EPA) Tier 3 Regulations

NOTICE

An engine certified to US Environmental Protection Agency (US EPA) Marine Tier 3 regulations which is installed in a US flagged vessel must use ultra-low sulfur diesel fuel (ULSD fuel) as defined by 40 CFR part 80.510(c). When an engine is not installed in a US flagged vessel, refer to applicable local or International Maritime Organization (IMO) regulations for fuel requirements.

Engines which are Not Certified to US Marine EPA Tier 3 Regulations

Lubricant Viscosity

In selecting oil for any engine application, both of the following must be satisfied: the oil viscosity and the category of oil performance or the specification for oil performance . Using only one of these parameters will not sufficiently define oil for an engine application.

The proper SAE viscosity grade of oil is determined by the following temperatures: minimum ambient temperature during cold engine start-up and maximum ambient temperature during engine operation.

Refer to the table below (minimum temperature) to determine the required oil viscosity for starting a cold engine.

Refer to the table below (maximum temperature) to select the oil viscosity for engine operation at the highest ambient temperature that is anticipated.

Note: Generally, use the highest oil viscosity that is available to meet the requirement for the temperature at start-up.

Lubricant Viscosities for Ambient Temperatures for Perkins Diesel Engines					
	Viscosity Grade	°C		°F	
		Min	Max	Min	Max
Oil Type and Performance Requirements	SAE 0W-40	-40	40	-40	104
	SAE 5W-40	-30	50	-22	122
	SAE 10W-30	-18	40	0	104
	SAE 15W-40	-10	50	14	122
	SAE 0W-30	-40	30	-40	86
	SAE 5W-30	-30	30	-22	86
	SAE 10W-40	-18	50	0	122

Note: A cold soaked start occurs when the engine has not been operated recently, allowing the oil to become more viscous due to cooler ambient temperatures. Supplemental heat is recommended for cold soaked starts below the minimum ambient temperature. Supplemental heat may be necessary for cold soaked starts that are above the minimum temperature depending on factors such as parasitic load.

Total Base Number (TBN) and Fuel Sulphur Levels

The use of Perkins oil analysis is recommended strongly for determining oil life.

The minimum required Total Base Number (TBN) for oil depends on the fuel sulfur level. The TBN for new oil is typically determined by the “ASTM D2896” procedure. For direct injection engines that use distillate fuel, the following guidelines apply:

TBN recommendations for applications in Perkins engines	
Fuel Sulphur Level percent (ppm)	TBN of Commercial Engine Oils
0.05 % (500ppm) or less	Min 7
0.05 - 0.2 % (>500 -2000 ppm[1]	Min 10

(1)The use of an oil analysis program to determine oil drain ntervals is recommended.

Oil Analysis

Regular engine oil analysis is recommended. Modern oil analysis can help to provide the following information about the health of the engine and oil:

- Component wear rate
- Oil condition
- Oil contamination
- Identification of oil

These four types of analysis are used to monitor the condition of your equipment. The four types of analysis will also help you identify potential problems. A properly administered oil analysis program reduces repair costs and the program will lessen the impact of downtime.

The Oil Analysis program uses a wide range of tests to determine the condition of the oil and the crankcase. Guidelines that are based on experience and a correlation to failures have been established for these tests. Exceeding one or more of these guidelines could indicate serious fluid degradation or a pending component failure.

NOTICE

Always use a designated pump for oil sampling, and use a separate designated pump for coolant sampling. Using the same pump for both types of samples may contaminate the samples that are being drawn. This contaminate may cause a false analysis and an incorrect interpretation that could lead to concerns by both dealers and customers.

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		
	Litres	US gal
E44	21	5.5
E70B	35.5	9.4
Please contact your Perkins Marine distributer for the correct coolant.		

E70B & E44: Heat exchanger. The coolant mixture must be a 50/50 mix with clean water.

E70B: 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.

E44: Keel cooled, under normal conditions. The coolant mixture must be a mix of 50% antifreeze and 50% 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.

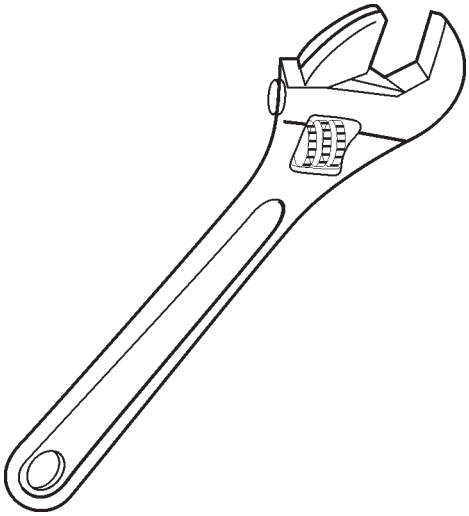
Caution: Using a coolant/anti-freeze which coats components with a protective layer to prevent corrosion may impair the efficiency of the cooling system and lead to the engine overheating.

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.

Note: In order to ensure maintained emission performance of the engine, scheduled maintenance must be followed. Failure to do so could rendered the exhaust emissions non-compliant.

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
- Coolant change
- Engine - clean
- Fuel system - prime
- Sea water strainer - clean/inspect

Daily

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

Every week

- Automatic Start/Stop - inspect
- Instrument panel - inspect
- Hoses and clamps - inspect/replace/retorque
- Jacket water heater - check

Every 250 service hours

- Coolant sample (Level 1) - obtain
- Engine oil sample - obtain

Initial 500 hours (for New Systems, Refilled Systems, and Converted Systems)

- Coolant sample (Level 2) - obtain

Every 500 service hours

- Fuel system secondary filter - replace
- Fuel system primary filter (water separator element - replace
- Auxiliary water impeller - replace (heat exchanger model only)
- Engine oil filter - change

Every 500 service hours or 1 year

- Auxiliary water pump (rubber impeller) - inspect/rplace
- Battery electrolyte level - check
- Cooling system supplemental coolantadditive (SCA) - test/add
- Engine air cleaner element (single element) - inspect/clean/replace
- Sea water strainer - clean/inspect

Every 1000 service hours

- Aftercooler core - inspect (Aftercooled engine models only)

- Belt - inspect
- Belt tensioner - check
- Aftercooler condensate drain valve - inspect
- Speed sensor - clean/inspect
- Water pump - inspect

Every 1000 service hours or 1 year

- Battery charger - check

Every 1500 service hours

- Engine crankcase breather - replace

Every 2000 service hours

- Coolant temperature regulator - replace
- Engine mounts - inspect
- Heat exchanger - inspect
- Starting motor - inspect
- Turbocharger - inspect

Every 2000 service hours or 1 year

- Alternator - inspect
- Coolant sample (Level 2) - obtain
- Heat exchanger/Aftercooler - 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

Overhaul

- Overhaul considerations
  - The need for preventive maintenance
  - The quality of the fuel that is being used
  - The operating conditions
  - The results of the S·O·S analysis

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 1 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.

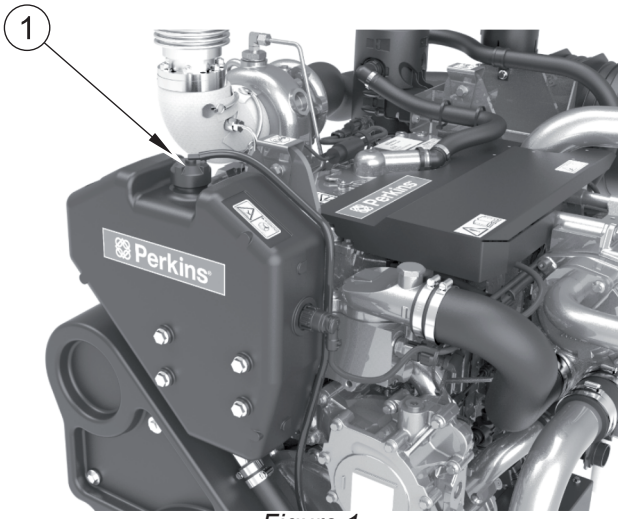


Figure 1

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 1 item 1).
2. Remove the drain plug (figure 2 item 1) from the heat exchanger pipe.
3. Remove the drain plug (figure 3 item 1) from the exhaust manifold and the sampling plug located on the left side of the cylinder block (figure 3 item 2).
4. Remove the drain plug (figure 4 item 1) from the top of the heat exchanger.

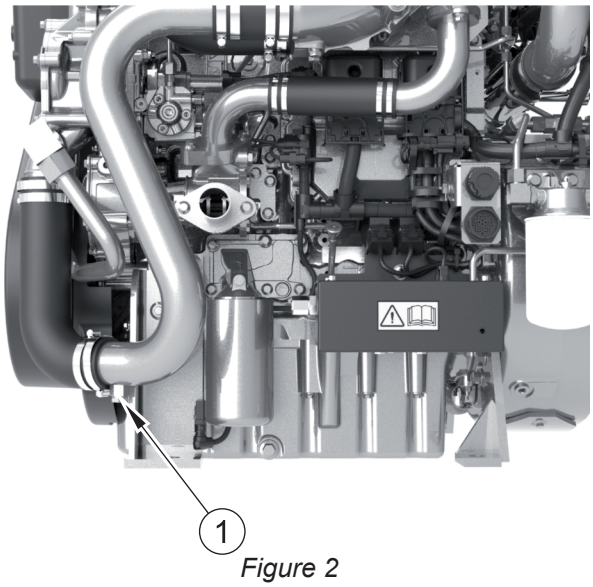


Figure 2

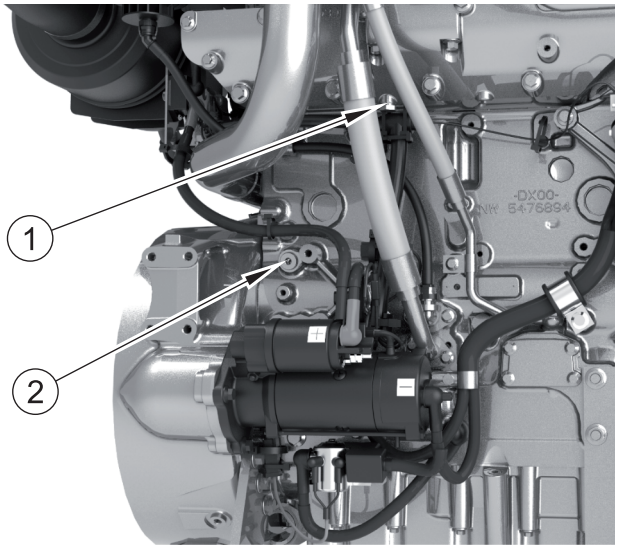


Figure 3

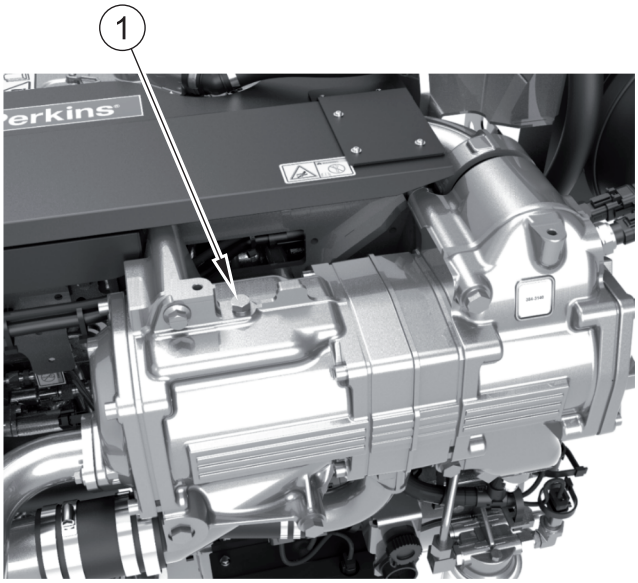


Figure 4

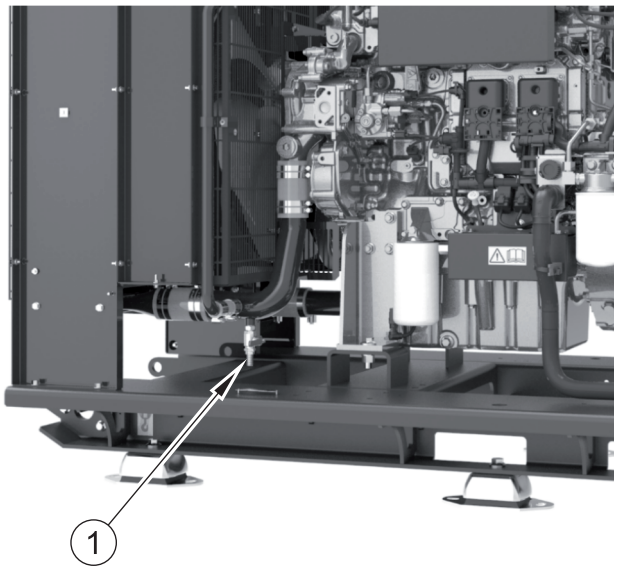


Figure 5

5. After the system has been drained, fit the filler cap and the drain plugs.
6. Fasten a label in a suitable place to indicate that the coolant system has been drained.

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.

Engines Fitted with Radiators

1. Loosen the coolant filler cap on the radiator.
2. Rotate the tap to the open position (figure 5 item 1).
3. After the system has been drained, fit the filler cap and close the tap.
4. Fasten a label in a suitable place to indicate that the coolant system has been drained.

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.

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.

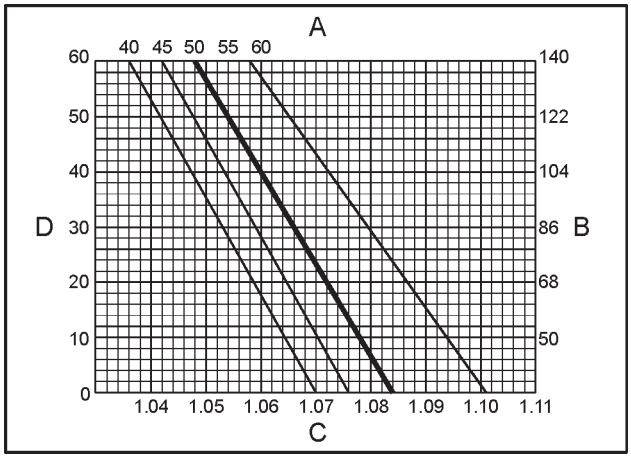
Use a special coolant hydrometer that will check the temperature and the specific gravity of the coolant, follow the manufacturer's instructions.

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° C (-31° 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 °F

C = Specific gravity

D = Mixture temperature in °C

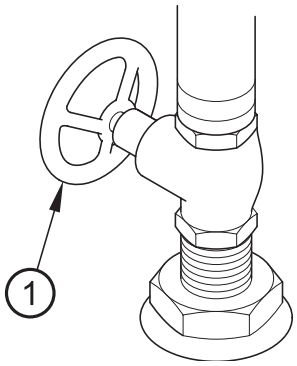


Figure 6

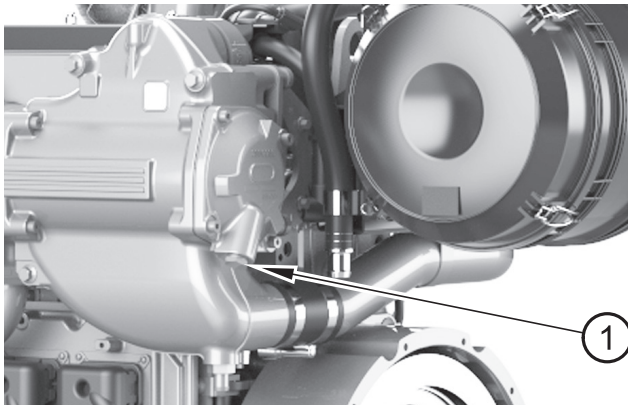


Figure 7

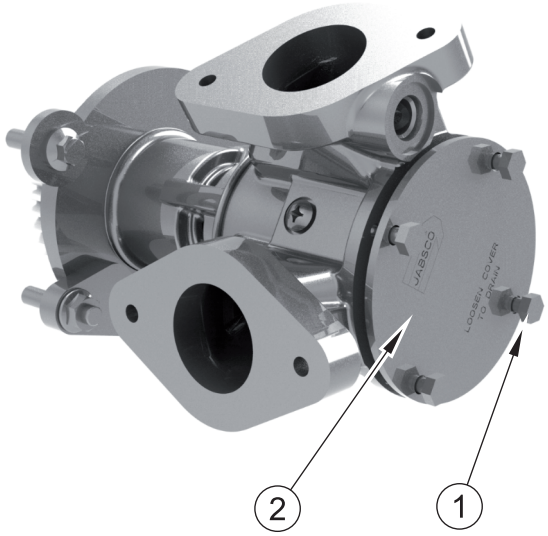


Figure 8

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 6 item 1 shows a typical example).
2. Remove the drain plug (figure 7 item 1), from the aftercooler. Ensure that the drain hole is not restricted.
3. Remove the auxiliary pump endplate (figure 8 item 2) by unscrewing the 4 retaining bolts (figure 8item 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 9 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 10 item 1).
4. Remove the rubber end cap (item 2) and then pull the impeller from the shaft (figure 11 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 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.

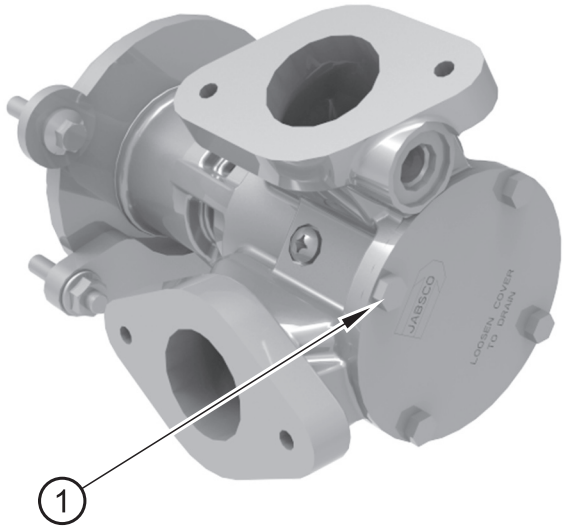


Figure 9

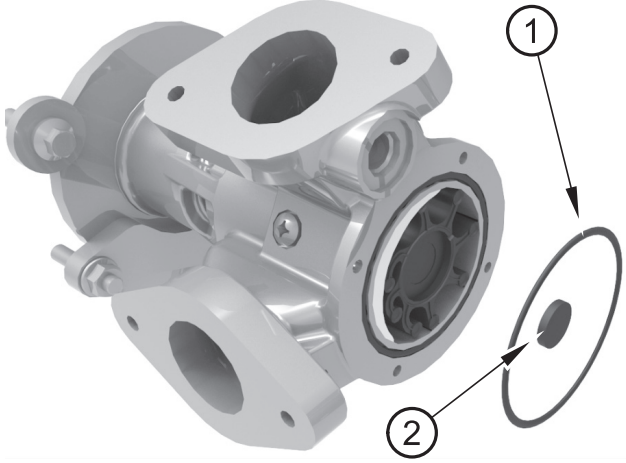


Figure 10

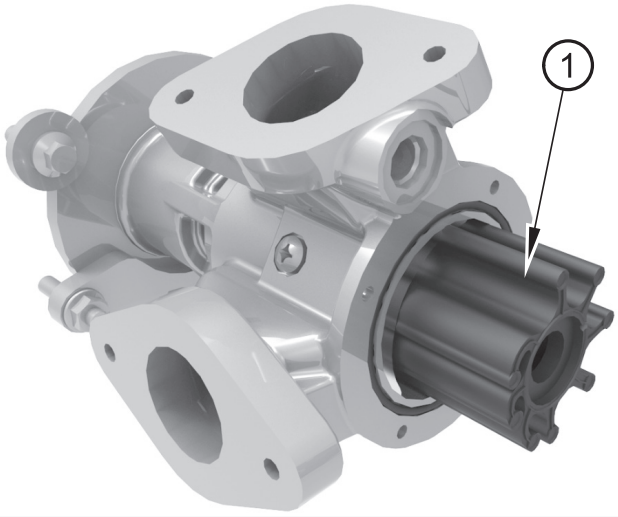


Figure 11

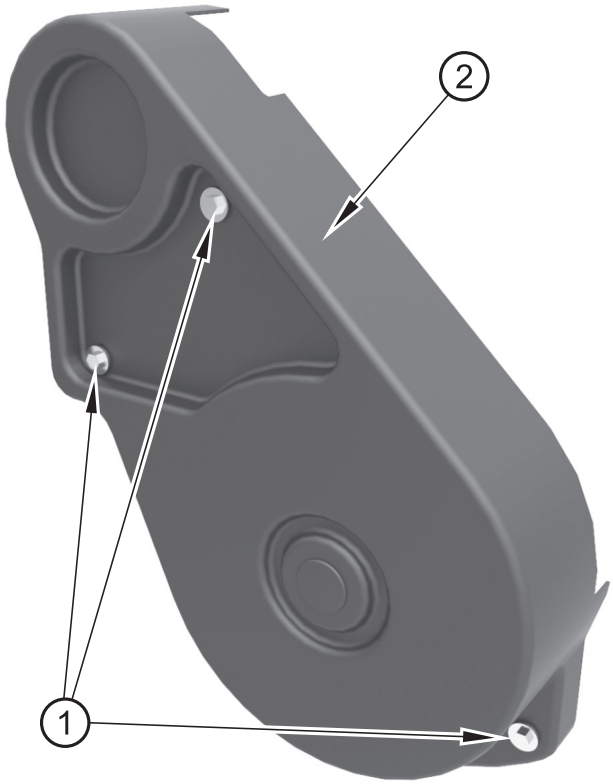


Figure 12

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 12 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.

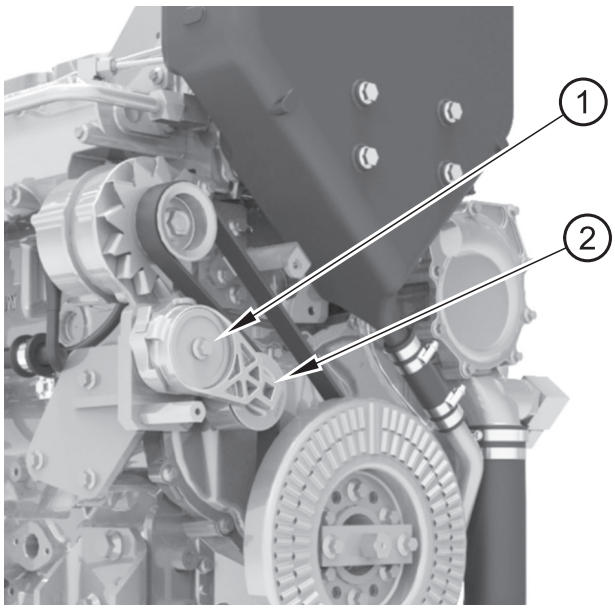


Figure 13

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 12 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 12 item 1) and remove the guard (item 2).
2. Insert a square drive tool (figure 13 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 14. 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.

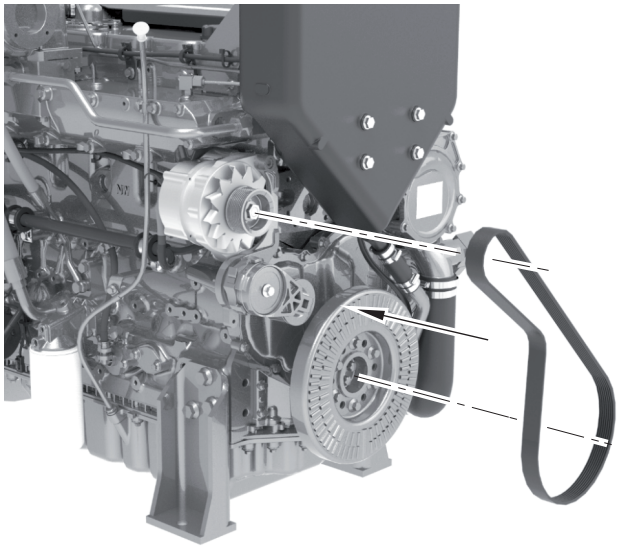


Figure 14

How to Check the Condition of the Heat Exchanger/Aftercooler

The interval for the maintenance of the tube type heat exchanger/aftercooler (figure 15 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

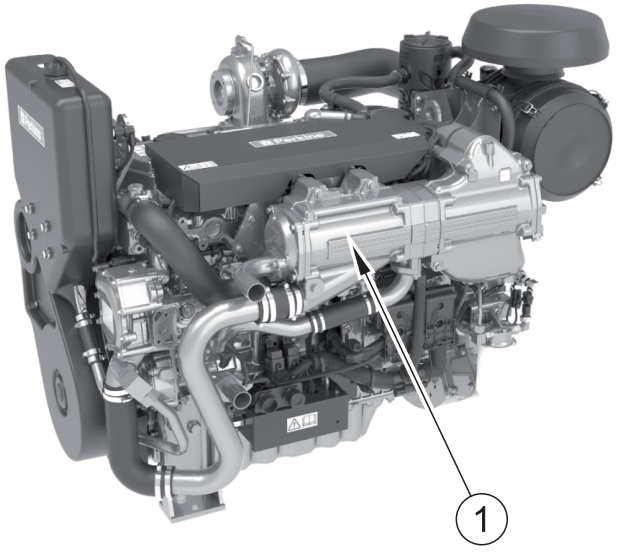


Figure 15

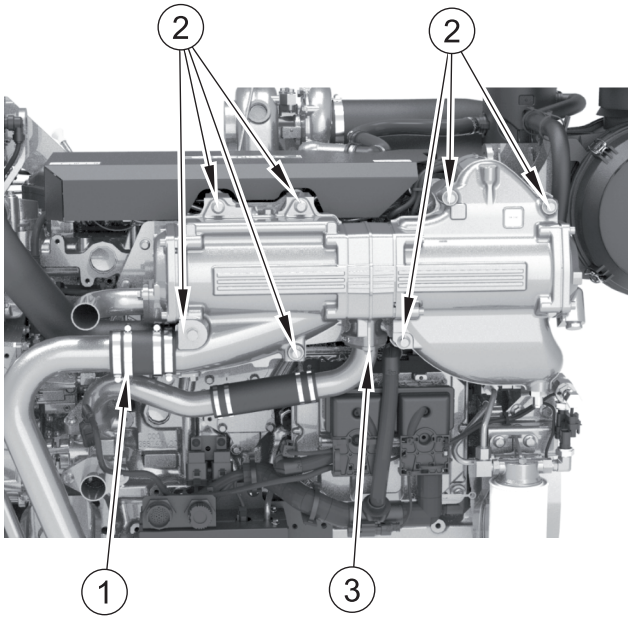


Figure 16

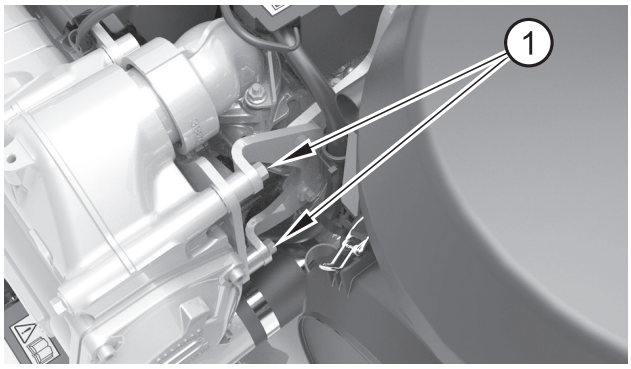


Figure 17

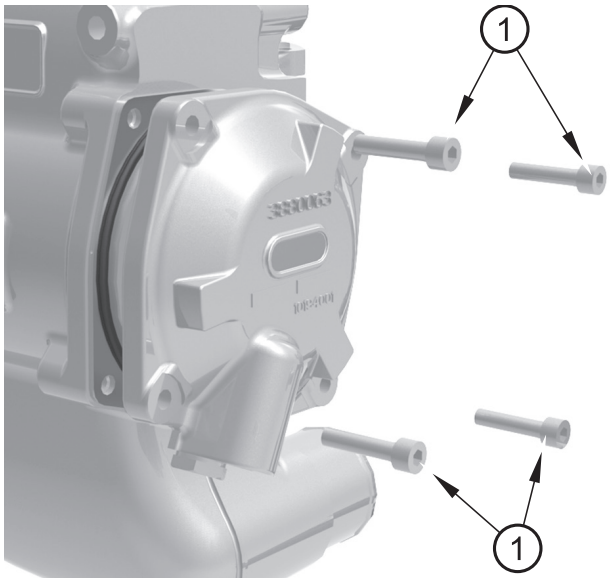


Figure 18

- 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 16 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 17 item 1).
6. Remove the heat exchanger assembly.
7. Remove the endcap by undoing the bolts (figure 18 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 19 item 1) and tubestack (item 2).
2. Undo the bolts (figure 20 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 21.
    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.

