Engine Operation & Maintenance

Engine Model:

SFGLD240 Gas

KOHLER®
Powered by
DRESSER-RAND®

Generator Set Models:

500REZK

See Inside Front Cover for Service Assistance Information

TP-7019 8/18b

⚠ WARNING: This product can expose you to chemicals, including carbon monoxide and benzene, which are known to the State of California to cause cancer and birth defects or other reproductive harm.
For more information go to
www.P65warnings.ca.gov

Service Assistance

For professional advice on generator set power requirements and conscientious service, please contact your nearest Kohler distributor or dealer.

- Visit the Kohler Co. website at KOHLERPower.com.
- Look at the labels and stickers on your Kohler product or review the appropriate literature or documents included with the product.
- Call toll free in the US and Canada 1-800-544-2444.
- Outside the US and Canada, call the nearest regional office.

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Dear Customers,

Please be advised that EPA regulation 40 CFR part 60 subpart JJJJ places certain requirements on owners and operators of new stationary spark ignition internal combustion engines. You have purchased a EPA pre-certified Guascor gas engine per 40 CFR part 60 subpart JJJJ and, therefore, should adhere to the compliance requirements for pre-certified engines Your engine has been certified for stationary emergency use only. As such, there is no time limit for use of this emergency stationary ICE engine in emergency situations - as determined by an authorized entity. However, the EPA does strictly regulate how much, and when this unit can be operated for non-emergency situations. Please consult the regulations for specifics.

This pre-certification does not exempt you from State or local air authority regulations. In fact, many State and local air authorities have adopted regulations more stringent than the EPA and will require on-site testing to their specific test protocols regardless of this pre-certification. We advise you to consult all applicable regulations in determining your compliance obligations and to check with your local authority to make sure your installation is in compliance with local laws and regulations.

Guascor engines will satisfy the aforementioned EPA regulations only if the engine configuration is not changed, the engine is commissioned by a factory technician, approved Dealer or Service Company technician, the engine maintenance schedule is followed, and the supply gas to the engines meets the following fuel specification IC-G-D-30-021. The Dresser-Rand business, part of Siemens Power and Gas Division, disclaims liability for all operational factors outside of its control, which may affect your engines emissions output.

Please contact Dresser-Rand if you have any questions about your engine's emissions performance.

Guascor Power, S.A.U., Sociedad Inscrita en el Registro Mercantil de Guipúzcoa, Tomo 1195, Folio 178, Sección 8, Hoja SS-3957 - C.I.F. A-48042709

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CHAPTER 1 – SAFETY FEATURES AND PRECAUTIONS

1. INTRODUCTION

All Kohler engines have been designed in accordance with European Machinery Safety Regulations, European Directive 2006/42/EC and the harmonised standards UNE-EN ISO 12100-1 and UNE-EN ISO 12100-2. Accordingly, we supply them with the EC Declaration of Conformity and «CE» mark.

The intention has been to supply an intrinsically-safe engine, although the nature of this machine does not rule out the possibility of potential risks, for which it is necessary to adopt certain safety precautions.

The aim of this document is to inform the users of Kohler equipment on the safety precautions which are required for handling and operating it adequately.

Engine installations and specially fuel-powered engines must be adapted in all cases to the local regulations.

2. PRELIMINARY OBSERVATIONS

We recommend you to read these safety precaution instructions on receiving your Kohler engine. They are part of the engine operation and maintenance manual we supply with each engine.

Therefore, we recommend that the manual be kept in perfect condition and readily available to the operator and those responsible for engine maintenance.

Our Network of Repair Shops is at your disposal to carry out revisions and repairs under the best conditions and in accordance with the standards established by Kohler.

The use of original spare parts ensures high performance over long periods of operation. These parts have been manufactured with the same strict quality controls, which were used for the manufacture of the original equipment.

3. BODILY PROTECTION

CAUTION

Wear approved bodily, sight, hearing and respiratory protection. Never wear loose clothing, jewellery or long hair around the engine.

4. EXHAUST GASES

CAUTION

IC engine exhaust products are toxic and may cause injury or death if inhaled. All engine installations must have an exhaust discharge pipe so that the exhaust gases are delivered into the outside air. A closed building or shelter must be adequately vented to provide a steady supply of fresh air.

5. ENGINE FUELS

CAUTION

If a gas engine has been cranked excessively without starting, shut off the gas fuel supply and continue cranking the engine to purge the cylinders and exhaust system of accumulated, unburned gas. If you fail to do this, a spark plug could ignite and cause an explosion.

Engine fuels may ignite or explode. These must be delivered to the engine with proper piping, free from leaks and designed to resist breakage from vibration.

6. POSITIVE FUEL SHUT-OFF

CAUTION

Some means of positive fuel shut-off should be provided for emergency use.

Pressurised fuels such as natural gas, landfill or digester gas should have another positive shut off valve (manual, automatic or valve train), other than those in the carburettor or gas pressure regulation equipment.

It is the final responsibility of the user to ensure that the installation is free from fuel or exhaust leakage and such installation meets all applicable codes.

7. SAFETY GUARDS

CAUTION

IC engines must be provided with guards to protect persons or structures from rotating or heated parts. It is the responsibility of the engine owner to fit such protection.

8. CRANKCASE GASES

WARNING

All the engines incorporate a crankcase gases vent to relieve pressure that builds up inside as a portion of the combustion gases flow in through the piston rings (blow by). Make sure the vent pipe is correctly fitted, allowing free passage of the gases.

9. COOLING SYSTEM PRESSURE CAPS AND CONNECTIONS

CAUTION

Do not remove the pressure caps while the engine is operating or while coolant is hot. The cooling system is under pressure and severe burns could result from the hot coolant spewing out when the cap is removed. Wait until the engine and coolants have cooled down before removing caps from the intercooler, thermostat box, radiator or surge tank. Always replace the weak hoses, lines and fittings.

10. IGNITION SYSTEM

CAUTION

Ignition systems can cause electric shocks. Avoid contacting ignition units and wiring.

A spark plug will fire if the storage capacitor in the electronic ignition module is connected. This may even happen when the cable is disconnected. When this cable is connected the capacitor will discharge and fire the spark plug which will ignite any gas which has accumulated in that cylinder. The crankshaft and driven equipment may rotate, possibly causing personal injury or damage to equipment. Gas which has accumulated In the exhaust system may also be ignited.

Before reconnecting the cabling of the electronic ignition module, shut off the supply of current.

Protect spark plugs, wires and coils from the rain and snow.

11. GENERATOR SETS

DANGER

The voltage produced by generator sets is dangerous for anyone who touches a part of the electrical system while this is working. Severe, possibly fatal shock may result from contact. Make sure the generator set is grounded before operation. Be extremely careful when the unit or surrounding area in damp or wet. When servicing any part of the electrical system or making any connections, make sure that the main power switch is off. Clean or service generator only when engine is shut down.

In case of an accident from electrical shock, shut down the generator set at once. If it cannot be shut down, free the victim from the live conductor.
Avoid direct contact with the victim. Use a dry board, dry rope or any non-conducting implement to free the victim. If the victim is unconscious, apply artificial respiration and get medical help.

Do not operate the generator set with the ammeter circuit open. Voltage, dangerous to both equipment and personnel, can be generated in an open secondary circuit of a current transformer.
If the generator set is stopped by operation of safety devices, do not attempt or operate until the cause has been eliminated.
When the generator set is shut down after operation, disconnect all line switches to all external power load and parallel circuits.

12. TIDINESS AND CLEANLINESS

WARNING

Tidiness and cleanliness are essential to endure a safe workplace. A tidy workspace with clean catwalks and well-ordered equipment and tools, allows one to do the job better and is an important factor in accident prevention.

13. ENGINE AND EQUIPMENT; REPAIR AND SERVICE

CAUTION

Always stop the engine before cleaning, servicing or repairing the engine or driven equipment. Place all controls in the off position to prevent accidental restarting. If possible, lock all controls in the off position and take the key. Put a sign on the instrument panel warning that the engine is being serviced. Before restarting, make sure that all tools and other material are removed from the engine and equipment.

Proper service and repair is important to the safe, reliable operation of the engine and related equipment. The procedures recommended by Kohler in this manual are effective methods for performing service and repair operations. Some of these procedures require the use of specially-designed tools. Special tools should be used when and as recommended. Anyone who uses a service, repair or installation procedure not recommended by Kohler must first satisfy themselves thoroughly that their safety will not be jeopardised by the service methods they selected.

14. ENGINE FAN BLADES

- Do not operate the engine with the fan bent, broken, modified or damaged in any way.

CAUTION

- Do not operate the engine if the fan contacts or strikes any engine accessory or the radiator shroud or core.
- Do not try to rebalance the fan. Contact the supplier if rebalancing is required.
- Ensure that all bolts attaching the fan are securely installed to a torque specified by the engine, vehicle or boat manufacturer.
- Install the fan so that it is directed correctly towards the radiator.
- Perform all required maintenance on the drive system, as described in this manual.
- Do not modify or substitute any parts of the engine without the approval of the Service Department of Kohler. Take special care not to make modifications which will increase the operating speed of the fan.

- Install the fan only if the engine has been approved for fan installation. Likewise, install a drive system defined by Kohler.

- If the fan or drive contains any plastic or rubber component, have the fan and drive inspected by a qualified mechanic after operation or exposure to excessively high temperatures (air temperature of over 120ºC).

- Replace the fan if indications of excessive corrosion or erosion appear in the fan.

- For reversible or adjustable pitch fans, make sure the blades are correctly locked in the proper position prior to operation. Also, inspect the fan prior to operation to ensure that ice and dirt have not accumulated on the fan to cause potential imbalance of the fan.

- Be sure that all fans, fan drives and belts are properly shielded.

15. TURBOCHARGERS

CAUTION

Turbochargers are designed specifically for each application. Turbochargers operate at high temperatures, therefore all inflammable material must be kept away from them. Engines must be shut down and at room temperature before working on turbochargers or burns will result.

16. ENGINE STORAGE CHEMICALS

DANGER

Protective oils contain a petroleum distillation, which is harmful or fatal if swallowed. Avoid contact with skin, eyes and clothes. Vapour is harmful and causes irritation of eyes, nose, throat and skin. Use only with adequate ventilation. Avoid breathing of vapour. Do not take internally. Keep container closed and away from heat. Always read and observe the <<CAUTION>> labels on the containers. Do not destroy the labels on the containers.

In general, protective compounds should not be heated over 90ºC. To heat at this temperature, the containers must be placed in a vessel with hot water. The cover must be removed and a hole must be made in the container to reduce the danger of explosion. Heating or direct heat is an unnecessary fire risk.

17. FIRE PROTECTION

WARNING

Locate fire extinguishers so that they are easily accessible if a fire start. Carefully maintain records of extinguisher inspection and recharging to ensure the fire extinguishing capabilities when required. Consult your fire extinguisher supplier or insurance engineering for recommendations required for the engine installation. It is also recommended to have well-identified fire emergency escape routes in all engine installations, in accordance with regulations.

18. CLEANING SOLVENT

CAUTION

Use approved cleaning solvents in a well ventilated area. Do not breathe fumes as some vapours can be fatal. Keep away from open flames or sparks. Do not use gasoline or paint thinners or other highly volatile fluids for cleaning. Always read and observe the <<CAUTION>> labels of containers. Do not destroy the labels on the containers. Cleaning solvents can cause various kinds of skin irritations.

19. WELDING EQUIPMENT

CAUTION

Welding gas cylinders can explode if damaged. Cylinders must be stored in accordance with manufacturer's specifications and applicable safety requirements.

When using acetylene, check valves should be installed between the regulators and hoses to prevent flashback into the regulators and supply tanks. Flashback could cause the regulators and supply tanks to explode.

Oily and greasy materials must be kept away from oxygen valves, hoses, etc. Oxygen, if combined with such materials, will cause and explosive reaction.

Always wear protective eyes shields when welding, cutting or watching welding operations. Protective clothing must be worn. Do not weld or cut near combustible materials.

20. GROUNDING PRECAUTIONS WHEN WELDING

CAUTION

When using an electrical welder on an engine, clip the ground lead as close to the welding site as possible. Putting the ground lead too far from the welding site may result in arching across the main bearings and fusing these to the crankshaft.

21. ELECTRICAL TOOLS

CAUTION

Make sure that electrical tools are properly grounded. Wear proper eye protection. Do not work in wet or damp conditions. Be sure that the tool is in good condition and safety guards are in position. An electric trouble light must also be grounded. Do not carry electric power tools by the cord. Do not yank the cord when removing from an outlet. Instead, grasp the plug to remove it from an outlet.

22. BATTERIES

CAUTION

Always disconnect the battery ground connection from batteries before performing any work on the engine or equipment. This will prevent sparks or burns when accidentally shorting an electrical connection.

Never expose batteries to open flame or electric spark. The chemical action of the battery produces hydrogenous gas which is inflammable and explosive. Do not allow the battery fluid to contact skin, eyes, clothes or painted surfaces. The electrolyte is a sulphuric acid solution, which could cause serious burns or damage equipment. Wear eye protection when working with batteries.

23. PRECAUTIONS WHEN USING BOOSTER BATTERIES AND CABLES

Do not attempt to jump start an engine having a frozen battery. The battery may rupture or explode. Before starting, examine all fill vents on the battery. If ice can be seen, or if the electrolyte fluid cannot be seen, do not attempt to start with jump cables. Batteries, charged and discharged, should be treated carefully when using jumper cables.

The following procedures assist in reducing sparks and explosion hazards always present in both batteries when connecting charged batteries to discharges batteries:

- Turn off all electrical loads. Remove vent caps and lay damp cloth over open vent well of each battery. The charged booster battery or batteries must have the same voltage capacity as the discharged battery or batteries.

- The positive post is identified by a <<+>>, pos. and red colour and is larger in diameter than the negative post.

- The negative post is identified by a <<->> neg, and natural lead colour (grey).

24. COMPRESSED AIR

Compressed air or gases should never be used to clean clothing or your body. Compressed air can pierce the skin and cause severe and very painful injury.

Never use your hand to check air, gas, or liquid flow rates, or check for leaks. Do not engage in <<horseplay>> with air, gas or liquid hoses. Observe all applicable regulations as related to compressed gases.

25. INTOXICANTS AND NARCOTICS

CAUTION

Anybody under the influence of intoxicants and/or narcotics is hazard to themselves and other employees.

26. SAFETY PRACTICES FOR HANDLING ACIDS

Cleaning with acid for certain castings and pieces of equipment is frequent. In handling them, follow these recommendations:

- Avoid contact with skin, clothing and eyes.
- Descaling operations should be performed away from all fire, spark or other ignition sources.
- Keep acid off of concrete floors because it attacks the lime in the concrete. If solution does get on concrete surfaces, apply an alkaline solution to neutralise.
- Acids can react with metals to form various gases. Generally, acid solutions on lime scale and rust result in the formation of harmless carbon dioxide. However, when acids contact aluminium, zinc, cadmium, tin, sulphur, arsenic or cyanide, poisonous and explosive gases may be generated. When descaling is done in closed equipment, install proper ventilation to carry the gases away.
- Always store containers closed, placing these in their normal position.
- Be sure that there are no leaks in the vessel being descaled, which will permit solution to leak into opposite side of equipment. Good practice is to fill the opposite side of the equipment being descaled with water to level higher than the acid solution.
- Use an acid-proof pump, or an inexpensive, throw-away pump.
- Do not agitate acid solutions with compressed air.
- Applications of acid should be followed by thorough rising, then neutralising with an alkaline solution to remove all acidic residue, to prevent further action.
- Store acid solutions in either an acid-proof wooden or synthetic rubber lined steel container.
- Check steel equipment to be treated with acid solution for copper or brass fittings or fusible metal plugs. If possible, dissimilar metals should be removed prior to descaling to prevent electrolytic action which might interfere with the inhibiting action of acid solution. Do not use acid to descale equipment constructed of aluminium.

27. ENGINE LIFTING AND HANDLING

- The use of cloth slings is recommended to avoid damaging the equipment with rough movements.
- Assure that the slings do not come into contact with sensitive parts of the equipment.
- Correctly inspect all anchor points so that there is no defective welding, loose screws, etc. that might jeopardize the lifting of the equipment.
- Verify that all pertinent structures have been inspected, are in good condition, and can support at least the weight of the equipment plus 10%. If you are not sure, weigh the equipment prior to lifting it.
- Prior to lifting it, be sure to balance the equipment to the maximum, using slings of different lengths if necessary.
- Keep all personnel away when the unit is in the air.
- Do not lift the equipment further than necessary.

REVIEW OF COMPLIANCE WITH EUROPEAN MACHINERY SAFETY REGULATIONS AND "CE" MARK

1. INTRODUCTION

This document describes all the design and operative features of our engines and their applications (generating sets or others) as well as the technical solutions that we have implemented to comply with the current machinery safety regulations. These include Royal Decree 1435/1992 and subsequent amendments, European Directive 2006/42/CE and the harmonised standards UNE-EN ISO 12100-1 and UNE-EN ISO 12100-2. Compliance with these is mandatory to be able to issue the Declaration of Conformity with the European Regulations and to use the "CE" mark.

2. ENGINE DESIGN

The check for compliance with the European Regulations on Machine Safety described in this document applies to Kohler gas and ethanol engines.

Those engines are mostly developments of their diesel counterparts whose design has passed technical audits by renowned certification agencies - Lloyd's Register, Bureau Veritas, Germanischer Lloyd's, Rina, Det Norske Veritas, Hellenic Register of Shipping, and others - for approval in marine applications and has been awarded the 'type approval' certificate that guarantees the suitability of the basic engineering design.

In designing and manufacturing the engines, Kohler follows risk suppression or reduction criteria, implementing adequate solutions and adopting the necessary protective measures when it is not possible to eliminate these risks. In this event, Kohler informs users of any residual hazards due to the incomplete effectiveness of the protective measures, advising them that they must have specific training and use personal protective equipment where necessary.

Similarly, in designing and manufacturing the machine as well as in writing the product information, Kohler bears in mind not only the normal use, but also any reasonably expectable use of the machine.

3. ENGINE ROOM

The engine room or the area surrounding the engine or generating set cannot be rated as a danger zone under current regulations since the running of the engine will under no circumstances give rise to the release of solids, liquids or heat in it that could affect the operators' safety.

Despite this, given that the engine's operation, service or control while running does not require anybody very close to it, we recommend that operators should stay at a suitable safety distance to prevent the effects of any fault or unforeseeable failure, should one occur.

Adjustment and fine-tuning operations (valve timing, oil and water level control, etc) are to be undertaken with the engine stopped. Only qualified and trained personnel must carry out carburetion adjustments with the engine running according to the set procedures, without putting any of the operators in danger.

4. RISK ANALYSIS

In designing the engines, we adopted technical options or solutions that avoid intrinsic and specific engine operation hazards.

Nevertheless, due to the very concept of the machine and its operation, there still exist various unavoidable, though limited hazards, representing a risk for the operator.

This section reviews the design solutions implemented to overcome any machine-specific risks and the preventive measures against unavoidable risks.

Kohler will not be liable for any injury or damage arising from any use of the engine
other than that described in the instruction manual. Operating the engine beyond its nominal conditions (e.g. in terms of power, ignition advance, mixture strength - carburetion, etc) can have serious consequences for the user or even put the user's life at risk and cause extensive material damage.

4.1. MATERIALS AND PRODUCTS

The materials and products used for the construction and operation of the machine do not involve any health or safety hazard as long as operators follow the user instructions and current regulations.

4.2. EQUIPMENT DRIVES

The drive systems are safe and reliable, with clearly identified and visible controls, including adequate alarms as well as normal and emergency stop devices.

4.3. MECHANICAL HAZARDS

The equipment supplied has been designed and built to offer sufficient stability under the planned operating conditions. Its components are designed for appropriate resistance in operation. Product information sheets specify the necessary inspection and maintenance programmes for safety's sake.

We design and manufacture the moving parts of the engine to avoid any risk. Therefore they incorporate guards or protective systems impeding physical contact that would cause injuries or accidents. Drive components (pulleys, belts, gears, etc) have covers that can be fixed or are movable depending on the frequency of servicing tasks. All protective devices are made solidly and resistant.

4.4. ELECTRICAL HAZARDS

The engines' design, construction and equipment prevent or ensure possible prevention of all electrical hazards. Refer to the "Electrical installation" section. The engines also have static elimination systems.

4.5. FIRE, EXPLOSION AND HIGH TEMPERATURE HAZARDS

We have taken precautionary measures to avoid injuries caused by hot parts or materials through physical contact or remotely. We also addressed the risk of flying hot matters and avoided fire and overheating hazards originating in the engine.

Various types of fluids of varying properties circulate through the engine at varying temperatures.

4.5.1. COOLING WATER

By design, all the connections in the water circuit are fitted with mechanical seals and/or bushed systems with ethylene propylene O-rings, suitable for the high temperature of the engine coolant in the main system (120 ºC) and in the auxiliary circuit (90 ºC). Therefore no rubber couplings are used.

4.5.2. LUBRICATING OIL

The oil circuit has been designed fully integrated into the engine so that the only outgoing pipes are those to and from the oil cooler. Sealing of all the tubes is through mechanical seals or bushed systems with Viton O-rings, avoiding the use of rubber couplings by all means.

4.5.3. FORCED INDUCTION

In the supercharging circuit (downstream of the turbocharger), the components are sealed is mechanically with Viton O-rings. Rubber sleeves and other materials have been totally discarded.

4.5.4. MANIFOLDS AND EXHAUST PIPE

To limit leak risks, the engine exhaust manifolds are mechanically sealed with special metal-reinforced joints.

For the purposes of protecting the operators from accidental contact, we have designed a cooled exhaust manifold with the engine cooling water circulating outside and around it so that the temperature on the exhaust manifold surface, otherwise 400 to 500 ºC, falls to the coolant temperature levels of 80 to 90 ºC.

As for the turbocharger, the turbine casing (exhaust side) is also very hot and cannot be cooled but is protected with a heat-insulating blanket (or jacket) limiting the surface temperature to less than 90 ºC. This solution also applies where the engine application requires the use of hot (uncooled) exhaust manifolds.

A similar type of protection covers that part of the exhaust elbow or pipe extending to the connecting flange on the hose for connection to the external exhaust pipe. The installation project must protect this exhaust pipe. When supplying the installation, we check for any contact with this piping and, where appropriate or for exhaust heat recovery if desired, we protect the pipe with a stainless steel lined heat-insulating blanket.

4.6. VIBRATION

Engine vibrations do not affect operator safety, although they could be transmitted through the engine mounting to other machines or to the building, causing a nuisance for people in the neighbourhood. Engines for applications where structure-borne vibrations are likely to occur will be isolated from their support by elastic vibration absorbers.

We also use flexible elements to connect all the utilities (water, fuel, oil, etc) to the outside of the engine.

4.7. NOISE

Noise generation is inherent to the engine and is generally inevitable although design approval is conditioned to a sustainable sound level when adequate and necessary means of protection are used.

Ear protection is necessary for all the people present in the engine room when the engines are running. Therefore, at the entrance to the engine room, there must be a clear and visible warning of the obligation for the operators to wear ear protection.

No type of ear protection is specified, as the certified personal protective equipment usually available on the market is considered suitable.
As regards noise outside the engine room (environmental noise pollution), it is necessary to install - and we do install in all cases - adequate exhaust silencers to meet the local or environmental rules and regulations in force where the engines operate.

4.8. ELECTRICAL INSTALLATION

The engine’s electrical installation consists of one terminal box for the connection of 24 V DC and 220 V, 400 V, 480 V, etc, devices, including sensors, contacts, etc. This terminal box and the wiring for these devices comply with the low voltage wiring regulations and Directive 73/23/EEC as amended by Directive 93/68/EEC. There is a switch on the front of this box for immediately stopping the engine in an emergency.

4.9. FUEL SYSTEM

- *GAS*

The gas system design always conforms to the applicable regulations (UNE 60.620) and comprises the following elements:

ERM. Gauge and meter panel built to the applicable standard for this type of engine to ensure a gas supply under the set pressure conditions.

VALVE TRAIN. Set of elements comprising a hand-operated shut-off valve, gas filters, a pressure control gauge, a double normally-closed solenoid valve to stop the gas flow to the engine and a venting line for leaks control or electronic leak control, all consistent with the standard specifications.

CONNECTIONS TO THE ENGINE, by DIN flanges and homologated hoses in all cases.

ENGINE-MOUNTED PRE-CARBURATION PIPING designed with a minimum of development and connections. In any case, the pipes are made to the installer's standards and checked for leaks during the engine tests.

POST-CARBURATION AIR/GAS MIXTURE PIPING. The whole circuit has been mechanically sealed with Viton O-rings (all rubber or silicone couplings have been suppressed).

- *ETHANOL*

The ethanol fuel system includes:

ERM. Gauge and meter panel built to the applicable standard for this type of engine to ensure an ethanol supply under the set pressure conditions.

VALVES Set of elements comprising a hand-operated shut-off valve, ethanol filters, a control pressure gauge and a double normally-closed solenoid valve to stop the ethanol flow to the engine, all in accordance with the specifications as required by regulation.

CONNECTIONS TO THE ENGINE in all cases by DIN flanges, NPT couplings and authorised hoses.