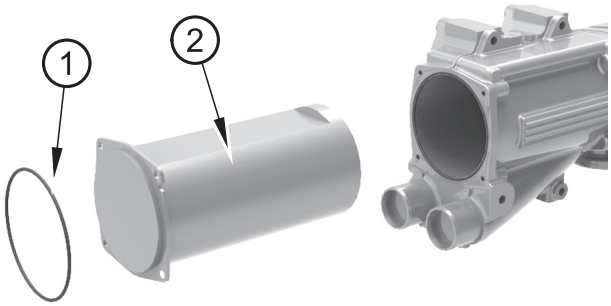


Figure 19

⚠ 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.

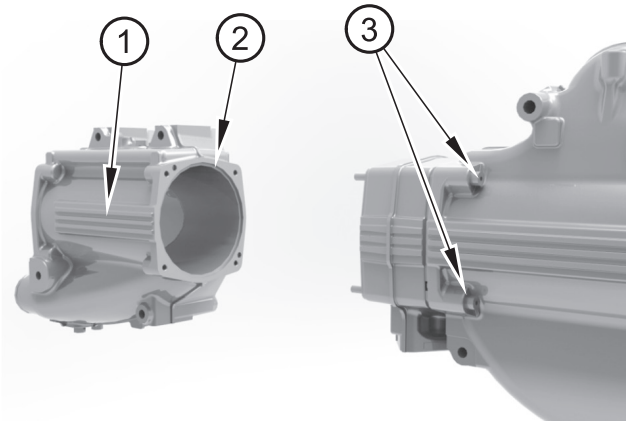


Figure 20

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.

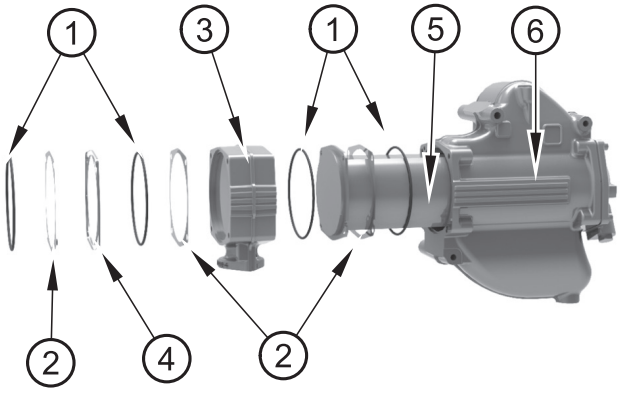


Figure 21

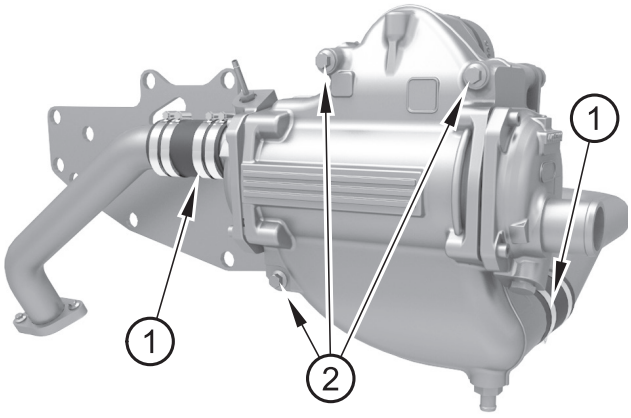


Figure 22

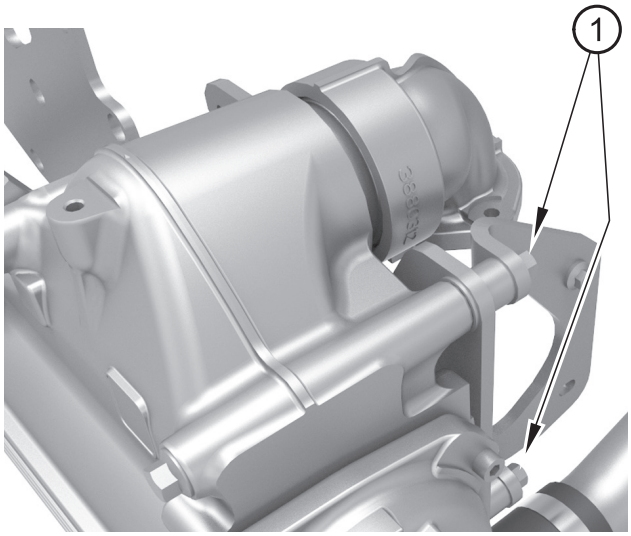


Figure 23

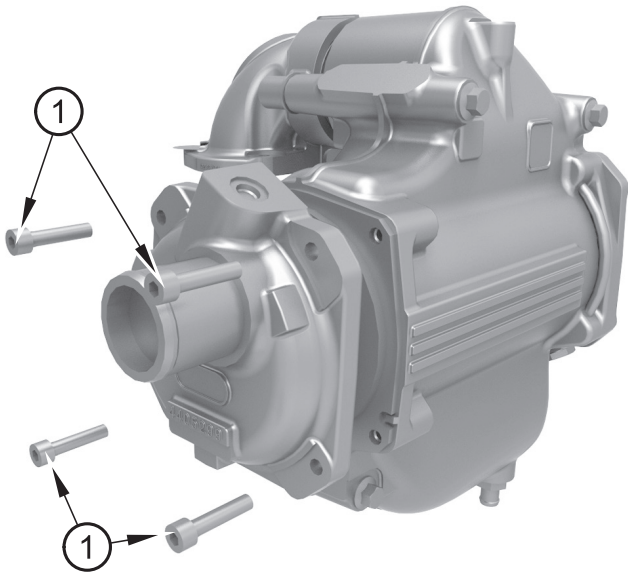


Figure 24

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 22 item 1).
3. Remove bolts (item 2) and remove hose assemblies.
4. Remove the bolts that secure the assembly at the rear (figure 23 item 1).
5. Remove the heat exchanger assembly.
6. Remove the endcap by undoing the bolts (figure 24 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 25 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.

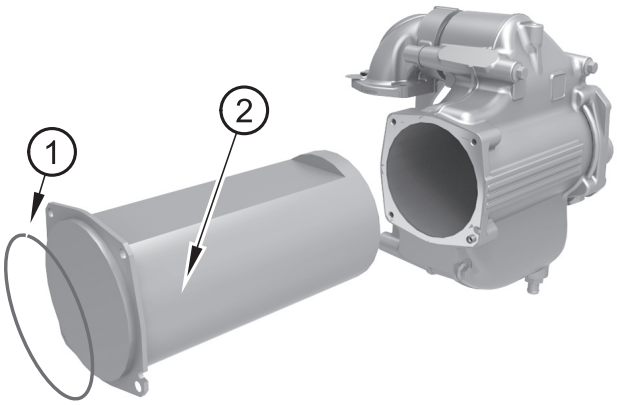


Figure 25

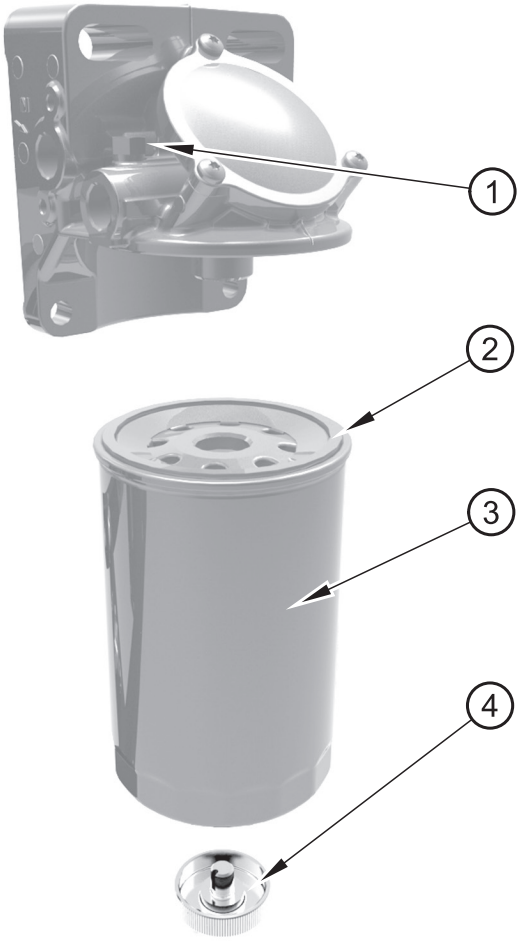


Figure 26

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 26 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" section 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.

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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.

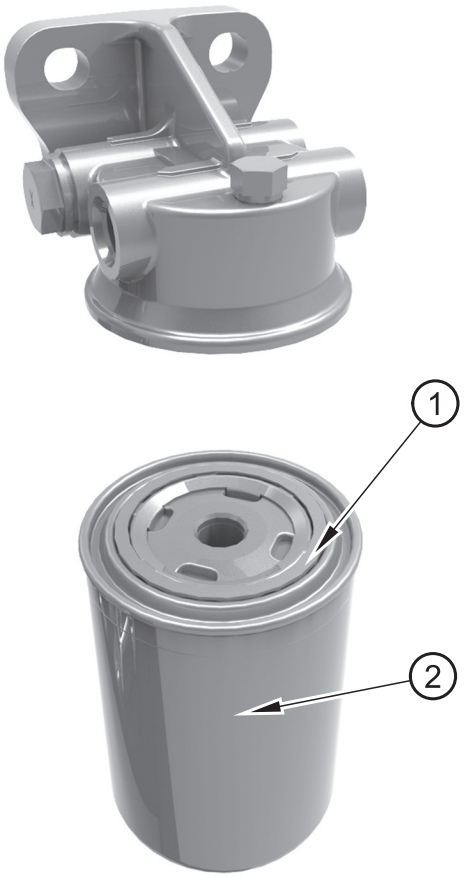


Figure 27

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 27 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.

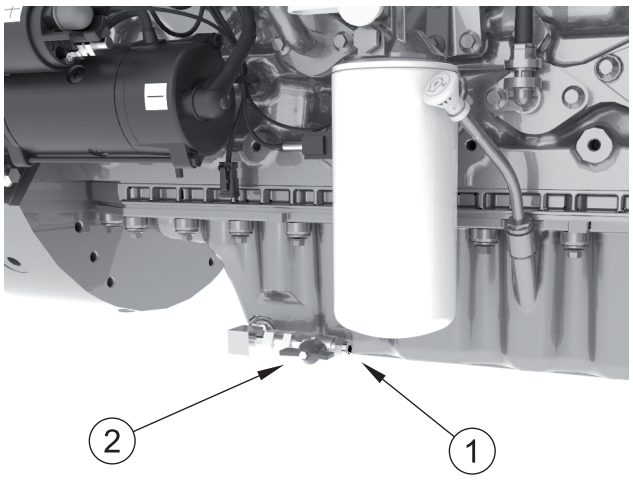


Figure 28

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 28 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 29 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 30 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.

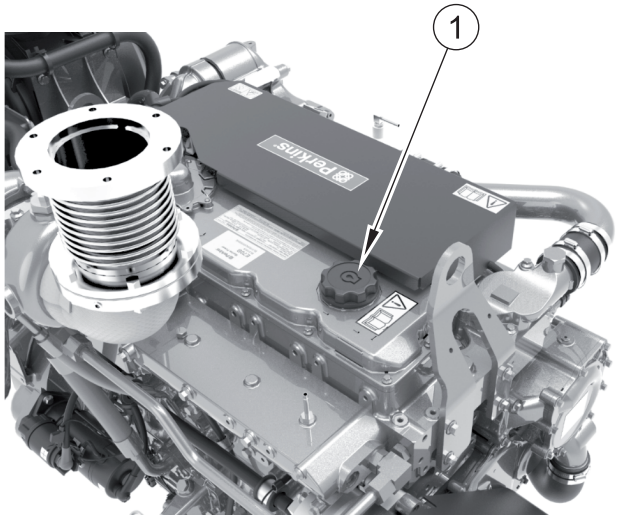


Figure 29

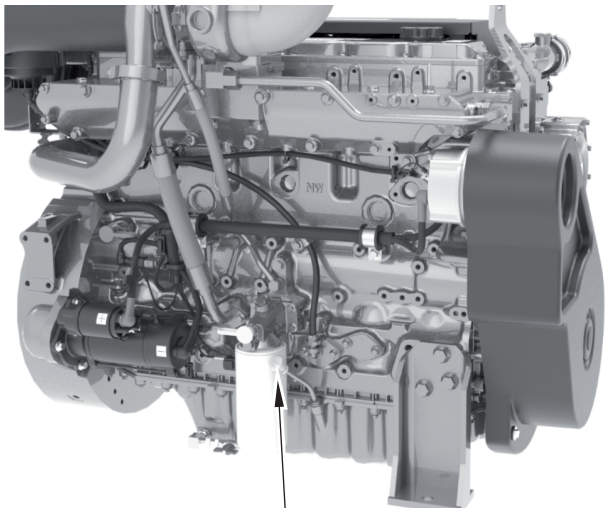


Figure 30

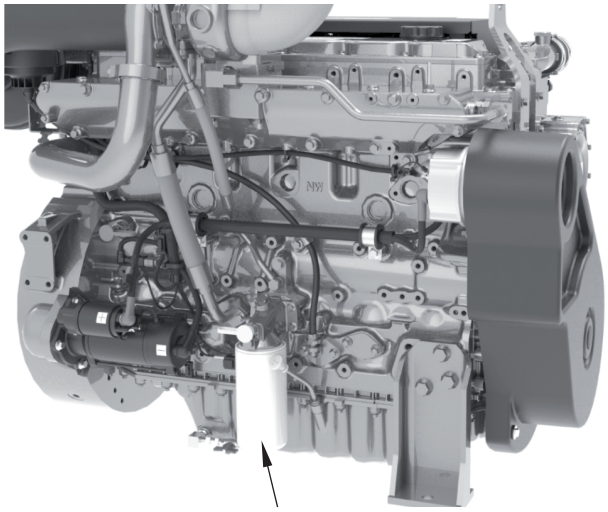


Figure 31

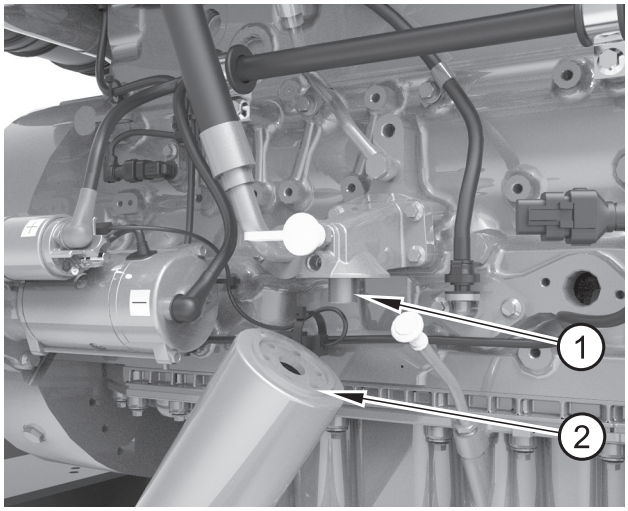


Figure 32

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 31 item 1) with a strap wrench or similar tool. Ensure that the adaptor (figure 32 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 33 item 1) anti -clockwise and pull away from the main body
2. Remove the filter canister (figure 34 item 1) and discard.
3. Insert new filter canister.
4. Replace breather cap and re attach hose

Oil Breather

The breather hose (figure 35 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.

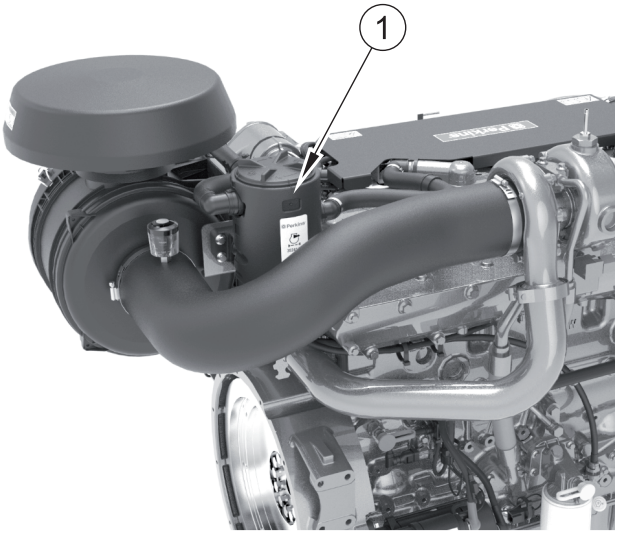


Figure 33

Figure 34

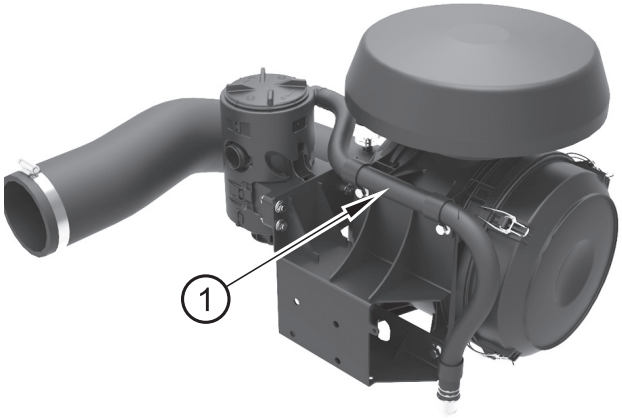


Figure 35

Figure 36

How to Inspect and Renew the Air Filter

The service indicator (figure 36) 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 37 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.

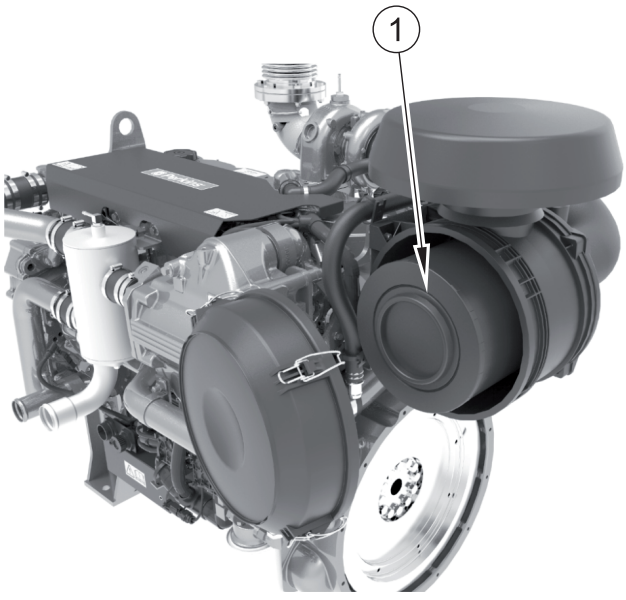


Figure 37

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 38 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 39 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.

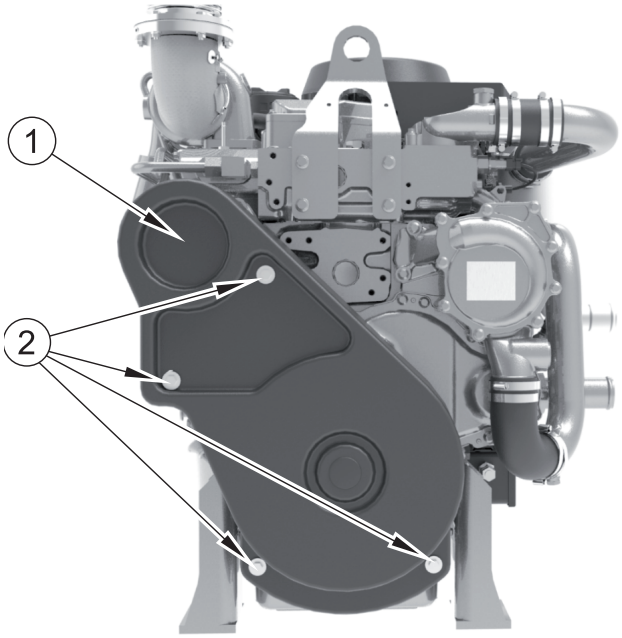


Figure 38

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.

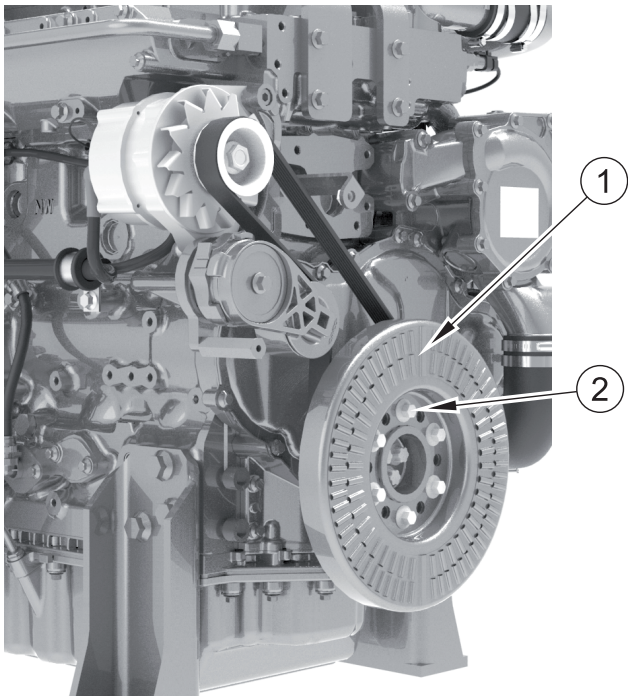


Figure 39

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.

For details on all fuel data please refer to the Customer Information Pack on the Perkins Marine Website.

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

E44 Turbo Aftercooled, Auxiliary, Heat Exchanged

Front and Left Side

1 Coolant filler cap.

2 Header tank.

3 Belt cover.

4 Fresh water drain point.

5 Lubricating oil filter.

6 Raw water inlet.

7 Fuel inlet.

8 Cover on fuel transfer pump.

9 Customer connect.

10 Fuel filter.

11 Fuel outlet.

12 Raw water outlet.

13 Heat exchanger.

14 Aftercooler.

15 Air cleaner.

16 Rear lifting eye.

17 Exhaust outlet.

18 Front lifting bracket.

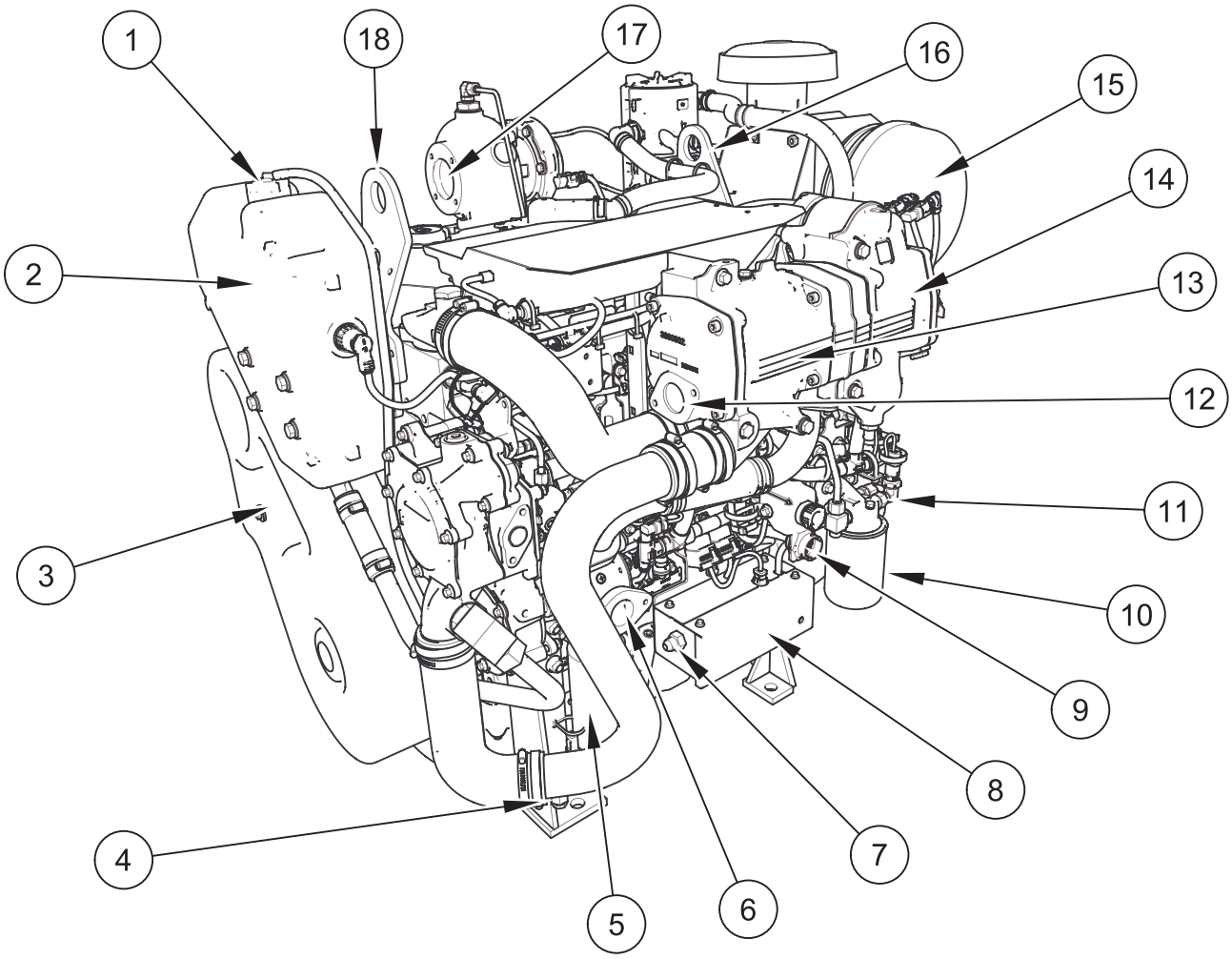


Illustration shows the common installation points

Rear and Right Side

19 Air cleaner indicator.

20 Fuel return.

21 Exhaust manifold.

22 Starter motor.

23 Alternator.

24 Turbocharger.

25 Crankcase breather.

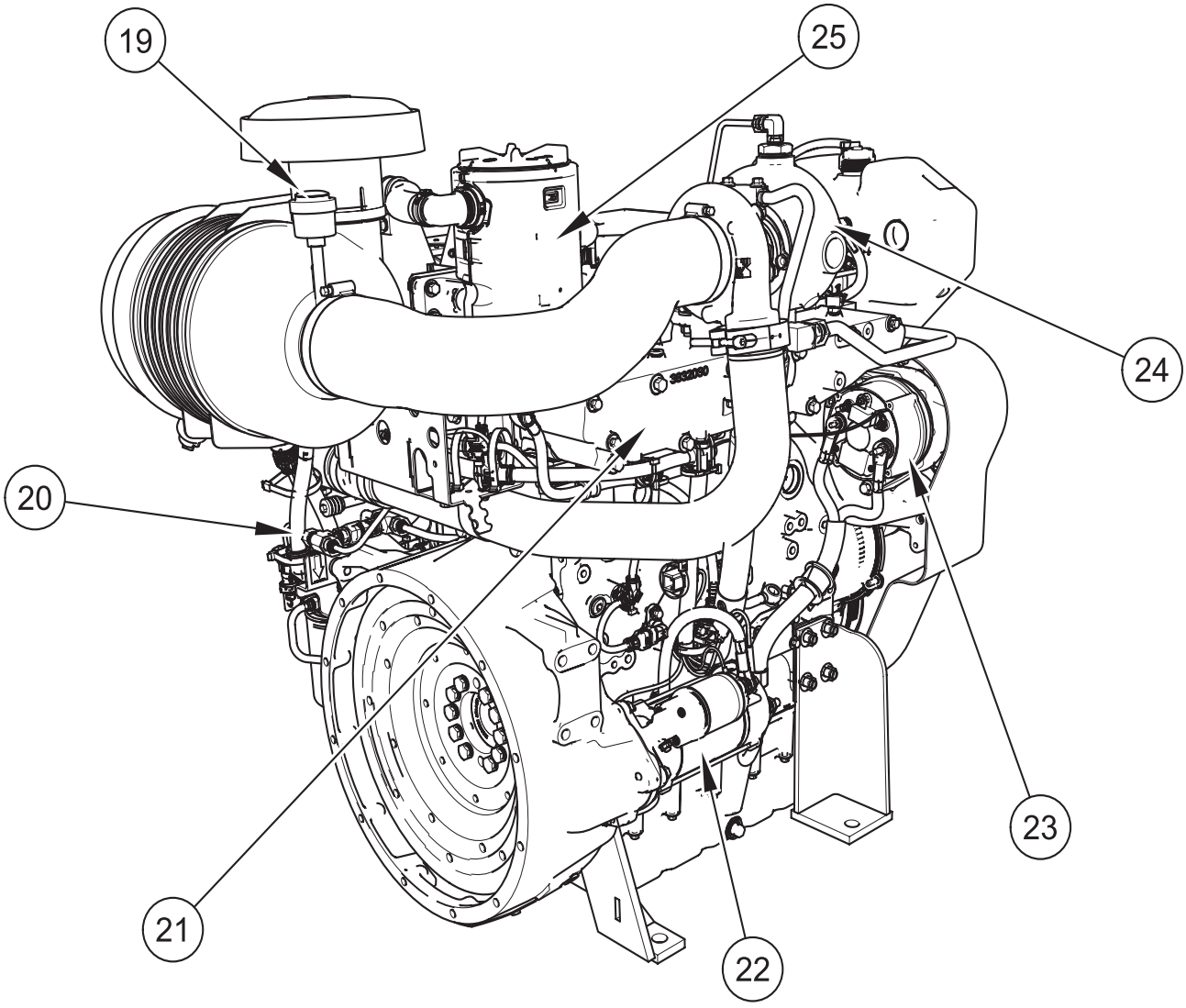


Illustration shows the common installation points

E44 Turbo, Keel Cooled, Aftercooled, Single Circuit, Auxiliary

Front and Left Side

1 Front lifting eye.

2 Thermostat.

3 Belt cover.

4 Coolant drain.

5 Keel cooler inlet.

6 Fuel inlet.

7 Cover on fuel transfer pump.

8 Dipstick.

9 Customer connect.

10 Fuel filter, (simplex).

11 Outlet to keel cooler.

12 Mixing tank.

13 Aftercooler.

14 Air cleaner.

15 Rear lifting eye.

16 Exhaust outlet.

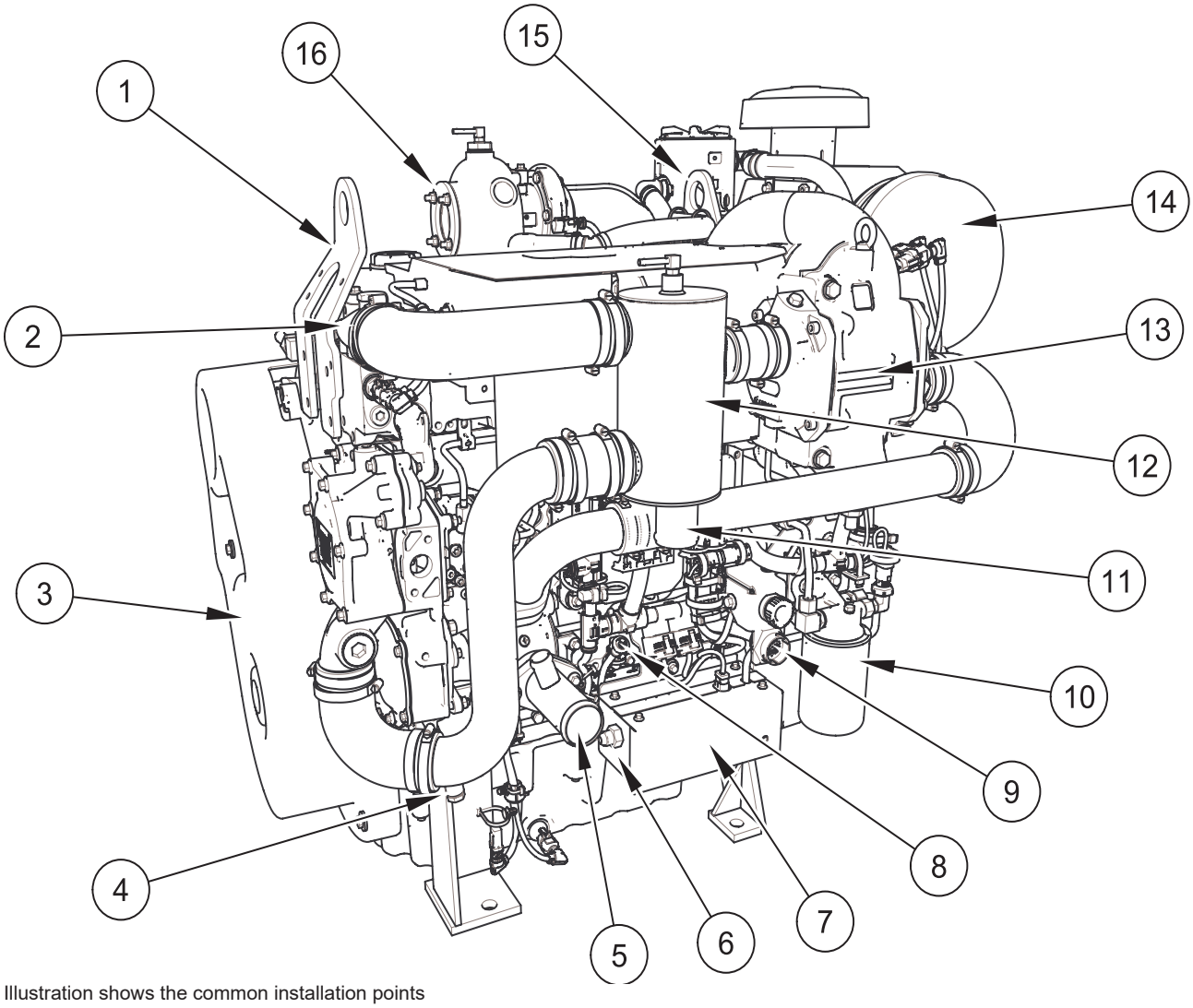


Illustration shows the common installation points

Rear and Right Side

17 Air cleaner indicator.

18 Fuel return.

19 Exhaust manifold.

20 Lubricating sump drain valve.

21 Starter motor.

22 Alternator.

23 Turbocharger.

24 Crankcase breather.

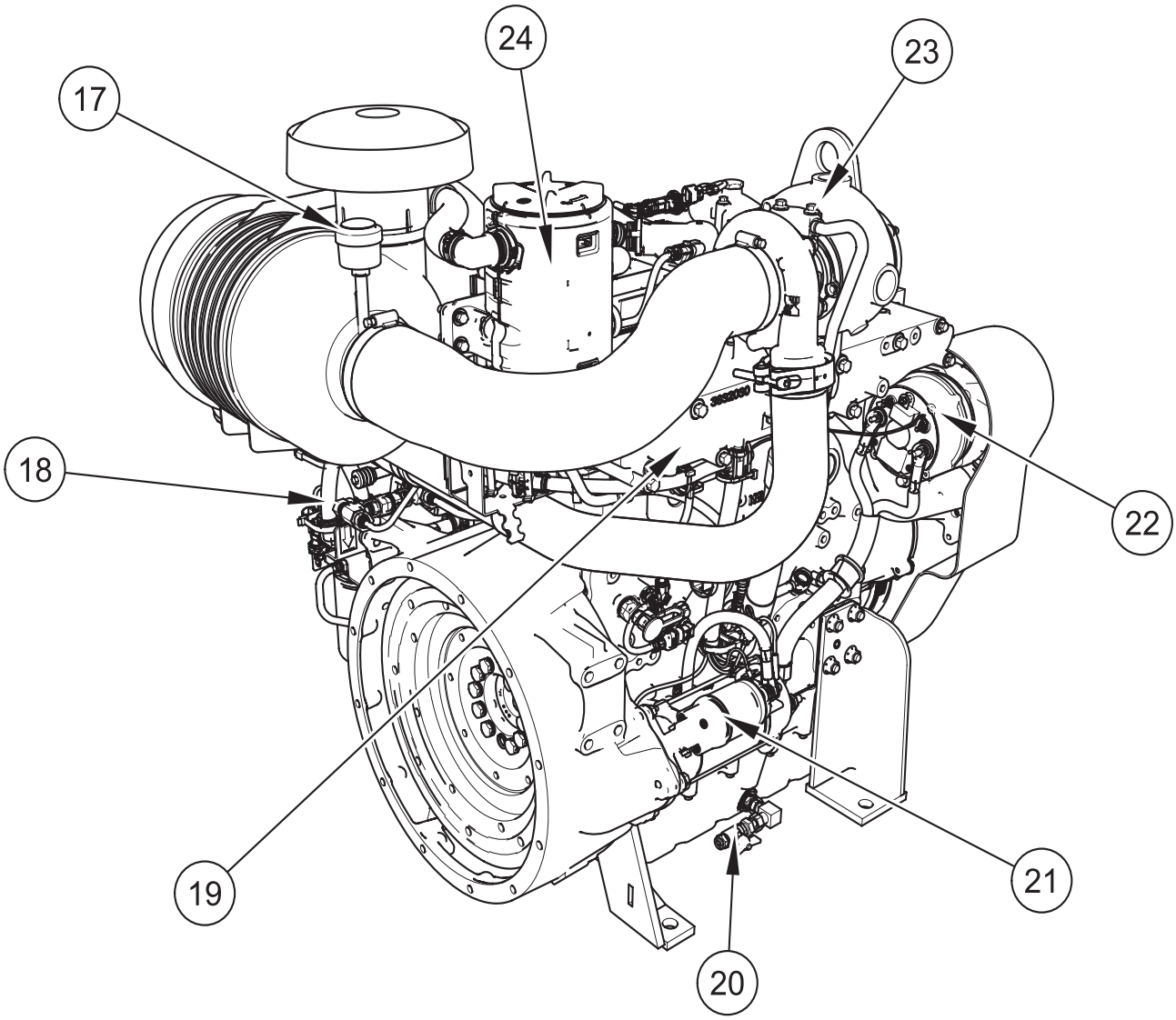


Illustration shows the common installation points

E44 Turbo, Keel Cooled, Auxiliary

Front and Left Side

1 Front lifting eye.

2 Thermostat.

3 Belt cover.

4 Engine coolant outlet.

5 Engine coolant inlet.

6 Oil filter

7 Fuel inlet.

8 Cover on fuel transfer pump.

9 Dipstick.

10 Fuel filter.

11 Customer connect.

12 Air cleaner.

13 Rear lifting eye.

14 Crankcase breather.

15 Exhaust elbow.

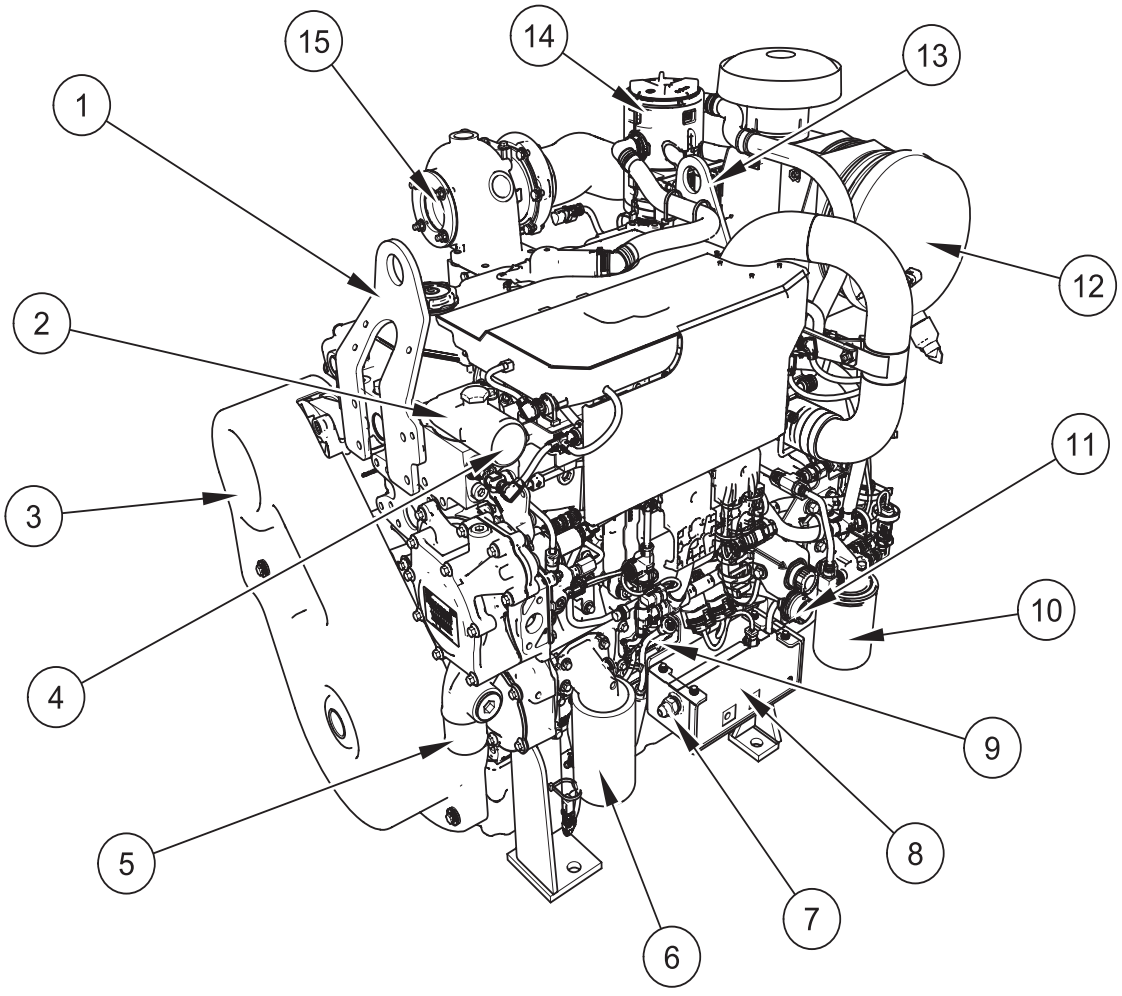


Illustration shows the common installation points

Rear and Right Side

16 Service indicator.

17 Fuel return.

18 Exhaust manifold.

19 Lubricating sump drain valve.

20 Starter motor.

21 Alternator.

22 Turbocharger.

23 Crankcase breather.

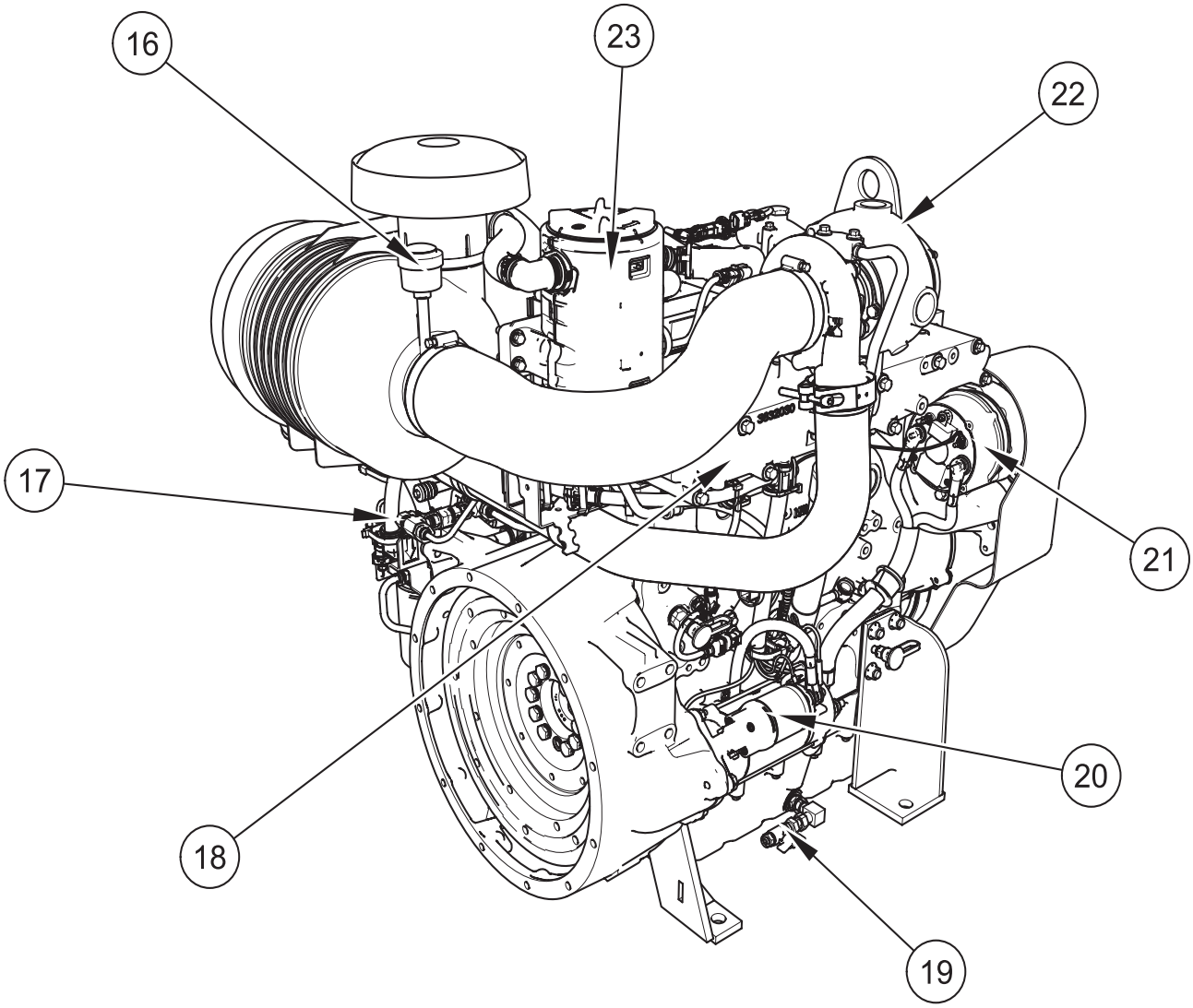


Illustration shows the common installation points

E44 Turbo, Aftercooled, Radiator Cooled, Genset

Front and Left Side

1 Coolant filler cap.

2 Lifting eyes, entire package.

3 Coolant drain.

4 Base frame.

5 Oil filter.

6 Fuel feed.

7 Cover on fuel transfer pump.

8 Dipstick.

9 Fuel filter.

10 Air cleaner.

11 Crankcase breather

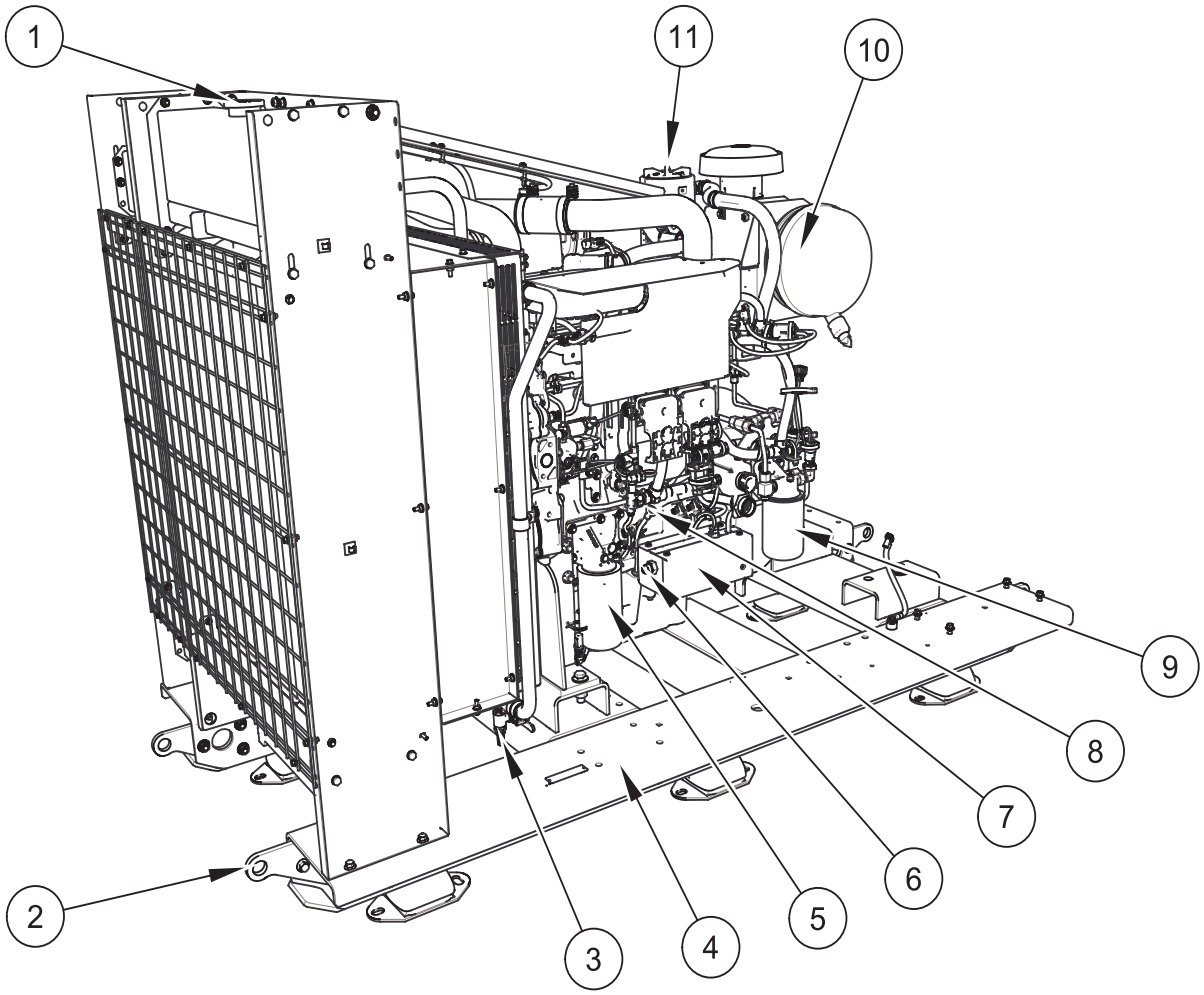


Illustration shows the common installation points

Rear and Right Side

12 Service indicator.

13 Exhaust manifold.

14 Lifting eyes, entire package.

15 Base frame.

16 Starter.

17 Lubricating sump drain valve.

18 Turbocharger.

19 Crankcase breather.

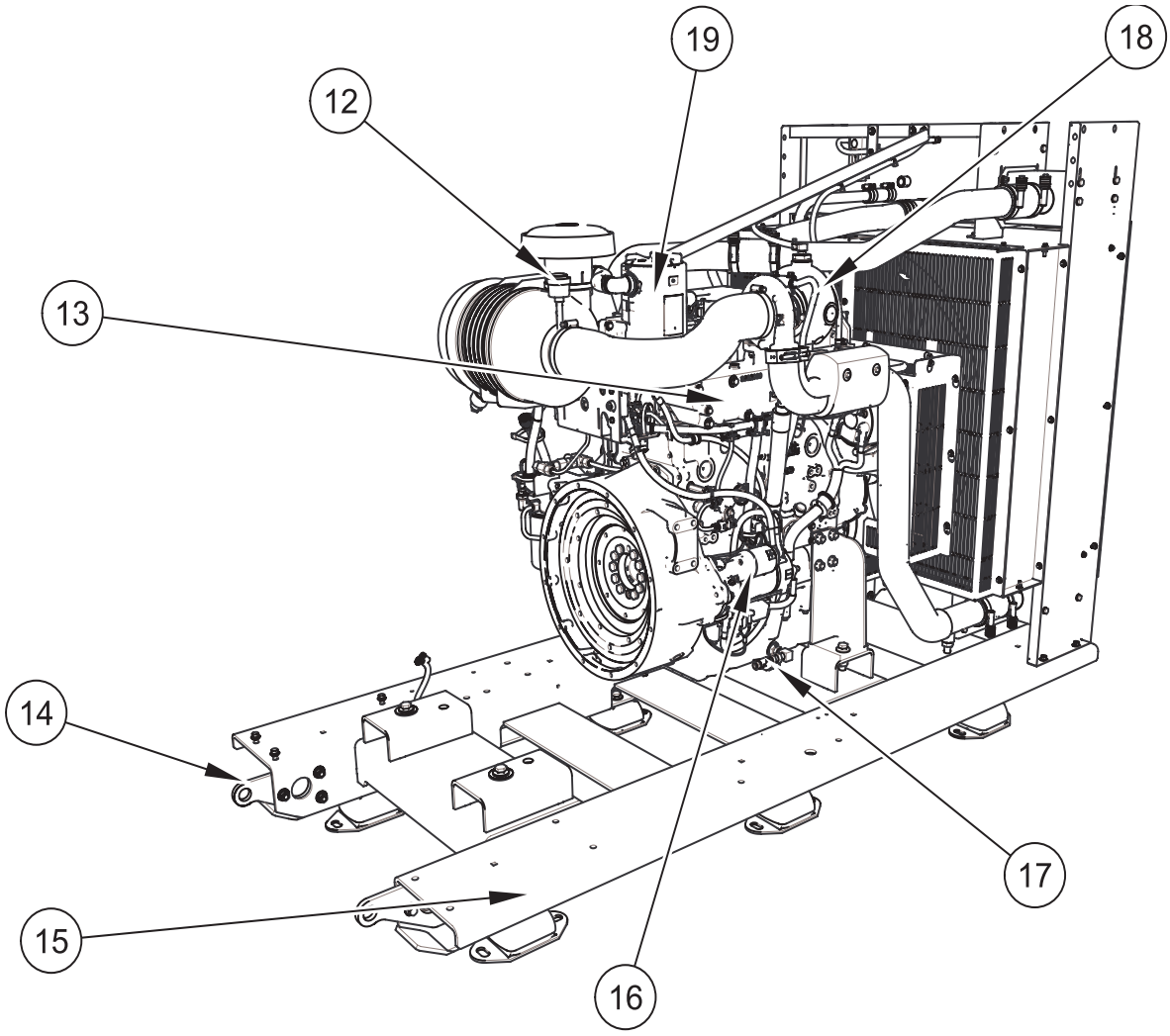


Illustration shows the common installation points

E70B Turbo Aftercooled, Auxiliary, Heat Exchanged

Front and Left Side

1 Coolant filler cap.

2 Header tank.

3 Belt cover.

4 Fresh water drain point.

5 Fuel inlet.

6 Raw water inlet.

7 Customer connect.

8 Cover on fuel transfer pump.

9 Fuel filter.

10 Fuel outlet.

11 Raw water outlet.

12 Heat exchanger.

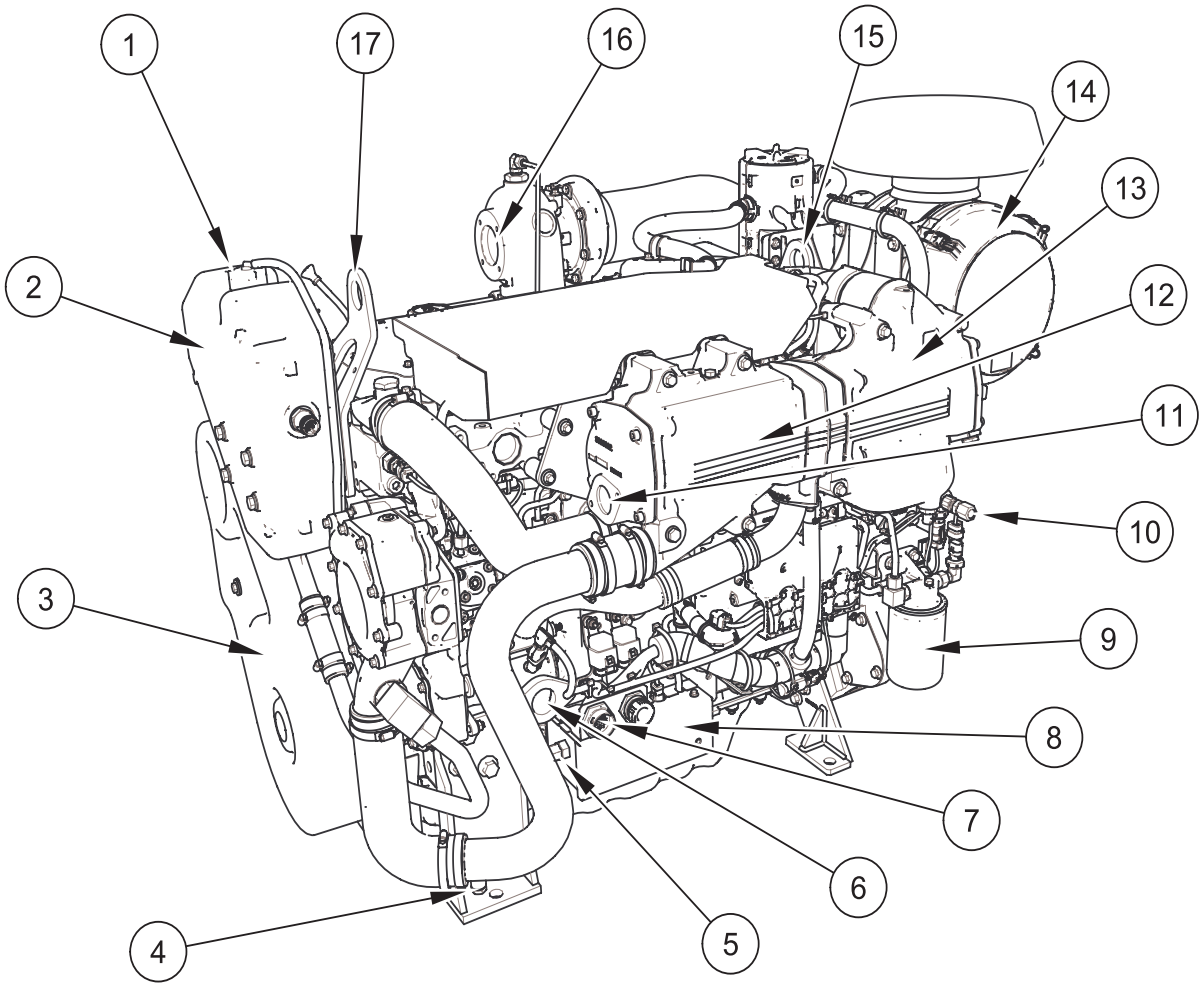
13 Aftercooler.