ENGINE-MOUNTED PIPING designed with a minimum of development and connections. In any case, the pipes are made in accordance with standards and checked for leaks during the engine test phase. To ensure sealing and avoid any incident, the solution adopted includes double layer hoses using a stainless braid without any type of elastomer that deteriorates on contact with ethanol.

Both fuel systems (gas and ethanol) come equipped with the following additional safeguards:

"BACKFIRING" or "DETONATION" PROTECTION. In a gas engine, backfiring may happen when burning of the fuel mixture takes place in the intake manifold because damaged valves do not seal the combustion chamber hermetically. Detonation occurs if the mixture strength varies out of control or when the mixture self-ignites in contact with hot surfaces.

Two forms of protection or safeguards have been adopted as a direct protection against these phenomena. The mechanical resistance of the equipment (as regards intake manifold joints, ribs, etc) has been increased with respect to the normal design specification (diesel type) and two pressure-relief valves have been installed in the intake manifold to permit a pressure leak while preventing any overload of the manifolds.

Indirect protection is provided by the engine's own control and regulating systems which have been designed to protect the engine against erratic or abnormal operation.

4.10. BLOW-BY GASES

Because it is impossible to have the combustion chamber completely sealed, combustion gases always accumulate in the crankcase and can give rise to oil splashing outside due to overpressure in the crankcase. To prevent this occurrence, all the engines come complete with an explosion relief valve to expel those gases, which are fed back after filtering into the engine intake system on environmental protection grounds.

4.11. EXHAUST FUMES

The emission of exhaust fumes is intrinsic to the engine's function and is thus inevitable. There are clear and specific instructions for installing exhaust gas piping to eliminate the risk of contaminating the engine room.

Those instructions specify the requisites for the exhaust piping layout, how to calculate the pipe diameters, standards for the placement of expansion joints, etc.

4.12. MAINTENANCE

Maintenance tasks must be undertaken with the machine idle. The maintenance, adjustment, lubrication and upkeep points lie outside dangerous areas. Staff can work safely and at ease and the reasons for their intervention are limited.

4.13. INFORMATION

Product information necessary for using the equipment is clear, concise and easy to understand. The machines include alarm systems that report any malfunction of the machine and warn exposed persons of possible risks. There are signalling devices (dial gauges, control panels, etc) on the equipment as well as warning signs informing of potential non-evident persistent hazards through icons that everybody understands.

All engines are delivered with a minimum of safety devices and operational controls and although their primary function may not be to protect operators, they do protect them indirectly by preventing malfunctions or inadequate operation.

The following information is legibly and indelibly available on each machine: nameplate (manufacturer's name and address, model, serial number, year of manufacture, power, fuel gas quality and pressure requirements), and specific "CE" mark tag. The product information also contains all the necessary instructions for the safe operation of the machine.

On the non-moving parts of the engine there are strong lugs for the safe handling of the engine with conventional lifting equipment. The product information also clearly states the engine's weights needed for tis suitable transport.

4.14. INSTALLATION, OPERATION AND MAINTENANCE INSTRUCTION MANUALS

Each machine has its instruction manual containing a reminder of the data required for the marking, except the serial number, as well as the instructions for easy maintenance, conditions of intended use, instructions for safe commissioning, operation, handling (including information about the machine's weight), installation, assembly, disassembly, adjustment, maintenance (preventive and corrective), and counter-indications.

Kohler has prepared an instruction manual in Spanish, English, French, German
and Italian. This manual must be kept close to the machine, when put into service. The mechanic's handbook, intended for specialist staff who source from the manufacturer, is available in English or Spanish. According to the standing regulations, to use the "CE" mark, it is compulsory to have the engine instruction manuals available in the official language of the member state in which the engine operates. Fulfilment of these regulations will be achieved by translating the current Installation, Operation and Maintenance Instruction Manuals in pace with the sales of our engines to the various countries in the European Union.

The instruction manuals include all necessary drawings and diagrams to install, operate, maintain and inspect the machine and check it for correct operation, and make any repair, if needed, in addition to other relevant recommendations, especially in relation to safety issues. Kohler has prepared the following manuals in compliance with the Machinery Safety Directive:

- Installation Manual (installation and start-up).
- Operation and Maintenance Manual (maintenance, inspection, safety and correct operation testing).
- Spare Parts Manual (list of spare parts for the equipment).
- Mechanic's Manual (specialist inspection and repair of the equipment).

Catalogues and other documents used to present the machine are consistent with the instruction manuals as regards safety. The Installation Manual provides assembly and installation recommendations to reduce noise and vibration (dampers, foundations, etc). Data on the machine’s airborne noise appear in the Instruction Manuals.

Engines are installed according to a specific installation manual for each application. This manual includes:

- General engine dimensions drawing.
- Engine peripherals drawing (includes information for installing all the necessary peripherals for engine operation - water, oil, fuel, exhaust, etc).
- Specific installation instructions for each peripheral.
- Specific instructions for engine complements or optional and additional devices (not mandatory).

The operation and maintenance manuals for each engine are written so the operator has readily available information for:

- The identification of the machine and its components.
- Instructions for proper adjustment and start-up.
- Operational instructions.
- Maintenance instructions (frequency of maintenance operations). These are of major importance as a direct safety element to insure proper engine condition and operation.

5. SAFEGUARDING AGAINST MALFUNCTION

The monitoring and safety systems, that verify the engine operating condition through the measurement of its major parameters, activate PREVENTIVE warning signals when current values exceed the predetermined setpoints or immediately STOP THE ENGINE if the alarm threshold is reached.

In any event, in prevision of any potential monitoring system failure, all gas engines are fitted with a communication and junction box connected to the electric control panels. This box, placed ON THE ENGINE, includes an EMERGENCY STOP SWITCH for the deliberate and immediate stoppage of the engine.

In all cases there is also an engine-mounted EMERGENCY STOP LEVER which, once operated MANUALLY and deliberately, blocks the air/gas supply to the engine immediately, causing the engine to stop at once.

6. SAFETY PRECAUTIONS

In all instances, together with the engine operation and maintenance documentation, we deliver Product Information IC-G-D-60-002e “Kohler gas engine safety precautions” which describes preventive measures for handling our engines and their environment.

7. CONCLUSION

The above review allows us to conclude that Kohler **engines have been designed in full awareness of and in compliance with the machinery safety regulations requirements,** as specified in Directive 2006/42/EC and the harmonised standards UNE-EN ISO 12100-1 and UNE-EN ISO 12100-2. Consequently, it is right to issue the relevant Declaration of Conformity and to use the "CE" mark that guarantees it.

Related product information:

- **IC-G-D-00-040e:** "General gas engines construction description.”
- **IC-L-D-00-001e:** "General ethanol engines construction description."
- **IC-G-D-60-002e:** "Safety precautions for engines."

NOTE

All certificates that support the statements and conclusions in this report have been documented and submitted to external auditing.

SOUND PRESSURE LEVEL IN GAS ENGINES

1. INTRODUCTION

The purpose of this information is to define the noise emission levels in Kohler gas engines.

2. ACOUSTIC DEFINITIONS

Decibel
Logarithmic unit that relates an energy magnitude with another, similar, magnitude accepted as a reference.

Sound power
Energy that a sound source emits to the surrounding medium by time unit.

Sound pressure
Atmospheric pressure variations at one point, produced by the propagation of a sound wave.

3. NOISE EMISSION AT 1200 RPM

The following table shows the **sound pressure** distribution in octave frequency bands and the total sound level with the engine running continuously at **1200 rpm and at 100% power.**

ENGINES F/SFGLD		180	240	360	480	560
LpA IN FREQUENCY BANDS (Hz)	125	--	59	--	66	71
	250	70	73	69	70	79
	500	82	79	76	76	81
	1000	84	85	82	81	83
	2000	81	83	83	80	84
	4000	76	77	79	73	79
LpA, ∑ dB(A)		88	88	87	85	89

HGM ENGINES		560
LpA IN FREQUENCY BANDS (Hz)	125	71
	250	77
	500	79
	1000	81
	2000	88
	4000	83
LpA, ∑ dB(A)		90

Notes

- Sound power levels obtained as per the **ISO 9614-2** standard.
- Sound pressure levels measured at 1 m from the engine, calculated as per the **UNE-EN ISO-11203:1996** standard.
- The uncertainty of the results is for class 3 determinations with a maximum standard deviation of σ **= ∓ 4 dB(A)**.

4. NOISE EMISSION AT 1500 RPM

The following table shows the **sound pressure** distribution in octave frequency bands and the total sound level with the engine running continuously at **1500 rpm and at 100% power**.

F/SFGLD/SFGM ENGINES		180	240	360	480	560
LpA IN FREQUENCY BANDS (Hz)	125	--	72	70	73	76
	250	73	82	81	83	92
	500	83	87	86	88	89
	1000	87	90	88	90	89
	2000	84	89	86	89	89
	4000	79	86	80	82	85
LpA, ∑ dB(A)		90	95	92	95	97

HGM ENGINES		240	420	560
LpA IN FREQUENCY BANDS (Hz)	125	73	71	73
	250	83	81	83
	500	85	84	85
	1000	88	87	88
	2000	92	90	92
	4000	89	89	89
LpA, ∑ dB(A)		96	94	96

Notes

- Sound power levels obtained as per the **ISO 9614-2** standard.
- Sound pressure levels measured at 1 m from the engine, calculated as per the **UNE-EN ISO-11203:1996** standard.
- The uncertainty of the results is for class 3 determinations with a maximum standard deviation of σ **= ∓ 4 dB(A)**.

5. NOISE EMISSION AT 1800 RPM

The following table shows the **sound pressure** distribution in octave frequency bands and the total sound level with the engine running continuously at **1800 rpm and at 100% power.**

F/SFGLD/SFGM ENGINES		180	240	360	480	560
LpA IN FREQUENCY BANDS (Hz)	125	--	70	--	70	73
	250	76	86	74	84	87
	500	88	84	90	84	85
	1000	91	89	85	88	87
	2000	87	87	87	89	91
	4000	83	83	82	83	86
LpA, ∑ dB(A)		94	94	93	93	95

HGM ENGINES		240	420	560
LpA IN FREQUENCY BANDS (Hz)	125	67	--	70
	250	77	74	84
	500	80	88	82
	1000	88	83	86
	2000	91	90	92
	4000	87	87	88
LpA, ∑ dB(A)		94	94	95

Notes

- Sound power levels obtained as per the **ISO 9614-2** standard.
- Sound pressure levels measured at 1 m from the engine, calculated as per the **UNE-EN ISO-11203:1996** standard.
- The uncertainty of the results is for class 3 determinations with a maximum standard deviation of **$\sigma = \mp 4$ dB(A)**.

1. INTRODUCTION

The purpose of this information is to define the noise emission levels in the Kohler gas engine exhausts.

2. ACOUSTIC DEFINITIONS

Decibel

Logarithmic unit that relates an energy magnitude with another, similar, magnitude accepted as a reference.

Sound power

Energy that a sound source emits to the surrounding medium by time unit.

Sound pressure

Atmospheric pressure variations at one point, produced by the propagation of a sound wave.

3. NOISE EMISSION AT 1200 RPM

The following table shows the **sound pressure** distribution in octave frequency bands and the total sound level with the engine running continuously at 1200 rpm and at 100% power.

F/SFGLD ENGINES		180	240	360	480	560
LpA IN FREQUENCY BANDS (Hz)	63	94	96	96	94	98
	125	106	109	109	111	109
	250	106	113	113	112	112
	500	112	115	115	119	117
	1000	108	111	112	116	113
	2000	109	113	113	117	113
	4000	109	112	114	116	114
LpA, ∑ dB(A)		117	120	121	124	121

HGM ENGINES		560
LpA IN FREQUENCY BANDS (Hz)	63	99
	125	109
	250	115
	500	116
	1000	114
	2000	114
	4000	116
LpA, ∑ dB(A)		122

Notes

- Sound power levels obtained as per the **ISO 9614-2** standard.
- Sound pressure levels measured at 1 m from the engine, calculated as per the **UNE-EN ISO-11203:1996** standard.
- The uncertainty of the results is for class 3 determinations with a maximum standard deviation of σ **= ∓ 4 dB(A).**

4. NOISE EMISSION AT 1500 RPM

The following table shows the **sound pressure** distribution in octave frequency bands and the total sound level with the engine running continuously at 1500 rpm and at 100% power.

F/SFGLD/SFGM ENGINES		180	240	360	480	560
LpA IN FREQUENCY BANDS (Hz)	63	97	99	100	98	102
	125	118	121	121	124	121
	250	124	127	126	125	125
	500	113	116	119	124	122
	1000	112	115	117	121	118
	2000	110	114	115	119	115
	4000	106	109	110	111	109
LpA, ∑ dB(A)		126	128	129	130	129

HGM ENGINES		240	420	560
LpA IN FREQUENCY BANDS (Hz)	63	100	105	102
	125	121	119	122
	250	129	129	128
	500	116	116	122
	1000	116	115	119
	2000	115	113	117
	4000	112	111	112
LpA, ∑ dB(A)		130	130	130

Notes

- Sound power levels obtained as per the ISO 9614-2 standard.
- Sound pressure levels measured at 1 m from the engine, calculated as per the UNE-EN ISO-11203:1996 standard.
- The uncertainty of the results is for class 3 determinations with a maximum standard deviation of σ = ∓ 4 dB(A).

5. NOISE EMISSION AT 1800 RPM

The following table shows the **sound pressure** distribution in octave frequency bands and the total sound level with the engine running continuously at 1800 rpm and at 100% power.

F/SFGLD/SFGM ENGINE		180	240	360	480	560
LpA IN FREQUENCY BANDS (Hz)	63	99	101	102	99	102
	125	128	131	131	127	125
	250	128	131	131	134	134
	500	120	123	126	130	128
	1000	115	118	119	123	120
	2000	112	116	116	119	115
	4000	105	108	110	112	110
LpA, ∑ dB(A)		132	135	135	136	135

HGM ENGINES		240	420	560
LpA IN FREQUENCY BANDS (Hz)	63	102	106	103
	125	131	129	125
	250	133	133	136
	500	122	123	127
	1000	119	117	121
	2000	117	114	117
	4000	110	111	113
LpA, ∑ dB(A)		136	135	137

Notes

- Sound power levels obtained as per the ISO 9614-2 standard.
- Sound pressure levels measured at 1 m from the engine, calculated as per the UNE-EN ISO-11203:1996 standard.
- The uncertainty of the results is for class 3 determinations with a maximum standard deviation of $\sigma = \mp 4$ dB(A).

GUIDE TO ENVIRONMENT-FRIENDLY WASTE MANAGEMENT DURING PRODUCT MAINTENANCE AND AT END OF LIFE

1. INTRODUCTION

Waste generated during the maintenance of Kohler equipment, or at the end of their useful life, demands environmentally correct management. This guide establishes adequate environment-friendly waste management procedures that aim at keeping the environmental impact as low as possible and at boosting waste recycling and valorisation processes.

It is thus essential to disassemble, handle and manage the parts, components and waste removed from Kohler machines according to the waste management procedures that legislation prevailing at the equipment's operating site might provide from time to time.

Most components of the machines are ferrous and non-ferrous materials (scrap) that are usable as raw materials in the iron and steel industry. All other non-reusable waste products will be disposed of to landfill sites. When performing the a.m. disassembling, removal and handling operations, it is necessary to bear in mind the impact they may have on the environment, including but not limited to contamination resulting from inadequate arrangement of stored supplies or from ground pollution at the place where said operations are carried on.

The environmental impact that improper handling of waste products may cause further originates in machines containing hazardous substances that must be considered throughout the operations said machines undergo.

2. DECONTAMINATION AND DISASSEMBLY

ATTENTION

Maintenance staff shall decontaminate the machine, stripping it of all the parts that contain hazardous substances and are classified as hazardous waste (see further below). Only if it is planned to reuse the complete engine block is it admissible to keep it lubricated, omitting to extract oil.

The area assigned to decontamination operations shall comprise pollution prevention systems against accidental spillage while handling the machines (sealed collection boxes) and (whenever possible) grease separation and settling systems. Likewise, provisions shall be made to store decontamination process waste under cover and separately in adequate containers, such as containers for batteries or sealed tanks for each type of liquid waste (fuels, oils, coolants, etc.). Those tanks must have individual retention basins per type of waste, or similar systems to ensure possible overflow containment.

All collected dangerous waste shall be forwarded, separately and subject to prior acceptance, to authorised hazardous waste managers.

Decontaminated machines, which thus rank as NON-HAZARDOUS WASTE, shall undergo the following process: disassembly and sorting of components and special waste products capable of reuse or recycling. This type of waste includes metallic components that contain copper, aluminium and magnesium, electric parts and plastic items.

It will thus be necessary to do the following: remove the battery as soon as possible, extract fuel and all other fluids, materials and components classified as hazardous waste, discharging them into their respective, properly tagged containers. Draining all the fluids must be carried on in the appropriate manner to minimise hazardous waste generation at subsequent pressing and fragmentation processes and to make recycling easier. The fluid removal means (funnels, drums, pumps, etc.) shall be assigned to one single duty exclusively and be duly identified and tagged to prevent using them for other duties. For instance, gas oil extracting means shall differ from lube oil draining equipment.

3. STAFF TRAINING

Operators in charge of decontamination and disassembly shall receive adequate information and training to ensure they qualify to do the jobs involved. Besides maintenance of the equipment to prevent contamination in the event of accidental spillage or leakage, training shall cover safety procedures in relation to: (i) the storage and labelling of hazardous chemicals (pollutant, inflammable, toxic, harmful, etc.); (ii) pouring inflammable liquids into other containers; (iii) manual handling of loads (carrying and lifting); (iv) correct use of personal protective equipment; and (v) correct use of extinguishers and fire-fighting systems.

4. DECONTAMINATION, WASTE PROCESSING AND MANAGEMENT METHODS

Another important issue refers to the choice of the waste products' final destination. As is the case for any other type of waste, this selection shall comply with the established hierarchical process structure:

1. **Reduce**, whenever possible, the amount of waste through good operating practices. That will avoid spillage, leakage, etc., which in turn will result in less soaked cloths, contaminated absorbent products, etc.
2. **Recycle**. Where reuse is not feasible, it will be necessary to look for processing methods enabling to re-incorporate the waste products into the production chain (scrap, retreading of tyres, etc.).
3. **Valorise**. If no other use is possible, energetic valorisation may be an option.
4. **Dump**. The portion of waste for dumping shall always be the lowest possible.

4.1. HAZARDOUS WASTE

DANGER

Fuels, motor oils, coolants and antifreeze products, batteries, oil filters and fuel filters are items classified as hazardous waste, which can be present in the machines at the end of their useful life and must be removed during the decontamination phase.

There are various methods available to remove and extract fluids from the machines: gravity draining, pumping out, etc. The simplest method consists in suction pumping any waste fluid.

To do so, open the fluid containing tank or cavity and install the **fluid recovery unit** in the adequate position. You must obligatorily use one such unit per type of fluid. Make sure it is properly identified and tagged to prevent cross contamination of the different fluids to be drained. It is advisable for you to use a unit fitted with a large funnel and telescopic pipe or another similar vertically adjustable system.

Pumping with a pneumatic pump will be the method for discharging waste fluid from the recovery unit tank to the storage vessel or container pending collection by the authorised waste manager. As an alternative to the a.m. mobile recovery unit, it is possible to use a funnel, connecting it to a drum through a hose.

4.1.1. RECOMMENDED HANDLING METHODS

Lead-Acid Battery. Selective disposal of batteries implies eliminating such contaminants as sulphuric acid and lead from the fragmentation waste products and recovering such materials as metals and plastic. Batteries are classified as corrosive. Decontamination: Remove the battery from its housing; cut the connection wires if the terminals are rusty and hard to detach. Check for leaks. Always make sure you have a battery acid neutraliser (e.g. sodium bicarbonate) within reach and ready for use in case of spill.

Fuels: They include petrols, gas oil and ethanol that are classified as inflammable and harmful. Decontamination: Empty the fuel tank. Pour waste fuel or non-reusable fuel into adequate and properly tagged tanks or vessels. Store them separately and forward them separately to the authorised waste manager.

Used motor oils: These fluids pollute soils; they are leaching-toxic to surface and underground waters. Therefore, correct management is essential to avoid transferring contamination to the receiving environments. Motor oils are classified as toxic and hazardous in addition to inflammable. Toxic additives are present in their composition and they can be spoiled and contaminated by combustion by-products or materials they have been in contact with. Decontamination: Open and remove the filling plugs and crankcase drain caps allowing oil to flow by gravity or pumping. Instead of an Oil Recovery unit, you may use a funnel connected to a container through a hose, complete with an antidrip tray.

Whenever possible, before removing motor oil, it is best to operate the engine for a certain time; this will improve draining, especially in case of low ambient temperature.

Antifreeze. Coolants for the engine cooling system consist of a water and antifreeze mixture. Antifreeze products generally are glycols or similar polyalcohols (ethylene glycol or propylene glycol). They are classified as toxic products. Decontamination: Visually inspect antifreeze to determine whether it is reusable or it is waste fluid. Install the available collecting system appropriately. Release or cut the sleeves to enable complete draining of the engine cooling circuit. This will be easier if you open the filling plug and drain caps. Waste antifreeze is recyclable for marketing again, either through an authorised waste manager or at the operating site itself, using the distillation, filtration, ultrafiltration or ion exchange techniques.

Used oil filter. Decontamination: The most efficient method for removing oil from the filter consists in taking off and emptying the filter, allowing oil to drain on the funnel of the collecting system or on a drip pan, before squeezing the filter to facilitate draining. An alternative procedure consists in carefully drilling the filter cap with an adequate (spark resistant) tool and setting it (with the hole downwards) on a collecting vessel or drip pan for 24 hours at least. Store the filter in an ad hoc container until you can forward it to the authorised waste manager.

Fuel filter. Decontamination: The most efficient method for removing fuel from the filter consists in taking off and emptying the filter, allowing fuel to drain on the funnel of the collecting system or on a drip pan, before squeezing the filter to drain fuel completely. An alternative procedure consists in removing the filter, carefully drilling the filter cap with an adequate (spark resistant) tool and setting it upside down, with the hole downwards, on a collecting vessel (drip pan, funnel, etc.) for 24 hours at least. Store the filter in an ad hoc container until you can forward it to the authorised waste manager.

Asbestos. Asbestos is classified as a toxic and hazardous (carcinogenic) substance. Presently, there is a ban put on its marketing and use. Kohler machines are free from asbestos.

Decontamination process waste and handling waste. Management of hazardous waste resulting from the decontamination process shall conform to the following. Absorbent products: Keep the absorbent products used to collect spills and leaks in adequate containers until you can forward them to the relevant waste manager. Empties: Non-reclaimable empty drums that contained hazardous substances shall be forwarded to the authorised manager. Contaminated rags: put them in an ad hoc container and forward them to the authorised waste manager.

4.2. NON-HAZARDOUS WASTE

Remove all reusable parts and components from the machine, as well as any items that can be disassembled and recycled through scrap reclamation.

5. WASTE MANAGEMENT

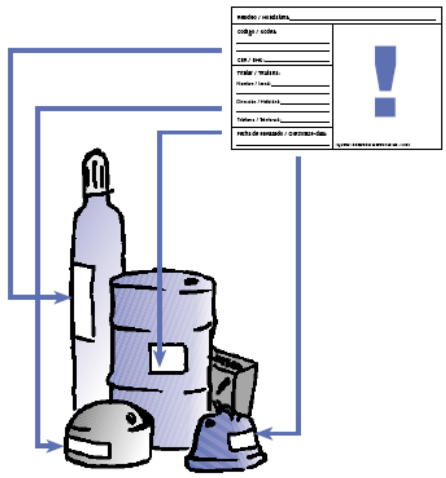
Effective management of the Hazardous Waste Products deriving from machine maintenance and end of life starts with appropriate packaging, labelling and storage at the operating site.

The producers of hazardous waste are under an obligation to refrain from pouring waste liquids into sewer systems, septic tanks, etc., as well as to use different methods and systems for collecting and processing each type of waste in order to avoid cross contamination, and to avoid mixing different classes of waste.

Packaging of Hazardous Waste. The containers and their seals shall be so designed and developed as to prevent leakage whatsoever. They shall be made of materials resistant to the type of waste they are to hold. Those constructional materials shall not be prone to hazardous combinations with the waste products.

Labelling of Hazardous Waste. Containers or packagings shall bear a firmly secured, clear, readable and indelible label stating the waste identification code, nature of waste intrinsic hazards, name and address and phone number of the owners of the waste products, date packed.

WASTE OIL	
Waste identification code: Q7//R1//L8//C51//H5/6//A241//B0019 **CER:** 13 02 05	T  POISON
Details of the owners of waste **Name**: **Address**: **Telephone nr.**:	
Date packed:	



Hazardous Waste	Waste Identification Code	CER	Pictogram
Used oil	Q7 //R_//L8//C51//H5/6//A935/B0019	130205	Toxic – T
Antifreeze	Q7 //D-R_//L20//C51//H6//A935/B9711	160114	Toxic – T
Lead-acid batteries	Q6 //R_//S37//C18/23//H8//A935/B0019	160601	Corrosive – C
Gas oil	Q7 //R_//L9//C51//H38//A935/B9711	130701	Flammable - F Harmful – Xn
Ethanol	Q8 //R13 //L9//C51//H3A//A870/B0019	130703	Flammable - F Toxic – T
Oil filters	Q6 //R_//S35//C51//H5//A935/B9711	160107	Harmful – Xn
Contaminated cloths and absorbent products	Q5 //D_//S40//C51//H5//A935/B9711	150202	Harmful –Xn
Fuel filters	Q6 //D_//S35//C51//H5//A935/B9711	160121	Harmful –Xn
Contaminated metal containers	Q5 //R_//S36//C41//H5//A935/B9711	150110	Harmful –Xn
Contaminated plastic containers	Q5 //D-R_//S36//C41/51//H5//A935/B9711	150110	Harmful –Xn

Hazardous Waste Register. Every company that produces hazardous waste shall keep a Register in such conditions as the prevailing legislation provides.

Storage of Hazardous Waste. Waste liquids shall be stored in individual and separate tanks or containers, by type of waste. Those containers, properly closed and tagged, shall be stored in a sheltered area, on an impermeable surface. Applicable legislation defines the storage conditions.

Transport and disposal. Before forwarding hazardous waste products resulting from the decontamination process to the authorised waste manager, it is necessary to verify that the selected carriers can take charge of waste transport to the manager’s premises, being duly authorised to do so and that the waste manager has the necessary permits to process the specific waste products to be disposed of.

CHAPTER 2 – ENGINE TECHNICAL DESCRIPTION

1. ENGINE IDENTIFICATION PLATE

The identification plate provides engine reference information which includes:

- Engine Model.
- The power and rating of the engine.
- Serial number and manufacturing date.

On the 180/240 in-line engines it is located on the right-hand side of the crankcase (See Fig. 2); on the 360/480 and SFGLD/SFGM 560 V engines, the plate is on the front right-hand side of the crankcase (See Fig. 3), and on the HGM 420/560 on the bottom right front panel of the water distribution box (See Fig. 4).

NOTE

When asking Kohler for information and spare parts, please state the engine model and serial number.

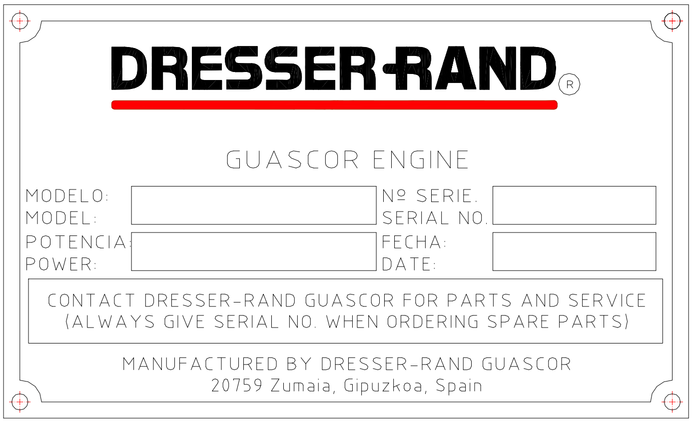


Fig. 1 – Kohler Gas Engine Identification Plate

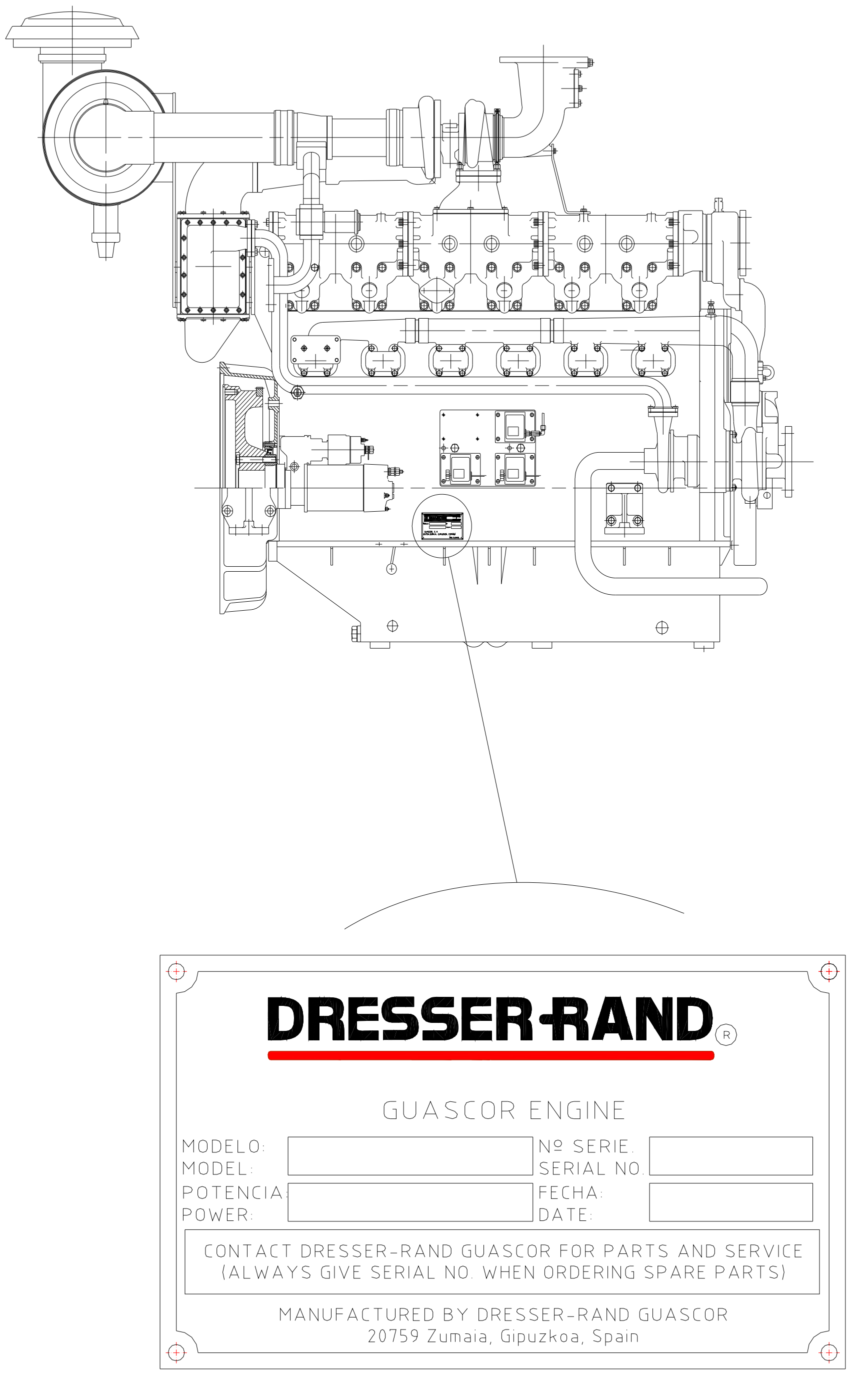


Fig. 2 – Identification Plate Location on 180/240 Series Engines

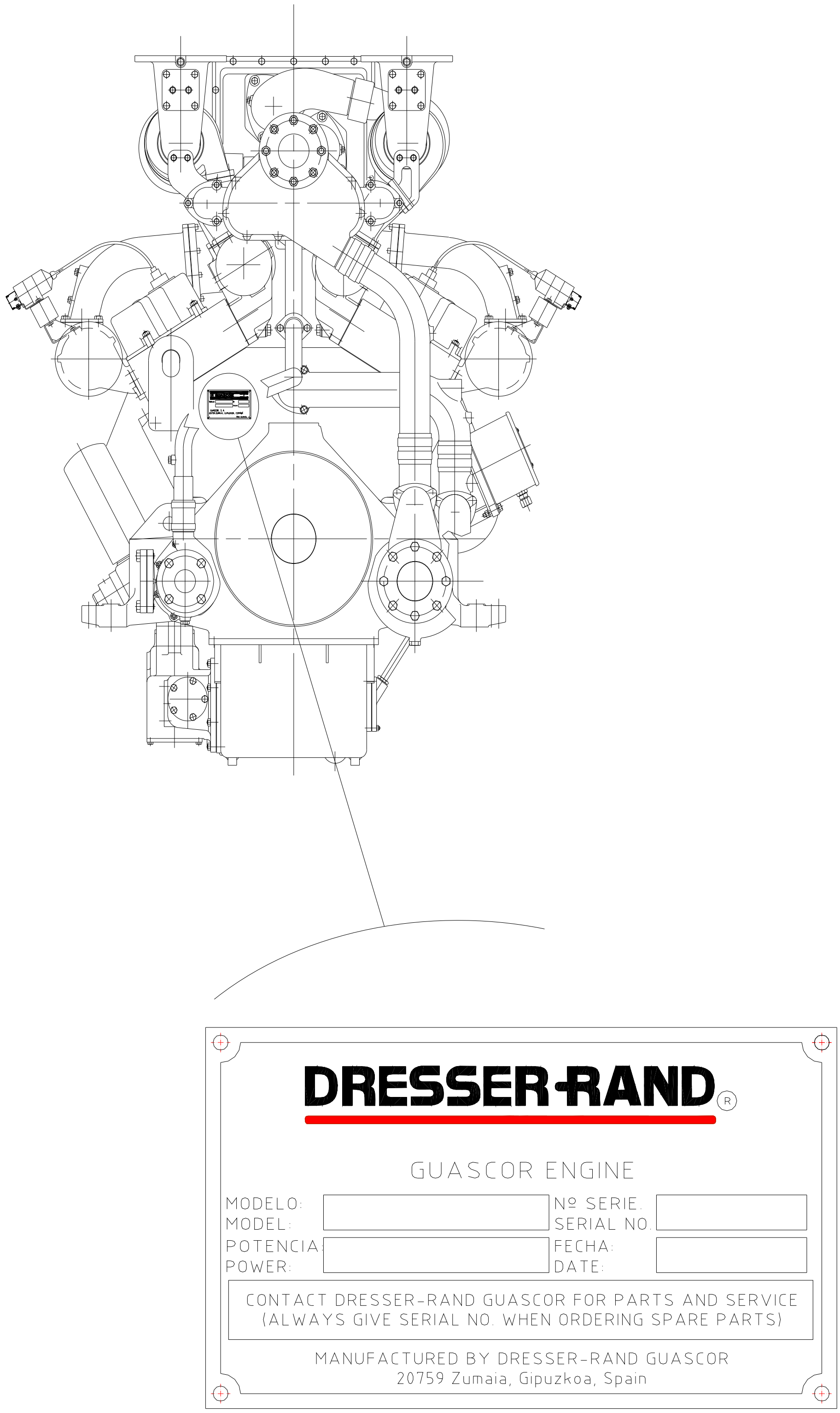


Fig. 3 – Identification Plate Location on 360/480/560 Series Engines

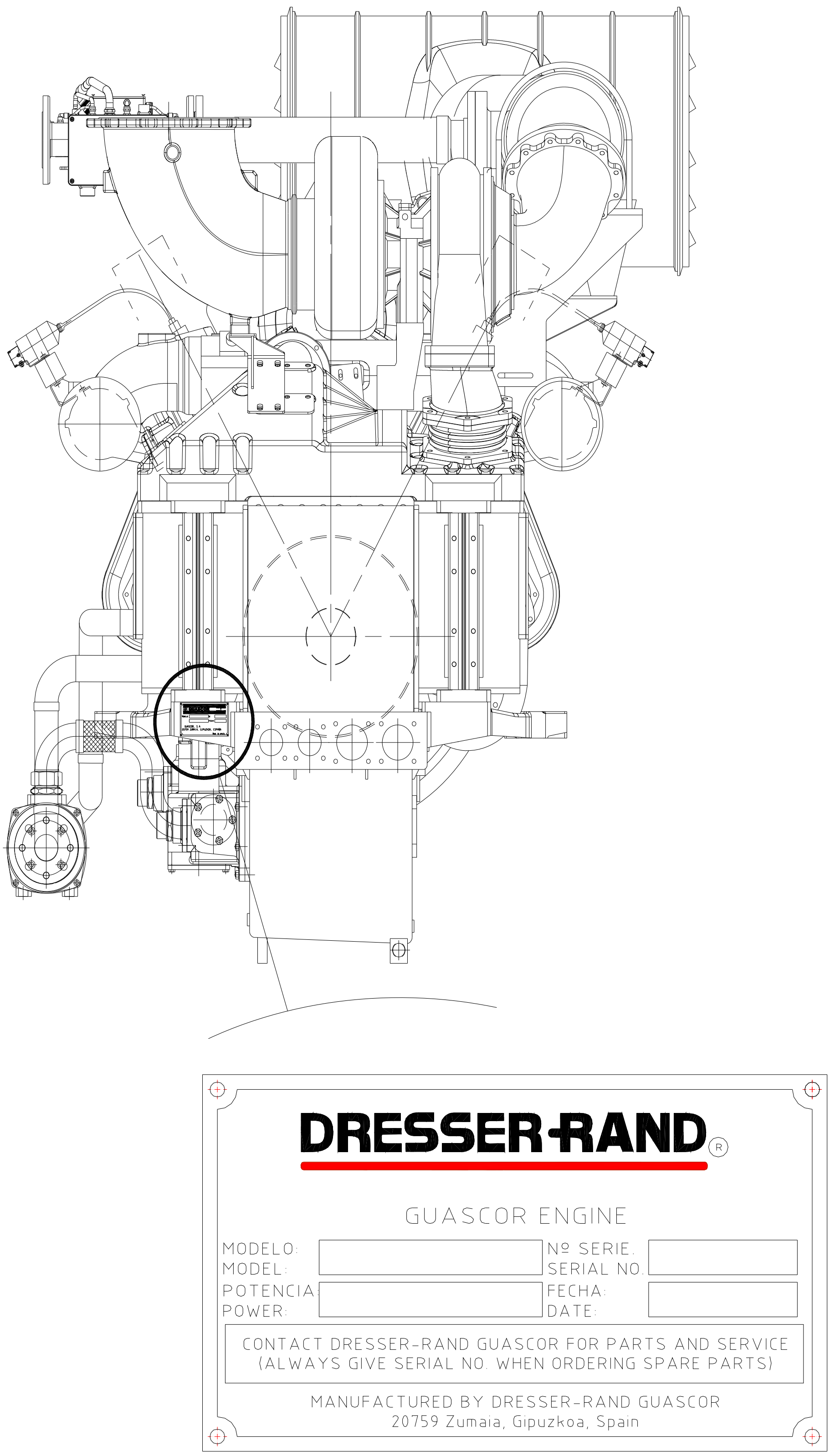


Fig. 4 – Identification Plate Location on “HGM 420/560” Engines

2. CHARACTERISTICS PLATE

The characteristics plate provides engine operating data including: Firing order, ignition timing, valve adjustment, auxiliary circuit temperature, type of gas to be used, and compression ratio.

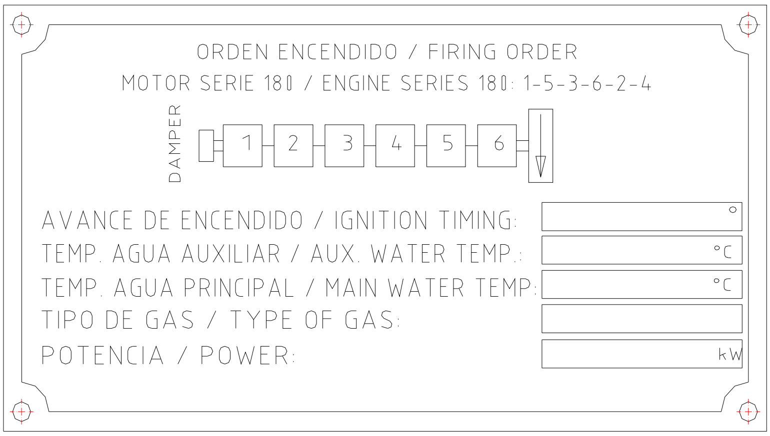


Fig. 5 - Characteristics Plate “180 Series” Engines

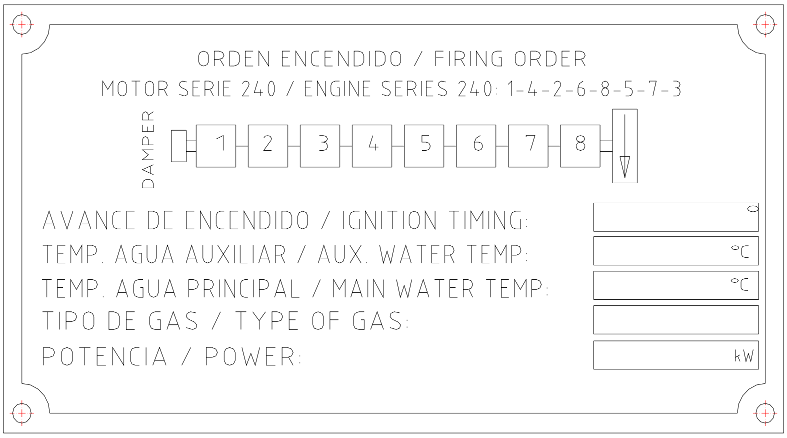


Fig. 6 - Characteristics Plate “240 Series” Engines

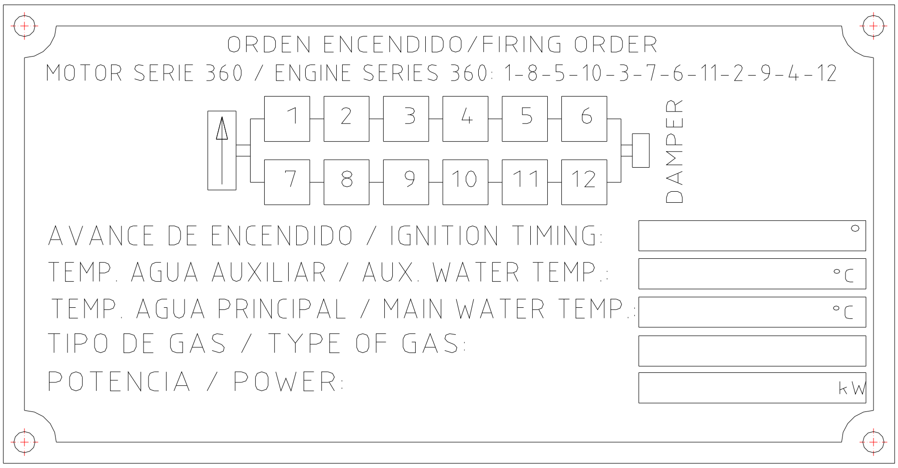


Fig. 7 - Characteristics Plate “360/420 Series” Engines

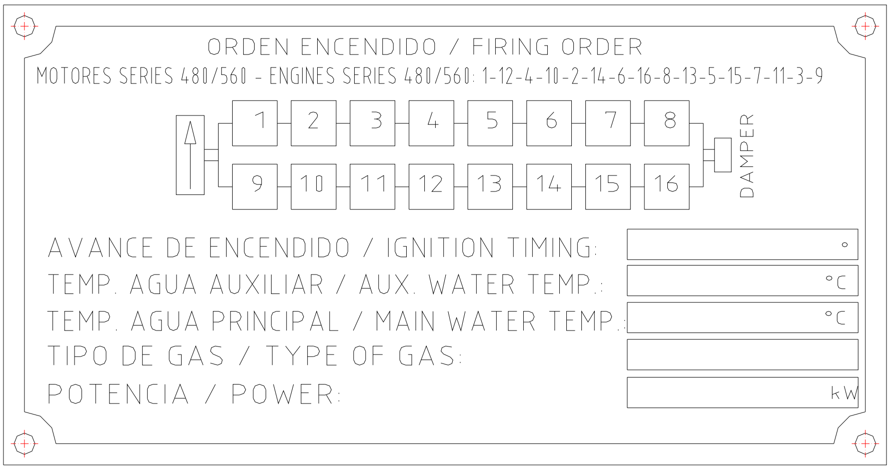


Fig. 8 - Characteristics Plate “480/560 Series” Engines

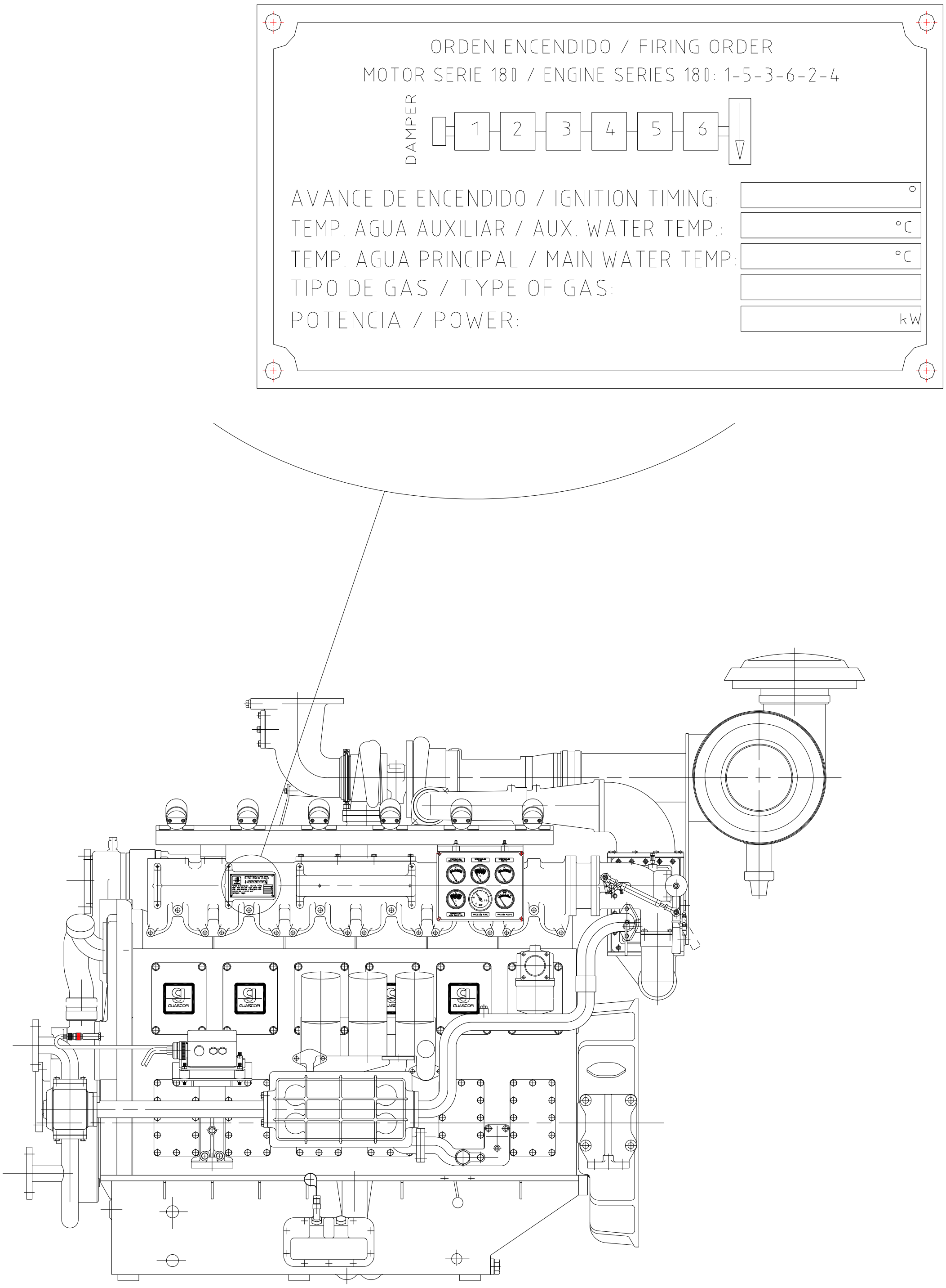


Fig. 9 – Characteristics Plate Location on “180/240 Series” Engines

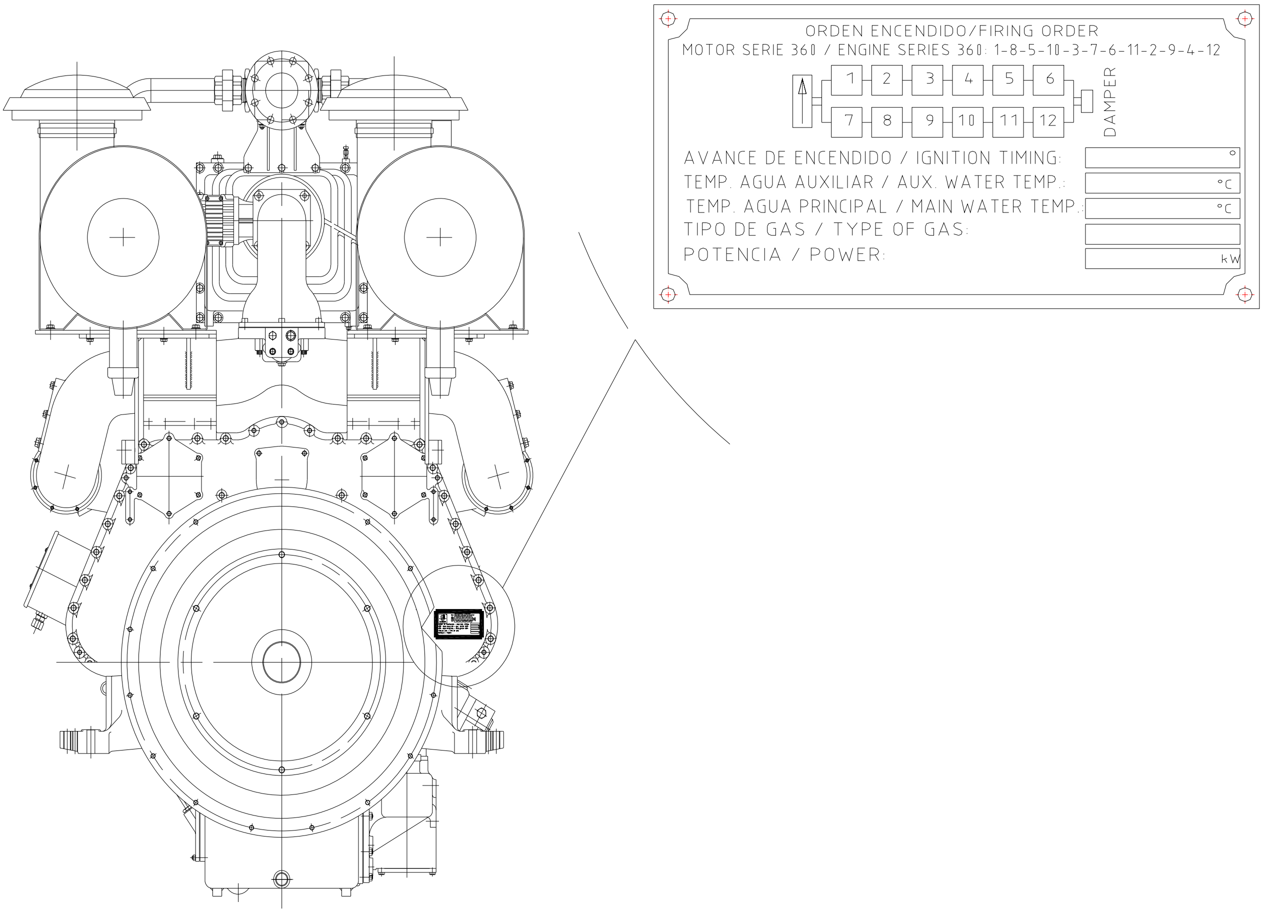


Fig. 10 – Characteristics Plate Location on “360/420/480/560 Series” Engines

1. ENGINE IDENTIFICATION PLATE

The emissions plate of the engines with EPA certification under 40 CFR part 60 subpart JJJJ includes the following information:

- ENGINE FAMILY: EPA certification code corresponding to the engine model
- ENGINE DISPLACEMENT: in litres
- MAX.RATED KW: maximum engine power (the nominal engine power except for Prime applications where a 10% of overload is allowed, see conditions in IC-C-D-00-002e or in the engine thermal balance)
- EMISSION CONTROL SYSTEM: related to the engine configuration:
    - ECM Electronic Control Module for the electronic control of the carburation
    - MIX for the mixture of air and fuel by a carburetor
    - TC with turbocharger
    - CAC with Chargecooler.
- THIS ENGINE IS CERTIFIED TO OPERATING ON: indicates the fuel which the certification is valid for
    - NG (gas natural)
- THE USEFUL LIFE: running hours/years (which occurs firts) of the engine emissions certifications warranty.
- THIS ENGINE IS CERTIFIED TO: certified emissions values of pollutants.
- EPA certification year and manufacture year.