14 Air cleaner.

15 Rear lifting eye.

16 Exhaust outlet.

17 Front lifting bracket.



Rear and Right Side

18 Service indicator.

19 Exhaust manifold.

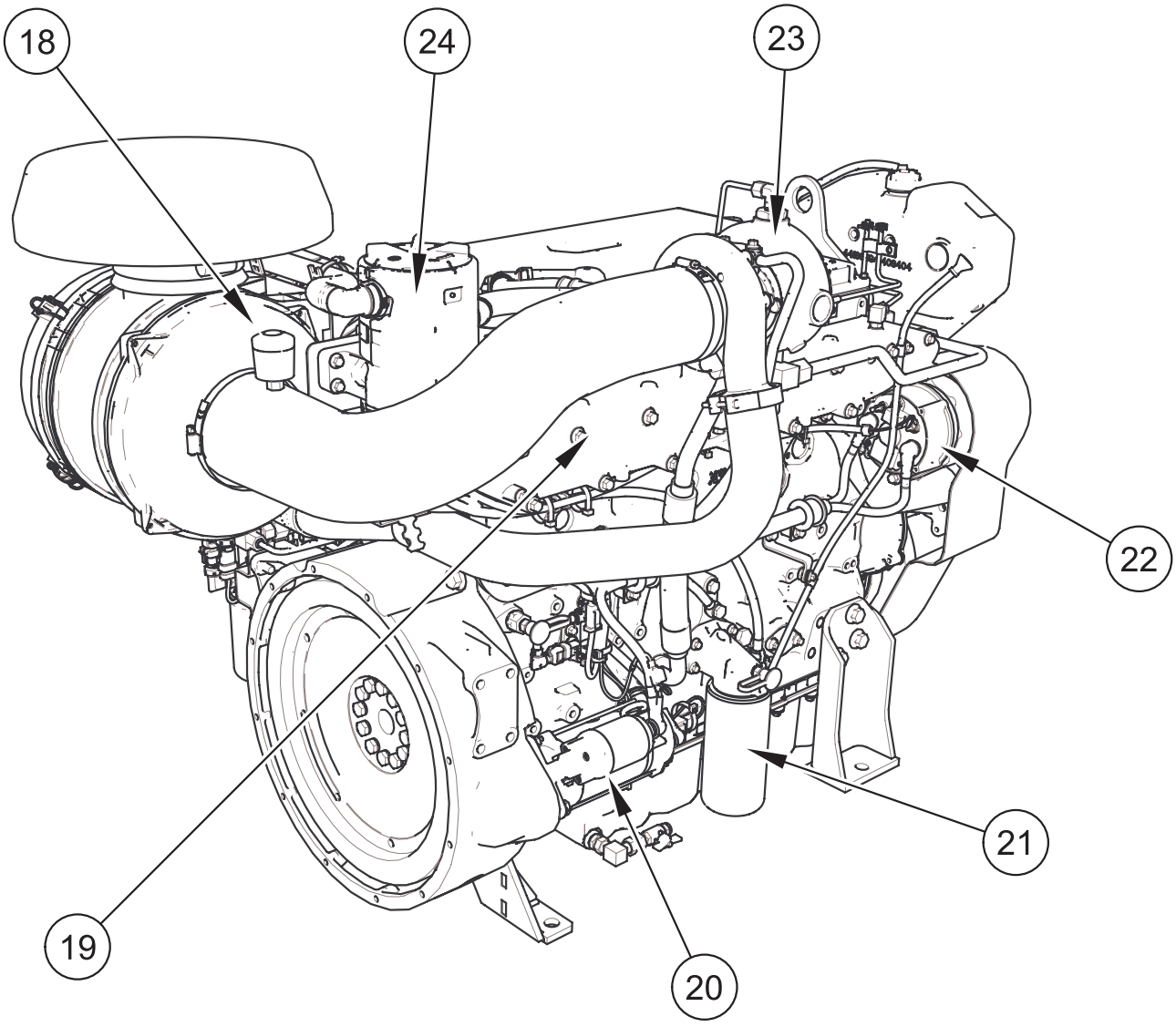
20 Starter.

21 Lubricating oil filter.

22 Alternator.

23 Turbocharger

24 Crankcase breather.



E70B Turbo, Keel Cooled, Aftercooled, Single Circuit, Auxiliary

Front and Left Side

1 Front lifting eye.

2 Thermostat.

3 Belt cover.

4 Coolant drain.

5 Keel cooler inlet.

6 Cover on fuel transfer pump.

7 Customer connect.

8 Outlet to keel cooler.

9 Fuel filter.

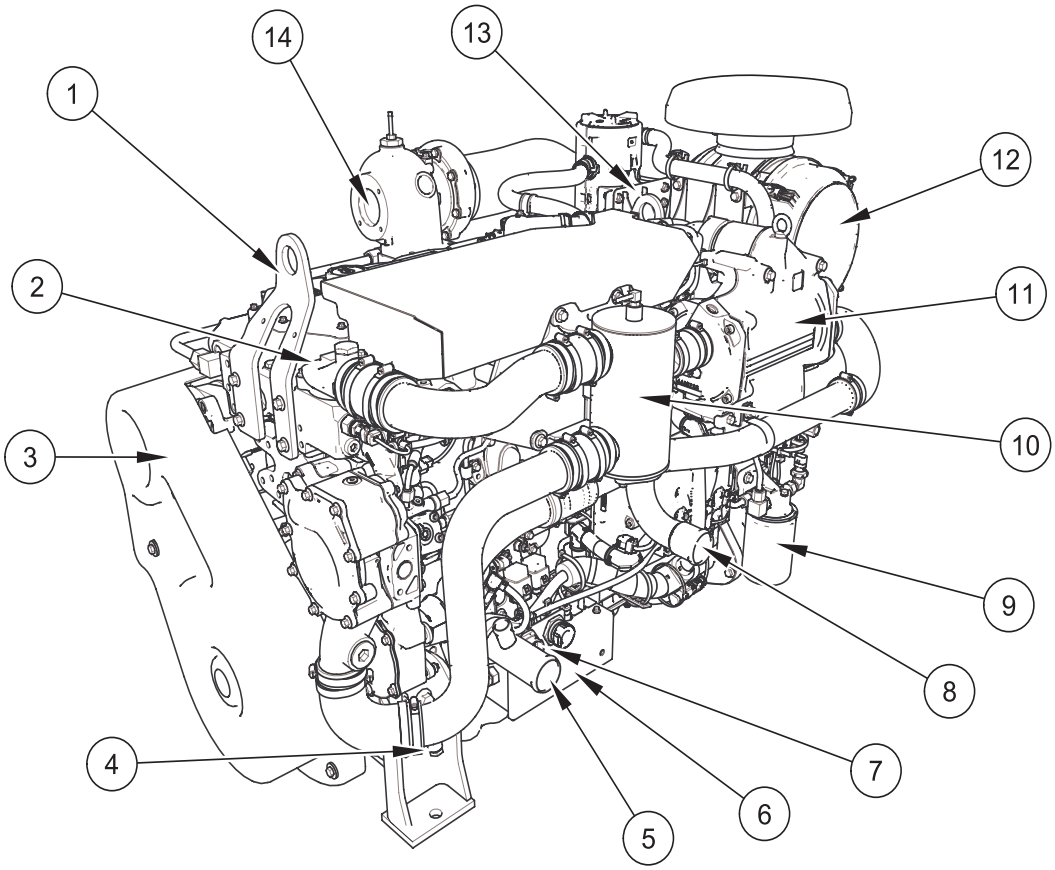
10 Mixing tank.

11 Aftercooler.

12 Air cleaner.

13 Rear lifting eye.

14 Exhaust outlet.



Rear and Right Side

15 Air cleaner indicator.

16 Fuel return.

17 Exhaust manifold.

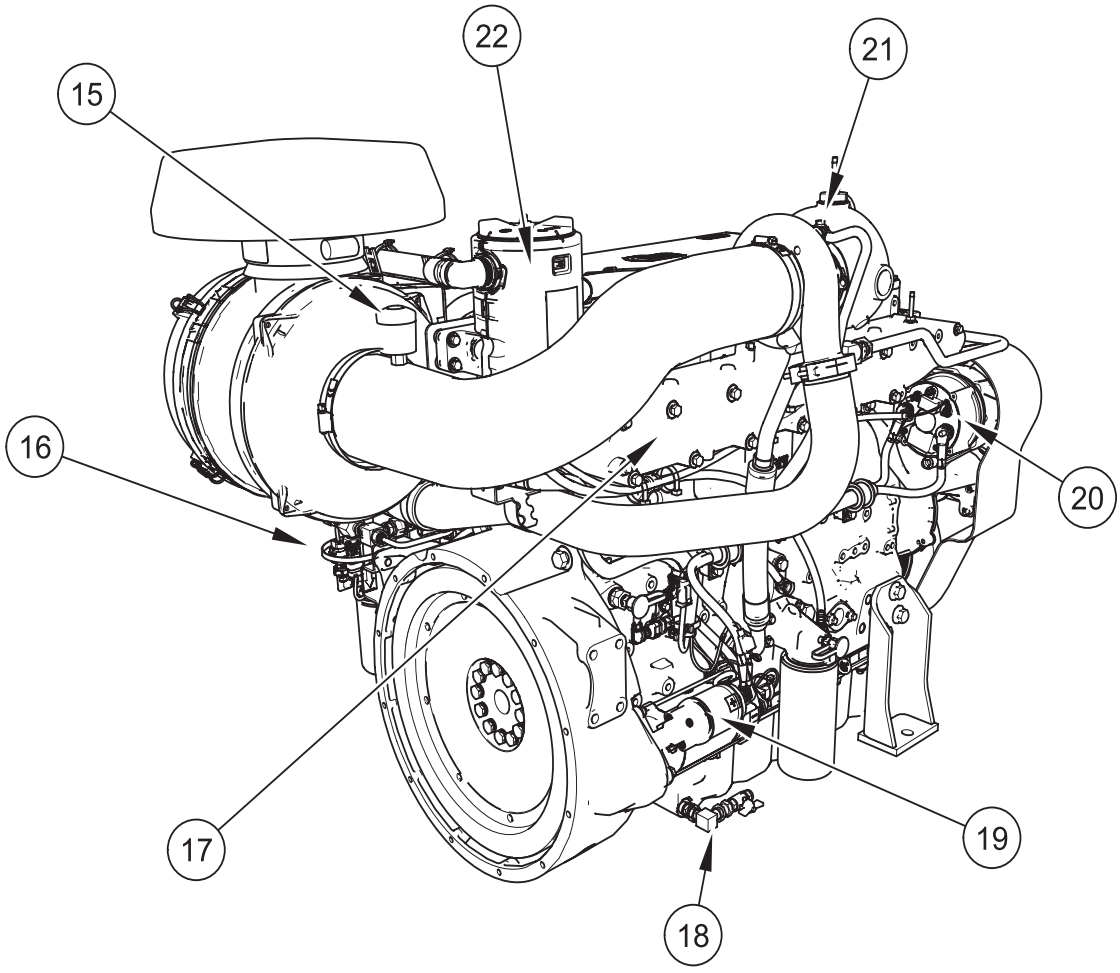
18 Lubricating sump drain valve.

19 Starter motor.

20 Alternator.

21 Turbocharger.

22 Crankcase breather.



E70B Turbo, Keel Cooled, Twin Circuit Auxiliary

Front and Left Side

1 Front lifting eye.

2 Thermostat.

3 Belt cover.

4 Engine coolant outlet.

5 Engine coolant inlet.

6 Engine coolant inlet.

7 Customer connect.

8 Fuel filter.

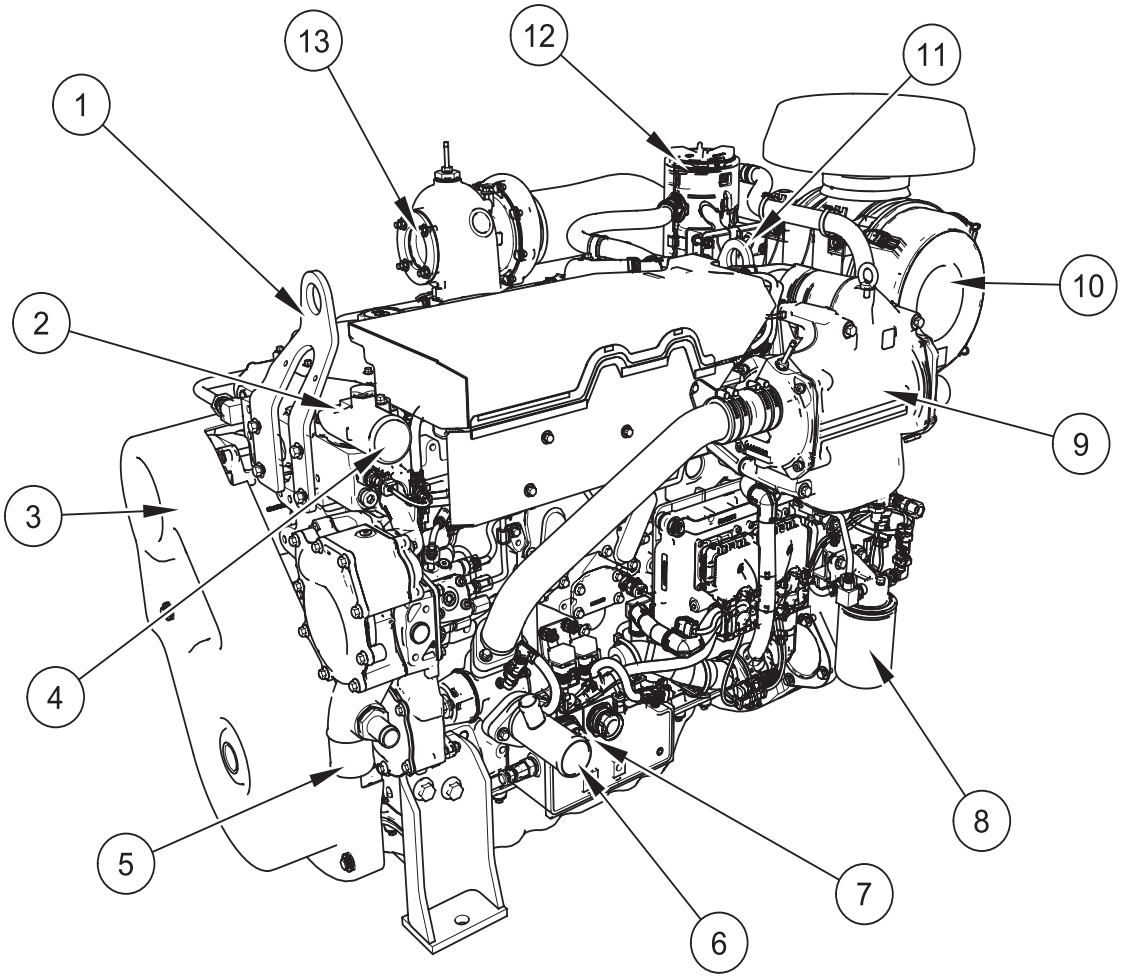
9 Aftercooler.

10 Air cleaner.

11 Rear lifting eye.

12 Crankcase breather.

13 Exhaust outlet.



Rear and Right Side

14 Air cleaner indicator.

15 Fuel return.

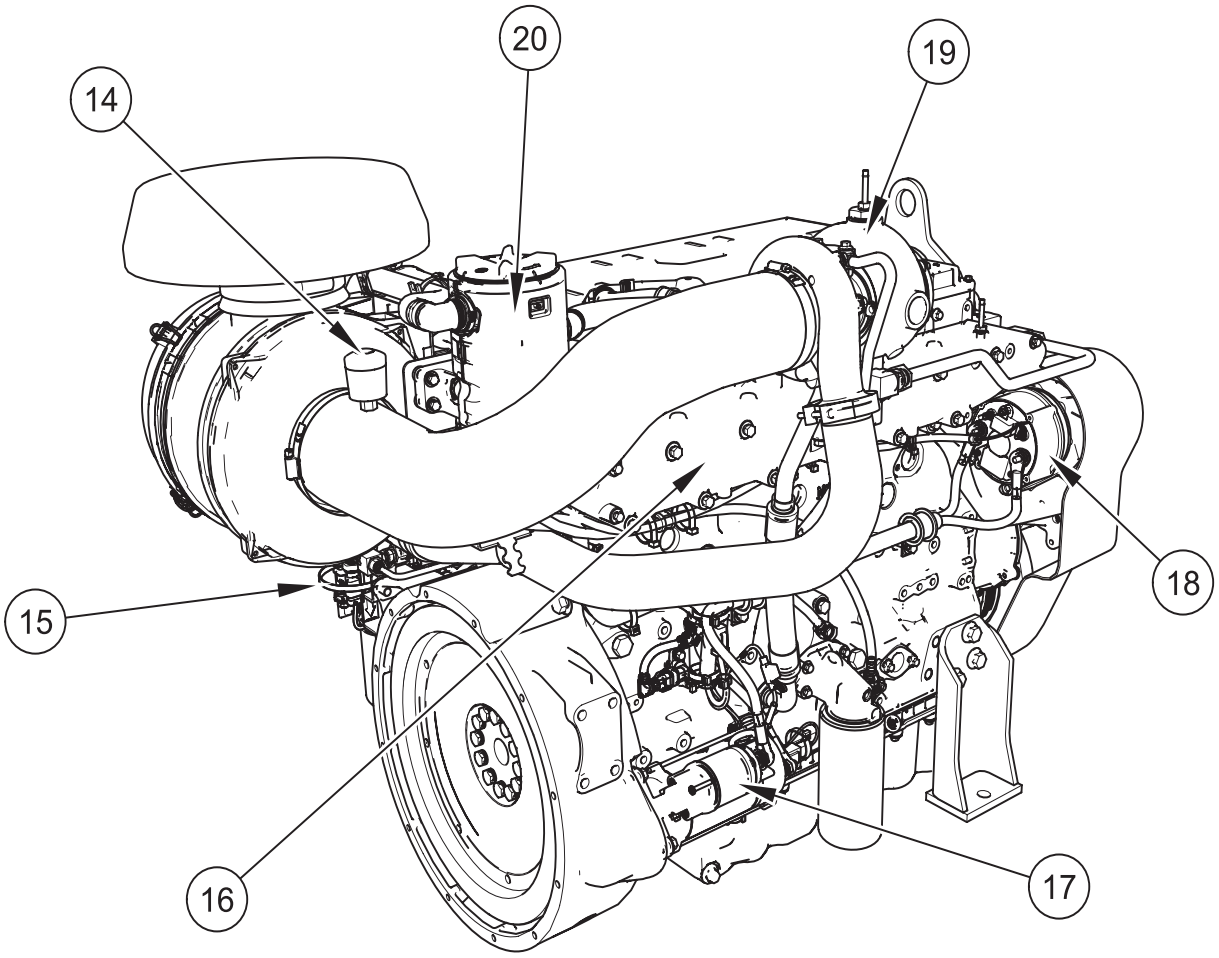
16 Exhaust manifold.

17 Starter motor.

18 Alternator.

19 Turbocharger.

20 Crankcase breather.



E70B Turbo, Aftercooled, Radiator Cooled, Genset

Front and Left Side

1 Coolant filler cap.

2 Lifting eyes, entire package.

3 Coolant drain.

4 Base frame.

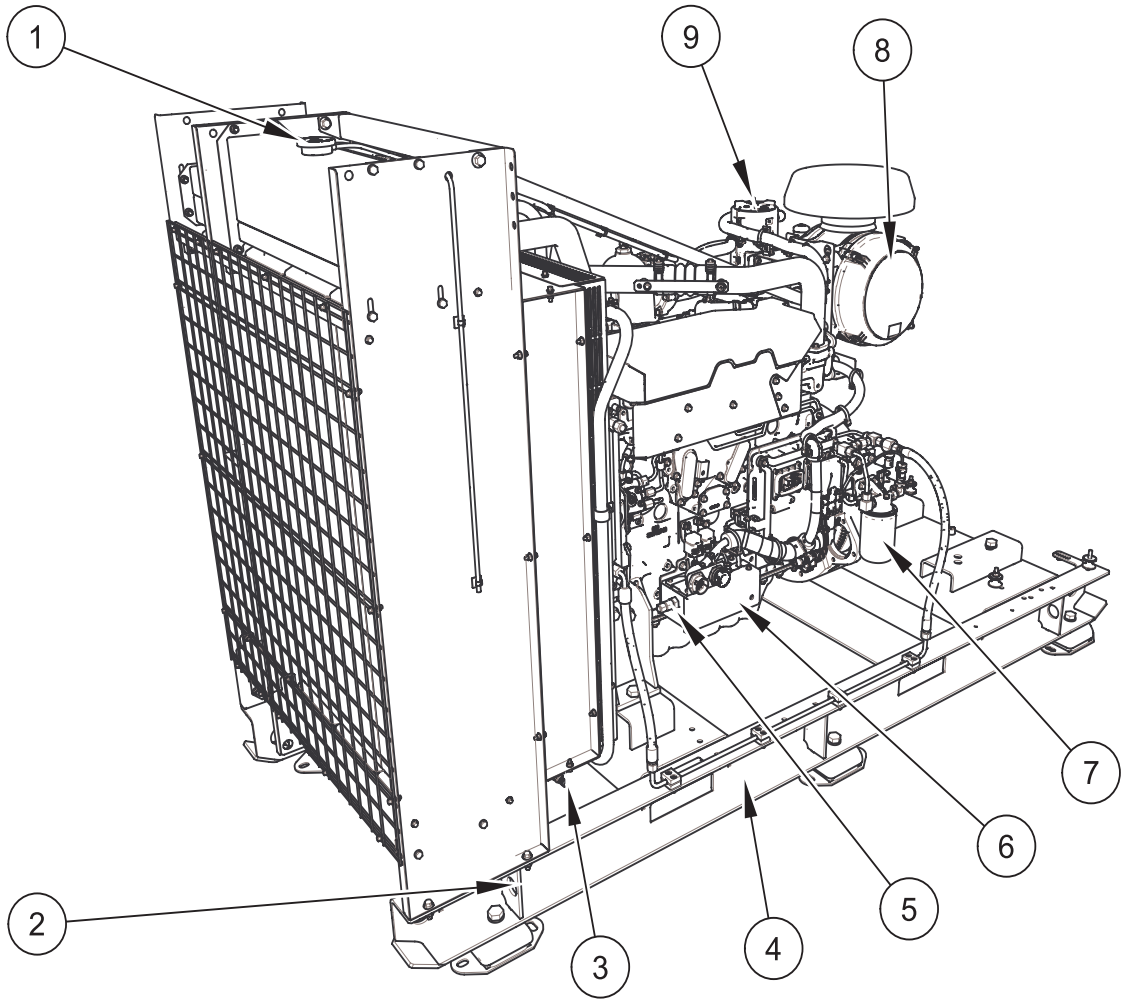
5 Fuel feed.

6 Cover on fuel transfer pump.

7 Fuel filter.

8 Air cleaner.

9 Crankcase breather



Rear and Right Side

10 Service indicator.

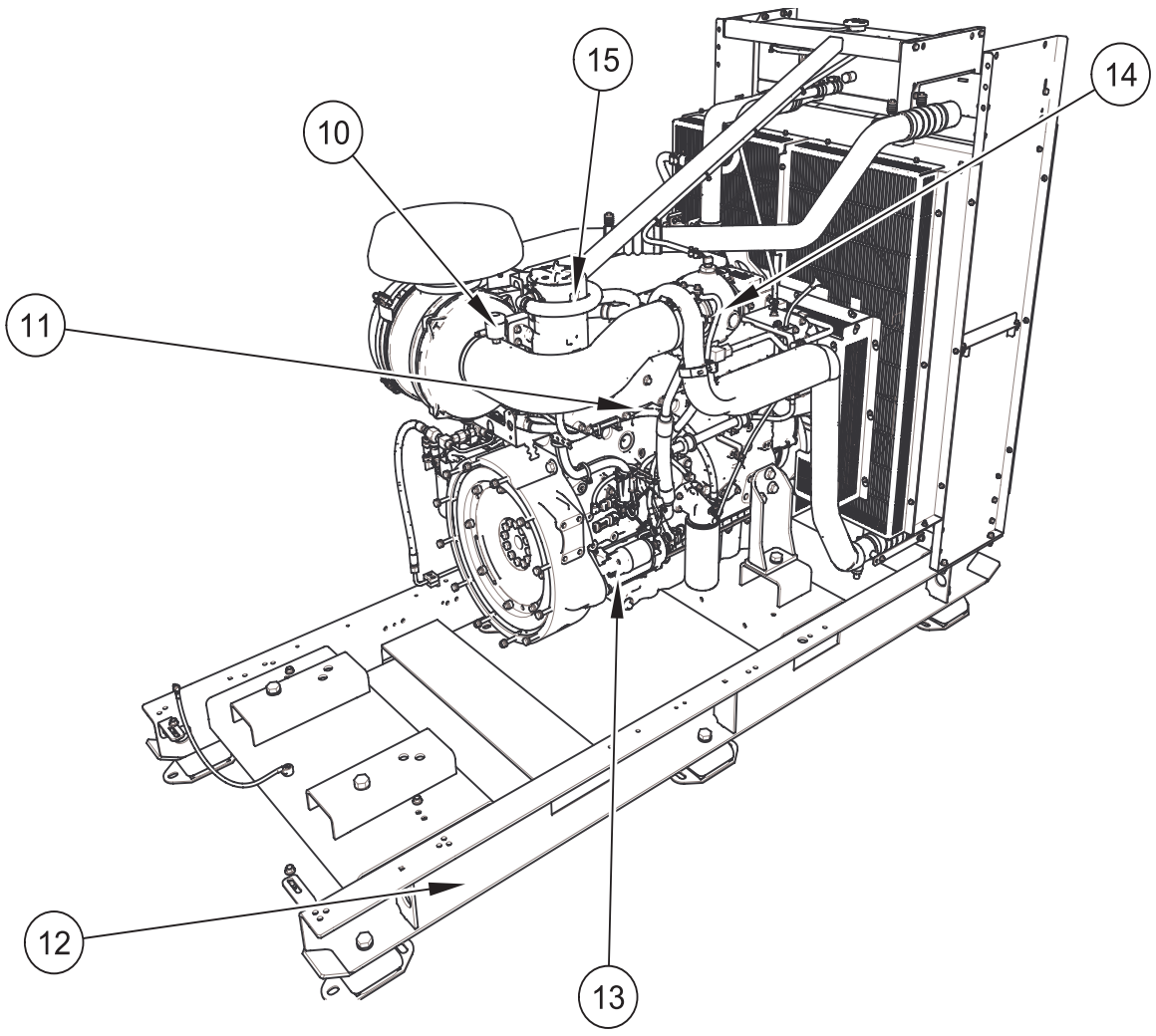
11 Exhaust manifold.