On the 180/240 in-line engines it is located on the right-hand side of the crankcase; on the 360/480 and SFGLD/SFGM 560 V engines, the plate is on the front right-hand side of the crankcase, and on the HGM 420/560 on the bottom right front panel of the water distribution box.

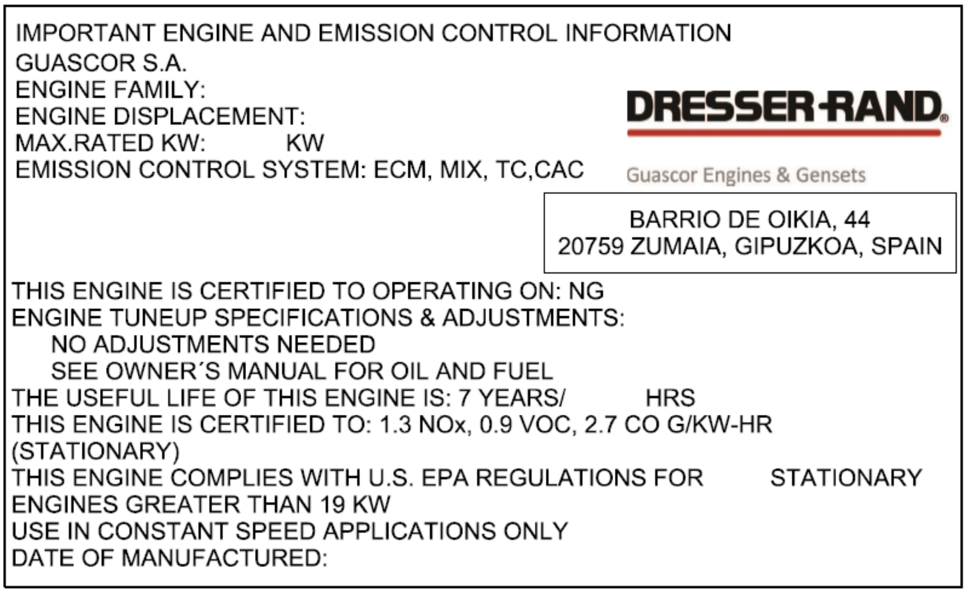


Fig. 1 - EPA emissions Plate

The next table shows the different engine codes (*ENGINE FAMILY*) the certified engines have been categorized

xGSRB18.0180	SFGLD180 continuous
xGSRB24.0240	SFGLD240 continuous, Prime
xGSRB36.0360	SFGLD360 continuous, Prime
xGSRB48.0480	SFGLD480 continuous, Prime
xGSRB56.0560	SFGLD560 continuous
xGSRB24.240E	SFGLD240 Stand-by
xGSRB36.360E	SFGLD360 Stand-by
xGSRB48.480E	SFGLD480 Stand-by

Table 1 - Engines Family codes

The first letter “x” of the code is related to the year of the certification (f.e. for 2016, the letter is a “G”).

1. BASIC SPECIFICATIONS OF GAS ENGINES

The technical characteristics of the engines are shown in:

- IC-G-D-00-034 FG engines
- IC-G-D-00-035 FGLD, SFGLD, SFGM in line engines
- IC-G-D-00-036 FGLD, SFGLD, SFGM V engines
- IC-G-D-00-131 SFGRD in line engines
- IC-G-D-00-132 SFGRD V engines
- IC-G-D-00-149 HGM engines

These are four-stroke engines with spark ignition (Otto Cycle). The SFGM and HGM series feature Miller cycle.

They belong to different categories, as follows:

- FG engines, naturally aspirated with stoichiometric combustion (lambda=1).
- SFGRD engines supercharged by turbocharger and aftercooler with rich burn technology (Lambda<1) and low-pressure air/gas mixture.
- FGLD/SFGLD/SFGM engines supercharged by turbocharger and aftercooler with lean burn technology (Lambda=1.3 / 1.6) and low-pressure air/gas mixture.
- HGM engines supercharged by high-compression ratio turbocharger and intercooler, with lean burn technology (Lambda=1.4 / 1.7) and low-pressure air/gas mixture.

Kohler engines can operate on gases with different calorific capacities (LHV), see Product Information **IC-G-D-30-001e**.

2. GENERAL DESCRIPTION OF THE CONSTRUCTION OF THE ENGINE

2.1. CRANKCASE

The crankcase is manufactured from grey cast iron with a stabilising heat treatment to eliminate residual stresses. It has a high mechanical sturdiness as befits its original design oriented towards diesel applications.

The crankcase is constructed with different side openings, which allows a high degree of accessibility to internal engine components such as connecting rods, camshafts, etc., to facilitate engine maintenance.

2.2. SLEEVES

Sleeves are from centrifuged grey cast iron and are installed on the engine block, due to which they are interchangeable, allowing easy maintenance.

2.3. CRANKSHAFT

The crankshaft is made from die-pressed alloy steel, which is given a general heat treatment (quenching and tempering).

It is of the suspended block type for which reason it is secured with nodular cast iron caps and alloy steel studs, making the engine assembly very sturdy.

The crankshaft bearings, crankpins and radii (bends) are induction-tempered to ensure surface hardness and better performance and longer life for the crankshaft.

The crankshaft is dynamically balanced by built-in counterweights and its ends are supported by an inertia flywheel to ensure regular operation and a torsion vibration damper.

2.4. BEARINGS

The semi-bearings used in the connecting rod head and crankshaft are manufactured from steel and the roller track is made from aluminium tin alloy.

2.5. CYLINDER HEADS

The cylinder heads are made from grey cast iron and are individual for each cylinder, allowing high engine maintenance.

Apart from housing the intake and exhaust piping, they have two water chambers that are part of the engine cooling system.

Each cylinder head comes complete with a four-valve system per cylinder (2 intake and 2 exhaust) which are formed by valve seats, valves and valve guides, as well as springs, valve plates and half-cones. All the components fitted into the cylinder heads allow easy replacement and maintenance.

The cylinder head also houses the spark plug sleeve that accommodates an easy-to-fit/remove firing spark plug.

2.6. CONNECTING RODS

The connecting rods are die-pressed in alloy steel and are then quenched and tempered to improve their mechanical characteristics. They are cut obliquely and with a saw-tooth joint which guarantees an adequate joint after assembly of crank head and cap.

2.7. PISTONS

The pistons are made from aluminium alloy. The volume for the combustion is formed by the volume between the piston TDC and the cylinder head. The pistons include a chamber shaped on piston top

The piston is jet cooled with refrigeration oil from a specific regulated pressure gallery either at the base of the piston or through a gallery inside the piston itself.

2.8. PISTON RINGS

A piston ring set consists of three rings:

- Compression ring, i.e. a chrome-plated rectangular ring on a piston ring carrier for engines with 152mm cylinder dia. and a ceramic trapezoidal ring for engines with 160mm dia. pistons
- Scraper ring, and
- Oil control ring

2.9. CAMSHAFT

The camshafts (one for in-line and two in V-engines) are made from alloy steel and induction tempered or case hardened (HGM and SFGM).

The cams have been calculated to optimise the operation of all the engine distribution; camshaft drive is through gear arrangement.

The cam followers are of the roller type, mounted on a rocker arm.

2.10. DISTRIBUTION

Timing gears, i.e. the drive system of such components as camshafts, regulators, oil pump and water, consist of spur gears on in-line engines and helical gears on V-engines.

2.11. LUBRICATION

The oil pump is a gear pump type, driven by means of gears from the crankshaft. The lubrication system also consists of interchangeable filters, thermostatic oil temperature regulation (V-engines), oil refrigeration, regulation of the lubrication oil pressure, in addition to safety systems like centrifugal filters according to the application concerned.

2.12. REFRIGERATION

There is two types of refrigeration:

- The engine is cooled by a double water circuit. A main circuit which cools the motor crankcase, cylinder heads and exhaust manifold (except in the case of dry exhaust manifold) as well as the air-fuel mixture on engines with double-stage intercooler, and an auxiliary circuit for cooling the oil and the air-fuel mixture. There are some configurations in which the oil cooler is cooled by the main circuit in parallel with the other parts of the engine.
- The engine is cooled by just one water circuit. In line engines the oilcooler and the mixture cooler are in series, and both in parallel to the block, cylinder-heads and exhaust manifold. In v engines oilcooler and mixture cooler are in parallel and both are in parallel to the block, cylinder-heads and exhaust manifold. the mixture cooler is one stage intercooler.

Cooling circuits can include pumps that can be driven by gears from the crankshaft.

2.13. CARBURETION

The gas system consists of an air/fuel ratio adjustment system (mechanical, screw-type on FG/FGLD/SFGLD/SFGM-series engines and electronic on SFGRD/SFGLD/SFGM and HGM series engines and a Venturi type carburettor.

Following the specifications and general standards, a valve train is always installed before the engine to guarantee the safety of the gas installation.

2.14. INTAKE

All the engines are supplied with an air filter system. Once the mixture has been made, it flows through the intake manifold immediately on a naturally aspirated engine, or after passing through the compressor and intercooler on a supercharged engine. The intake manifolds are made from aluminium in In-line engines, from nodular casting in V engines and are provided with a safety, explosion and pressure relief valve system.

2.15. MISCELLANEOUS

The engine incorporates a crankcase gas vent for relieving pressure due to blow-by gases.

In order to ensure performance consistent with their different applications, our engines include auxiliary pre-lubrication systems, oil draining, oil level control, etc.

KOHLER Powered by **DRESSER-RAND**	PRODUCT INFORMATION **IC-G-D-00-035e**	INDEX **F**	DATE *June 2016*	*Dep. 2*

TABLE OF TECHNICAL CHARACTERISTICS IN-LINE FGLD/SFGLD/SFGM ENGINES

O&M_2.002262.810_10_2016

<table>
<tr><th>ITEM</th><th>UNITS</th><th colspan="2">FGLD/SFGLD/SFGM 180</th><th colspan="2">FGLD/SFGLD/SFGM 240</th></tr>
<tr><td>Nº of Cylinders</td><td></td><td colspan="2">6</td><td colspan="2">8</td></tr>
<tr><td>Cycle</td><td></td><td colspan="4">4 strokes per cycle</td></tr>
<tr><td>Cylinder Bore X Stroke</td><td>mm / (in)</td><td colspan="4">152 x 165 / (5.98x6.50)</td></tr>
<tr><td>Displacement</td><td>L / (in^3)</td><td colspan="2">17.96 / (1096)</td><td colspan="2">23.95 / (1462)</td></tr>
<tr><td>Compression Ratio</td><td>FGLD/SFGLD/SFGM</td><td colspan="4">11:1 / 11,6:1 – 9,2.1 (A)(B) / 8:1 (C)</td></tr>
<tr><td>Firing Order</td><td></td><td colspan="2">1-5-3-6-2-4</td><td colspan="2">1-4-2-6-8-5-7-3</td></tr>
<tr><td>Rotation as viewed from the Flywheel end</td><td></td><td colspan="4">Counter-clockwise</td></tr>
<tr><td>Flywheel Housing / Flywheel</td><td></td><td colspan="4">SAE 0 / 18"-14"</td></tr>
<tr><td>Valve Set</td><td>mm / (in)</td><td colspan="4">Intake 0.3 / (0.012) - Exhaust 0.8 / (0.031)</td></tr>
<tr><td>Engine Weight</td><td>Kg / (Lb)</td><td colspan="2">2510-2700 / (5534-5952)</td><td colspan="2">3210-3500 / (7077-7716)</td></tr>
<tr><td rowspan="3">General Dimensions</td><td>W mm / (in)</td><td colspan="2">1225 / (48.23)</td><td colspan="2">1248 / (49.13)</td></tr>
<tr><td>L mm / (in)</td><td colspan="2">2365 / (93.11)</td><td colspan="2">2864 / (112.76)</td></tr>
<tr><td>H mm / (in)</td><td colspan="2">1850 / (72.83)</td><td colspan="2">1914 / (75.35)</td></tr>
<tr><td colspan="6">COOLING SYSTEM</td></tr>
<tr><td>Types</td><td></td><td colspan="4">Water-Water or Water-Air</td></tr>
<tr><td>Main Circuit capacity</td><td>L / (gal)</td><td colspan="2">70 / (18.5)</td><td colspan="2">90 / (23.7)</td></tr>
<tr><td>Auxiliary Circuit capacity</td><td>L / (gal)</td><td colspan="4">25 (6.6)</td></tr>
<tr><td>Standard Jacket Water Temp.</td><td>ºC / (°F) min-std</td><td colspan="4">75-90 /(167-194) // 105-120 (D) / (221-248)</td></tr>
<tr><td>High Jacket Water Temp.</td><td>ºC / (°F) max</td><td colspan="4">96 / (205) // 125 (D) / (257)</td></tr>
<tr><td>Auxiliary Water Temp.</td><td>ºC / (°F)</td><td>/55 /(131)</td><td>/80 (D) /(176)</td><td>/55 /(131)</td><td>/80 (D) (176)</td></tr>
<tr><td colspan="6">LUBRICATION SYSTEM</td></tr>
<tr><td rowspan="3">Oil type</td><td>Natural Gas</td><td colspan="4">KOHLER MOTOROIL 3040 Plus See IC-G-D-25-003e</td></tr>
<tr><td>Biogas / Syngas</td><td colspan="4">KOHLER MOTOROIL 2040 See IC-G-D-25-002e</td></tr>
<tr><td>Propane (B)</td><td colspan="4">KOHLER MOTOROIL 99.27.046 See IC-G-D-25-004e</td></tr>
<tr><td>Normal Oil Pressure</td><td>Bar / (psi)</td><td colspan="4">4 – 6 / (58-87)</td></tr>
<tr><td>Oil Temperature</td><td>ºC / (°F)</td><td colspan="4">80 – 95 / (176-203) // 80-100 / (176-212) (E)</td></tr>
<tr><td>Oil capacity</td><td>L (gal)</td><td colspan="2">86 / (22.72)</td><td colspan="2">116 / (30.64)</td></tr>
<tr><td>Approximate oil consumption</td><td>gr/kWh / (gr/hphr)</td><td colspan="4">0.35 / (0.26)</td></tr>
<tr><td colspan="6">COMBUSTION SYSTEM</td></tr>
<tr><td>Type of Combustion</td><td></td><td colspan="4">Lean Burn (Lambda = 1.3 / 1.7)
F: mixture regulation by screw (mechanical)
SF: Electronic Mixture Regulation
And also mixture regulation by screw (mechanical)</td></tr>
<tr><td>Combustible Gases</td><td></td><td colspan="4">Natural Gas /Biogas(Digester / Landfill)
Well gases (A)(C) / Syngas (A) / Propane (B)</td></tr>
<tr><td>Gas regulation valve</td><td></td><td colspan="4">Dungs (Zero Pressure) (Mechanical regulation)</td></tr>
</table>

(A) SFGLD engines, Syngas and low methane number (45<MN<65)

(B) SFGM 180 y SFGM 240 propane engines

(C) SFGLD engines mechanical drive applications and low methane number (35<MN)

(D) Only natural gas engines

(E) SFGLD emergency engines

DESCRIPTION OF THE COMPONENTS IN ONE CIRCUIT IN LINE GAS ENGINES

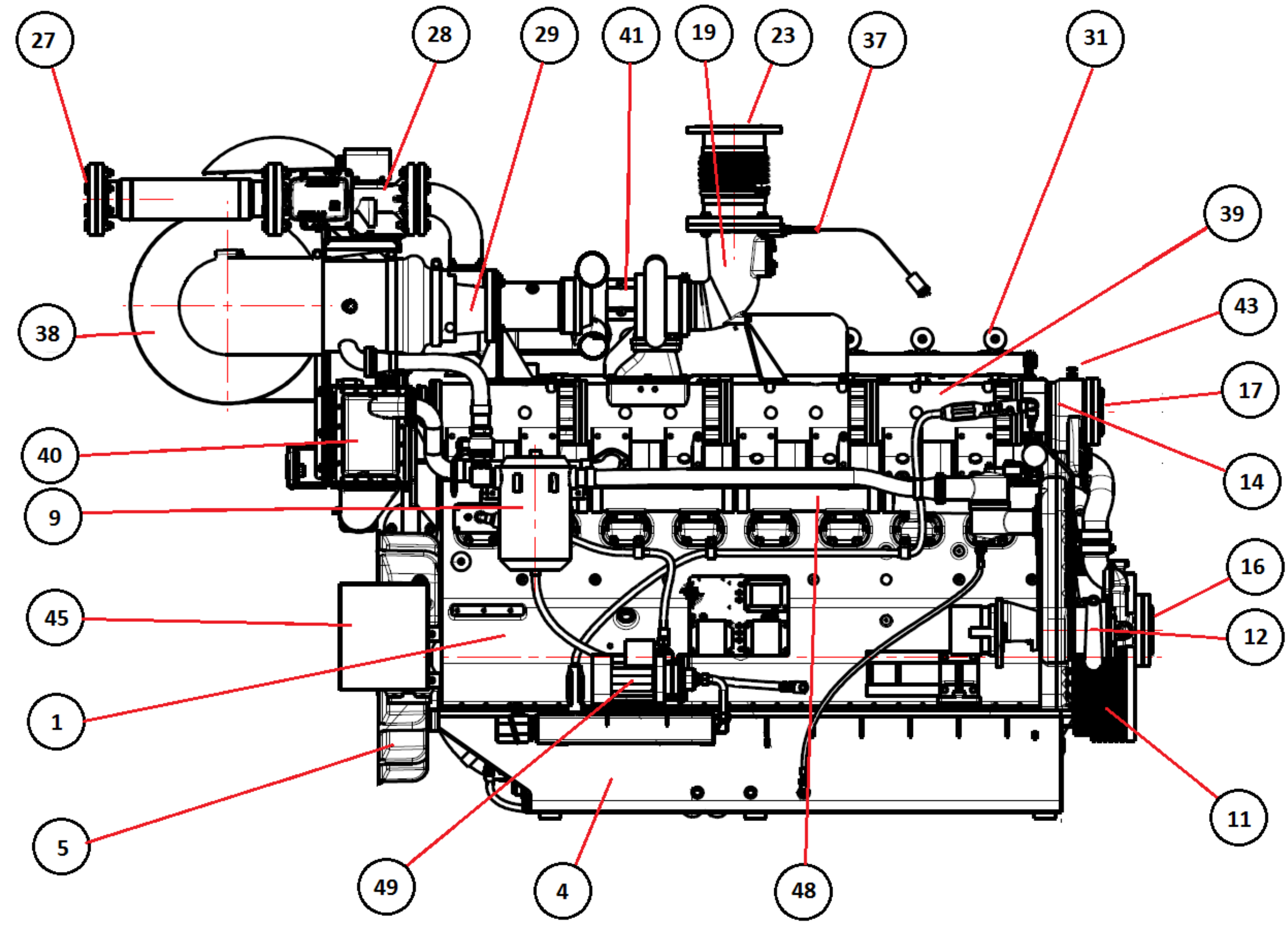


Fig. 1 – Right side view

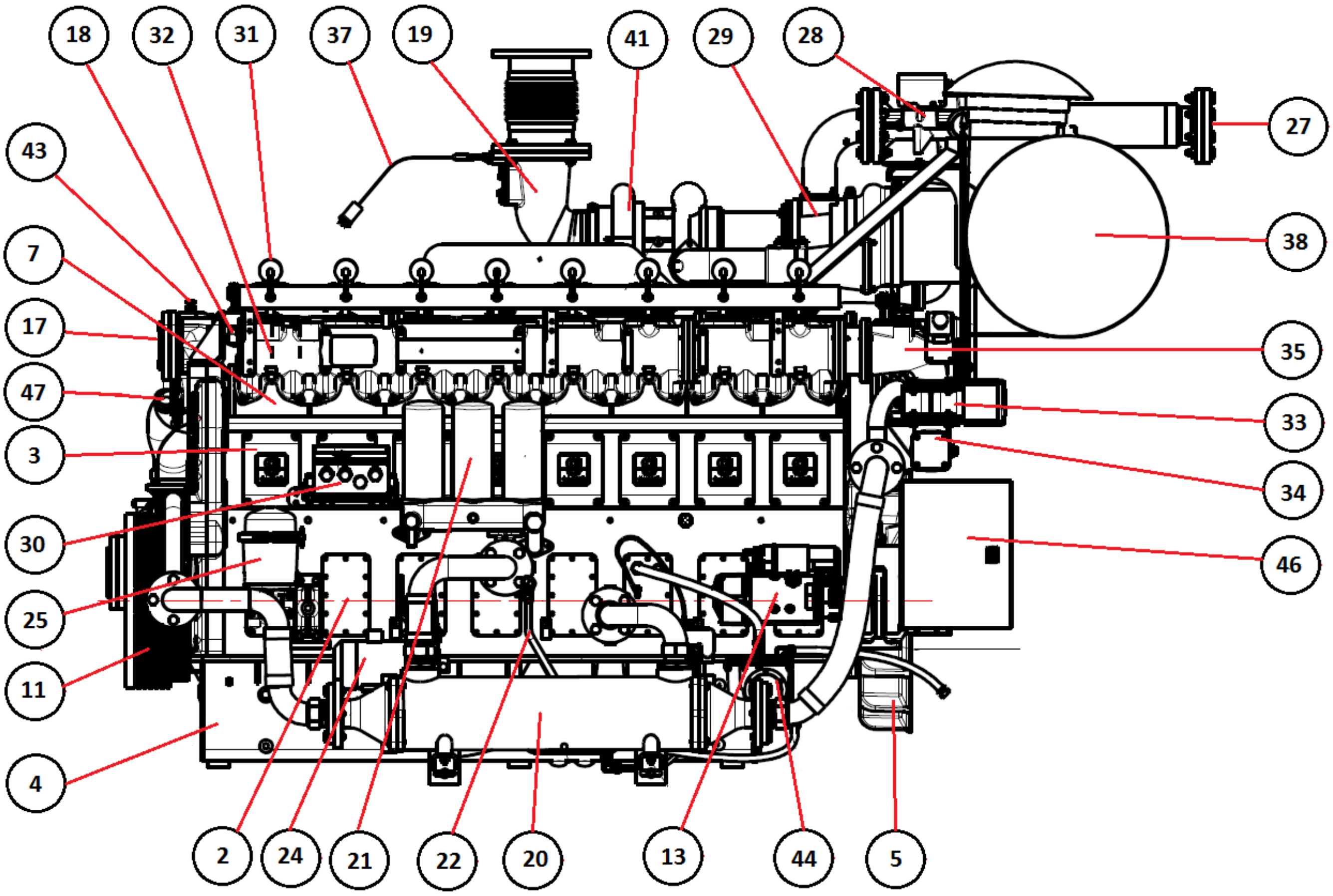


Fig. 2 – Left side view

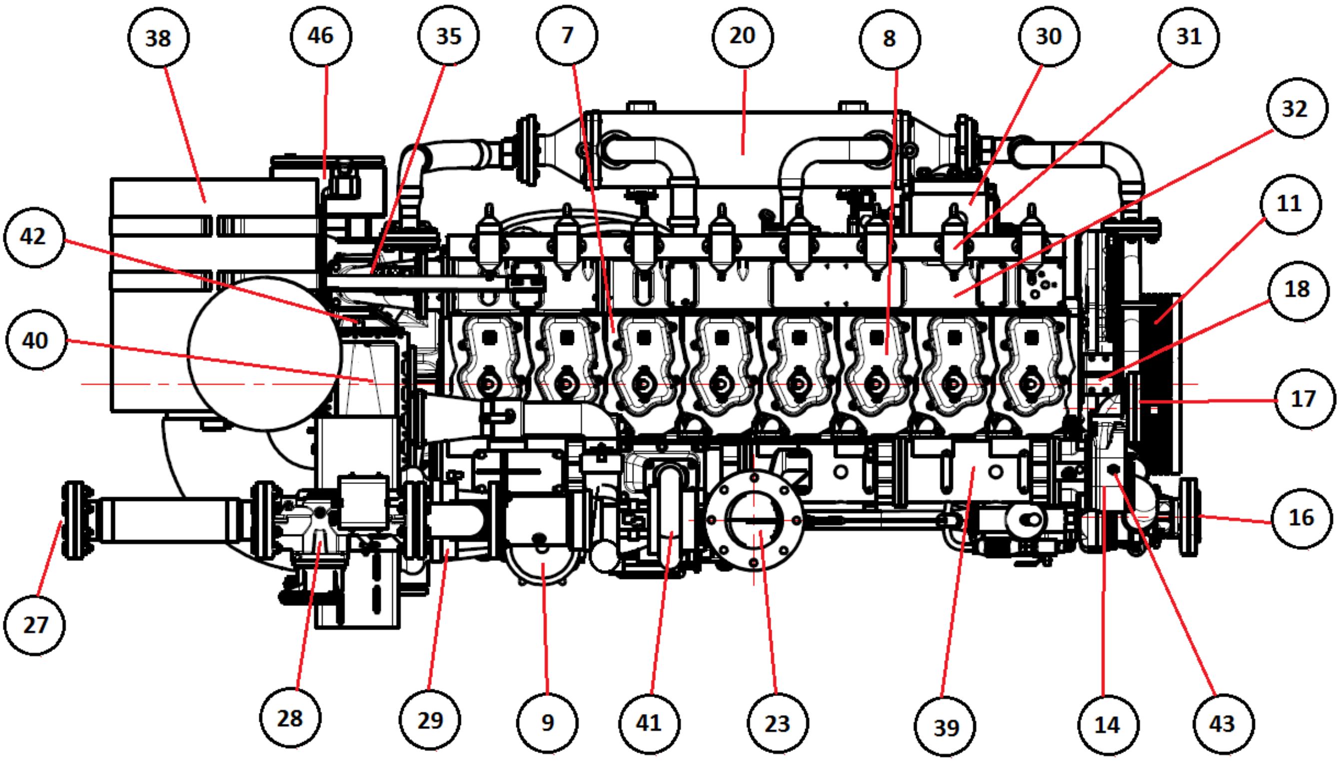


Fig. 3 – Top view

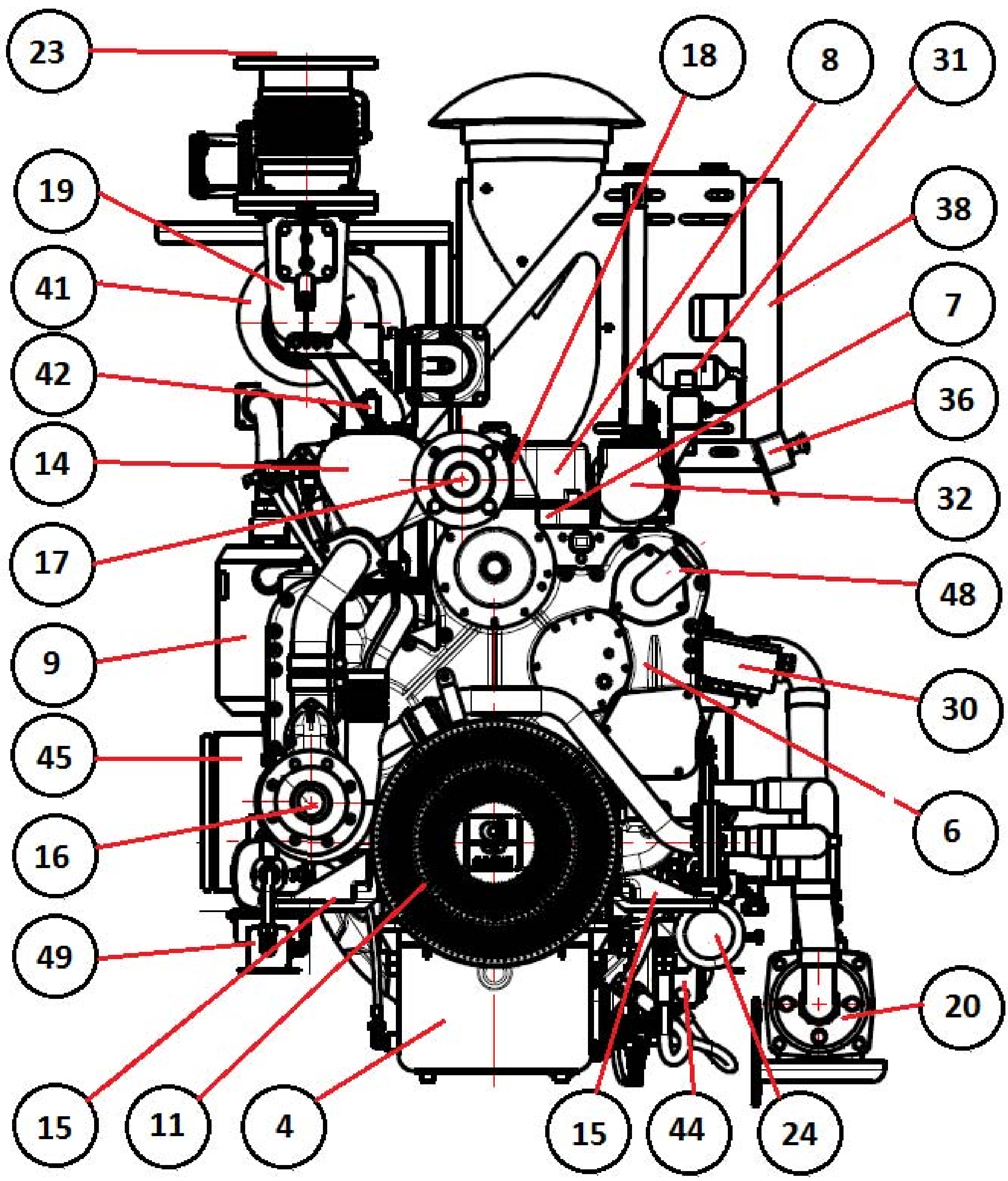


Fig. 4 – Front view

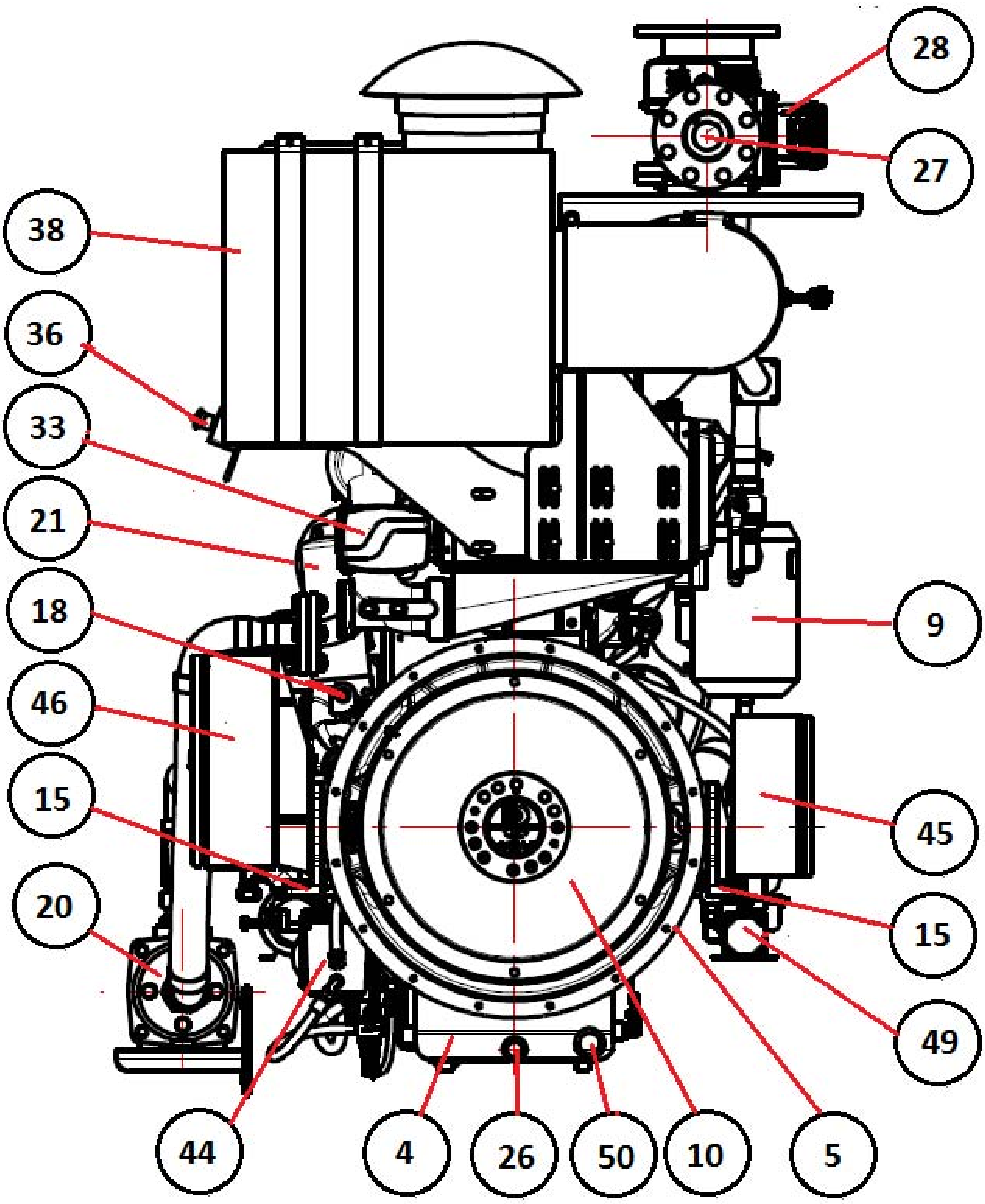


Fig. 5 – Rear view

1	Crankcase
2	Connecting rod inspection door
3	Rocker arm inspection doors
4	Oil pan
5	Flywheel housing
6	Front gear cover
7	Cylinder head
8	Rocker arm cover
9	Filter Crankase gas recirculation
10	Flywheel
11	Vibration damper
12	Water pump
13	Starter
14	Jacket water thermostatic valve
15	Engine supports
16	Jacket water inlet
17	Jacket water outlet
18	Lifting eye
19	Exhaust gas outlet elbow
20	Oil cooler
21	Oil filters
22	Dipstick
23	Exhaust gases outlet
24	Lubrication pump
25	Oil centrifugal filter
26	Oil drain plug
27	Fuel gas inlet
28	Fuel gas regulator (tecjet)
29	Carburetor
30	Electronic ignition module
31	Ignition coil
32	Intake manifold
33	Throttle valve body
34	Throttle valve elbow
35	Intake manifold elbow

36	Emergency button
37	Exhaust thermocouple
38	Air filter
39	Exhaust manifold
40	Intercooler
41	Turbocharger
42	Air cooler drain
43	Water circuit drain
44	Oil level controller
45	Wiring Box 220V
46	Wiring Box 24V
47	Oil filling plug
48	Engine inlet water manifold
49	Water preheating
50	Oil preheating

GAPS AND WEAR LIMITS FOR IN-LINE GAS AND ETHANOL ENGINES

O&M_2.002262.810_10_2016

ITEM	REFERENCE		GAPS & LIMITS (mm)	
	In line 180	In line 240	Normal	Limit
DISTRIBUTION				
Camshaft bushing Ø	Front / Central / Rear		68 / 68.001 / 68.001	68.15
Longitudinal gap on camshaft (locked pinion)			0.15 to 0.30	0.3
Gap between flanks of timing gears				
OIL CIRCUIT				
Axial clearance of internal pump gears			0.10 to 0.209	
Radial clearance of internal pump gears			0.24 to 0.325	
Gap between gear tooth faces			0.14 to 0.22	
Diametral clearance of drive shaft in pump cover and sleeve			0.06 to 0.139	
Oil pump safety valve rating			8 bar	
Lube oil pressure control valve rating			4.5bar	
Piston coolant pressure control valve rating			3 bar	
VALVE LIFTER				
Lifter guide housing inside Ø			14.05 to 14.077	
Clearance between housing and lifter			0.006 to 0.044	
Lifter guide Ø			14.033 to 14.044	
Clearance between lifter and rocker arm (intake)			0.3	
Clearance between lifter and rocker arm (exhaust)			0.8	
CYLINDER				
Liner inside Ø (top)			152.0 to 152.025	152.4
Maximum out-of-roundness			0.03	0.2
Upper Ø of bore (liner housing)			175.50 to 175.54	
Lower Ø of bore (liner housing)			172.00 to 172.04	
Protrusion of liner over cylinder block			0.04 to 0.10	
CONNECTING ROD				
Width of connecting rod big end (LCR piston)			57,77 to 57,73	
Clearance between piston pin and connecting rod bearing insert (LCR piston)			0.035 to 0.086 (0.050 a 0.102)	
Diametral clearance between crankpin and bearing			0.077 to 0.144	
PISTON-RINGS				
Height of piston groove 1 (compression ring)			3.56 to 3.54	3.7
Height of piston groove 2 (scraper ring)			3.56 to 3.54	3.7
Height of piston groove 3 (oil control ring)			4.04 to 4.02	4.15
Height of compression ring 1			3.475 to 3.490	3.4
Height of scraper ring 2			3.478 to 3.490	3.4
Height of oil control ring 3			3.978 to 3.990	3.9
Protrusion of the piston over the liner (dwell)			-0.90 to -0.30	

GAPS AND WEAR LIMITS FOR IN-LINE GAS AND ETHANOL ENGINES

O&M_2.002262.810_10_2016

ITEM	REFERENCE		GAPS & LIMITS (mm)	
	In line 180	In line 240	Normal	Limit
Clearance of ring 1 in groove 1			1 0.05 to 0.085	0.15
Clearance of ring 2 in groove 2			2 0.05 to 0.082	0.15
Clearance of ring 3 in groove 3			3 0.03 to 0.06	0.15
End-to-end clearance of compression ring (1)			0.50 to 0.75	1.7
End-to-end clearance of scraper ring (2)			0.60 to 0.85	1.7
End-to-end clearance of oil control ring (3)			0.50 to 0.80	1.7
CRANKSHAFT				
Crankpin Ø			114.991 to 115.03	114.9
Crankpin Ø 1st repair size			114.491 to 114.513	114.4
Crankpin Ø 2nd repair size			113.991 to 114.013	113.9
Crankshaft journal Ø			134.96 to 135.00	134.84
Crankshaft journal Ø 1st crankshaft repair size			134.46 to 134.50	134.34
Crankshaft journal Ø 2nd crankshaft repair size			133.96 to 134.00	133.84
Diametral gap between journal and bearing			0,100 a 0,199	
Axial thrust disk thickness			3.5 to 3.62	3.3
End play of crankshaft			0.22 to 0.586	0.8
VALVES				
Head angle, intake / exhaust valves			141º ±0º15’	
Milling angle, intake / exhaust valve seats			141º ±0º15’	
Free length of external spring			67.1	65
Free length of internal spring			56.6	55
Clearance of valve stem in removable guide - (LF)			0,055 to 0,08	0.45
Clearance of valve stem in removable guide			0,055 to 0,08	0.15
Depression of valve with regard to cylinder head plane			1.25 to 1.75	3
ROCKER ARM				
Rocker arm shaft			31.975 to 31.991	31.9
Clearance of rocker arm shaft in removable bushing			0.018 to 0.059	0.1

Other considerations for taking into account with all the engines:

The connecting rods and their bearing caps are marked with matching identification numbers in addition to the revelant cylinder number for assembly purposes.

It is necessary to replace the connecting rod bolts after either their third retightening or according to the relevant maintenance instructions.

The lips of the front and rear seals must be oriented towards the inside of the engine and impregnated with motor oil on assembly.

Change the counterweight screws each time the crankshaft is rectified.

The damper is a precision device, the internal parts of which are adjusted to very close tolerances. Any wear of its external housing can reduce its performance and cause serious damage to the engine crankshaft. It should be changed, following the relevant instructions for that purpose.

Main bearing caps are marked with figures in ascending order from the flywheel side. These figures are reproduced on the lower face of the cylinder block

TIGHTENING TORQUES FOR GAS AND ETHANOL ENGINES

In line 180/240

ITEM	REFERENCE	TIGHTENING TORQUE	
		Kgm.	Nm.
ENGINE BLOCK			
Bearing capscrew (See IM-C-C-10-001e)		82*	804*
Bearing cap cross bolt (See IM-C-C-10-001e)		13*	128*
Cylinder head stud to crankcase (with Loctite 511)		5	49
MOVING PARTS			
Counterweight to crankshaft capscrew		28.5*	280*
Connecting rod capscrew (See IM-C-C-15-002e)		50*	491*
Flywheel mounting capscrew (with Loctite 243)		36	353
Screws crankshaft companion flange front (with Loctite 243)		16	157
Vibration damper capscrew		14	137
CYLINDER HEAD			
Cylinder head nut (See IM-C-C-10-002e)		48*	471*
Spark plug sleeve		23	226
Rocker arm adjusting screw		10	98
Valve lifter adjusting screw		4.5	44
SPARK PLUG (See IO-G-M-33-001, IO-G-M-33-004, IO-G-M-33-007)			
DISTRIBUTION			
Oil pump gear fixing nut (with Loctite 243)		30	294
OTHERS			
Nut for water pump impeller, main circuit (with Loctite 243)		10	98
Water pump gear drive and bearing capscrew, main circuit (with Loctite 243)		10	98
Engine to skid / subbase capscrew (M.20)	--	33	324
Exhaust manifold to cylinder head capscrew	Wet / Dry	6 / 4,5	59 / 44
		8.3 / 4,5	81 / 44
Turbocharger to manifold nut		4,5 / 4,5	44 / 44

NOTE

*** Oil lubricated (with plenty of motor oil)**

General directive for tightening torques based on screw quality and diameter.
These values should be used unless expressly specified otherwise. See IM-C-C-00-002e.

	PRODUCT INFORMATION	INDEX	DATE	
KOHLER Powered by DRESSER-RAND	**IM-G-C-00-001e**	**F**	*January 2015*	*Dep. 1*
	TIGHTENING TORQUES FOR GAS AND ETHANOL ENGINES			

O&M_2.002262.810_10_2016

FGLD/SFGLD/SFGM 360/480/560			
ITEM	**REFERENCE**	**TIGHTENING TORQUE**	
		Kgm.	**Nm.**
ENGINE BLOCK			
Bearing cap fixing stud		10*	98*
Bearing cap nut (See IM-C-C-10-001e)		102*	1001*
Bearing cap cross bolt (See IM-C-C-10-001e)		28*	275*
Cylinder head stud to crankcase (with Loctite 511)		5	49
Cyl. head stud SFGLD 560 (with Loctite 511)		5	49
MOVING PARTS			
Counterweight to crankshaft capscrew		28,5*	280*
Vibration damper capscrew		14	137
Connecting rod capscrew (See IM-C-C-15-002e)		50*	491*
Crankshaft rear output flange capscrew (flywheel)		43*	421*
Flywheel capscrew		31*	304*
CYLINDER HEAD			
Cylinder head nut (See IM-C-C-10-002e)		48*	471*
Cyl. head nut **SFGLD/SFGM 560** (See IM-C-C-10-002e)		45*	441*
Spark plug sleeve / SFGM560		23	226
Rocker arm adjusting screw		10	98
Valve lifter adjusting nut		4,5	44
SPARK PLUG (See IO-G-M-33-001, IO-G-M-33-004, IO-G-M-33-007)			
DISTRIBUTION			
Oil pump gear fixing nut (with Loctite 243)		35	343
OTHERS			
Nut for water pump impeller, main & auxiliary circuits (with Loctite 243)		10	98
Water pump gear drive and bearing capscrew, main & auxiliary circuits (with Loctite 243)		18	177
Engine to skid / subbase capscrew (M.20)	--	33	324
Exhaust manifold to cylinder head capscrew	Wet / Dry	6,5 / 4,5	64 / 44
		8,3 / 4,5	81 / 44
Turbocharger to manifold capscrew		4,5 / 4,5	44 / 44

NOTE

*** Oil lubricated (with plenty of motor oil)**

General directive for tightening torques based on screw quality and diameter.
These values should be used unless expressly specified otherwise. See IM-C-C-00-002e.

HGM 420 / 560			
ITEM	REFERENCE	TIGHTENING TORQUE	
		Kgm.	Nm.
ENGINE BLOCK			
Bearing cap fixing stud		10*	98*
Bearing cap nut (See IM-C-C-10-001e)		102*	1001*
Bearing cap cross bolt (See IM-C-C-10-001e)		28*	275*
Cylinder head stud to crankcase (with Loctite 511)		5	49
MOVING PARTS			
Counterweight to crankshaft capscrew		28,5*	280*
Vibration damper capscrew		14	137
Connecting rod capscrew (See IM-C-C-15-002e)		50*	491*
Crankshaft rear output flange capscrew (flywheel)		43*	421*
Flywheel capscrew		31*	304*
CYLINDER HEAD			
Cylinder head nut		48*	441*
Spark plug sleeve		23	226
Rocker arm adjusting screw		10	98
Valve lifter adjusting screw		4,5	44
SPARK PLUG (See IO-G-M-33-001, IO-G-M-33-004, IO-G-M-33-007)			
DISTRIBUTION			
Oil pump gear fixing nut (with Loctite 243)		35	343
OTHERS			
Nut for water pump impeller, main & auxiliary circuits (with Loctite 243)		10	98
Water pump gear drive and bearing capscrew, main & auxiliary circuits (with Loctite 243)		18	177
Engine to skid / subbase capscrew (M.20)	--	33	324
Exhaust manifold to cylinder head capscrew		4,5	44
Turbocharger to manifold nut		4,5	44

NOTE

*** Oil lubricated (with plenty of motor oil)**

General directive for tightening torques based on screw quality and diameter.
These values should be used unless expressly specified otherwise. See IM-C-C-00-002e.

1. STANDARD TIGHTENING TORQUE SPECIFICATION

Tabulated below are the tightening torques for commercial bolts and nuts according to their metric threads and grades.

THREAD	GRADE					
	8.8		10.9		12.9	
	N.m	Ft.lb	N.m	Ft.lb	N.m	Ft.lb
M.5	6	4.4	9	6,6	11	8.1
M.6	11	8	15	11	18	13.3
M.8	25	18	34	25	43	32
M.10	47	35	65	48	83	61
M.12	78	58	113	83	140	103
M.14	120	86	175	129	210	155
M.16	180	133	260	192	310	229
M.18	250	184	360	266	430	317
M.20	330	243	470	347	560	413
M.22	430	317	600	443	720	531
M.24	560	413	790	583	950	701
M.27	710	524	1060	782	1180	870
M.33	1110	819	1540	1136	1730	1276

Table 1 – Tightening torques for the fasteners' different threads and grades

Screw tightening torques outside this standard specification are listed in documents IM-F-C-00-002e and IM-F-C-00-004e for diesel and dual-fuel engines and IM-G-C-00-001e for gas and ethanol engines.

2. CALCULATING THE SCREW PRE-STRESSING FORCE ACCORDING TO THE APPLIED TIGHTENING TORQUE

The screw tightening torque is useful for two purposes:

- To overcome friction between contact areas, whether between screw and nut threads or between screw head and bearing surface.
- To apply a pre-stressing force to the fastener.

The amount of tightening torque usable for applying the pre-stressing force varies depending on the coefficient of friction to overcome. Therefore, even though the same tightening torque is applied to two identical screws, the pre-stressing force can vary if the coefficient of friction is different in both instances. The lower the coefficient, the lower the effort needed to overcome friction and consequently, the pre-stressing force will be greater.

Torques table 1 has been calculated with a coefficient of friction standard for steel μ=0.14. For other coatings, look at Table 2.