12 Base frame.

13 Starter.

14 Turbocharger.

15 Crankcase breather.



10. Introduction

Emissions Related Installation and Operation Instructions

Emissions Related Installation Instructions

The engine and generator set packages covered by this guide are certified to various exhaust emissions standards and regulations. In-order for the engine or generator set to remain compliant once installed in a vessel and operational the recommendations and instruction provided in this guide should be followed.

The engines and generator set packages covered by this guide are available in several power and speed ratings. Each rating has been developed and certified to the correct exhaust emissions standard based on the rated power and speed of each rating. As such no external control system should be connected, or existing control system modified in any way which would constrain engine operation to be different to that of the designed rated power and speed of the engine's selected power and speed rating. Doing so can render the engine or generator set package non-compliant.

The emissions control system fitted to the engines covered by this manual should not be deliberately tampered with or misused, doing so could render the engine to be no longer emissions compliant.

Engines and generator set packages maybe equipped with a cool down feature, whereby engine speed is dropped to a lower speed, typically 1100RPM, in order to allow the engine to cool down prior to being shut-down. By default, this feature is disabled at factory. If enabled then it must be ensured that this feature is de-selected or disabled prior to putting the engine on load, such that under any load the engine is operating at its designated rated speed.

Engine operation when the engine or control system has a fault should be kept to the minimum required to move or operate the vessel or equipment to a safe position or condition. The fault should then be rectified prior to resuming operation of the engine. Operating the engine with a fault could render the engine exhaust emissions non-compliant. For engines supplied without an instrument or gauge panel, a suitable panel must be provided in vessel to display diagnostics and warnings to the operator, such that it is clear if the engine is operating under fault conditions.

Rating Conditions

The engine ratings are determined at the ISO 3046-1 standard reference conditions, 25°C air temperature, barometric pressure 100 kPa, and 30% relative humidity. Additionally Gensets are capable of producing their rated electrical output at IACS ambient reference conditions of 45°C air temperature, barometric pressure 100 kPa, and 60% relative humidity. If the engine is to operate in ambient conditions other than the reference conditions then suitable adjustments must be made to the expected power output.

Generator Set Ratings

The most fundamental factor governing the correct sizing of a Genset is the power rating required. By considering 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 Genset packages. For standby or emergency service, only the essential loads need to be included.

Having established the power requirement and possible Genset size we now need to look at the specific supply details, environmental conditions and performance criteria required when supplying this particular load. This next stage will ‘fine tune’ things 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 in relating these a power factor of 0.8 lagging is assumed:

i.e., kW = 0.8 x kVA

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 Gensets solely for emergency service, when only the essential loads need be included.

There are two basic conditions to check when sizing GenSets. 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 from 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; and 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.

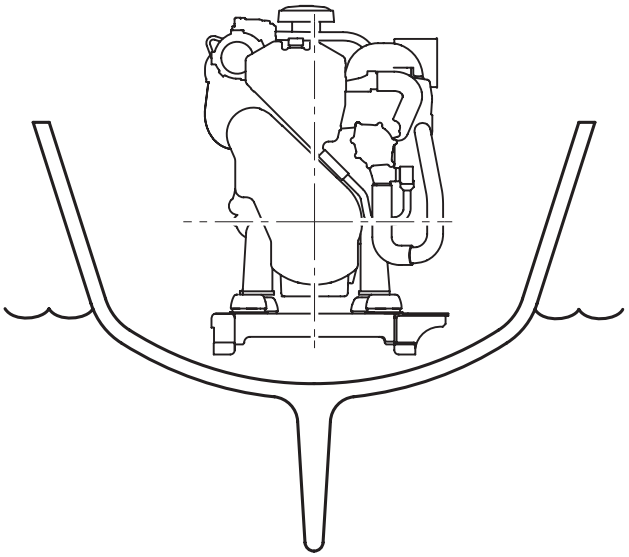


Figure 1

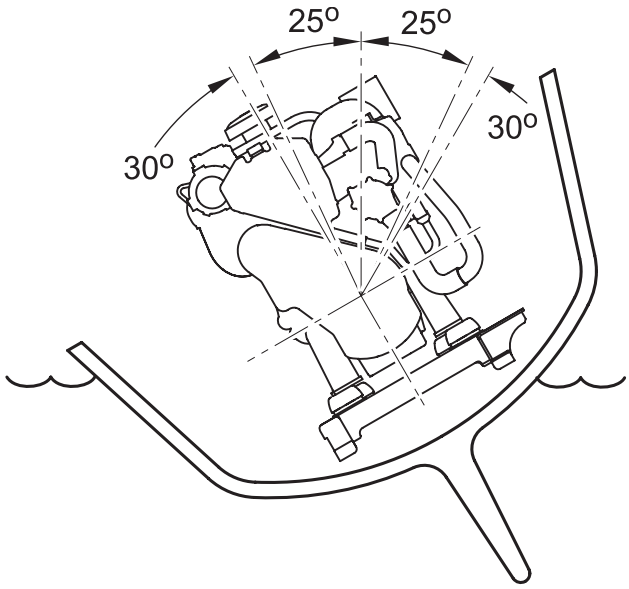


Figure 2

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 manual.

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

Caution: Where the genset 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° and 30° intermittent in any direction as figure 2.

Genset Base Radiator

1 Base mounting points.

Note: Refer to the General Arrangement drawing for dimensions.

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 radiator cooled units.

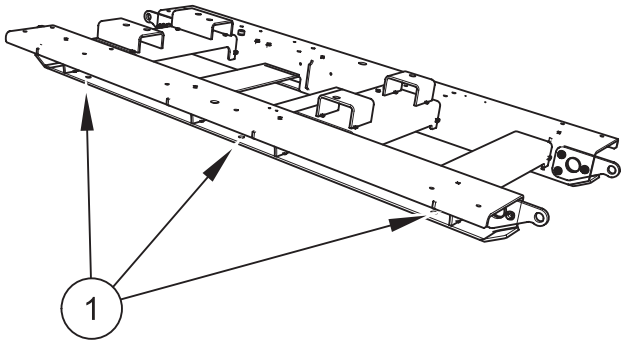


Figure 3

Engine Mounting (Customer Driven Equipment)

Standard methods

There are four standard methods available:

1 The engine can be installed on solid mountings, independent of the driven machinery but on a common base, (not desired).

2 The complete engine, can be installed on solid mountings on a frame. Install the frame on flexible mountings on a solid base.

3 Install the engine on flexible mountings,

4 Connect the engine and install the complete unit on flexible mountings.

Flexible Mountings

The purpose of the flexible mountings must be to:

- Control the movement of the engine at normal speed and during engine start and stop procedure.
- Remove as much vibration as possible from the frame.
- Give the engine support and hold it during sudden increase or decrease in speed, shock loads.
- Prevent stress to the engine, caused through distortion of the machine and the engine frame.
- Control the movement of the engine.

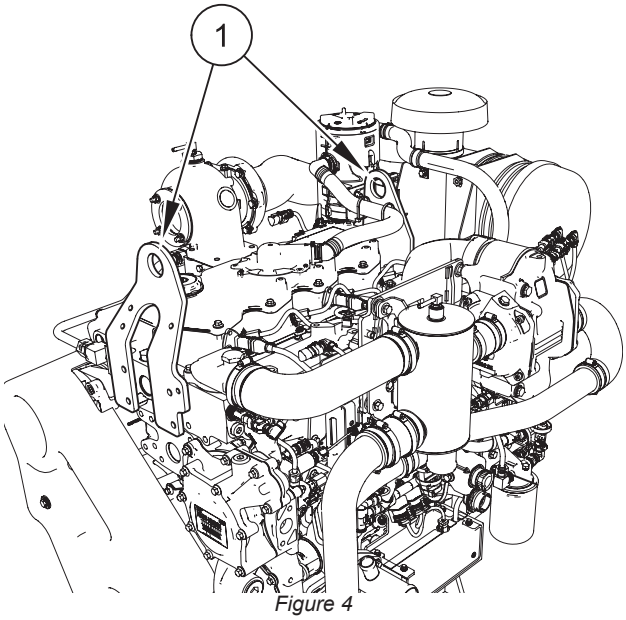


Figure 4

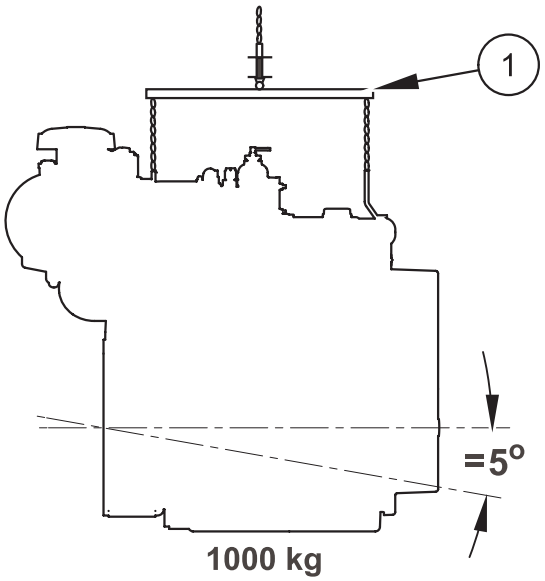


Figure 5

Lifting Heat Exchanger & Keel Cooled Engines

Caution: Only use the lifting eyes on the engine to lift the engine when separated from the generator.

Note: Ensure that the generator is adequately supported, when lifting the engine only.

To lift the engine only, once separated from the generator, use the lifting eyes as shown in figure 4.

Caution: Lifting strops and spreader bars must be used to lift the engine.

The arrangement must be capable of lifting 750 kg (1650 lbs) and care must be taken not to let the package tilt anymore than 5^{O} as shown in figure 5.

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

Lifting the Genset Package, Radiator

Caution: Do not use the lifting eyes located on the generator or 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 generator.

Caution: Only use the lifting eyes on the generator to lift the generator when it has been removed from the engine.

Caution: Care must be taken when lifting the genset 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.

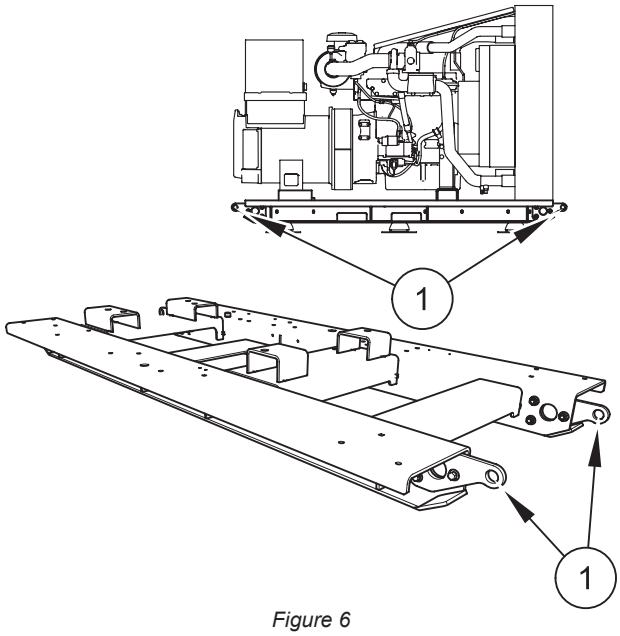


Figure 6

Lifting Data		
Model	A	B
E44	5°	2000 kg (4409 lbs)
E70B	5°	3000 kg (6607 lbs)

Lifting points have been provided (figure 6) on the base rails of the generator set for lifting the entire package.

Lifting the engine and the generator 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 2000 kg (4409 lbs) and care must be taken not to let the package tilt anymore than 5° as shown in figure 7.

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

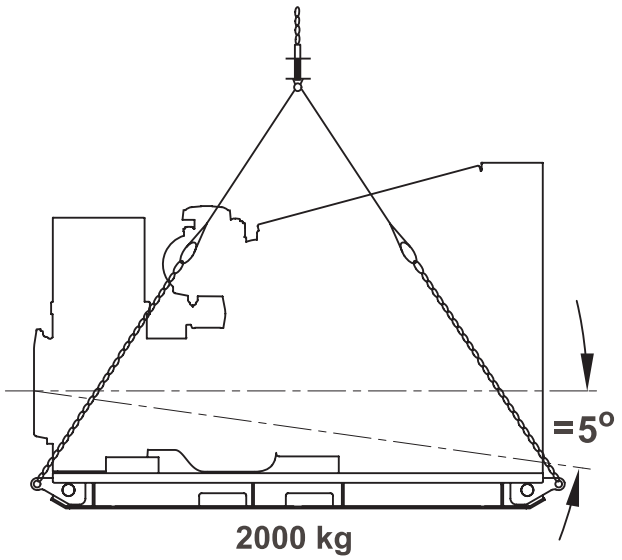


Figure 7

Torsional Vibration

Torsional vibration can cause extra stresses at certain speeds, particularly where the moment of inertia of the driven machinery is high. Examples of this include generators, pumps and compressors. Similar stresses and deflections can also occur with equipment that is driven off the front of the engine. It is strongly recommended that applications such as these undergo a torsional vibration analysis. If the analysis results indicate that the torsional vibratory torques, stresses or deflections are unacceptable, mitigations must be made prior to bringing the equipment into service.

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.

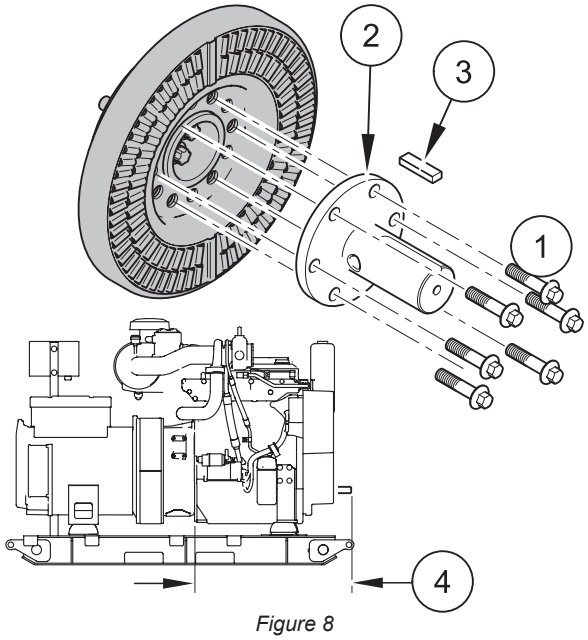


Figure 8

Dimension from rear face of engine block to end of PTO shaft item 4	
Model	mm
E44	762
E70B	1135

1 M12 bolts, tighten to 115 Nm

2 PTO shaft.

3 Key.

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 and hydraulic winch motors for example.

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

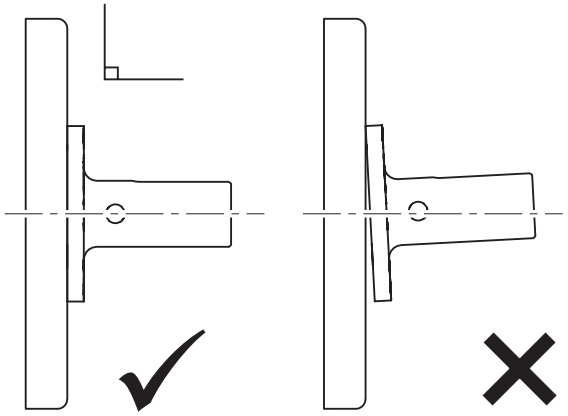


Figure 9

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

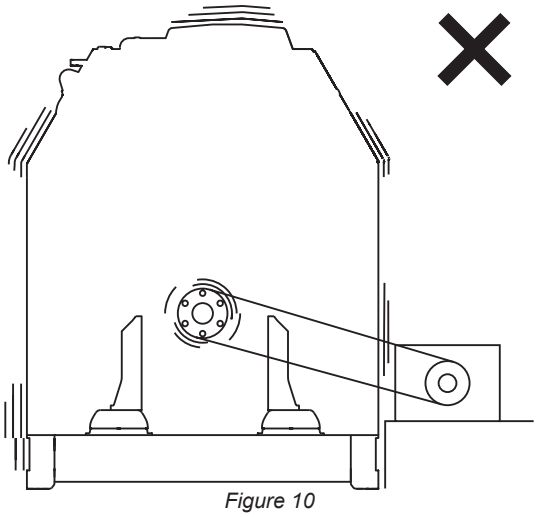


Figure 10

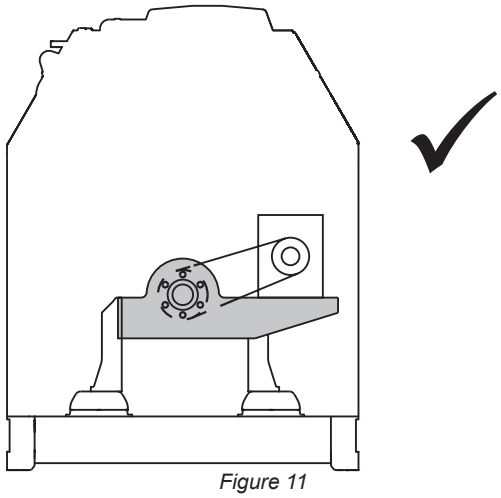


Figure 11

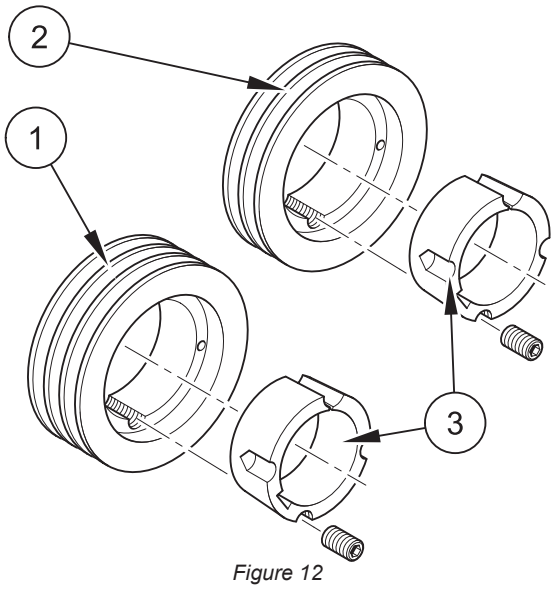


Figure 12

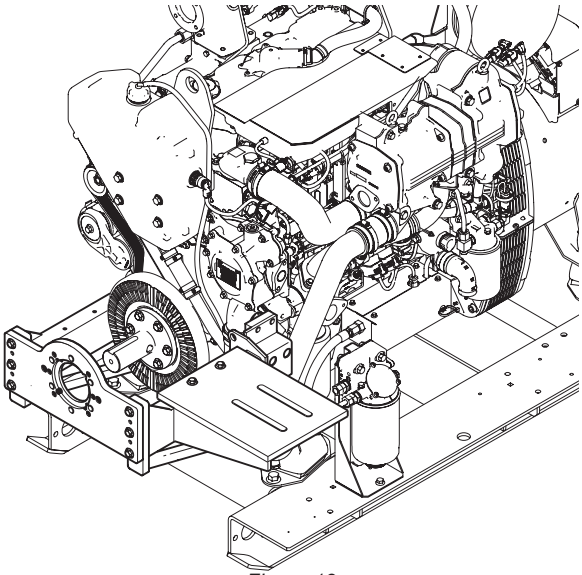


Figure 13

The arrangement shown in figure 11 should be adopted with a suitable frame mounted on the engine and not the genset base to support the additional equipment.

Figure 12 shows a taper lock drive for belt driven PTO arrangements (not a factory option).

Five inch 'A' section pulley with 3 grooves (1) and five inch 'B' section pulley with 2 grooves (2) are recommended, secured in place by taper locks (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 13, 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.

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 genset 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 15 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 15, 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.

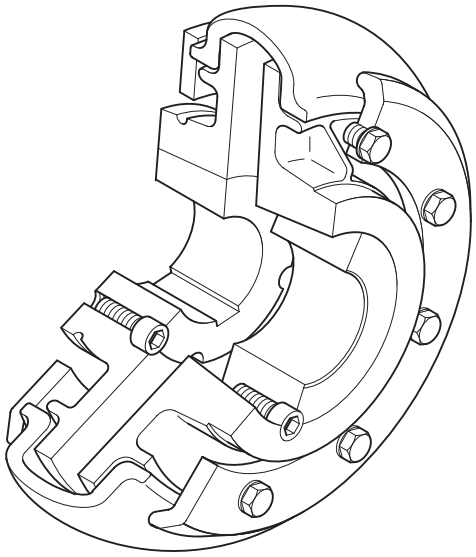


Figure 14

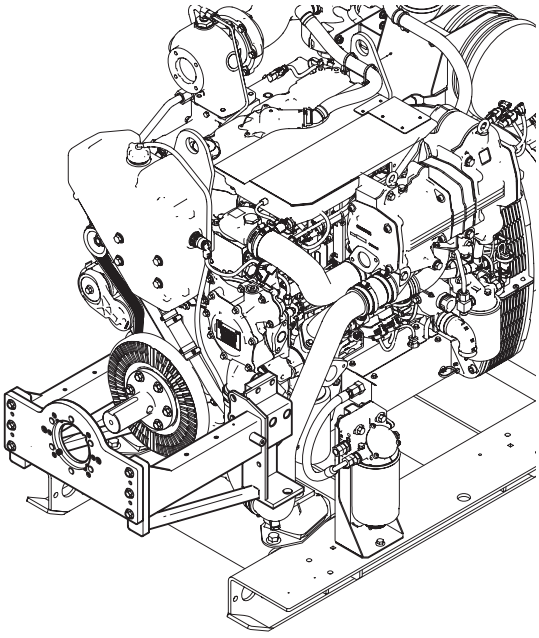
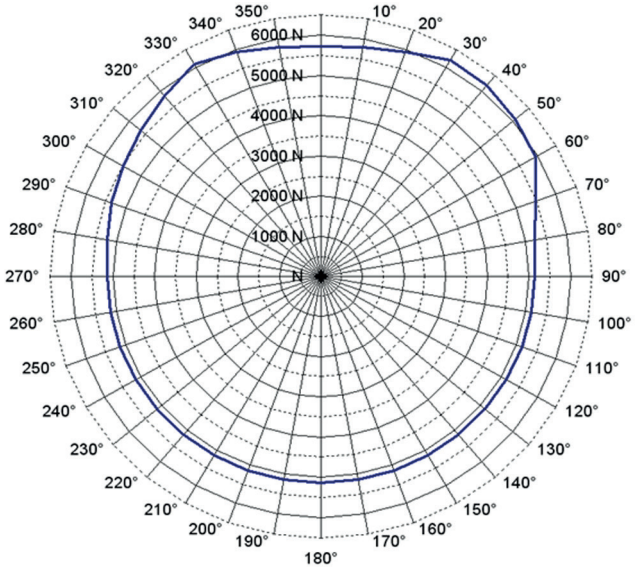


Figure 15



Polar 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 (103mm 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 2kN in a vertical (0°) direction onto the crankshaft pulley (103mm from front face of cylinder block).

The load needs to be taken into consideration if the engine takes a belt drive arrangement. The diagram below shows the overall capability of the crankshaft overhung load this excludes factory or customer supplied attachments.

It is recommended not to exceed 3000 N customer load when it is applied 176 mm from the front face of the block.

Consult the factory for advice if in doubt.

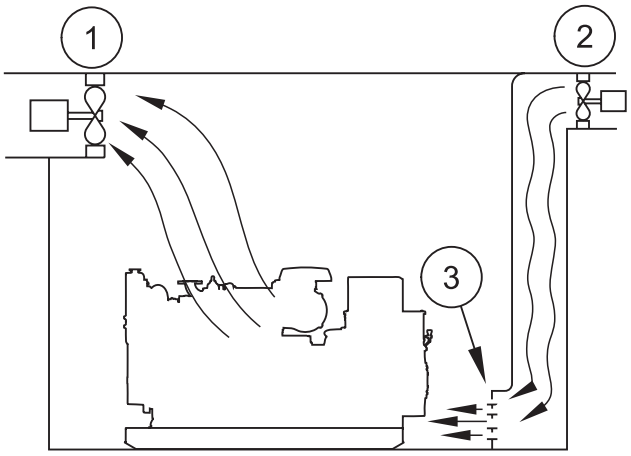


Figure 16

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 16 shows a typical installation.

1 Exhaust fan.

2 Intake air.

3 Intake louvres.

Correct ventilation air routing is vital for proper operation of these 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. Engine radiated heat does not include any heat radiated from the exhaust system. In practice additional radiated heat may be 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, generator, 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)

ΔT = 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 gensets 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 however if the gensets are mounted below a wheel house, then unpleasantly warm conditions may result. In these circumstances genset room ventilation fans are beneficial, preferably arranged to exhaust air from over the genset.

Crankcase Breather

The breather hose 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. Under all circumstances, the breather hose must be routed to free atmosphere.

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

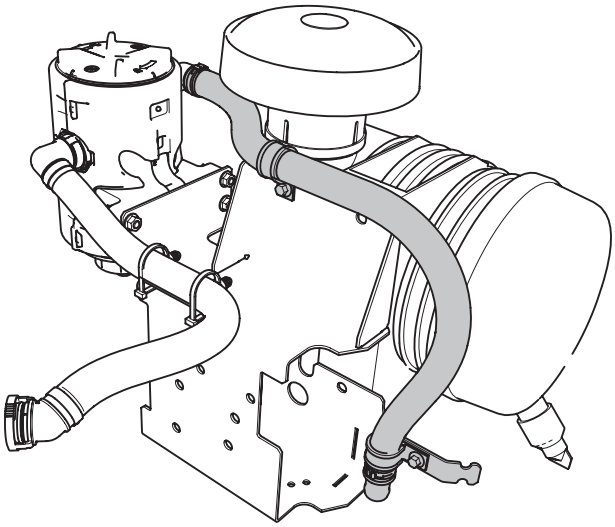


Figure 17

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 18.

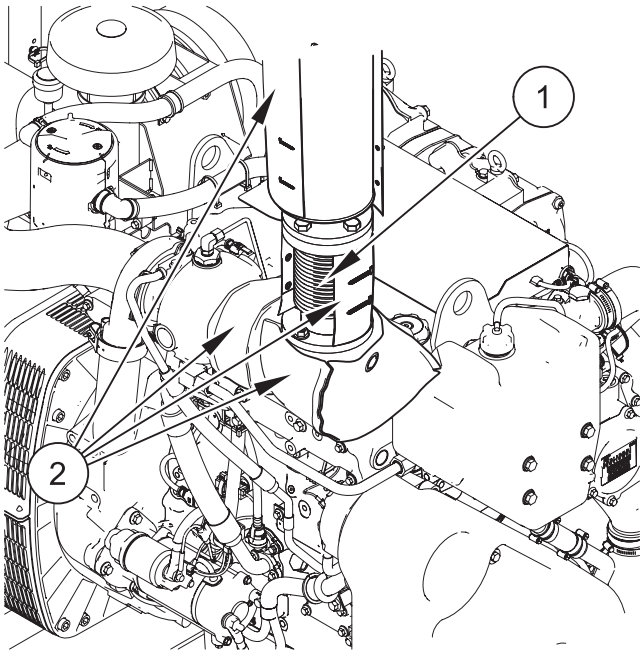


Figure 18

The first part of a dry system should include flexible connections (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 (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	
E44	70 mm (2.75 ins)
E70B	101.5 mm (3.99 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 19.