Coating	Coefficient of friction	
	Normal	Lubricated
Steel with cadmium	0.07	0.07
Cadmium with zinc	0.1	0.08
Cadmium with cadmium	0.1	0.07
Steel with phosphate	0.11	0.1
Phosphate with cadmium	0.11	0.08
Phosphate with zinc	0.11	0.11
Phosphate with phosphate	0.12	0.1
Steel with zinc	0.14	0.07

Table 2 – Coefficient of friction for different coatings

In any case, the normal coefficient of friction used is 0.14 for clean and non-lubricated steel-to-steel assembly. If the screw and the mating threads are of steel, clean and lubricated, this coefficient is 0.1.

From a known coefficient of friction, it is possible to calculate the pre-stressing force using this formula.

$$\boxed{M = P_v[\mu(\frac{S+dn}{4} + 0.58df) + 0.16p]}$$

df = side diameter
μ = The average coeficient of friction of :
μ_1 = Coeficient of friction between screw and part
μ_2 = Coeficient of friction in screw and part´s thread
S = Washer´s diameter
dn = Screw nominal diameter
p = Screw pitch
P_v = Pre - stressing force obtained with the torque M

To determine whether a screw will resist a pre-stressing force (as calculated from a known tightening torque and coefficient of friction), it is necessary to know the mechanical properties of that screw. The following table shows those properties.

GRADE		8.8	10.9	12.9
Tensile strength (N/mm^2)	Min.	784	980	1176
	Max.	980	1176	1372
Yield strength (N/mm^2)		627	882	1058
Extension to the breakage (%) min		12	9	8
Resilience (N.m/cm^2)		59	39	29,4
Hardness HRC	Min.	18	27	34
	Max.	31	38	44

Table 3 – Mechanical properties of screws used by Kohler
(acc. to DIN 267)

3. AUXILIARY SCREW DRIVING PRODUCTS

All screwed joints must have all their parts perfectly clean and assembled applying oil to the threads. For special applications, different products are usable for assembly. The following situations occur.

- Screws that never need to be removed, which can come loose due to vibration or for other reasons. In those cases, high strength threadlocker (Loctite 270) will be used.

- Screws that will be removed only on rare occasions, which can come loose due to vibration or for other reasons. In those cases, medium strength threadlocker (Loctite 243) will be used.

- Screws that never need to be removed, which fix low-pressure oil or water pipes, where gaps between threads are small. Medium strength thread sealant (Loctite 542) will be used.

- Screws that will have to be removed, which fix low-pressure oil or water pipes, where gaps between threads are small. They require low-strength thread sealant (Loctite 511).

- Screws that never need to be removed, which fix high-pressure oil or water pipes, where gaps between threads are important. They require high-strength threadlocker (Loctite 270 with Activator N [7649]).

- Awkward bolts and nuts, where high tightening torque accuracy and a known steady coefficient of friction are necessary, which will have to be removed, even after working in bad conditions. They require the application of solid lubricants for bolted metal joints (Molykote 1000).

UNITS CONVERSION

Length			
1 inch (in)	25.4 mm 2.54 cm 0.0254 m	1 mm	0.039370 in 0.0032808 ft 0.0010936 yd
12 in 1 foot (ft)	304.8 mm 30.48 cm 0.3048 m	10 mm 1 cm	0.39370 in 0.032808 ft 0.010936 yd
3 ft 1 yard (yd)	914.4 mm 91.44 cm 0.9144 m	100 cm 1 m	39.370 in 3.2808 ft 1.0936 yd
Area			
1 sq.in	645.16 mm^2 6.4516 cm^2	1 cm^2	0.155 sq. In 0.0010764 sq ft
1 sq.ft	929.03 cm^2 0.092903 m^2	10000 cm^2 1 m^2	1550 sq. In 10.764 sq ft
Volume			
1 cubic.in	16.387 cm^3 (c.c) 0.016387 dm^3 (liters)	1 cm^3 (c.c)	0.061024 cu.in 0.000035315 cu.ft 0.00026417 gal
1 cubic ft	28.317 dm^3 (liters) 0.028317 m^3	1000 cm^3 (c.c) 1 dm^3 (liters)	61.024 cu.in 0.035315 cu.ft 0.26417 gal
1 US gallon	3.7854 dm^3 (liters) 0.0037854 m^3	1000 dm^3 (liters) 1 m^3	61024 cu.in 35.315 cu.ft 264.17 gal
Mass			
1 pound (lb)	453.59 g 0.45359 kg	1 kg	2.2046 lb
Torque			
1 ft lb	1.3558 N m	1 N m	0.73756 ft lb
Power			
1 hp	0.7457 kW	1 W	0.0013410 HP 3,4121 Btu/hr 0.056838 Btu/min
1000 Btu/hr	0.293 kW	1000 W 1 kW	1.3410 HP 3412.1 Btu/hr 56.838 Btu/min
1 Btu/min	0.01759 kW	1000 kW 1 MW	1341.0 HP 3412100 Btu/hr 56868 Btu/min

UNITS CONVERSION

Energy			
1 Btu	1.0551 kJ 0.00029307 kWh	1 kJ (0.00027778 KWh)	0.94782 Btu
Temperature			
ºF = ºC x 1,8 + 32		K = ºC + 273,15	

Presure

psi	In HG	in H_2O	kPa	bar	kg/cm^2	mmH_2O
1	2.0360	27.68	6.8948	0.068948	0.070307	703.07
0.49115	1	13.595	3.3864	0.033864	0.034532	345.32
0.036127	0.073556	1	0.24909	0.0024909	0.00254	25.400
0.14504	0.2953	4.0146	1	0.01	0.010197	101.97
14.504	29.53	401.46	100	1	1.0197	10197
14.223	28.959	393.70	98.067	0.98067	1	10000
0.0014223	0.0028959	0.039370	0.0098066	0.000098066	0.0001000	1

1 INTRODUCTION

KOHLER engines require a cooling system able to dissipate the thermal energy they generate when in operation.

In order to cool the engine, water is used as the coolant fluid, after being treated to ensure optimum heat transfer and the non-appearance of problems related to the low quality of the same

In the case of gas engines with single cooling circuit, all engine components, including the air/mixture cooler, are cooled by the same circuit.

2 COOLING CIRCUIT DIAGRAM

Below we have an example of a cooling system of an in line engine with one cooling circuit, showing all its components: (Fig. 1):

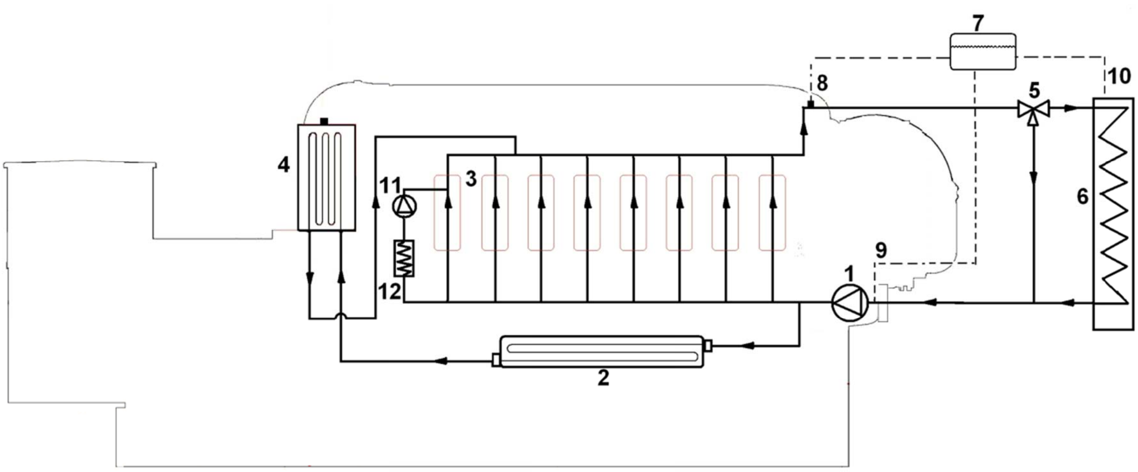


Figure 1 In line engine, one cooling circuit

1. Main circuit water impeller pump
2. Main circuit oil cooler
3. Engine block. Linings and cylinder heads
4. Air or air/fuel mixture cooler
5. Main circuit temperature regulator
6. Cooling system external to the engine of the main circuit
7. Main circuit expansion tank
8. Venting piping at the highest point of the engine of the main circuit and engine water vent
9. Venting piping at the main circuit pump inlet
10. Venting piping at the highest point of cooling system external to the engine of the main circuit
11. Auxiliary water preheating pump
12. Water preheating resistor

2.1ENGINE-MOUNTED COOLING CIRCUIT

2.1.1 JACKET WATER CIRCUIT

The jacket water pump draws water from the heat exchanger, thermostatic valve or both and discharges it to the water manifold located on the right side of the engine. Water then flows through the block, around the cylinder sleeves, up through the cylinder heads then to the cooled exhaust manifolds. From the exhaust manifolds, water is directed to the thermostatic valve (see page 4/7 for a full description of the thermostatic valve) that either recirculates water to the pump inlet or diverts water to the heat exchanger, depending on water outlet temperature.

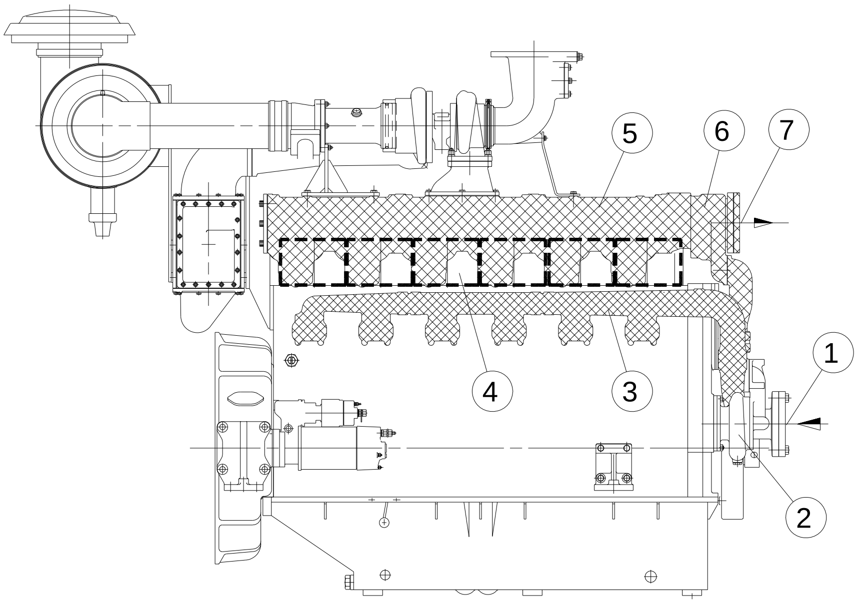


Figure 2 Jacket Water circuit

1	Water inlet (from external cooling system)
2	Water pump
3	Water manifold
4	Water cooled cylinder head
5	Water cooled exhaust manifold
6	Thermostatic valve
7	Water outlet (to external cooling system)

2.1.2 OILCOOLER AND INTERCOOLER CIRCUIT

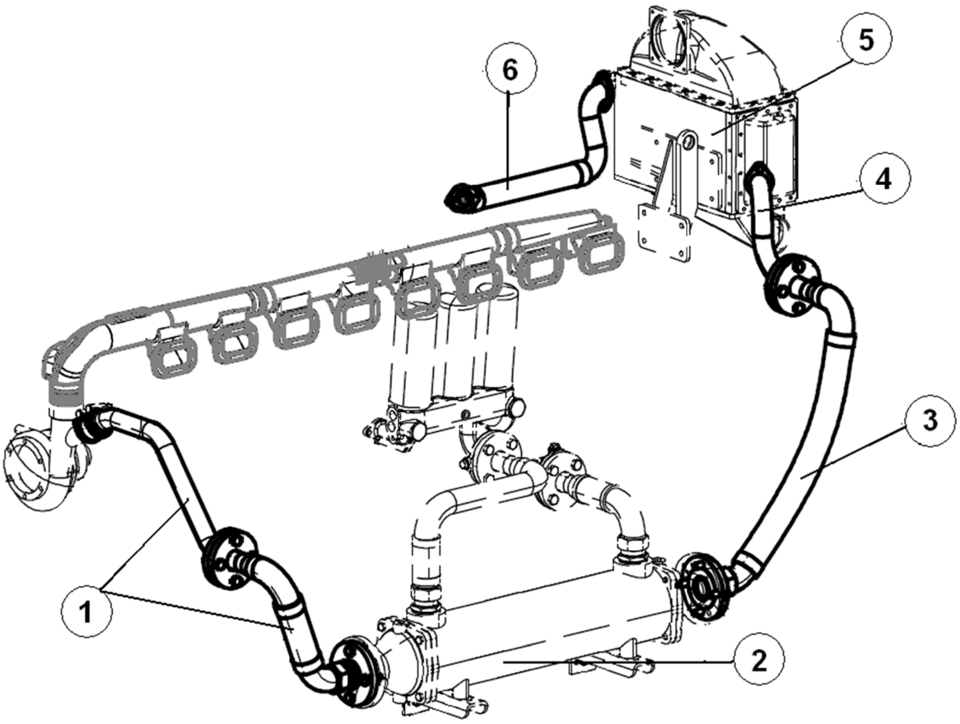


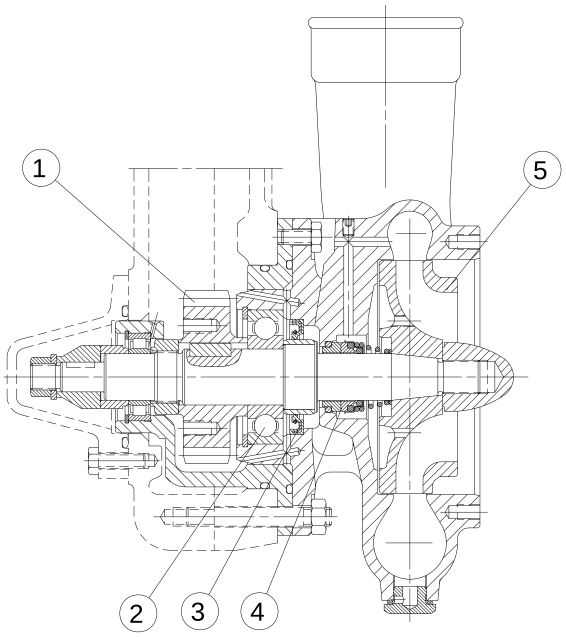
Figura 3 Oilcoler and intercooler

1	Oilcooler inlet pipe
2	Oilcooler
3	Oilcooler outlet pipe
4	Intercooler inlet pipe
5	Intercooler
6	Intercooler outlet pipe

3 COOLING SYSTEM COMPONENTS

3.1 IMPELLER PUMP

Responsible for passing the right amount and pressure of cooling water past all elements of the engine. It can be operated mechanically by the engine itself. This is a gear-driven centrifugal pump located on the front right side of the engine.



1	Drive gear
2	Bearing
3	Seal
4	Seal
5	Impeller

.

Figure 4 Water pump

3.2 OIL COOLER

Lubrication and cooling oil cooling system.

3.3 ENGINE BLOCK

Distributes water to the engine block to cool the liners and then the cylinder heads.

3.4 AIR OR AIR/FUEL INLET COOLER

This is the component of turbocharged engines that cools the air or air/fuel inlet mixture, which is heated by compression in the turbocharger, before it enters the combustion chamber.

3.5 WATER PREHEATING SYSTEM

This is an auxiliary system that allows the engine cooling water to be at the optimum temperature when the engine starts from cold. This system consists of a heating element that heats up the water and, occasionally, an auxiliary water pump that distributes the water throughout the engine. See IT-C-A-20-009.

3.6 WATER TEMPERATURE REGULATOR

The temperature of the water in the circuit needs to be controlled in order to stay at the right temperature. This can be done by means of thermostatic valves that are installed in a thermostat box or by electronic regulation using 3-way valves.

Temperature regulation using thermostatic valves is generally used for cases where precise temperature control is needed, as they control ranges from 8 to 10ºC. Electronic regulation is used for cases where precise temperature control is needed, in heat recovery applications for example.

3.6.1 THERMOSTATIC VALVE

The thermostatic valve contains 3 thermostats and is designed to maintain the operating temperature of water in the engine between 75 ºC and 88 ºC (167 ºF to 190 ºF).

Most of the coolant flows back to the suction side of the jacket water pump if the temperature is less than 75 ºC (167 ºF).

A small amount of cooling water will always circulate through the thermostatic valve to the external cooling system. This flow is used for purging air, thus avoiding the formation of air pockets in the cooling system.

When the cooling water temperature exceeds that which causes the thermostats to open, water circulates around thermostats and exits to the external cooling system.

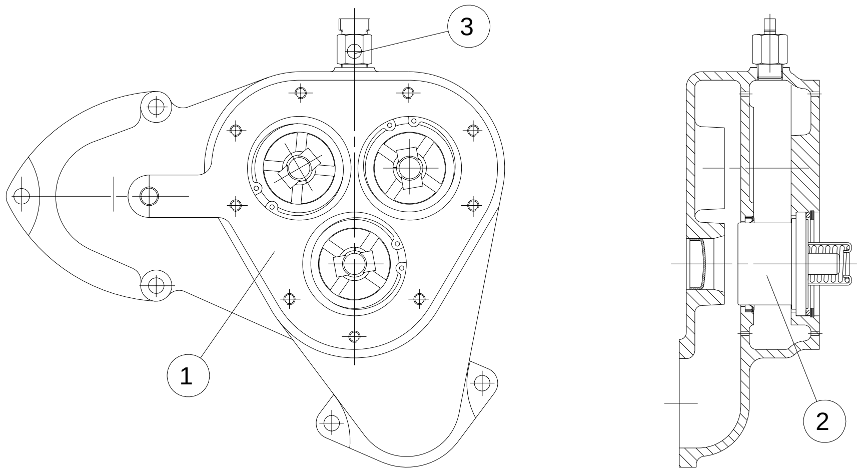


Figure 5 Thermostatic valve

1	Thermostatic valve body
2	Thermostats
3	Bleed valve

3.7 VENT

An element that purges any possible air pockets from the circuit while the cooling circuit is being filled.

3.8 EXPANSION TANK

Due to the increased volume of heated water, a tank has to be installed to control said increases in volume.

The expansion tank has to be installed at the highest point of the cooling circuit.

A pipe must run from the expansion tank to the circuit water pump inlet.

All venting pipes on the circuit must lead to the expansion tank below water level.

The expansion tank must be fitted with a low water level sensor that does not allow the water level to fall below a minimum level and a safety valve that allows air to enter the circuit at negative pressure and water, steam or air to leave at positive overpressure.

The expansion tank must have a capacity of at least 15% of the total volume of water in the cooling circuit.

NOTE

Pressurized expansion tanks must be used in those cases where the minimum pressure requirement of the cooling circuit cannot be reached with cooling systems using unpressurised expansion tanks or where engine temperature exceeds 100ºC.

3.9 VENTING PIPES

This is a system of pipes that avoid air from collecting in the cooling system.

At least the following venting pipes should be installed, leading to the expansion tank, always below the water level in the tank:

- From the circuit water pump inlet to the expansion tank
- From the highest point of the cooling circuit in the engine to the expansion tank
- From the highest point of the external cooling circuit to the expansion tank

3.10 EXTERNAL COOLING SYSTEM

This part of the cooling circuit is responsible for cooling the heat produced by the engine.

These systems may be of different types, depending on the requirements and application in question.

4 REQUIREMENTS OF THE ENGINE COOLING SYSTEM

- The cooling system must be able to dissipate all the heat generated by the engine and keep the same at the correct in all possible operating conditions.
- The heat generated and the cooling temperature are reflected in the thermal balances of each engine.

  The heat generated by the engine and shown on the thermal balance sheet is a value determined under specific operating parameters and standard conditions, meaning that in real conditions the heat generated by the engine may vary, depending on its operating conditions and on environmental conditions. The cooling circuit should be sized taking into account these variations, as well as taking into account the fact that the cooling system may well get dirty. Kohler recommends having a reserve capacity of 15%.

  The cooling liquid must satisfy the requirements listed in product information IO-C-M-20-001. The cooling circuit must be designed to take into account the fact that using antifreeze in the coolant reduces heat transfer by 3% for each 10% of antifreeze added to the coolant.
- The cooling circuit pressure must always be positive throughout the circuit and comply with all minimum requirements laid down for each engine in product information sheets IO-G-M-60-002, IO-G-M-60-006, IO-F-M-60-002 and IO-D-M-60-001.
- The cooling circuit must have a certain flow rate, defined in product information sheets IT-G-A-20-007 and IT-F-A-20-005.

1. INTRODUCTION

When calculating pressure losses in the cooling circuits of gas engines. Product Information Datasheets IT-C-A-20-001e and IT-C-A-20-002e apply. The former explains how to calculate pressure losses based on the components layout. while the latter summarises the pressure losses for each separate component.

To define flowrates in addition to the parameters that guarantee correct performance of the engine against seizing or knocking. we take it into account that the flowing-through velocity in the heat exchanger pipes should not be less than 1m/s nor greater than 3m/s.

CAUTION

Maximum flowrate in the ***main circuit*** depends on the external cooling system. while the maximum flowrate in the ***auxiliary circuit*** is determined by the passage cross section in the air and oil coolers and should not exceed **30m^3/h**.

According to the temperature of the primary and/or secondary cooling circuit(s). the minimum flowrates will vary.

WARNING

The circuit's pressure loss (Delta P) and restriction (K) are valid for a basic engine configuration with mechanical pumps as defined in section 5 of this document. Any change to the components of said configuration will entail recalculating both aforementioned parameters. For instance. if the engine incorporates electric pumps. the thermostat box is different from that specified for engines with mechanical pumps; therefore. you need to recalculate both the restriction and the pressure loss.

Considerations to take into account in other engine applications or engine configurations

- The minimum flowrates specified for both cooling circuits apply to "continuous" duty equipment. For "standby" units. the minimum flowrate shall be determined. increasing it in the same proportion as power does in relation to the tabulated flowrates.
- Minimum flowrates are the same for engines with **dry exhaust manifolds** and with (wet) cooled exhaust manifold.
- For variable speed engines the Minimum flows are the same that for constant speed engines

2. MINIMUM FLOWRATES FOR FGLD ENGINES

2.1 MAIN COOLING CIRCUIT

Engine	Speed [rpm]	Minimum flowrate [m^3/h]	Delta P [bar]	K
FGLD180 FG180	1500	25	0.28	$4.5 \cdot 10^{-4}$
	1800	30	0.41	
FGLD240 FG240	1500	30	0.30	$3.3 \cdot 10^{-4}$
	1800	35	0.40	
FGLD360	1500	50	0.25	$1.0 \cdot 10^{-4}$
	1800	60	0.36	
FGLD480	1500	60	0.40	$1.1 \cdot 10^{-4}$
	1800	70	0.54	

2.2 AUXILIARY COOLING CIRCUIT

Engine	Speed [rpm]	Temperature [ºC]	Minimum Flowrate [m^3/h]	Delta P [bar]	K
FGLD180	1500	55(Biogas)	15	0.42	$1.86 \cdot 10^{-3}$
		55		0.45	$2.01 \cdot 10^{-3}$
		80		0.46	$2.04 \cdot 10^{-3}$
	1800	55	20	0.81	$2.01 \cdot 10^{-3}$
		80		0.82	$2.04 \cdot 10^{-3}$
FGLD240	1500	55(Biogas)	20	0.74	$1.86 \cdot 10^{-3}$
		55 (90 Main C.)		0.80	$2.01 \cdot 10^{-3}$
		55 (120 Main C.)		0.82	$2.04 \cdot 10^{-3}$
		80		0.7	$1.76 \cdot 10^{-3}$
	1800	55(Biogas)	25	1.16	$1.86 \cdot 10^{-3}$
		55		1.26	$2.01 \cdot 10^{-3}$
		80		1.10	$1.76 \cdot 10^{-3}$
FGLD360	1500	55 (90 Main C.)	20	0.45	$1.13 \cdot 10^{-3}$
		55 (120 Main C.)		0.45	$1.13 \cdot 10^{-3}$
		80 (90 Main C.)		0.45	$1.13 \cdot 10^{-3}$
		80 (120 Main C.)		0.46	$1.16 \cdot 10^{-3}$
	1800	55	25	0.68	$1.09 \cdot 10^{-3}$
		80		0.71	$1.13 \cdot 10^{-3}$
FGLD480	1500	55 (90 Main C.)	20	0.45	$1.13 \cdot 10^{-3}$
		55 (120 Main C.)		0.46	$1.16 \cdot 10^{-3}$
		80		0.47	$1.18 \cdot 10^{-3}$
	1800	55	25	0.71	$1.13 \cdot 10^{-3}$
		80		0.74	$1.18 \cdot 10^{-3}$

3. MINIMUM FLOWRATES FOR SFGLD / SFGRD / SFGM ENGINES

3.1 MAIN COOLING CIRCUIT – TWO CIRCUITS

Engine	Speed	Minimum flowrate	Delta P	K
	[rpm]	[m^3/h]	[bar]	
SFGLD/SFGRD/SFGM180	1200	20	0.18	$4.5 \cdot 10^{-4}$
	1500	25	0.28	
	1800	30	0.41	
SFGLD/SFGRD/SFGM 240	1200	25	0.21	$3.3 \cdot 10^{-4}$
	1500	30	0.30	
	1800	40	0.53	
SFGLD/SFGRD/SFGM 360	1200	40	0.16	$1.0 \cdot 10^{-4}$
	1500	50	0.25	
	1800	60	0.36	
SFGLD/SFGRD/SFGM 480	1200	50	0.28	$1.1 \cdot 10^{-4}$
	1500	60	0.40	
	1800	80	0.70	
SFGLD/SFGRD SFGM /560	1200	60	0.40	
	1500	70	0.54	
	1800	75	0.62	

3.2 MAIN COOLING CIRCUIT – ONE CIRCUIT

Engine	Speed	Minimum flowrate	Delta P	K
	[rpm]	[m^3/h]	[bar]	
SFGLD 180	1800	40	0,43	$2,7 \cdot 10^{-4}$
SFGLD 240	1800	50	0,30	$1,2 \cdot 10^{-4}$
SFGLD 360	1800	60	0,14	$3,9 \cdot 10^{-5}$
SFGLD 480	1800	80	0,25	$3,9 \cdot 10^{-5}$
SFGLD 560	1800	88	0,30	$3,9 \cdot 10^{-5}$

3.3 AUXILIARY COOLING CIRCUIT. SINGLE-STAGE AIRCOOLER

Engine	Speed	Temperature	Minimum Flowrate	Delta P	K
	[rpm]	[ºC]	[m^3/h]	[bar]	
SFGLD/SFGRD/SFGM180	1200/1500	55	15	0.42	$1.86 \cdot 10^{-3}$
		80		0.43	$1.89 \cdot 10^{-3}$
	1800	55	20	0.74	$1.86 \cdot 10^{-3}$
		80		0.76	$1.89 \cdot 10^{-3}$
SFGLD/SFGRD/SFGM240	1200	55	15	0.43	$1.89 \cdot 10^{-3}$
	1500	40 – 55	20	0.76	$1.89 \cdot 10^{-3}$
		80		0.64	$1.61 \cdot 10^{-3}$
	1800	55	25	1.18	$1.89 \cdot 10^{-3}$
		80		1.01	$1.61 \cdot 10^{-3}$
SFGLD360	1200	55	15	0.25	$1.09 \cdot 10^{-3}$
	1500	40 – 55 (90 Main C)	20	0.44	$1.09 \cdot 10^{-3}$
		55 (120 Main C)		0.45	$1.13 \cdot 10^{-3}$
		80 (90 Main C)			
		80 (120 Main C)		0.46	$1.16 \cdot 10^{-3}$
	1800	55 (90 Main C)	25	0.68	$1.09 \cdot 10^{-3}$
		80 (90 Main C)		0.71	$1.13 \cdot 10^{-3}$
		80 (90 Main C)		0.71	
		80 (120 Main C)		0.73	$1.16 \cdot 10^{-3}$
SFGLD480	1200	55	15	0.25	$1.13 \cdot 10^{-3}$
	1500	40 – 55 (90 Main C)	20	0.45	$1.13 \cdot 10^{-3}$
		55 (120 Main C)		0.46	$1.16 \cdot 10^{-3}$
		80		0.47	$1.18 \cdot 10^{-3}$
	1800	55	25	0.71	$1.13 \cdot 10^{-3}$
		80		0.74	$1.18 \cdot 10^{-3}$
SFGLD560	1200	55	15	0.25	$1.13 \cdot 10^{-3}$
	1500	32 – 55	25	0.71	

3.4 AUXILIARY COOLING CIRCUIT. DOUBLE-STAGE AIRCOOLER

Engine	Speed	Temperature	Minimum Flowrate	Delta P	K
	[rpm]	[ºC]	[m^3/h]	[bar]	
SFGLD/SFGRD/SFGM 360	1200	55	15	0.47	$2.06 \cdot 10^{-3}$
	1500	40 – 55	23	1.09	
	1800	55	25	1.29	
SFGLD/SFGRD/SFGM 480	1200	55	18	0.67	$2.06 \cdot 10^{-3}$
	1500	40 – 55	23	1.09	
	1800	55	25	1.29	
SFGLD/SFGRD/SFGM 560	1200	55	17	0.6	
	1500	40 – 55	21	0.9	
	1800	55	25	1.28	

4. MINIMUM FLOWRATES FOR HGM ENGINES

4.1 MAIN COOLING CIRCUIT

Engine	Speed	Minimum Flowrate	Delta P	K
	[rpm]	[m^3/h]	[bar]	
HGM240	1500	36	0,71	$5,48 \cdot 10^{-4}$
	1800	45	1.11	
HGM420	1500	55	1.27	$4.23 \cdot 10^{-4}$
	1800	60	1.52	
HGM560	1200	55	0.53	$1.78 \cdot 10^{-4}$
	1500	70	0.87	
	1800	80	1.13	

4.2 AUXILIARY COOLING CIRCUIT.

4.2.1 DOUBLE STAGE INTERCOOLER

Engine	Speed	Temperature	Minimum Flowrate	Delta P	K
	[rpm]	[ºC]	[m^3/h]	[bar]	
HGM420	1500	40-55	21	0.83	$1.90 \cdot 10^{-3}$
	1800		25	1.18	
HGM560	1200		12	0.27	
	1500		21	0.83	
	1800		25	1.18	

4.2.2 SINGLE STAGE INTERCOOLER

Engine	Speed [rpm]	Temperature [ºC]	Minimum Flowrate [m3/h]	Delta P [bar]	K
HGM240	1500	55	20	0,46	$1{,}16\cdot10^{-3}$
	1800		22	0.56	

5. BASIC CONFIGURATIONS

The following are the basic configurations used to determine the pressure losses in the main and auxiliary cooling circuits of the above-listed engines.

5.1 MAIN COOLING CIRCUIT

Engine	Cyl. Block	Thermostat Box
SFGLD/SFGRD/SFGM/FGLD/FG180	YES	YES (3 Thermostats)
SFGLD/SFGRD/SFGM/FGLD/FG240	YES	YES (3 Thermostats)
SFGLD/SFGRD/SFGM/FGLD360	YES	YES (7 Thermostats)
SFGLD/SFGRD/SFGM/FGLD480	YES	YES (7 Thermostats)
SFGLD/SFGRD/SFGM560	YES	YES (7 Thermostats)

5.2 AUXILIARY COOLING CIRCUIT. SINGLE-STAGE AIRCOOLER

Engine	Oil cooler	Aircooler	Thermostat Box
FGLD180	YES	YES	YES (1 Thermostat)
FGLD180 (Landfill/Digester)	YES	YES	YES (1 Thermostat)
FGLD240	YES	YES	YES (1 Thermostat)
FGLD240 (Landfill/Digester)	YES	YES	YES (1 Thermostat)
FGLD360	YES	YES	YES (2 Thermostats)
FGLD480	YES	YES	YES (2 Thermostats)

Engine	Oil cooler	Aircooler	Thermostat Box
SFGLD/SFGRD/SFGM180	YES	YES	YES (1 Thermostat)
SFGLD/SFGRD/SFGM240	YES	YES	YES (1 Thermostat)
SFGLD360	YES	YES	YES (2 Thermostats)
SFGLD480	YES	YES	YES (2 Thermostats)
SFGLD560	YES	YES	YES (2 Thermostats)

5.3 AUXILIARY COOLING CIRCUIT. DOUBLE-STAGE AIRCOOLER

Engine	Oil cooler	Aircooler	Thermostat Box
SFGLD/SFGRD/SFGM360	YES	YES	YES (2 Thermostats)
SFGLD/SFGRD/SFGM480	YES	YES	YES (2 Thermostats)
SFGLD/SFGRD/SFGM560	YES	YES	YES (2 Thermostats)

3.4 AUXILIARY COOLING CIRCUIT. DOUBLE-STAGE AIRCOOLER

Engine	Speed	Temperature	Minimum Flowrate	Delta P	K
	[rpm]	[ºC]	[m^3/h]	[bar]	
SFGLD/SFGRD/SFGM 360	1200	55	15	0.47	$2.06\cdot10^{-3}$
	1500	40 – 55	23	1.09	
	1800	55	25	1.29	
SFGLD/SFGRD/SFGM 480	1200	55	18	0.67	$2.06\cdot10^{-3}$
	1500	40 – 55	23	1.09	
	1800	55	25	1.29	
SFGLD/SFGRD/SFGM 560	1200	55	17	0.6	
	1500	40 – 55	21	0.9	
	1800	55	25	1.28	

4. MINIMUM FLOWRATES FOR HGM ENGINES

4.1 MAIN COOLING CIRCUIT

Engine	Speed	Minimum Flowrate	Delta P	K
	[rpm]	[m^3/h]	[bar]	
HGM240	1500	36	0,71	$5,48\cdot10^{-4}$
	1800	45	1.11	
HGM420	1500	55	1.27	$4.23\cdot 10^{-4}$
	1800	60	1.52	
HGM560	1200	55	0.53	$1.78\cdot10^{-4}$
	1500	70	0.87	
	1800	80	1.13	

4.2 AUXILIARY COOLING CIRCUIT.

4.2.1 DOUBLE STAGE INTERCOOLER

Engine	Speed	Temperature	Minimum Flowrate	Delta P	K
	[rpm]	[ºC]	[m^3/h]	[bar]	
HGM420	1500	40-55	21	0.83	$1.90\cdot10^{-3}$
	1800		25	1.18	
HGM560	1200		12	0.27	
	1500		21	0.83	
	1800		25	1.18	

PRODUCT INFORMATION	INDEX	DATE	
IC-C-D-25-004e	**C**	*February 2012*	*Dep. 2*

DESCRIPTION OF LUBRICATION SYSTEM FOR "IN-LINE" ENGINES

O&M_2.002262.810_10_2016

1. INTRODUCTION

The purpose of the engine lubrication system is to:

- Provide pressurised oil for hydrodynamic lubrication, minimizing friction between parts moving in relation to each other (crankshaft, connecting rods, etc.).
- Regulate the oil pressure so as to ensure correct lubrication.
- Filter oil adequately in order to maintain its lubricating properties.
- Cool the engine.
- Protect the engine parts, like the filters, seals, etc., against oil overpressure by means of relief valves.

2. DESCRIPTION

The lubricating system is made up of the following elements:

- Wet oil sump, suction tube and oil level indicator.
- Geared oil pump with overpressure safety valve.
- Lube oil pressure regulating valve.
- Oil cooler.
- Oil filters.
- Jet pressure regulation valve.
- Centrifugal filter (diesel, biogas, low methane number gases and propane engines)
- Blow-by gas exhaust system: crankcase breather.

2.1. Oil sump

The bottom of the crankcase is enclosed by the oil sump or oil tank. The amount of oil it contains depends on the engine model. A threaded drain plug is fitted to the lowest point in the sump.

Located in the crankcase is the oil suction tube which is fitted with a grille, preventing the suction of foreign material into the oil circuit.

The dipstick, which allows visual control of the oil level, is also located in the sump.

2.2. Oil pump

This a gear type positive displacement pump driven through the timing gears, which ensures the pump operates when the engine is running.

It is the oil pump function to supply oil to the other components of the engine. The pump consists of: a pump body, cover or suction hood, two gears (a driving gear and an idler gear), and an overpressure safety valve.

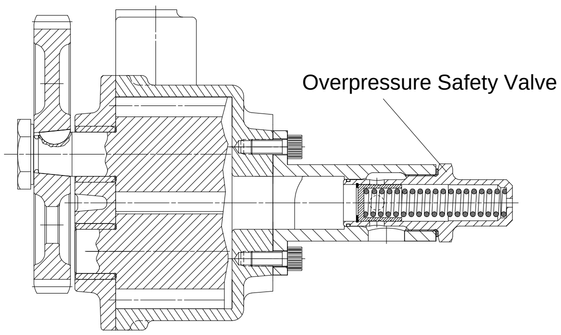


Fig.1 Oil Pump

2.3. Overpressure safety valve

The overpressure safety valve or relief valve is located at the outlet of the oil pump. Its function is to discharge oil directly to the sump if the impulse pressure exceeds the rated pressure (8 bar / 116 psi), thus protecting engine components from failure. The valve is fixed to a bracket attached to the ribs of the oil sump. (See Fig. 1)

2.4. Lubricating oil pressure regulating valve

Its function is to regulate the lubricating oil pressure of the engine. It is located at the inlet of the oil filters and is rated at 4.5 bar (65 psi). Its function is to discharge the surplus oil when the rated pressure is exceeded, ensuring that the pressure is constant under all the engine operating or load conditions. (See Fig. 2.)

2.5. Oil cooler

Either of two types can be used:

- Plate type: housed in a casing, fitted integrally on the engine.
- External oil cooler: the standard version is the pipe type, housed in a casing. The design of the oil cooler can be adapted to the application requirements.

2.6. Oil filters

The filters are of the interchangeable and full flow cartridge type, oil being entirely cleaned in a set of three parallel filters. They have no bypass or non-return valve. Filtering efficiency is 99% at 30μm and 50% at 15μm.

2.7. Jet pressure regulation valve

This is located downstream of the filters and it is rated at 3 bar (43.5 psi). Its function is to allow oil to pass to the jet gallery and to the piston coolant jets themselves when the rated pressure is reached. Piston coolant oil is filtered. (See Fig. 2.)

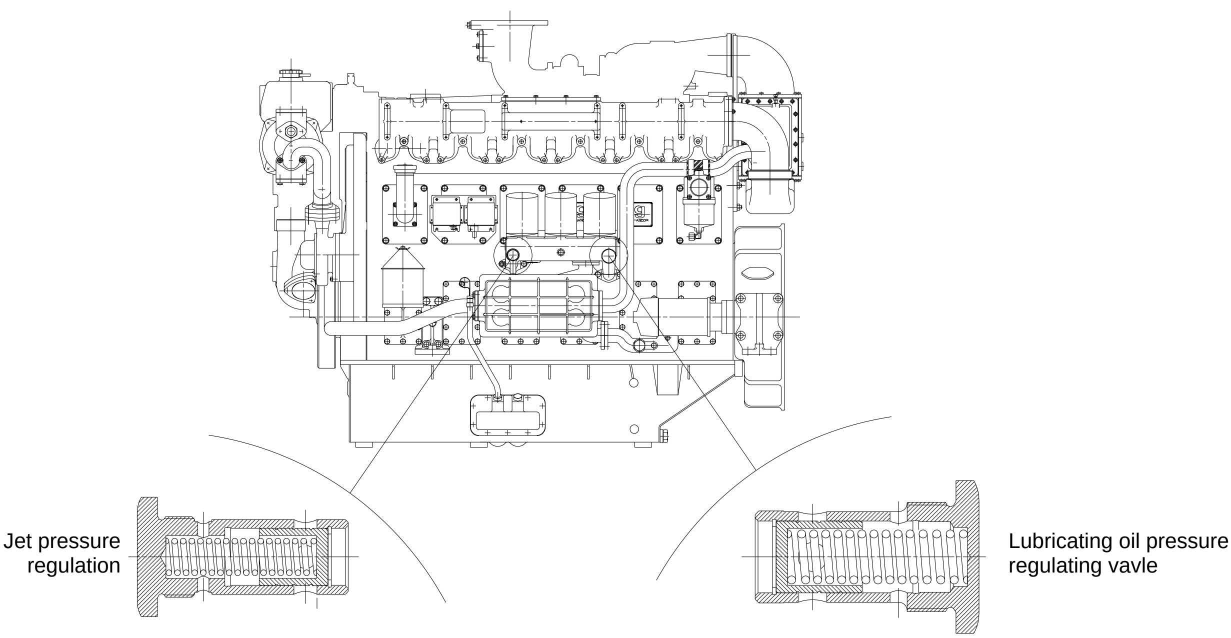


Fig.2 Jets and Regulation Valves Disposition

2.8. Centrifugal filter

Combustion in diesel engines produces a large amount of soot or very fine-grained pulverised carbon particles that are absolutely not retained in the oil filter.

In case of the gas engines, the main problem is the presence of pollutants in gas fuel (such as biogases) which are carried by the oil.

Centrifugal filters are not so common as the oil filters; their underlying principle is the heavier weight of solids compared to oil. A centrifugal filter comprises a rotating circular body on the wall of which the solid particles settle, while purified oil flows through a central duct to the oil sump.

2.9. Blow-by gas exhaust system

KOHLER engines can have either a passive or an active venting system.

2.9.1 Passive or open system (diesel, gas and ethanol engines):

This is the standard venting system. It consists of a breather which allows oil vapours and blow-by gases to get out into the atmosphere through an exhaust pipe. These are the components of such an open gas exhaust system:

- The crankcase, which finally collects the gases that escape from the combustion chamber through the interstice between the piston rings and the cylinder liner.

- The blow-by gas breather. It is made of one or various wire-mesh separators which separate the gas-borne thick liquid drops and feed them back to the crankcase by gravity.

- An exhaust pipe.

2.9.1 Active or crankcase gas recirculating system (only gas engines):

The crankcase gas recirculating system aims to introduce the engine-produced blow-by gases into the inlet airstream in a clean and efficient manner.

Besides the open system elements, adding a filter, to clean the gases previous their recirculation, is required.

3. OPERATION

- Oil is drawn from the sump through the grille in the suction tube by means of the oil pump.

- The pump supplies a specific flow of oil at a certain pressure. If the pressure exceeds 8 bar (116 psi), oil is drained in the safety valve directly to the crankcase.

- Oil flows from the pump to the oil cooler then to the filter access gallery.

- This gallery is fitted with the lubricating oil pressure regulating valve. If the pressure does not exceed 4.5 bar (65 psi), oil is allowed in the filter access gallery; otherwise, part of the oil stream is diverted to the crankcase. The oil circulates in parallel through the filters.

- On the one side, filtered oil reaches the jet pressure regulation valve which allows it to pass on to the jet gallery if the rated pressure of 3 bar (43 psi) is exceeded. From here it flows to the piston cooling jets.

- On the other side, filtered oil gains access to the main lubrication gallery, from which oil is distributed to different parts of the engine, namely:

The crankshaft, bearing caps and small and big ends of the connecting rod: on reaching the crankshaft, oil flows through internal channels which lead it to the bearing caps and big-end bearings. Oil circulates through ducts inside the connecting rod to reach the upper part of the conrod, i.e. the small end bushings and the pin, which are coated with a lubricating film.

The camshaft, cylinder heads, rocker arms on the engine. Oil flows inside the camshaft, from end to end, along the longitudinal direction of the engine block. Also, oil is distributed through individual passages to the bearings and the auxiliary rocker arm shaft. Holes in the rocker arm shaft bushing allow oil to lubricate the camshaft rollers.

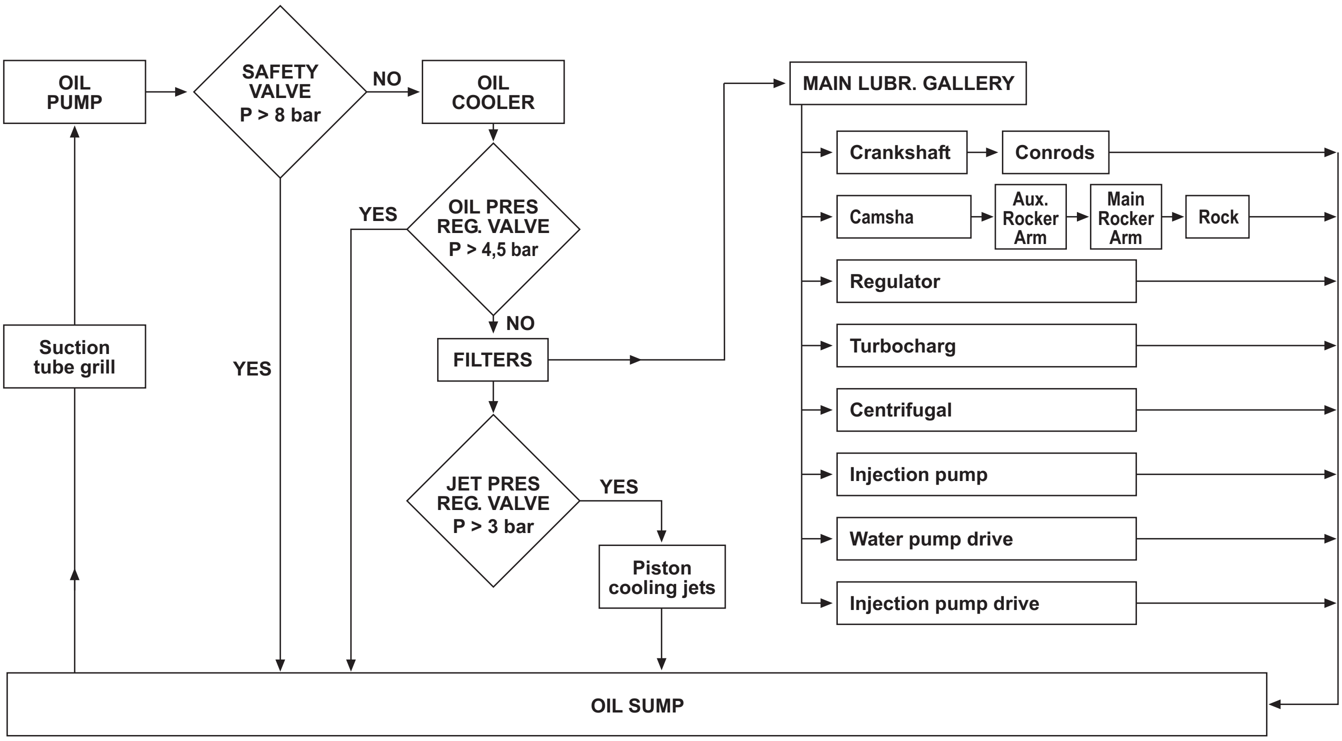
Part of the oil that flows through the camshaft flows into an external channel which is machined on the engine block and cylinder head and conveys oil to the main rocker arm shaft. From this point, oil passes through the shaft orifices to the oiling holes of the intake and exhaust valve rockers and to the valve stems. The rest of the cylinder head is spray-lubricated.

On turbocharged engines, oil reaches the turbocharger by an external pipe.

From the main lubrication gallery, oil is fed to the injection pump driving coupling, to the injection pump and to the water pump.

Part of the oil flows to the centrifugal filter that retains dispersed soot and contributes to keeping oil cleaner and to extending the oil change intervals.

- Finally, the oil returns to the sump.



AUTOMATIC ENGINE OIL LEVEL CONTROLLER

O&M_2.002262.810_10_2016

1. INTRODUCTION

If engine-driven equipment is intended for 24-hour operation or similar, it is recommended that the engine should be fitted with an oil level controller.