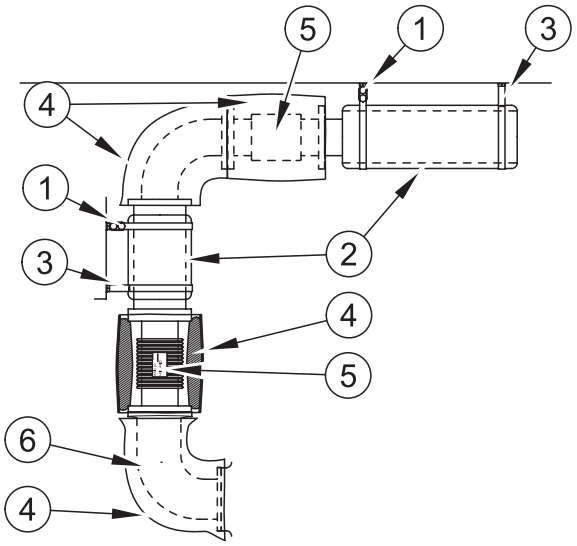


Figure 19

1 Bracket with link to allow movement due to expansion in the exhaust system.

2 Insulating lagging.

3 Rigid bracket to support the weight of the 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.

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

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. Contact your local Perkins dealer for more information.

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 + M14 x 1.5 tappings are located in the dry exhaust outlet elbow for measuring exhaust back pressure.

Wet Systems

Wet exhaust systems, where the auxiliary water used to circulate through the heat exchangers on the engine is finally dumped into the exhaust pipe to cool the exhaust gases, are the most common choice for small craft. Their principal advantage is that a rubber exhaust hose may be used, with a fairly low surface temperature, which presents no risk of fire.

A general arrangement for such a system is shown on illustration figure 20. In many cases the exhaust outlet passes through the transom, just above the waterline (1). It will be seen that a fall of 10º (2) is required, and that the point of water injection (4) must be at least 8 inches above the waterline (3), although the actual height necessary for a particular boat can only be decided in the light of the exhaust system design, and the pitch and roll which may be encountered in service.

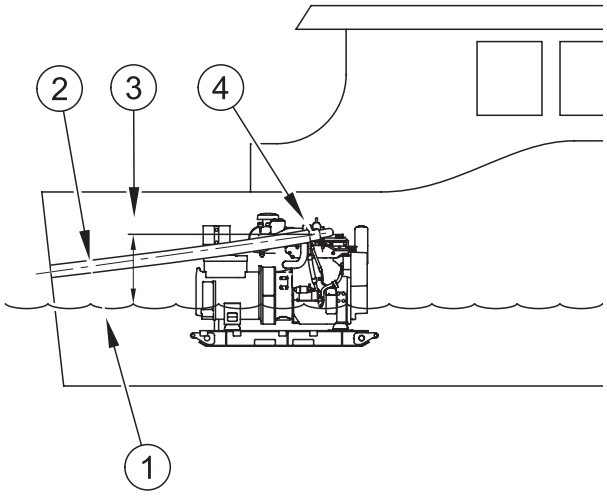


Figure 20

Caution: It is essential that the exhaust system is designed so that water from the exhaust does not enter the engine under any conceivable operational condition.

Figure 21 shows a typical exhaust elbow (1) with water injection (3). The elbow can be rotated (2) to achieve the optimal position.

A tapping and plug (4) is located on some elbows in the dry exhaust outlet elbow (if supplied) for measuring exhaust back pressure.

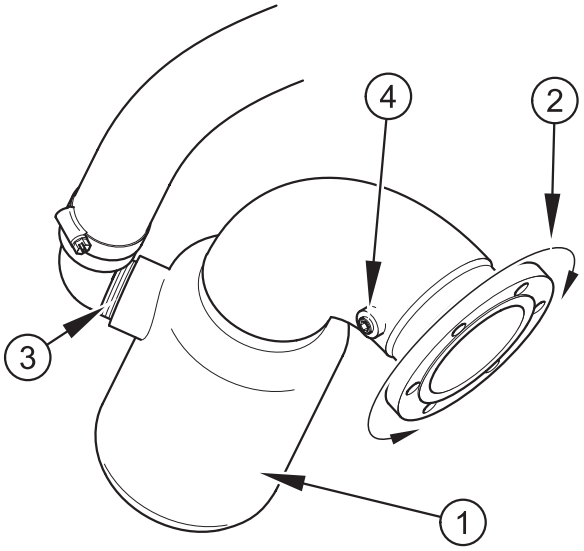


Figure 21

Note: The exhaust elbow must have a fall of 10º downwards.

Due consideration must be given to providing flexibility in the exhaust hose, particularly if the engine is flexibly mounted. Where the exhaust hose must pass through a bulkhead immediately behind the engine it is preferable that the arrangement shown in figure 22 is adopted, using rubber bellows (1) to provide flexibility.

Note: that the bellows should be in an unstrained condition when fitted, a minimum fall of 10º (3) is required, and that the point of water injection must be at least 8 inches above the waterline (2).

Note: A single double hump bellows can be used where space is restricted.

Caution: Movement of the engine on the flexible mounts must not be restricted by the exhaust hose.

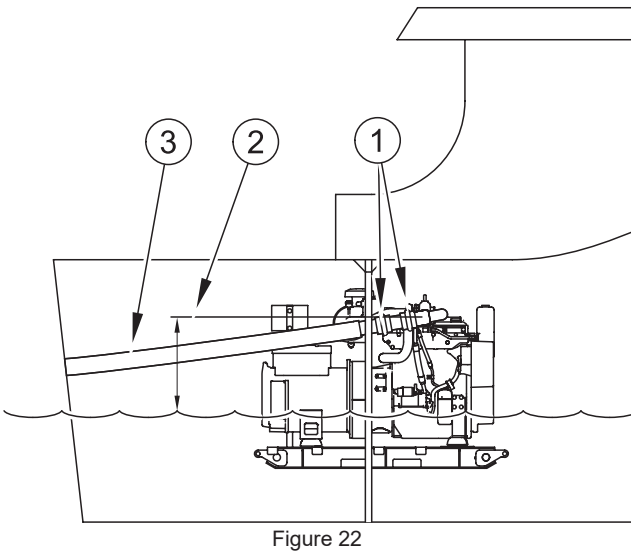


Figure 22

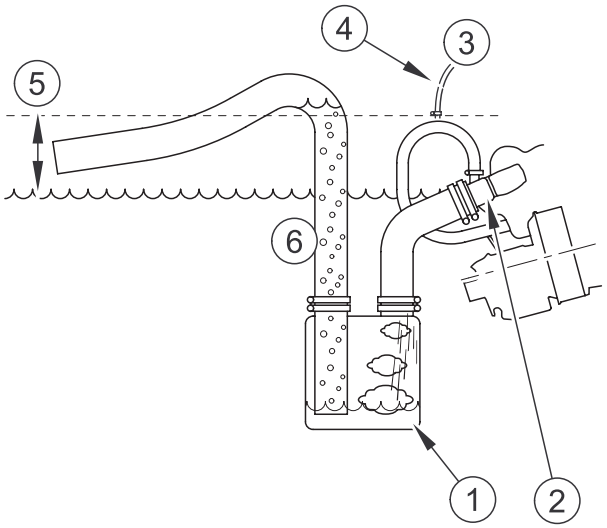


Figure 23

Water Lift Systems

Note: that the system must meet the requirement for the maximum exhaust back pressure to be not greater than 15 kPa, measured within 305 mm (12 inches) of the turbocharger / exhaust outlet. Minimum volume of exhaust tank should be 3 times the volume of the water in the riser. The tank should be installed near the centre-line of sailing craft.

Figure 23 shows the main features of such a system, which utilises pressure developed by the exhaust gases to force a mixture of gas and water to a height which may be considerably above the engine. When the engine is stopped the exhaust tank contains the water which falls back from the exhaust riser.

If a proprietary unit is used the manufacturers instructions should be carefully followed, but illustration (F) identifies the key features.

1 Exhaust tank (water lock).

2 Water injection elbow.

3 To overboard outlet.

4 1/2” bore siphon break.

5 Top of exhaust riser and point at which the siphon break is connected to the engine pipe work must be above the water line under the worst possible conditions (normally a distance of 450 mm (18”) under static conditions will be sufficient)

6 Exhaust riser.

Note: Do not overcrank the engine. Overcranking the engine may cause water from the exhaust system to enter into the cylinders.

14. Fuel systems

Fuel Connections

⚠ WARNING

Do not operate the engine/vessel if the fuel return line is sealed closed.

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

Fuel Feed and Return	
Feed/Return	**Aux**
Standard Fuel Feed and Return	3/4”-16 JIC
Optional Fuel Feed and Return	0.3 m flex hose 3/4”-16 JIC
Optional Fuel Feed and Return	1 m flex hose 3/4”-16 JIC

Refer to General Arrangement drawing.

Low Pressure Fuel System

The fuel lift pump should be no more than 1 metre above the minimum fuel level in the tank or 2 metres below the maximum fuel level in the tank.

Feed pressure must be less than 17 kPa and greater than -30 kPa (at the inlet to the fuel lift pump. If the engine is equipped with primary filter(s) make allowances for this as needed).

Return pressure must be less than 37 kPa and greater than -8.5 kPa. (At the engine return fuel connection point).

Maximum feed or return line restriction: 20 kPa.

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.

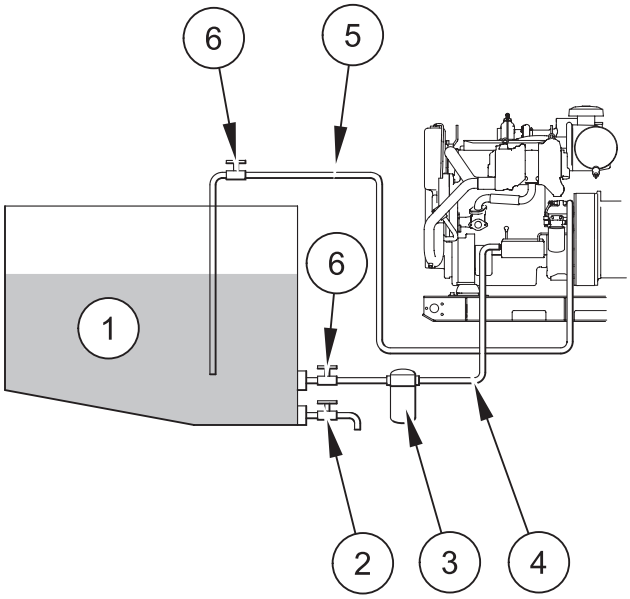


Figure 24

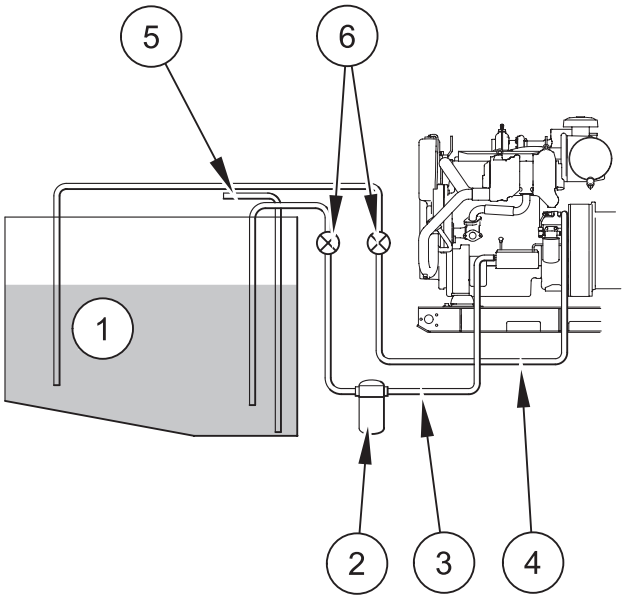


Figure 25

Typical Fuel Systems

⚠ WARNING

Do not operate the engine/vessel if the fuel return line is sealed closed.

Figure 24.

1 Fuel tank.

2 Drain point.

3 Water separator/pre filter.

4 Main fuel feed.

5 Fuel return.

6 Stop cock.

Figure 25.

1 Fuel tank.

2 Water separator/pre filter.

3 Main fuel feed.

4 Fuel return.

5 Drain tube.

6 Stop cocks.

The more simple the fuel system, the better it will perform in service. Figure 24 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 25 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 (1) so that all the fuel is available for use when under way when the hull will be at an angle.

The fuel return (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 (5) should be fitted to aid servicing and cleaning.

From the tank the main engine feed line (2) goes first

to a water separator (3), preferably one fitted with either a thick clear plastic bottom or in accordance with marine societies requirements.and a drain cock (use only if allowed by local regulations).

The fuel lines may be of metal 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 (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

⚠ WARNING

Do not operate the engine/vessel if the fuel return line is sealed closed.

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.

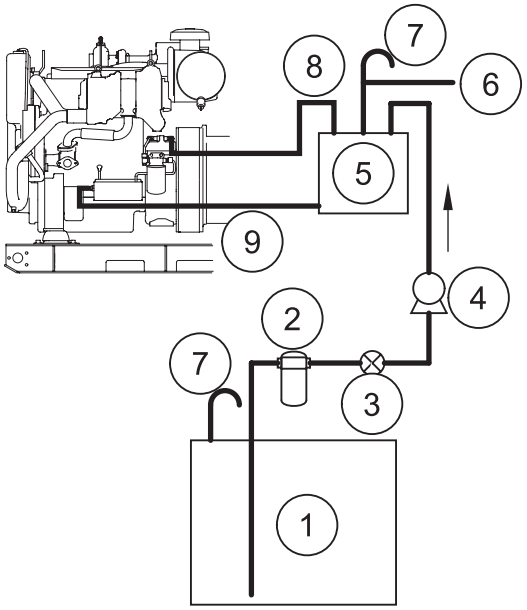


Figure 26

Figure 26.

1 Main fuel tank.

2 Water separator/pre-filter (recommended option).

3 Valve.

4 Pump.

5 Day tank.

6 Overflow.

7 Vent.

8 Fuel return.

9 Fuel feed.

Figure 26 shows a fuel system with a day tank situated above the main fuel tank, requiring a pump to transfer fuel into it.

Excessive fuel return line pressure can cause fuel 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 37 kPa.

Practically, this means the height of the fuel return into the day tank must not be greater than 2 metres above the engine crankshaft.

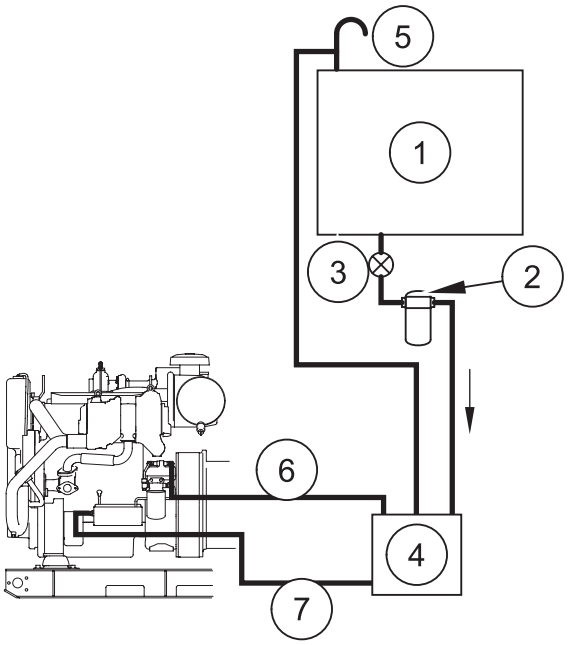


Figure 27

Figure 27.

1 Main fuel tank.

2 Water separator/pre-filter (recommended option).

3 Valve.

4 Day tank.

5 Vent.

6 Fuel return.

7 Fuel feed.

Figure 27 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 (E) should be used.

Figure 28 shows a collector tank (1),fed by all the storage tanks (2) and connected to the engine feed and return systems, but with a vent pipe (3) taken to any convenient tank and connected to it at the highest point. The fuel feeds (5) should be taken from the bottom of the collector tank and the fuel returns (6) at the top.

A water separator (4) 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 24 or 25 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.

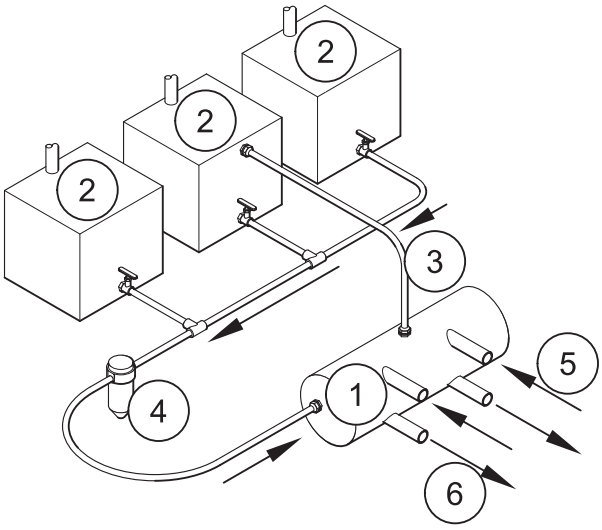


Figure 28

Primary Fuel Filter

A primary filter and water separator must be fitted between the fuel tank(s) and engine fuel inlet connection. A chosen filter must meet the following specification:

- Maximum pressure drop must not exceed 16 kPa with a clogged filter.
- Fuel flow rate: 5 l/min.
- Emulsified water separation efficiency: at least 85% or better.

Filtration efficiency

5 microns	72%
10 microns	97%
20 microns	100%

Perkins offer a filter kit, and replacement filter elements which meets the above specification and is highly recommended.

The use of a water in fuel sensor is strongly recommended to warn the operator of the presents of water in the fuel. This can help the operator ensure water is removed before it causes damage to the engine fuel system.

15. Engine cooling system

Engine Cooling

Heat exchanger cooling is when a ‘fresh’ to ‘raw’ 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.

Cooling Flow Diagrams

Fresh Water

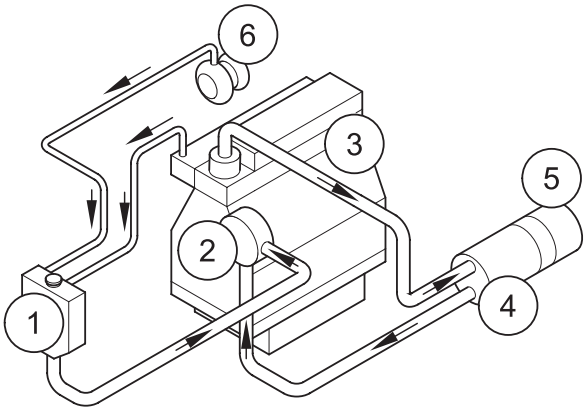


Figure 29

Figure 29.

1 Header tank.

2 Fresh water pump.

3 Engine.

4 Heat exchanger.

5 Aftercooler.

6 Turbocharger.

Raw Water

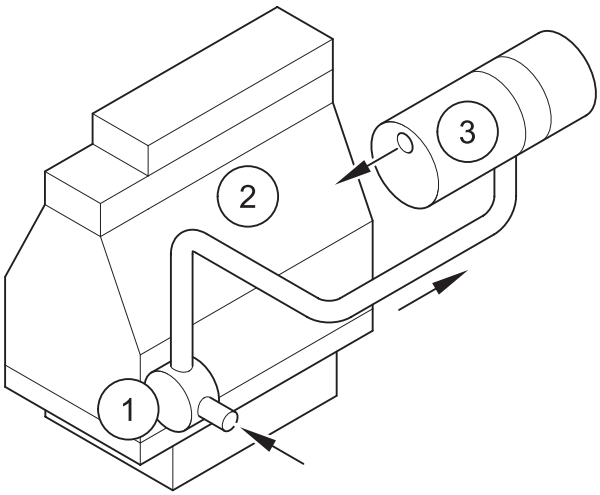


Figure 30

Figure 30.

1 Auxiliary water pump.

2 Engine.

3 Heat exchanger.

Keel Cooling

Figure 31.

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

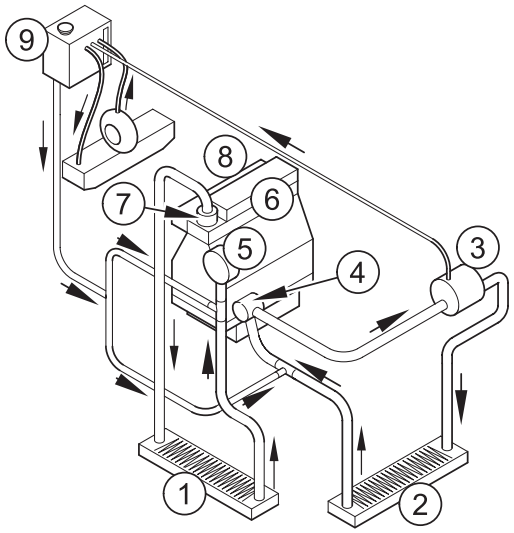


Figure 31

Single Grid, Keel Cooling

Figure 32.

1 Remote tank.

2 Fresh water pump.

3 Engine.

4 Auxiliary water pump.

5 Grid cooler.

6 Aftercooler.

7 Mixing tank.

8 Turbocharger.

9 Thermostat.

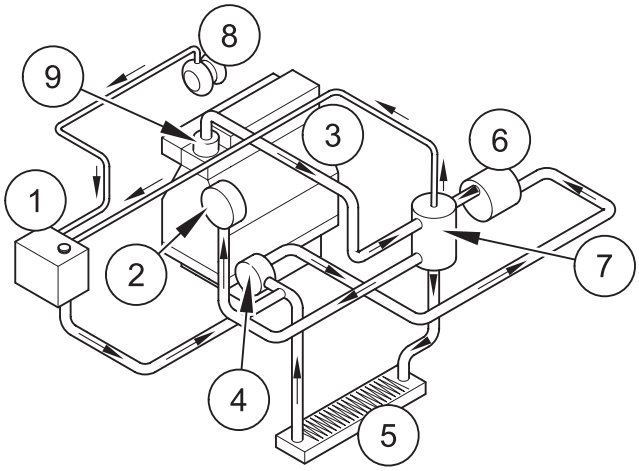


Figure 32

Radiator

Figure 33.

1 Engine.

2 Turbocharger.

3 Fresh water pump.

4 Thermostat.

5 Radiator.

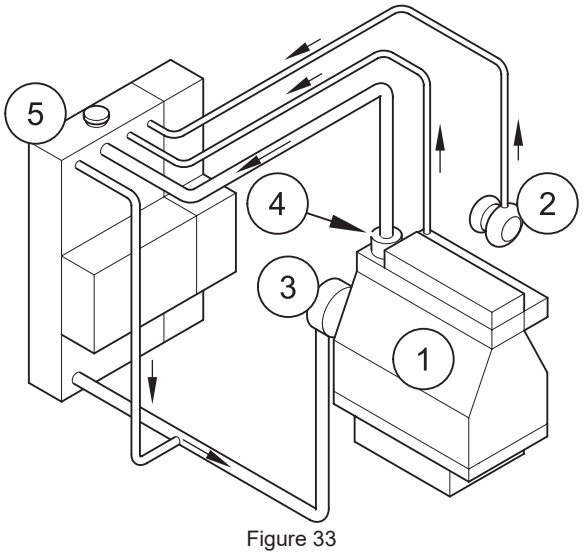


Figure 33

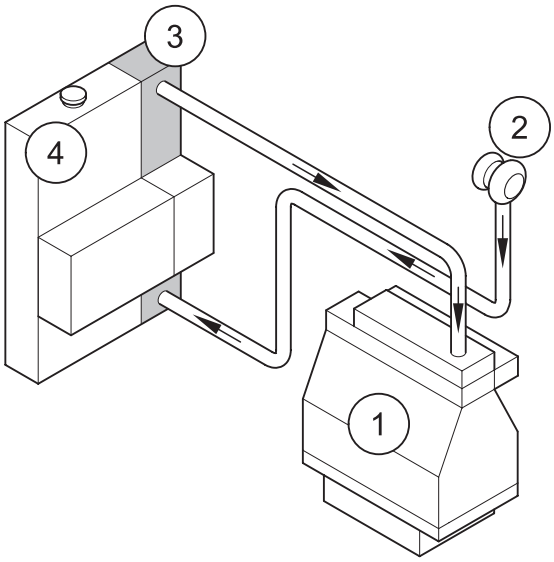


Figure 34

Air Flow, Radiator

Figure 34.

1 Engine.

2 Turbocharger.

3 Charge air cooler.

4 Radiator.

Fresh Water System

Caution: Care should be taken when removing the header tank pressure cap. Allow the engine to cool down before removing the cap as hot fluids and steam can be forced out at high pressure if not allowed to settle.

The fresh water circuit cools the engine block, cylinder head, exhaust manifold, turbo, aftercooler and heat exchanger.

Fresh water is circulated through the engine core and turbocharger at start up, and when the normal working temperature is achieved, the thermostat opens and allows water to flow through the aftercooler/heat exchanger.

Raw Water Systems

Caution: The maximum pressure into the sea water pump should not exceed 100 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.

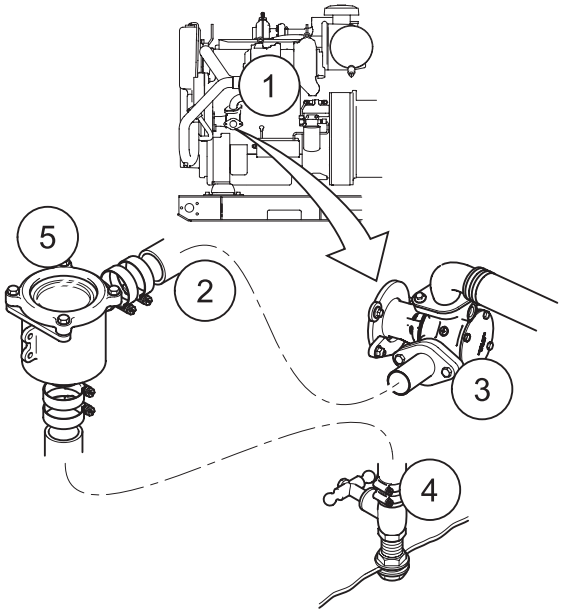


Figure 35

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 35.

The water intake fitting (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 and rudders to prevent flow problems at high speeds.

The intake fittings and pipe work should have a minimum bore of 39 mm (1.5”) (2). Inboard of the intake fitting a sea cock must be provided (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 (3) on the engine, there should be a strainer (5) which should be easily accessible for routine examination, and should be easily removable.

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, 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 genset 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 be 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 both the engine and charge air. In order to provide engine protection an antifreeze mixture must be used for both the engine and charge air cooling circuits. Refer to table below:

Antifreeze mix	
Model	Mix %
E44	50/50 glycol
E70B	80/20 glycol

The coolant specified here is mandatory for use in the climates specified 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). A 50% mixture will give 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 genset 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 be 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

Please refer to Customer Information Pack on the Perkins Marine website.

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:-

- Glycol mixture to be used.
- 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.

Single Grid Cooling

These engines are equipped with a single grid cooling system and provides both jacket water and charge air cooling from a single external cooling circuit. This eliminates the need for two external keel or grid coolers. The external cooling circuit is driven by the auxiliary coolant pump.

System Description

These engines are equipped with the combined cooling system and provides both jacket water and charge air cooling from a single external cooling circuit. This eliminates the need for two external keel or grid coolers. The external cooling circuit is driven by the auxiliary coolant pump.

Coolant Return Temperature

For maximum coolant return temperature information refer to the Customer Information Pack on the Perkins Marine website. The temperature listed is the maximum temperature allowable when operating in a sea water at 27^{O}C. This maximum temperature must be adhered to in-order to ensure exhaust emissions compliance.

Above sea water temperatures of 27^{O}C, the coolant temperature returning to the auxiliary pump may rise inline with sea water temperature.

External Circuit Flow

The external coolant flow is driven by the auxiliary coolant pump. Performance of the auxiliary pump performance can be found in the Customer Information Pack on the Perkins Marine Website and should be used to specify the coolant flow in the external circuit. Ensure the data for the correct engine speed is observed. A pressure drop on the external circuit between the mixing tank outlet and auxiliary pump inlet should not exceed 50kPa.

External Cooling System Connections

The external grid or ‘keel’ cooler should return cooled coolant to the auxiliary water pump inlet. In addition, an external header (expansion) tank should be provided and its return connection should also feed the inlet of the auxiliary pump. The bottom of the on-engine coolant mix tank has an outlet which should be connected to the external grid cooler inlet.

Two coolant bleeds locations on the engine should be connected back to the header tank. One bleed is located on the top of the coolant mix tank. The second bleed is located on the top of the turbocharger. On existing separate circuit cooled engines there is a third bleed located at the front of the exhaust manifold. If the engine is converted to combined circuit cooling, then this bleed location should be removed and plugged.

Sizing the Coolers for Single Circuit Aftercooled Systems

Please refer to Customer Information Pack on the Perkins Marine website.

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:-

- Glycol mixture to be used.
- 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.

Equipped with the combined cooling system provides both jacket water and charge air cooling from a single external cooling circuit. This eliminates the need for two external keel or grid coolers. The external cooling circuit is driven by the auxiliary coolant pump.

The external coolant flow is driven by the auxiliary coolant pump. Ensure the data for the correct engine speed is observed. A pressure drop on the external circuit between the mixing tank outlet and auxiliary pump inlet should not exceed 50 kPa.

The external grid or ‘keel’ cooler should return cooled coolant to the auxiliary water pump inlet. In addition, an external header (expansion) tank should be provided, and its return connection should also feed the inlet of the auxiliary pump. The bottom of the on-engine coolant mix tank has an outlet which should be connected to the external grid cooler inlet.

Two coolant bleeds locations on the engine should be connected back to the header tank. One bleed is located on the top of the coolant mix tank. The second bleed is located on the top of the turbocharger. On existing separate circuit cooled engines there is a third bleed located at the front of the exhaust manifold. If the engine is converted to combined circuit cooling, then this bleed location should be removed and plugged.

Heat Rejection Data

Please refer to Customer Information Pack on the Perkins Marine website.

As a general rule the pressure drop across the grid coolers should be between 14-28 kPa when operating with the thermostat fully open. Keeping the water velocity below 0.46 m/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 85^{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 apply to separate circuit keel cooled engines and should ensure that there is sufficient cooler capacity should the engine operate in seas hotter than 25^{O} C.

The maximum coolant inlet temperatures allowable to the aftercooler circuit, or engine inlet in the case of single circuit keel cooled, when operating in a sea temperature of 27^{O} C. Temperatures are specified at given glycol mixtures, and care should be taken to ensure the correct temperature is selected for the target glycol mixture. The temperatures quoted should be taken as maximum temperatures when the engine is operating at full load. Further they are critical to ensure compliance with exhaust emission certification.

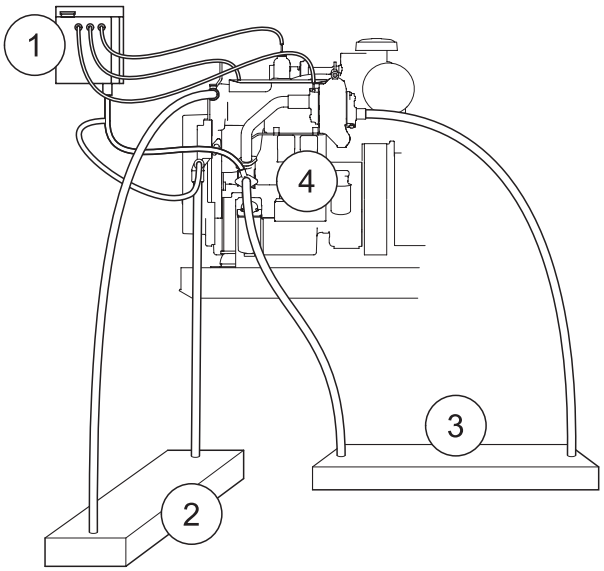


Figure 36

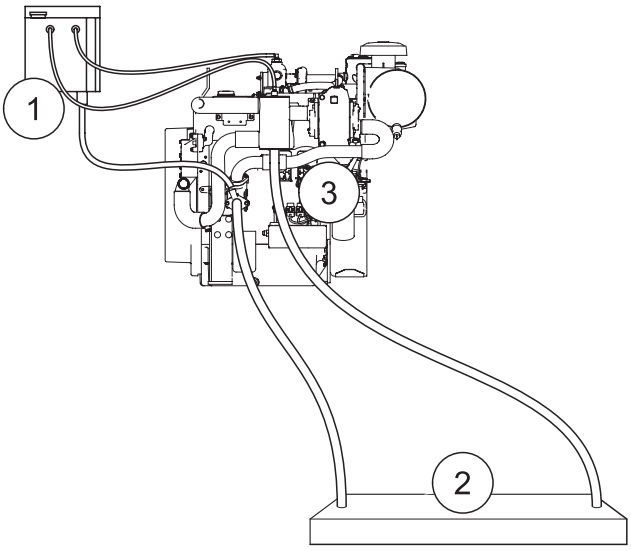


Figure 37

Keel Cooling Connections

Dual Grids

Figure 36 shows the connections

1 Remote tank.

2 Fresh water circuit keel cooler (not factory supplied).

3 Aftercooler circuit keel cooler (not factory supplied).

4 Engine.

Single Grid

Figure 37 shows the connections

1 Remote tank.

2 Keel cooler (not factory supplied).

3 Engine.

Connections to keel coolers 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.

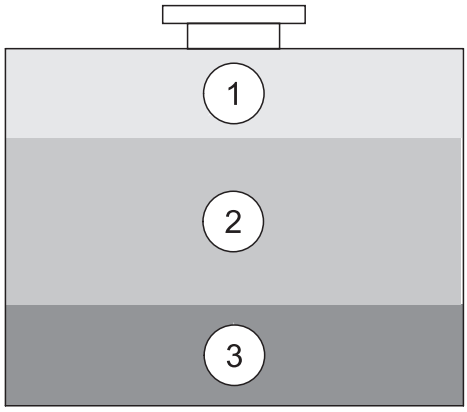


Figure 38

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 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 38 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 39.

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

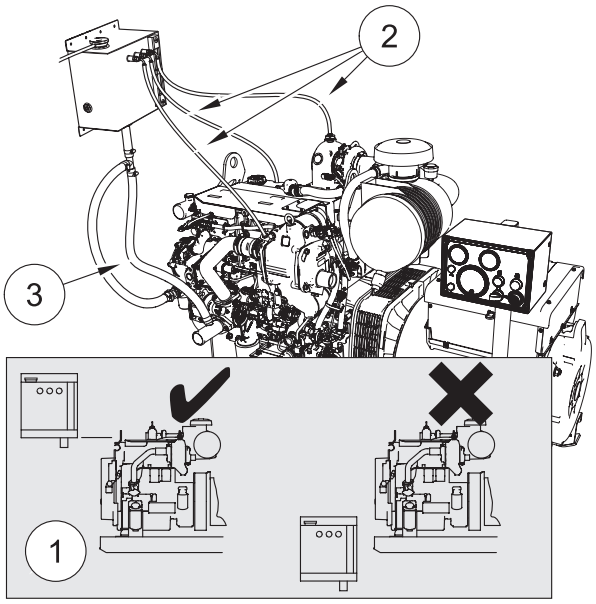


Figure 39

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

4 Fill the remote expansion tank with 50% antifreeze solution as in figure 40 (1), to the maximum position on the sight glass (2). (Refer to the Customer Information Pack on the Perkins Marine website. for the correct coolant specification).

5 Start the engine according to the procedure in the Operation & Maintenance Manual instructions.

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

7 Stop the engine according to the Operation & Maintenance Manual instructions.

8 Check coolant level in the sight glass as in figure 41 (1).

9 Top-up with 20% antifreeze solution , for normal operation, (50% for extreme conditions) to maximum level shown in figure 42 (1).

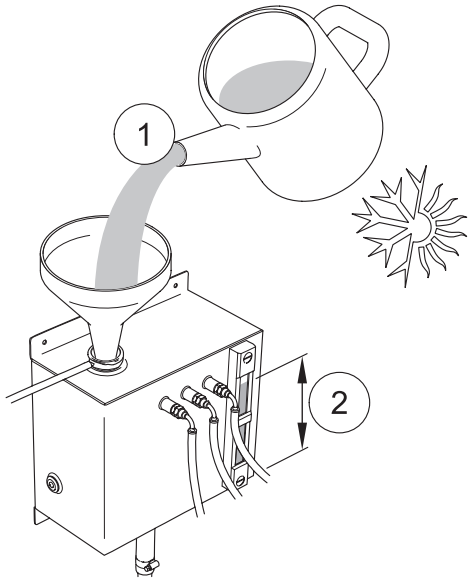


Figure 40

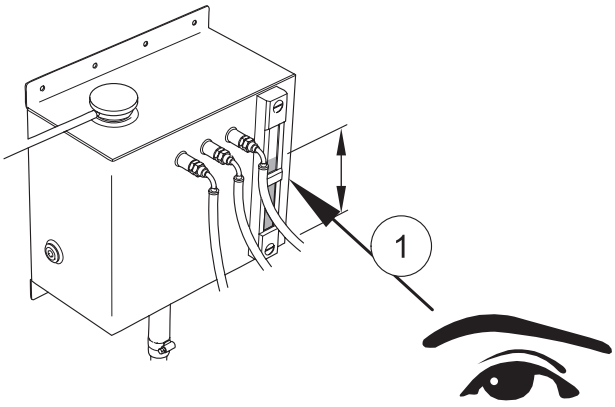


Figure 41

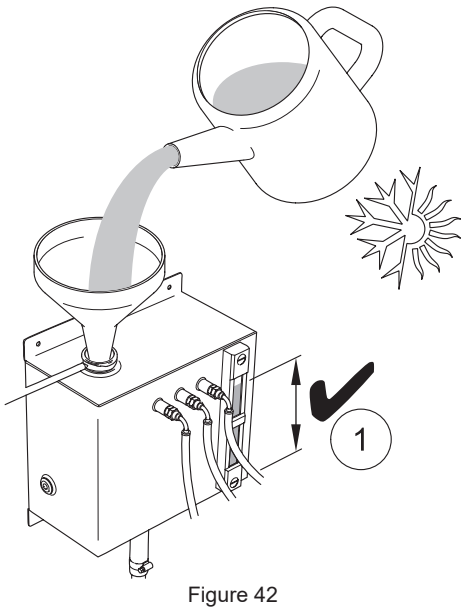


Figure 42

Radiator Cooling:

Note: Only flexible ducts to be used on the front of the radiator.

Note: Ducting or duct-work should not be hard mounted to the genset or radiator. The genset is fitted with flexible mounts and therefore is able to vibrate and slightly move in operation. A flexible compensation section should be used in any duct which is fitted to the genset or radiator, in order to take up slight movements without causing undue stress to either the duct-work or genset components.

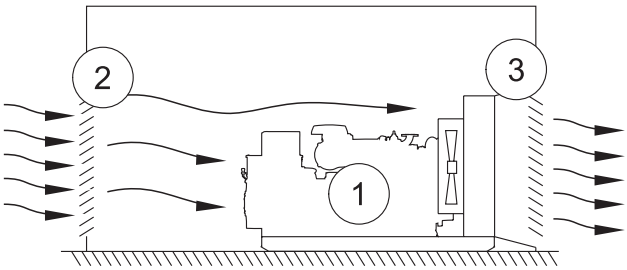


Figure 43

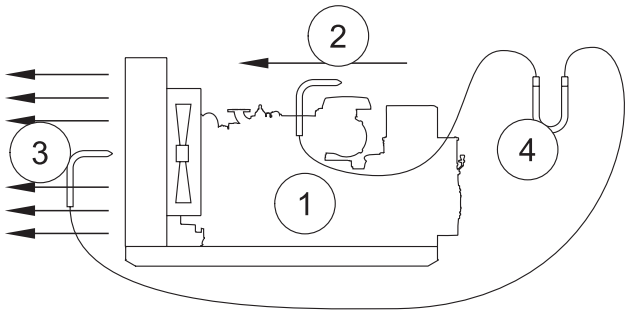


Figure 44

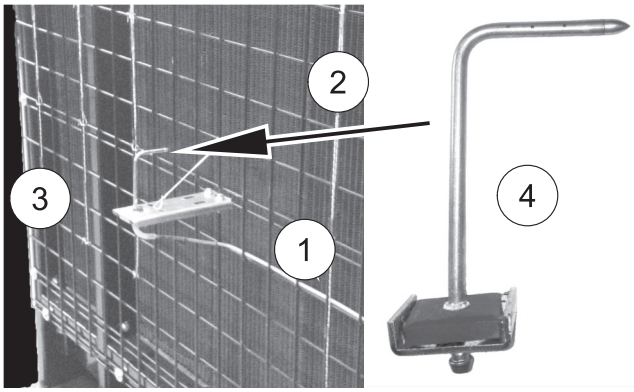


Figure 45

The radiator cooling pack option uses air to cool the engine, rather than sea water. As such a good supply of air is vital to achieving the correct cooling performance. Not only is the supply of air important but so is the exhaust of air from the radiator. The complete air circuit must be given great consideration to achieve the correct cooling performance.

Figure 43 shows the cooling air circuit. Although the exact details of the layout will need to vary from installation to installation, the basic air circuit will remain the same. The marine genset utilises a pusher fan, which draws cooling air from the inlet (figure 44 item 2) over the generator and engine (1), and then pushes through the radiator and charge air cooler. Typically the exhaust from the radiator and charge air cooler then exit the engine room via a vent to outside (3). Cool air enters the engine room from outside through another set of vents.

The radiator cooling system is designed for a maximum air temperature behind the genset of 50^{O} C. The design accounts for the radiated heat from the engine and generator which will lead to air temperatures greater than 50^{O} C at the inlet to of the radiator fan. The design does not account for any other heat sources in the engine bay. If other sources of heat are present then additional ventilation will need to be considered. This is especially important for gensets likely to operate in hotter climates.

The radiator cooling system is designed to operate with a maximum duct restriction pressure of 127 Pa (0.5 in H20). The pressure is measured from a location in-front of the fan (typically along the length of the engine) to a location directly in-front of the radiator outlet, figure 44 item 3 and figure 45. In this way the total pressure over the cooling pack (2) is measured, including both the restrictions encountered in drawing the air into the engine and the restriction encountered in air exiting the engine room. When designing the engine room ventilation a pressure restriction target of 63.5 Pa should be aimed for, although lower is better.

In order to measure the duct restriction of an installation, static pressure tubes will be required. Use of any other means is likely to give inaccurate results. A water manometer (4) is normally sufficient for measuring the pressure. The static tube should be aligned parallel with the air flow. A fine thread on a stick is a useful tool in identifying the direction of air flow over the engine. (Care should be taken to keep it away from rotating parts, including the fan) figures 44 and 45 shows typical locations of the static tubes used for taking pressure readings.

Air Flow Measurements

Figure 46.

1 Width.

2 Height.

3 Air flow.

An alternative to taking pressure measurements is to measure the air flow through the radiator. This can be done using an anemometer to measure the air velocity through an opening of known area, from which the volumetric flow can be calculated. As air density decreases with temperature, to get an accurate reading air flow measurements should be taken with the generator running, but at no load, such that there is minimum heating of the air flow.

Anemometers are specifically available for ventilation and duct work, an instrument of this type should be used where possible. Measurements should be made where air flow is uniform, ideally just after the radiator outlet, but not after any louvers, bends or obstructions which could lead to non-uniform air velocities. An accurate measurement of volumetric flow is best made by taking at least twelve air velocity readings across the opening. It is best to draw up a grid with each cell being of equal area. Air velocity readings are then averaged, to give a total average air velocity through the opening. This is then multiplied by the opening area to give the volumetric air flow.

Figure 46 shows the layout of the grid for calculating the volumetric flow

Please refer to Customer Information Pack on the Perkins Marine website for air flow data for the fans fitted to Perkins generator sets along with the restriction curves for radiator cores. Overlaying the two curves will give the operating volumetric air flow at the curve intersection point. If the air flow is measured then the total pressure across the fan can be measured of the fan curve. Given the air flow reading, the pressure drop can also be read off the radiator restriction curve. The difference in the two

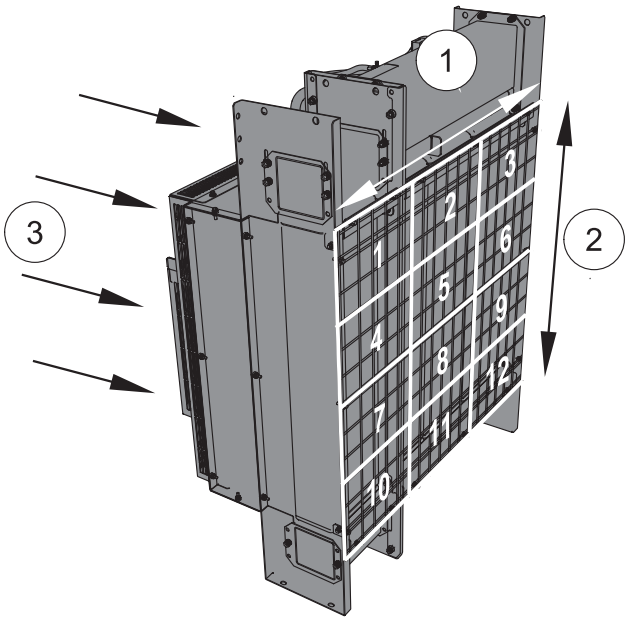


Figure 46

pressures is the total duct restriction present within the air system.

Volumetric Flow is given by:

- $Q = h \times w \times v_m$
- $v_m = (v_1 + v_2 + v_3 + v_4 + \ldots + v_{12}) / 12$

Where:

- $V_{1\text{-}12}$: Air velocity readings 1->12 (m/s or ft/min)
- v_m : Average air velocity (m/s or ft/min)
- h : Opening height (m or ft)
- w : Opening width (m or ft)
- Q : Air volumetric flow (m^3/s or cfm)

Whilst taking pressure and air flow measurements can be useful verification methods, good design practice should be used to correctly size and locate inlet and exhaust vents. The biggest restriction around the air circuit is likely to be due to the inlet and exhaust vents themselves. As such the supplier of the vents should be consulted for correct sizing. Other good practices include:

- Exhaust pipes should be lagged, right from the turbine outlet. The lagging should be sufficient to ensure that the external surface temperature does not exceed 220^{O} C at full load. This helps to ensure that no extra heat is carried into the radiator air.
- Exhaust routing should, where possible, be away from the radiator so that the air flow into the radiator is not impeded.
- Ensure there is sufficient space in front and behind of any exhaust or inlet vent (see figure 47, this includes:
    - Fire / heavy weather hatches should be able to fully open away from the vent.
    - Placing the vent such that a bulkhead is not immediately in front or behind the opening.
    - A suggested clearance between the vent and any bulkhead or otherwise is at least the longest of the height or width of the vent itself.
- Inlet air vents should be placed such that they pick up cool ambient air, not air which has picked up any additional heat, such as air exhausted from another engine room.

- The exhaust vent should have a frontal area equivalent to the total radiator exit area and ideally the same dimensions. If this cannot be achieved then tapered ductwork should be used to adapt the two together. A minimum length of 1 m (3’ 3”) is recommended for any adapting ductwork, where a significant dimension change needs to take place.

Figure 47 shows the basic considerations for allowing the genset to cool and breath.

1 Engine room.

2 Vents.

3 *D_M: minimum distance.

4 V_W: vent width.

5 V_H: vent height.

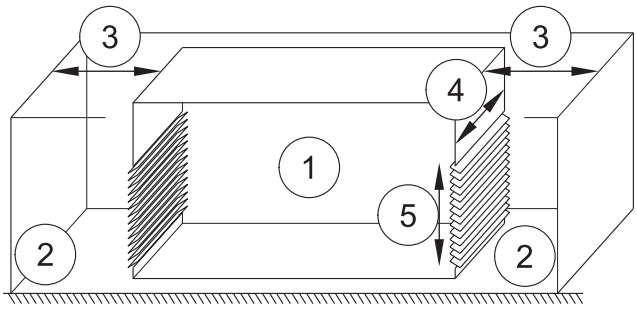


Figure 47

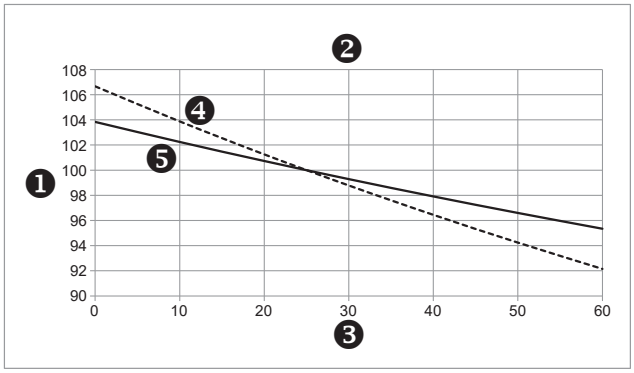
*Dm should meet the following conditions:
Dm ≥ Vw
and
Dm ≥ VH

Power Variability

All engines are subject to variability of power output dependant on various external factors. Two of these factors with high significance are inlet air and fuel. Inlet air is largely affected by temperature, with atmospheric pressure variation being minor for marine sea-level installations. Diesel engines inject fuel by volume, and as such density changes vary the mass of fuel being injected.

The graphs below show the variation on engine power output based on changes to air inlet temperature and fuel density. The power output change with fuel is the same across all engines regardless of cooling system. The power output change with inlet air temperature does however depend on the charge air cooling method. Engines using an air to water cooler, Heat Exchanged and Keel Cooled, have less variation. This is due to the water being a more stable heat-sink, with resulting inlet manifold air temperatures being stable also. Air to air cooling methods, Radiators, are less stable with the ambient air being used to cool the charge air, leading to high output variability.

These engines have their rated power defined at standardised conditions; typically these are 25^{O} C air and 850 kg/m^3 fuel. As such operating in conditions away from these will likely cause engine power output to drop. This should be born in mind when designing engine room ventilation, so that ambient air temperatures are kept to a minimum.



1 Power adjustment - %.

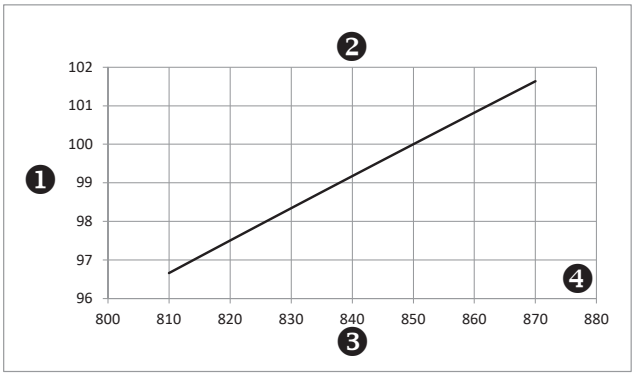
2 Engine power adjustment by ambient temperature. SAE J1995 rating standard.

3 Ambient temperature.

4 Radiator.

5 Heat exchanger & keel cooled.

P_{Baro} = 100 kPa
P_{vap} = 1 kPa
F_m = 0.614 (engine factor).
Turbocharged engines only.



1 Power adjustment - %.

2 Engine power adjustment by fuel density. SAE J1995 rating standard.

3 Fuel density - kg/m^3.

4 All cooling options.

Jacket Water Heaters

Jacket water heaters help to improve starting in ambient temperatures that are below 21 °C (70 °F) and will ensure quick winter start-ups whilst also reducing engine wear.

Note: The Jacket Water heaters are optional and not a standard engine requirement, the engine is already equipped with an automatic device for cold starting down to a temperature of -15°C.

Block Heater - Occasional Use

This block heater (Immersion type) is for occasional use only (figure 48).

The immersion style of Block Heater provides direct heat to the engine coolant and block.

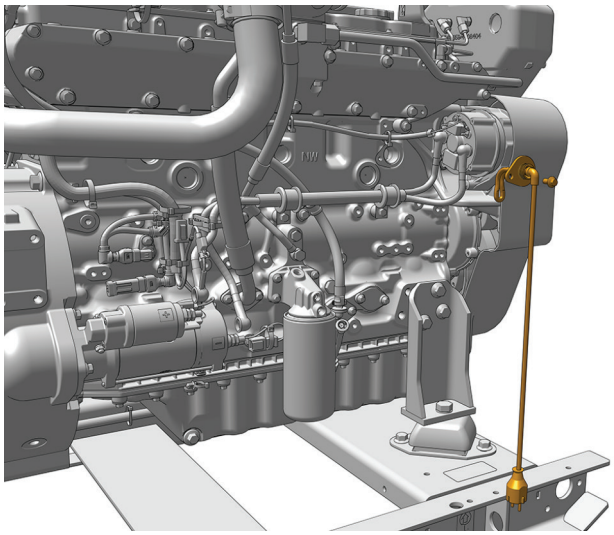


Figure 48

Operation

Depending on vessel wiring design and installation, plug in or switch on the jacket water heater 3-4 hours before you plan to start your engine.

Then, turn off the heater before you start the engine, failure to do so will prevent the jacket water heater from dissipating heat properly as the coolant can become turbulent when the engine is in operation and circulating coolant.

Caution: The heater element is NOT designed to be permanently switched on or in use while the engine is in operation, this will result in early heater failures.

Technical Data

The Block heater comes supplied with a cord and plug, depending on vessel design and local wiring regulations the heater can either be plugged directly into a local A/C power socket or hardwired into the vessels distribution board, this can allow the heater to be controlled remotely.

The heater can also be thermostatically controlled with a thermostat supplied from a third party, this measures the coolant temperature and regulates the engine block heater by cycling the heater on and off according to the temperature range setting of the thermostat.

Voltage - 240	
Power (Watts)	1000
Current (AMPS)	4.17

Voltage - 120	
Power (Watts)	1000
Current (AMPS)	8.33

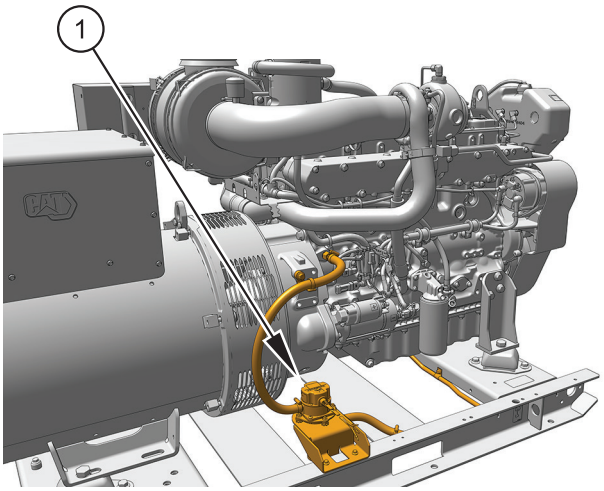


Figure 49

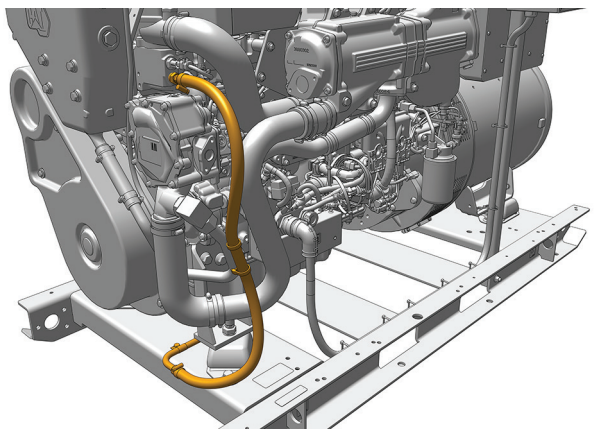


Figure 50

Jacket Water Circulation Heater - Continuous Use

The forced circulation Jacket Water heater is designed for standby and emergency applications that require an immediate start-up in cold weather conditions.

This off engine circulation heater is equipped with a built-in thermostat and integrated pump that continuously circulates warm coolant throughout the engine at uniform temperatures, figures 49 & 50.

Technical Data

Flow – 13.3 L/min at 28 kPa

Ingress – IP44

Temp Control (Fixed) – 38-49°C

Voltage - 240	
Power (kW)	1.5
Current (AMPS)	6.5

Voltage - 120	
Power (kW)	1.5
Current (AMPS)	13.0

Cord Length – 9.8’ (3m) no plug

The forced circulation heater is supplied with a

3 m cord and no plug, this allows the heater to be hardwired to the vessels distribution board or wired with a euro plug (Schuko) or NEMA plug and plugged directly into a local AC power supply.

Note: The heater must be connected to a suitable protective earthing conductor and the power supply to be protected by a suitable overcurrent limiting device. A means of disconnection from power supply is required and recommend that a power switch or circuit-breaker be located near the heater for safety and ease of use. Make sure installation is in line with local wiring regulations.

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 genset.

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

1 Propulsion engines.

2 Genset.

3 Sea cock.

4 Common bonding system wire in a ring as shown.

5 Through the hull metal fittings.

6 Zinc anode.

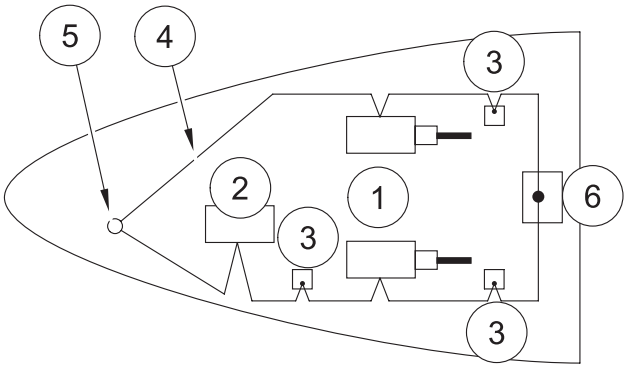


Figure 51

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 genset 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. A typical layout is shown in (A).

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 (6mm^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.

Use the earthing strap bolt (figure 51 item 1) to to ground the unit.

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

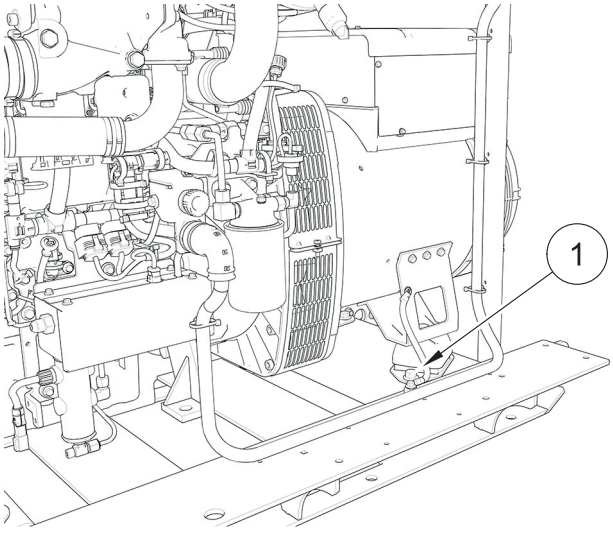


Figure 52

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.

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 genset.

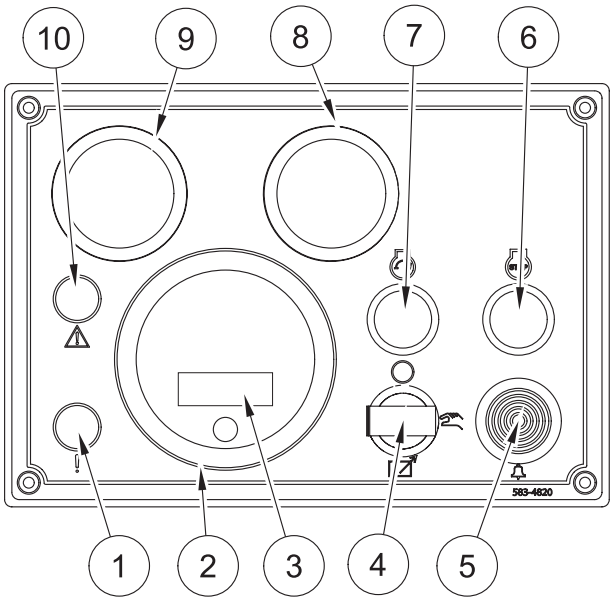


Figure 53

Control Panels

Marine Generator Gauge Panel 200 (MGGP 200) - If Supplied

Warning Indicator

7 Tachometer with LCD display for engine diagnostic information

8 LCD Display

9 3 Position Mode Select Switch

10 Horn

11 Local Engine Stop Push Button

12 Local Engine Start Push Button

13 Oil Pressure

14 Coolant Temp

15 Shutdown/Stop Indicator

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: 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° C (23° 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° C (5° 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)

Starter Cables

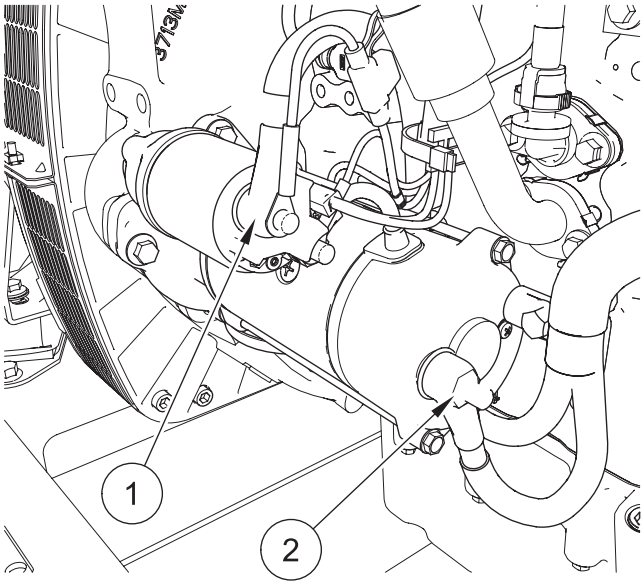


Figure 54

Starter Motor and Control System Connection

Typical starter motor arrangement is shown in figure 54.

1 Starter +ve

2 Starter -ve

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
Customer supply wiring size				
16 mm^2				

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’.

Battery and Starter Connections

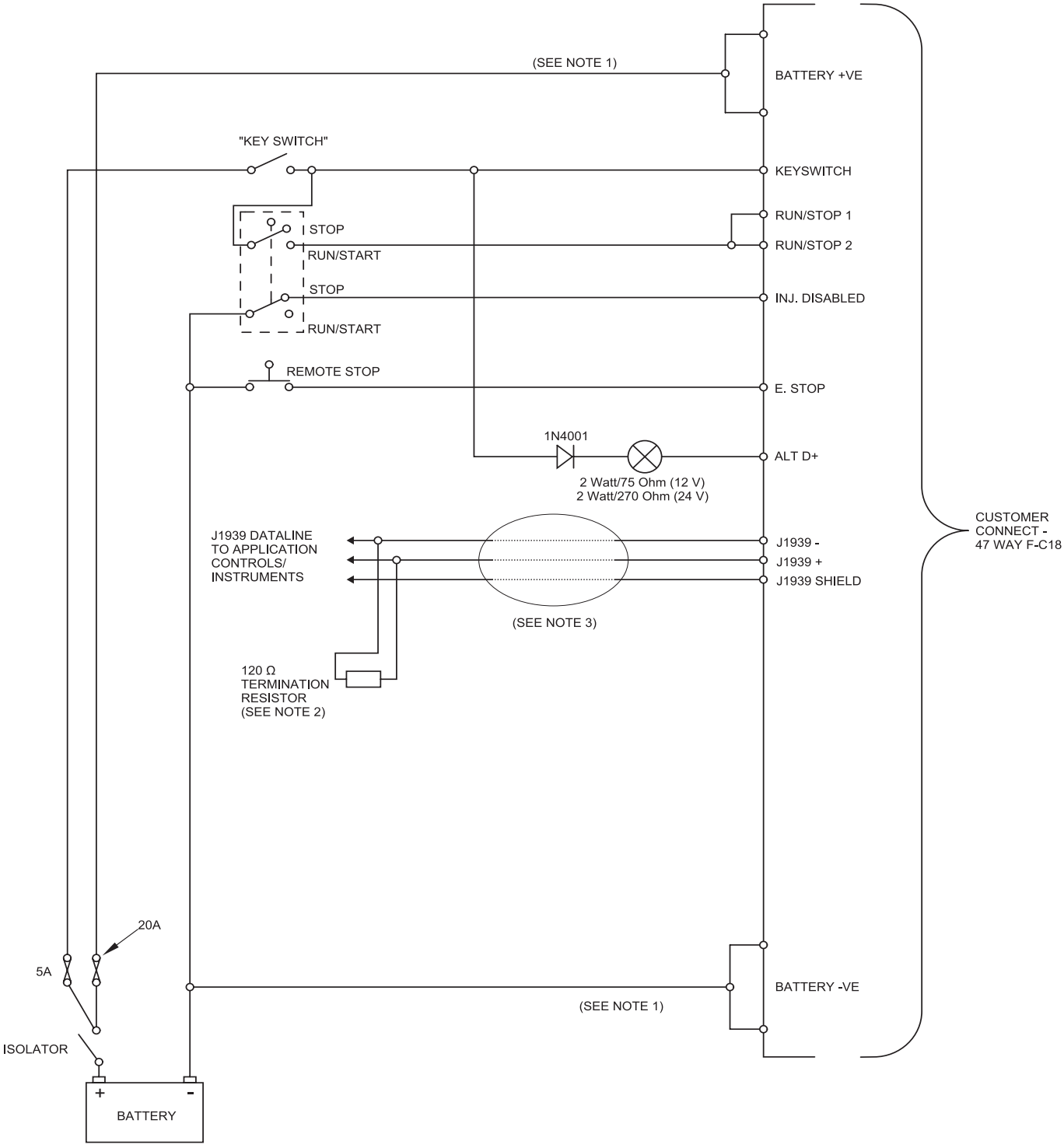
Note: Main supply for starter and supply for control and start aid must be run separately from the battery.

The following wiring diagram shows the battery and starter connections:

Wiring Diagrams

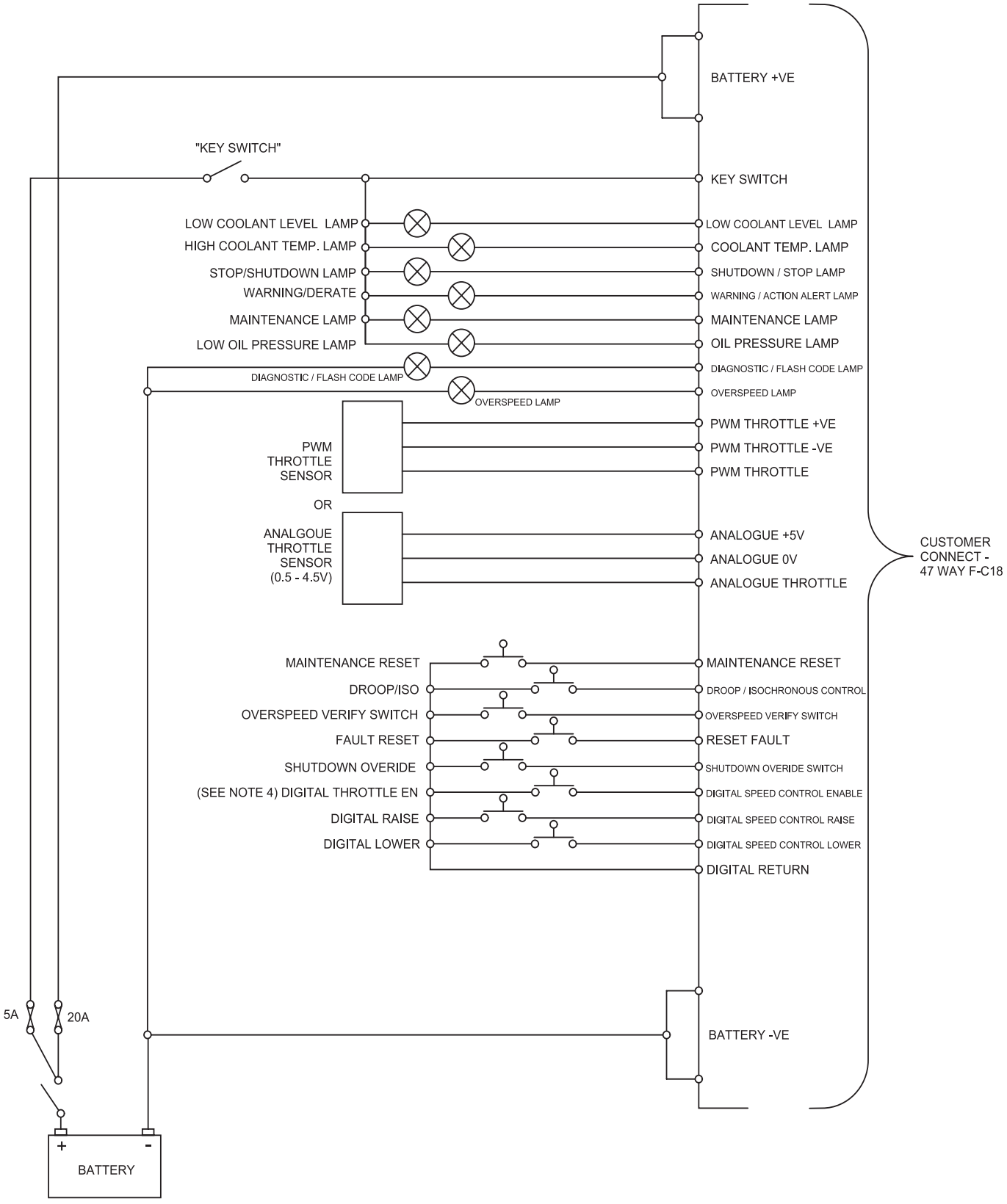
The following diagrams are for reference only. More detailed diagrams can be found on the Perkins Marine Website.

Basic Engine Wiring (Constant Speed)



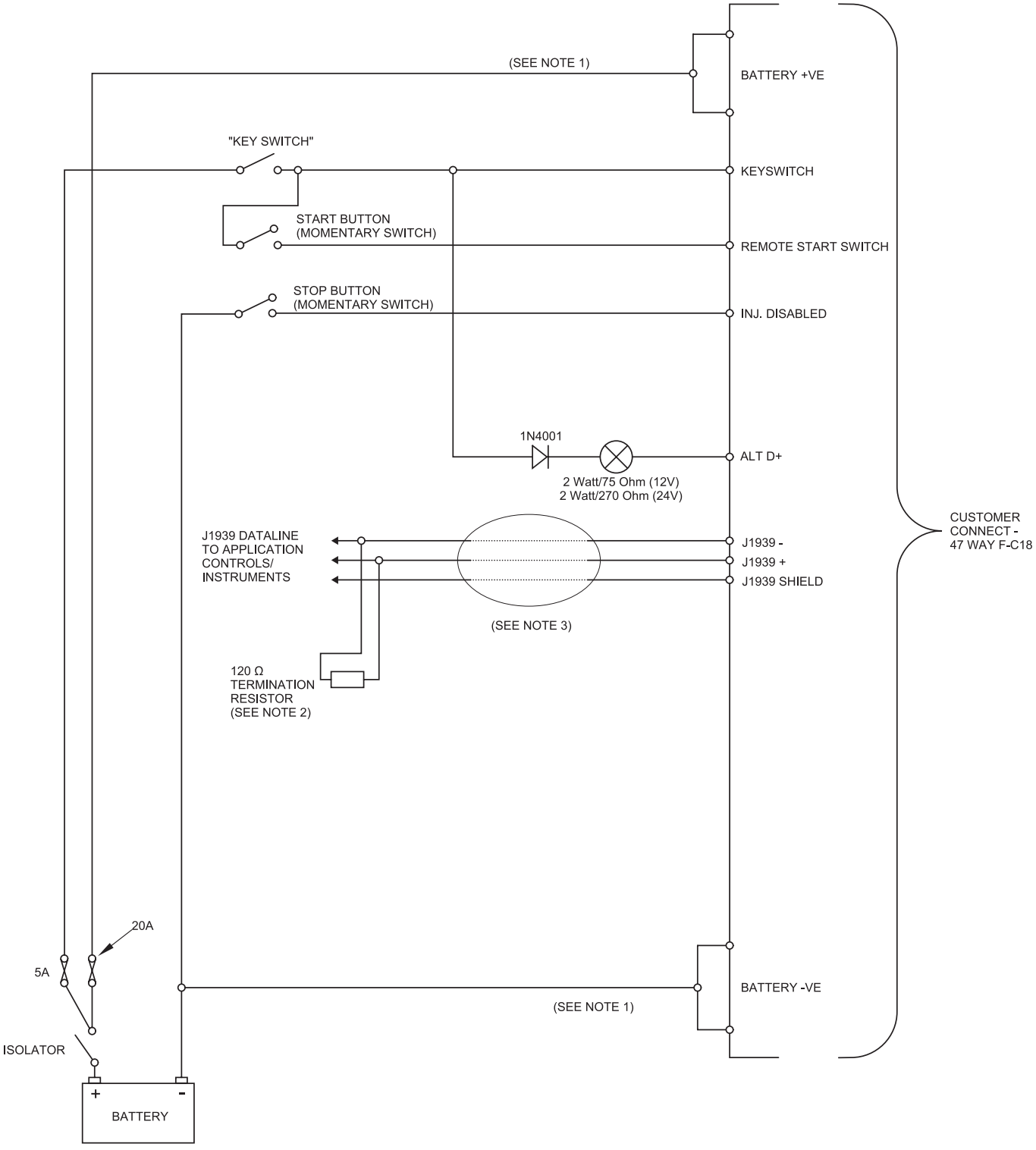
1. The main power supply wires to the ECM should be individually at least 1.5 mm² in size. The length of wiring between battery and ECM should also be kept as short as possible. These requirements apply to both ECM Battery Positive and ECM Battery Negative connections. See further section on ECM Power Supply.
2. Ensure 120 Ohm termination resistor is fitted at the control / instrumentation end of the J1939 data lanes.
3. The wiring should conform to the SAE J1939-15 or J1939-11 standard, being a twisted pair with approximately 1 turn per inch.

Throttle/Lamps/Inputs Wiring (Constant Speed)



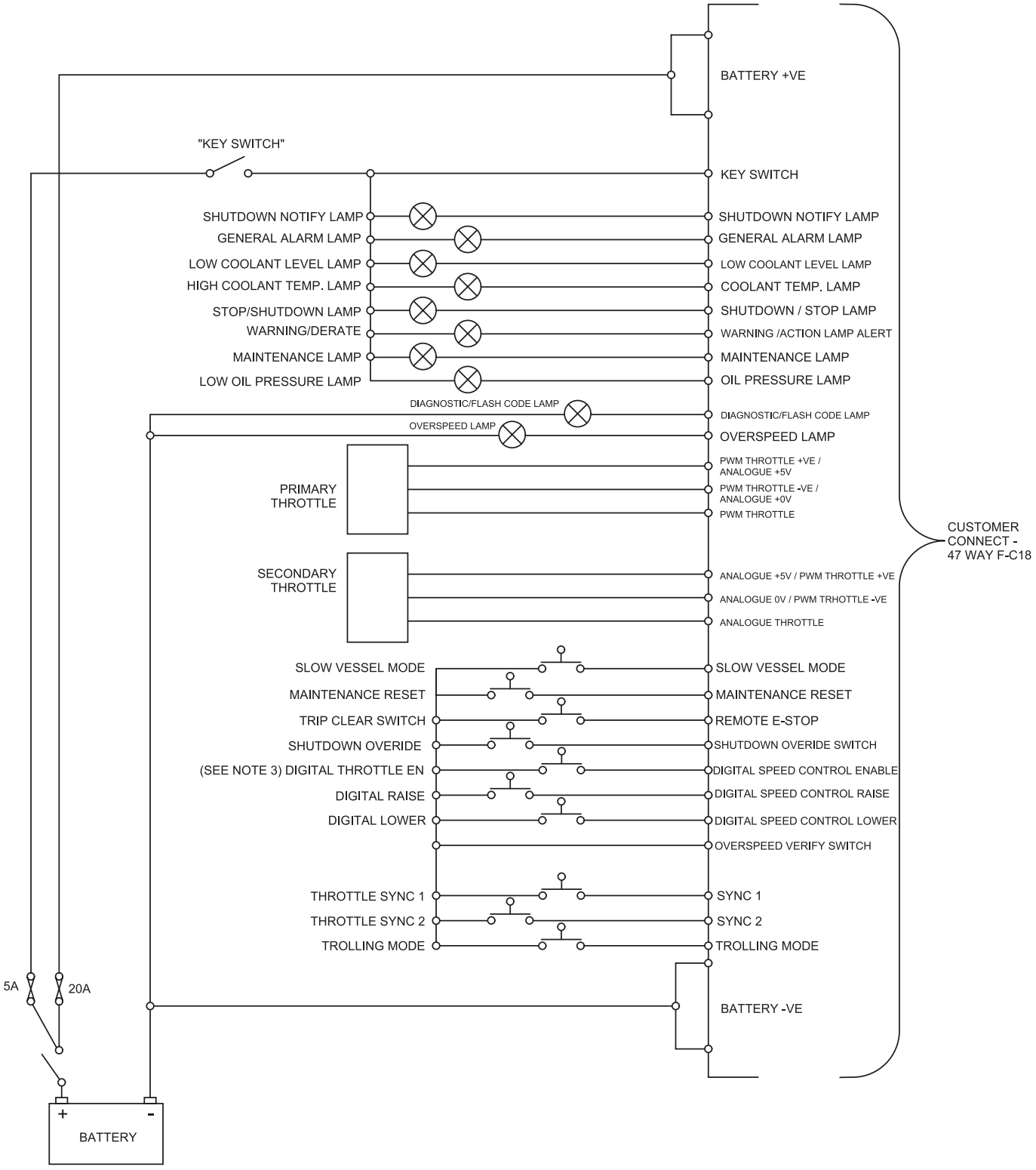
4. Link to ground if not using PWM/Anologue Throttle.

Basic Engine Wiring (Variable Speed)



1. 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.
2. Ensure 120 Ohm termination resistor is fitted at the control / instrumentation end of the J1939 data lanes.
3. The wiring should conform to the SAE J1939-15 or J1939-11 standard, being a twisted pair with approximately 1 turn per inch.

Throttle/Lamps/Inputs Wiring
(Variable Speed)



The basic auxiliary engine is supplied with a 47-way customer connector to which Perkins supplied control panels can be directly connected. If no panel is used then the following section details the interface provided on this connector to allow the engine to operate.

Basic Requirements For Engine To Function - Constant & Variable Speed

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 suggested positive and negative wiring. It is recommended that 1.5 mm² (16 AWG) wire is used to connect to the 47-way F-C18 customer connector. There are two pins for the positive connection and two 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 two positive wires and two negative wires. If required, the wire size should be increased externally from the 47-way connector. 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, Run/Start or Remote Start inputs (see later sections).

Remote Stop: A remote stop input is available. Connecting this input to battery negative will cause the engine to shut down. The engine will not start if this condition exists.

Indicator Lamps: The engine provides for a total of ten indication lamps. Out of these ten the Stop / Shutdown and Warning / Derate lamps must be 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.

There are six additional indicator lamps which can be connected to the engine. 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.

There are also two further lamp outputs, however these are sourcing outputs which will power the lamp. These require that the lamp is connected to battery negative. Refer to the table below for information on all ten of the lamp outputs.

Lamp Function	Customer Connect Description	Output Type	Constant Speed	Variable Speed	Description
Low Oil Pressure Lamp	Oil Pressure Lamp	Sinking	X	X	Activates when low engine oil pressure is detected
High Coolant Temperature Lamp	Coolant Temp Lamp	Sinking	X	X	Activates when high engine coolant temperature is detected
Overspeed Lamp	Overspeed Lamp	Sourcing	X	X	Activates when engine overspeed is detected
Maintenance Lamp (Also see Maintenance Reset Switch)	Maint Lamp.	Sinking	X	X	Activates when engine is due routine maintenance
Diagnostic / Flash Code Lamp	Flash Code Lamp	Sourcing	X	X	Displays engine diagnostics via flash code(s)
Low Coolant Level	Low Coolant Level	Sinking	X	X	Activates when low coolant level is detected
Shutdown Notify Lamp	Shutdown Notify	Sinking		X	Activates when the engine has shutdown or stopped
General Alarm Lamp	General Alarm	Sinking		X	Activates when any alarm or event is active
Stop / Shutdown Lamp	Shutdown / Stop Lamp	Sinking	X	X	Activates when the engine needs to advise the operator to stop the engine to protect the engine from damage
Warning / Derate Lamp	Warning / Action Alert / Derate Lamp	Sinking	X	X	Activates when the engine needs to advise the operator of an engine fault or event condition which needs operator attention

Digital Input Switches: There are nine additional digital inputs which can be connected to the engine. A switch can be connected between each input and the shared digital input return on customer connector.

Input Function	Customer Connect Pin Description	Constant Speed	Variable Speed	Description
Maintenance Reset Switch	Maintenance Reset	X	X	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	Droop / Isochronous Control	X		Allows the selection of either fixed speed isochronous governing or droop governing.

Shutdown Override Switch	Shutdown Override Switch	**X**	**X**	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	Reset Fault	**X**		Allows the reset of specific ECM diagnostics and events.
Overspeed Verify Switch	Overspeed Verify Switch	**X**		Allows to operator to acknowledge an overspeed event to allow the engine to be restarted.
Slow Vessel Mode	Low Idle Switch		**X**	Enables slow vessel mode – Switches low idle speed to extra low speed.
Trip Clear Switch	Remote E-Stop		**X**	Resets the ECM trip totals (Fuel and Hours)
Throttle Sync 1	Overspeed Verify Switch		**X**	Combined with Throttle Sync 2 logic selects if Primary or Secondary throttle inputs are used for desired engine speed.
Throttle Sync 2	Sync 2		**X**	Combined with Throttle Sync 1 logic selects if Primary or Secondary throttle inputs are used for desired engine speed.
Trolling Mode	Troll Mode		**X**	Enables trolling mode – Throttle range scaled with low top speed to improve precision of the throttle input.

CANBus (J1939): A J1939 CANBus connection is provided on the customer 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 a connection is provided on the 47 way customer connector for this purpose. The end of the bus should be correctly terminated with a 120 Ω resistor. The CANBus runs at 250 kbit/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 for constant speed engines the GC1 message can be used for engine start / stop control (SPN 3542). In order for 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

Constant Speed Specific Features

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 customer connector inputs Run/Stop Parity 1 and Run/Stop Parity 2. The engine is stopped by removing power from these two inputs. In addition, applying negative battery to the injection disable input will cause the engine to stop. The wiring diagram shows the suggested wiring, where the Run / Stop switch maybe either a switch or relay.

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 8 V or 5 V power provided on customer connector. 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.

Variable Speed Specific Features

Start / Stop: The engine maybe started and stopped using hardwired inputs to the ECM. To start the engine the key switch signal should be on, and the remote start switch input should be taken to key switch potential for the engine to crank. The remote start switch input should be deactivated once the engine is running. To stop the engine either remove the key switch input or applying negative battery to the injection disable input will cause the engine to stop. The wiring diagram shows the suggested wiring.

Engine Speed 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 8V or 5V power provided on customer connector. The specification of the sensor should be checked to ensure the correct power source is chosen.

For the specification of the PWM or 5V throttle signal, refer to the Constant Speed Specific Features section above.

For propulsion application it may be desirable to have a primary and secondary throttle connected. This can typically be used for synchronising engine speeds between multiple engine installations. If using a secondary throttle is desired, then the throttle sync inputs need to be used to select which throttle input (Primary or Secondary) is in use. Refer to the factory for further information.

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.

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.

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