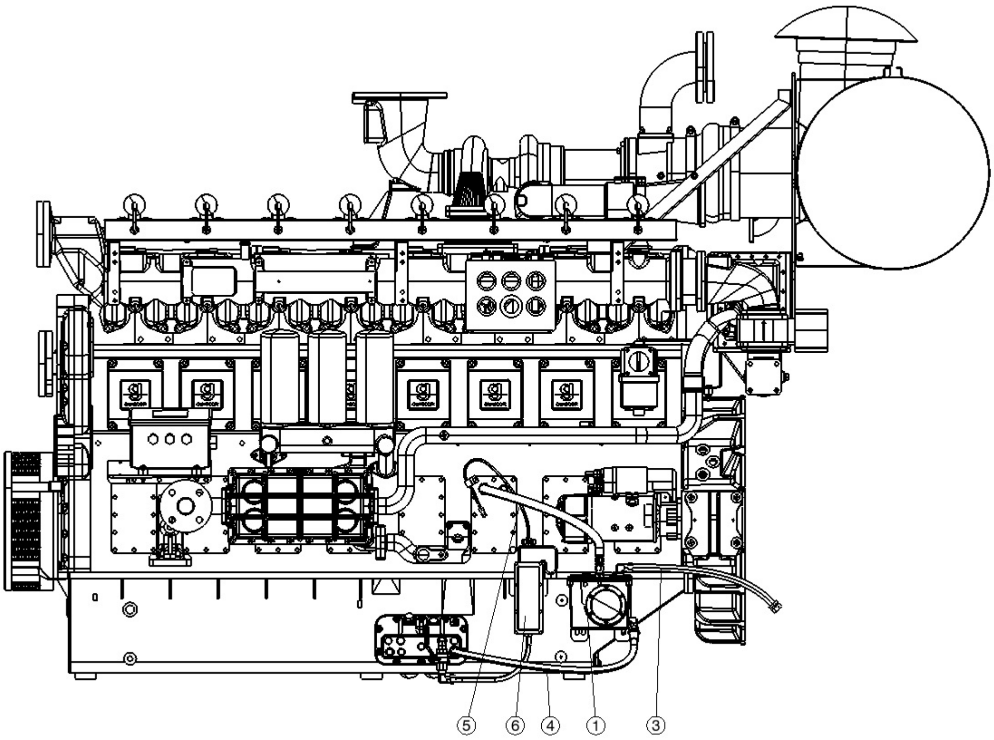


Fig. 1 – General layout on 180/240 series engines

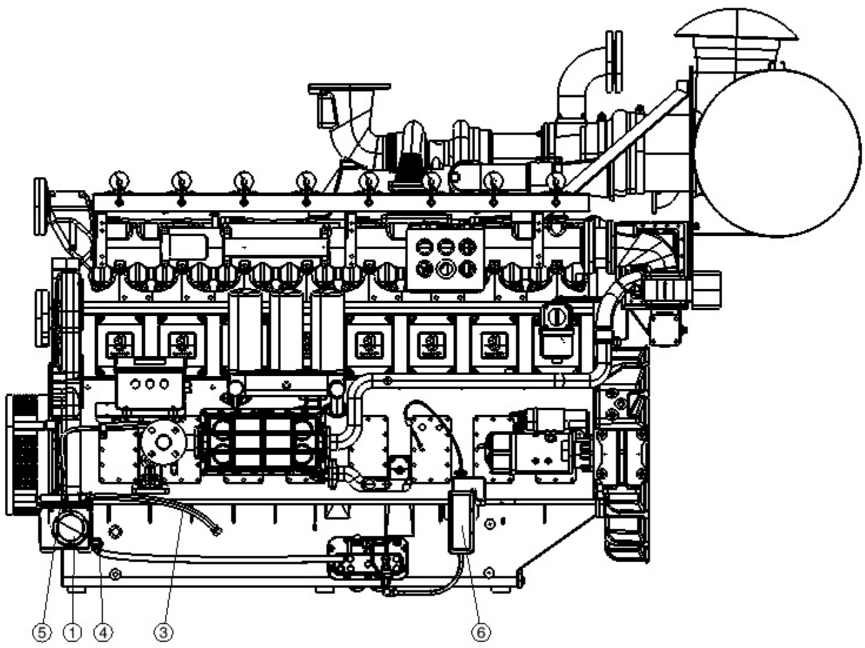


Fig. 2 – General layout on 180/240 series generating sets

AUTOMATIC ENGINE OIL LEVEL CONTROLLER

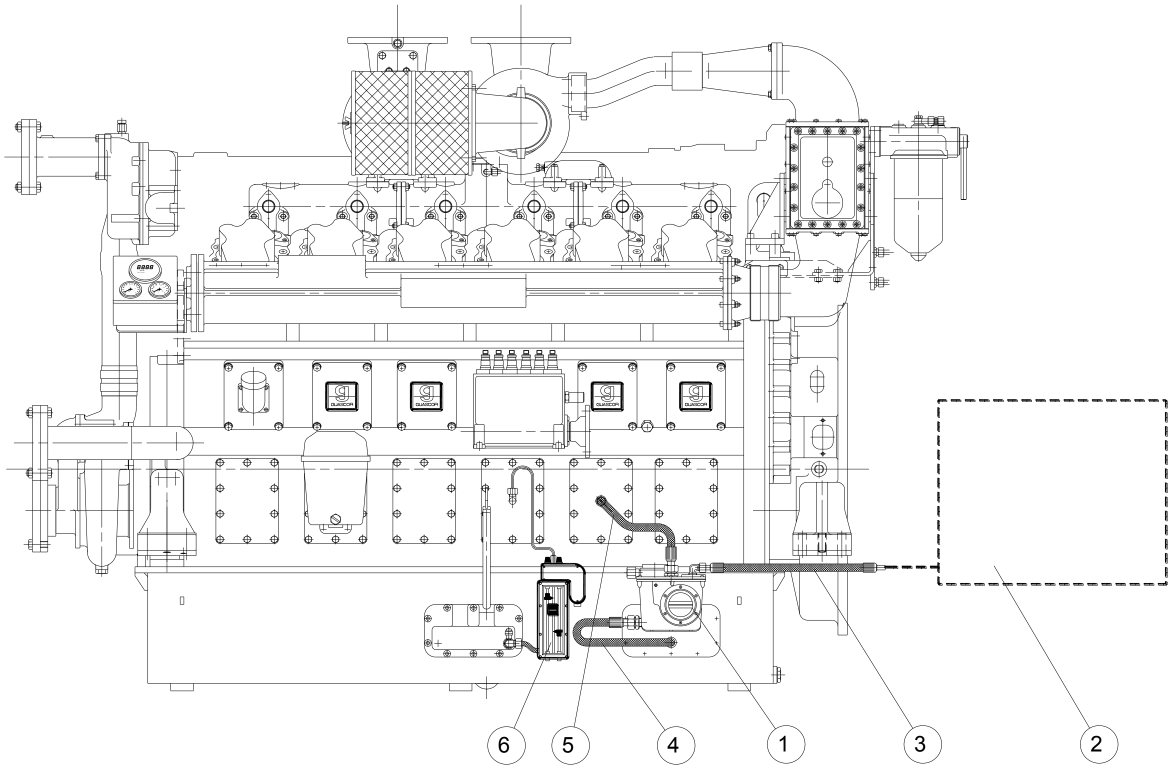


Fig. 3 – General layout on 360/480/560 series engines/generating sets

1	Automatic oil level controller
2	Oil tank
3	Filling hose
4	Oil sump to level controller hose
5	Venting hose
6	Lube oil level indicator (Refer to IT-C-A-25-009e or IT-G-A-25-009e)

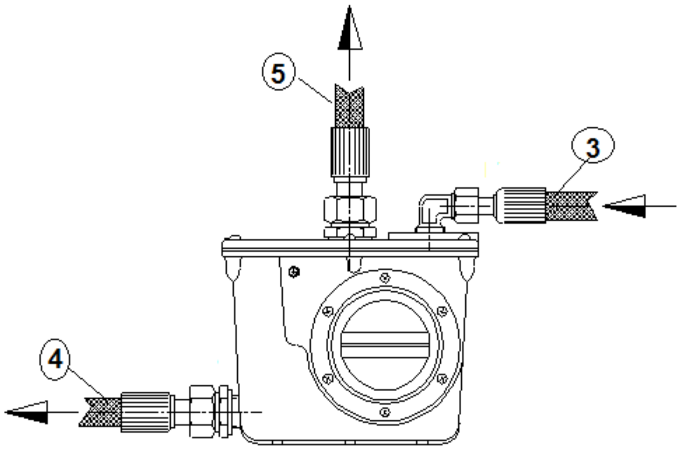


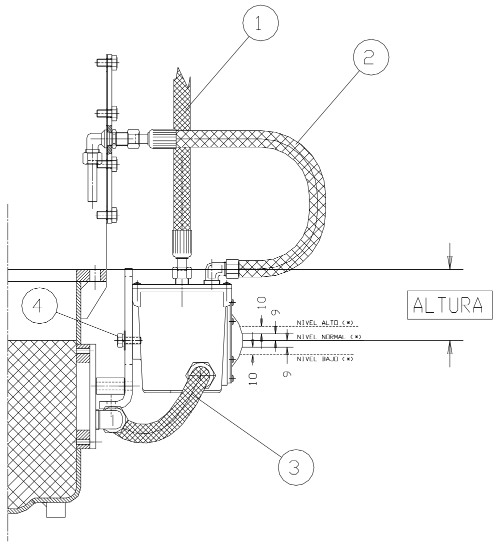
Fig. 4 – Automatic Oil Level Controller

2. DESCRIPTION AND ASSEMBLY

The oil level controller is a mechanical actuator placed on the oil sump at the bottom of the engine. It is equipped with a floater inside a small reservoir which opens or closes the oil flow into the engine crankcase.

When assembling the level controller in the sump, the latter is equipped with a universal bracket with two screws whose task is not only to secure the unit to the engine but to adjust the height thereof such that with the engine running and oil hot, the indicator level should be aligned with the oil level in the engine crankcase.

Therefore, the height from the adjusting nut to the oil sump base will vary according to the engine model. Variations with respect to its height or position on the engine can cause the oil sump to overfill. It is also important to tighten the fasteners correctly to prevent engine vibrations from altering the position of the oil controller (see enclosed table).



ENGINE	HEIGHT (MM)
F/SF 180/240	122
SFE/FG/FGLD/SFGLD/SFGM/SFGRD 180/240	92
HGM240	122
F/SF 360/480	92
SFE/FGLD/SFGLD/SFGM/SFGRD 360	55
SFE/FGLD/SFGLD/SFGM/SFGRD 480	92
SFGLD/SFGM/SFGRD 560	47
HGM420/560	92

1	Oil supply hose
2	Venting hose
3	Oil controller hose to oil sump
4	Height adjustment screw

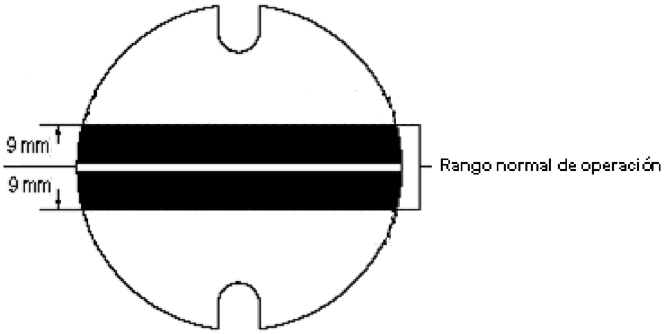
As the automatic filling equipment is connected by a hose to the oil sump, the oil level displayed always matches the actual reading, whether in applications where ventilation airs to the atmosphere or for applications with crankcase gas recirculation to intake. This crankcase ventilation hose (2) must be 12mm in diameter and the connection must be located above the oil level. Improper installation of crankcase ventilation can cause overflow.

The discharge hose to the crankcase (3) should be approximately 25mm in diameter and should be free from buckling.

The charging hose (1) should have a downward pitch with no sags and be 12mm in diameter.

If fed from a booster tank, the height thereof must NOT exceed 4.6 m. If this height is exceeded, the oil sump may overfill due to excess inlet pressure.

When the engine is running, the oil level in the display must be within the normal operating range.



When the engine is stopped due to oil backflow in the circuit, the oil level will exceed this range and overflow will occur, but once the engine has been started, it will return to its regular position.

1. INTRODUCTION

The UL oil level indicator is a box with high and low limit adjustable switches. It provides protection against the high and low level of lubricant caused by overfilling of water inside the sump.

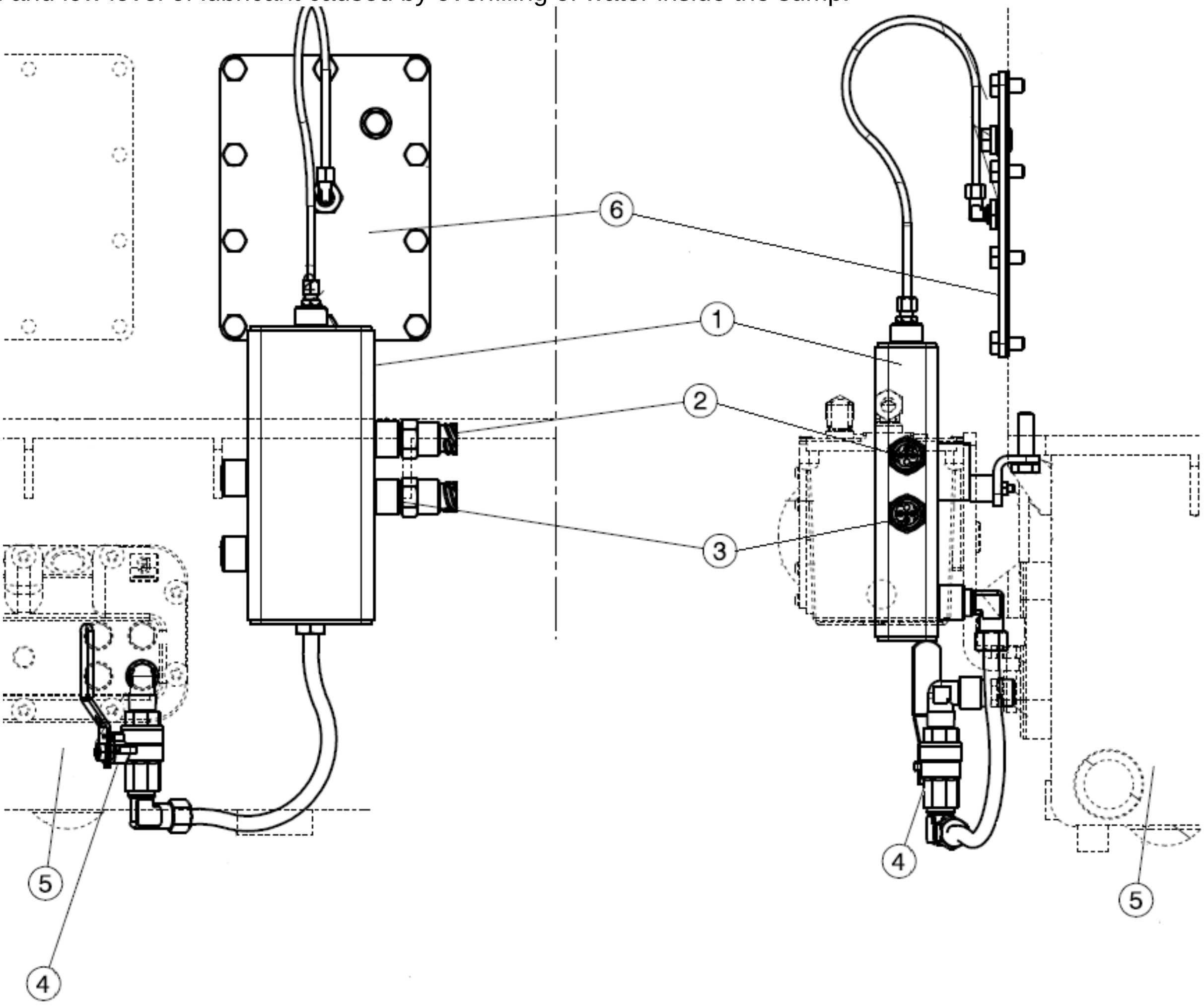


Fig. 1 – General Layout

1	Lube oil level sesors box
2	High level indicator sensor
3	Low level indicator sensor
4	Two-way valve
5	Lube oil pan
6	Connecting rods inspection cover

Table 1 – Components Specification.

2. DESCRIPTION AND ASSEMBLY

The function of this device is to trigger a warning alarm when the level reaches the defined low or high limit. Therefore, the high and low oil limits will vary according to the oil capacity of the sump for each model of engine, as shown hereafter. There two different positions of the sensors depending on engine type.

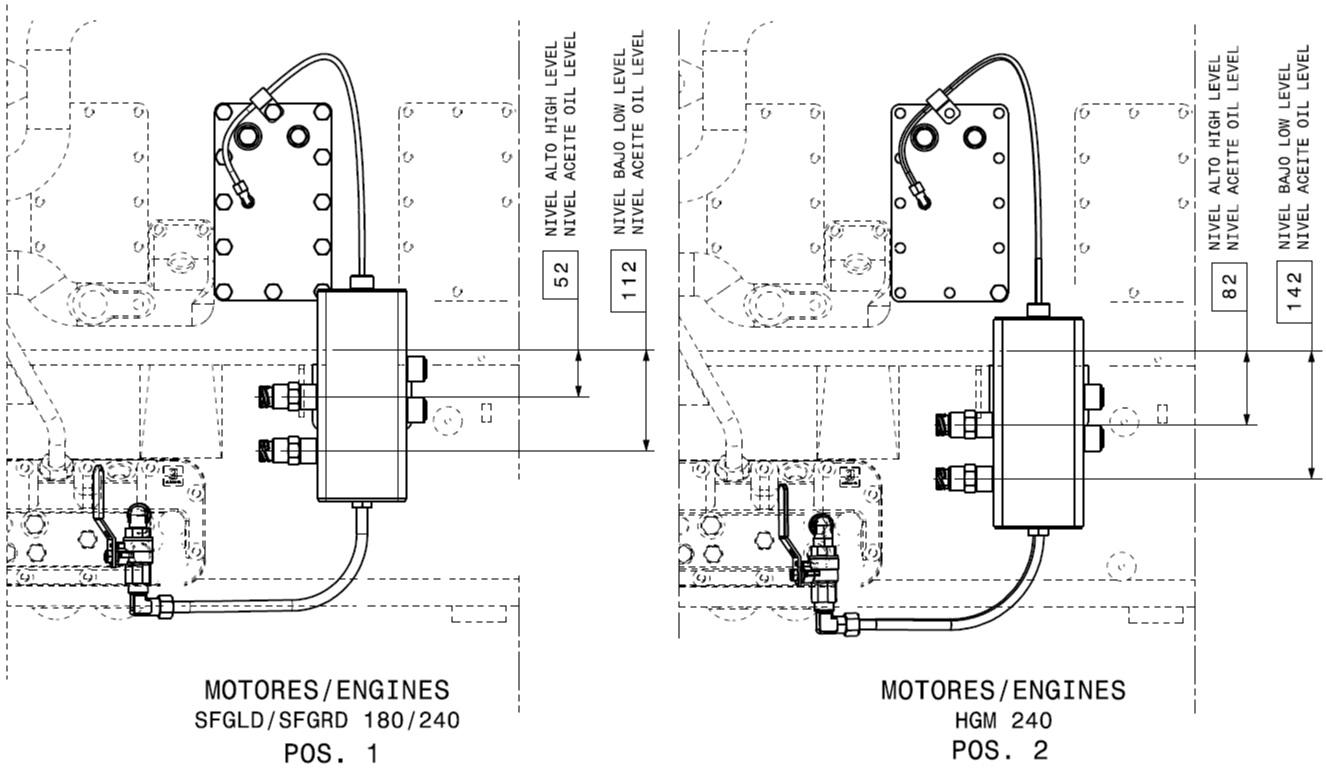


Fig. 2 – In line engines Layout

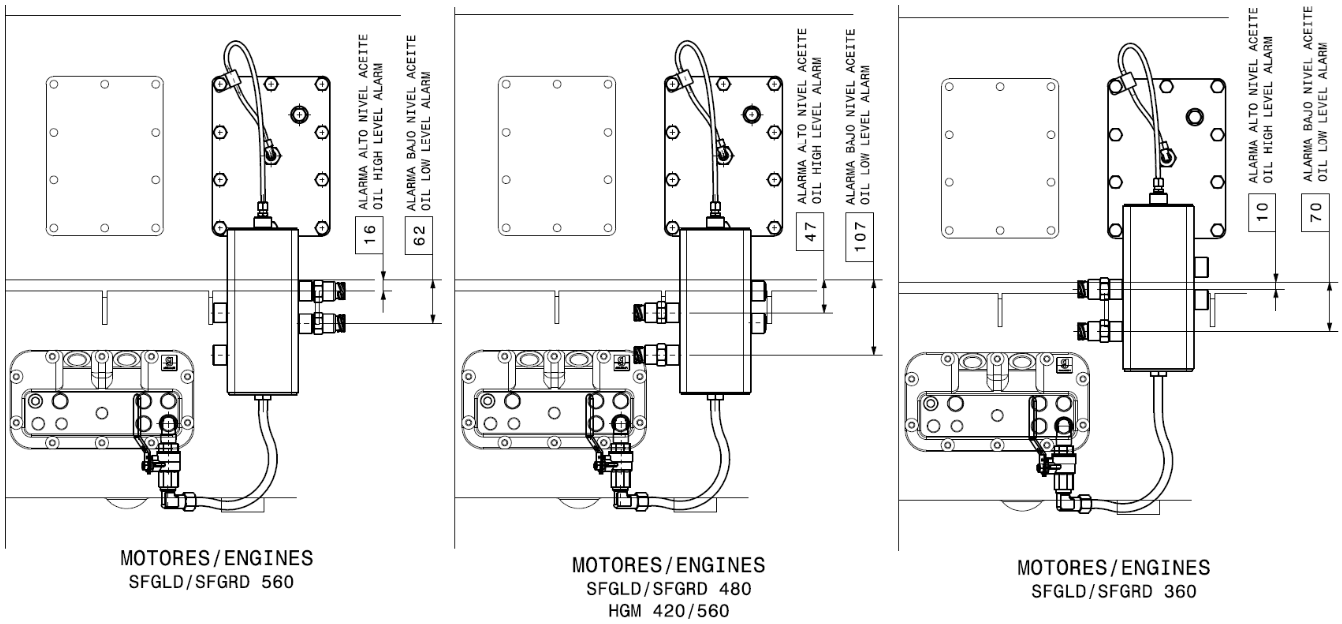


Fig. 3 – V engines Layout

The inside diameter of the outlet pipe to the sump must be at least 12 mm. The venting pipe to the sump must be 6 mm in outside diameter, connected to a point above the lubricant level and free of restriction due to bends or obstacles of any kind.

With the engine running, the oil level in the box must lie between the two defined limits. This way, in the event of oil overfilling due to a failure of the automatic supply system, fuel or water ingress or oil leaks, the device outputs the high-level or low-level alarm signal, as appropriate.

With the engine at rest, the oil level may rise up to the high limit, occasionally indicating a situation of excess oil. This results from backflow, i.e. oil flows back from the lubricating circuit to the sump, when the engine has stopped.

3. CONNECTION

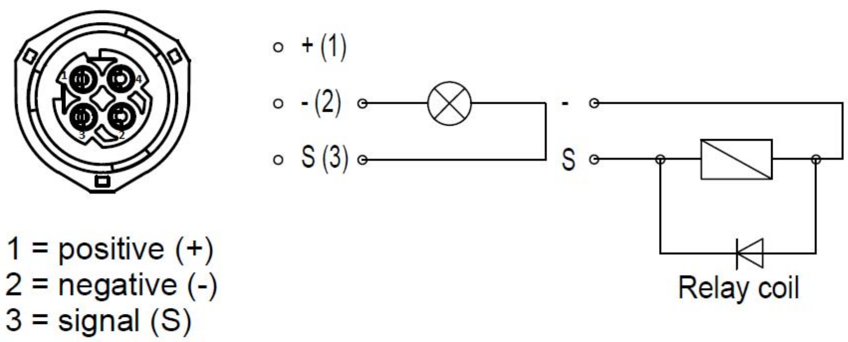


Fig. 4 – Electric Diagram.

Functional diagram for MINIMUM Probes

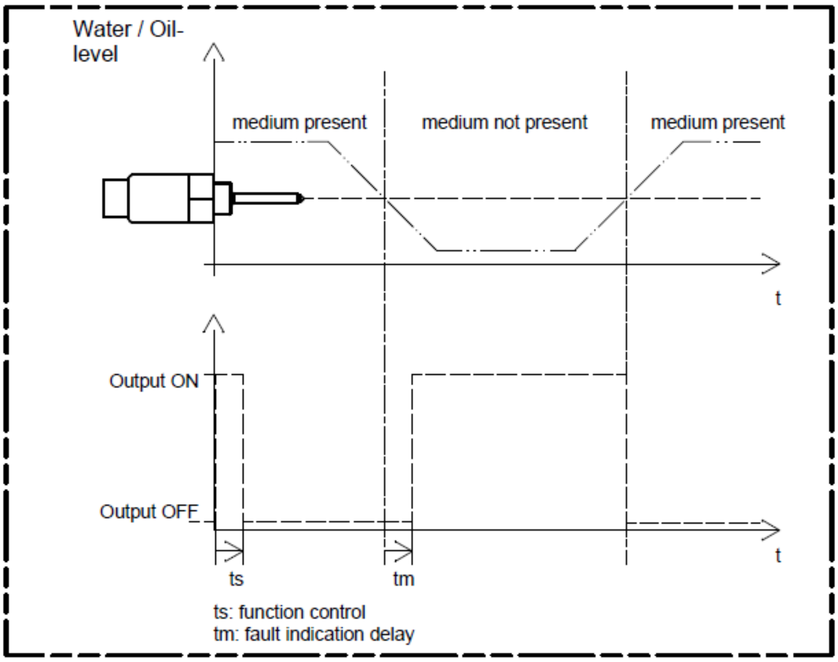


Fig. 5 – Low level sensor signal

Functional diagram for MAXIMUM Probes

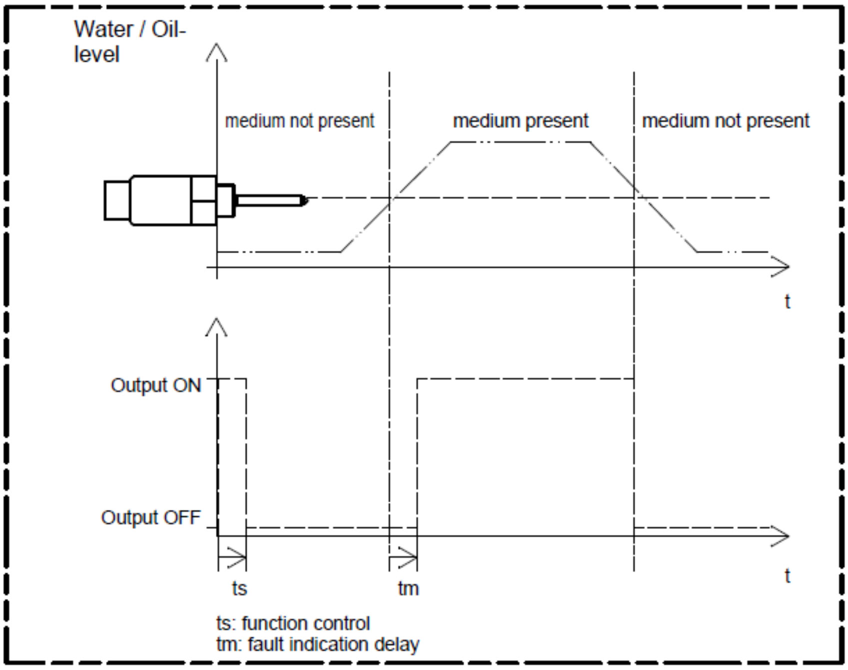


Fig. 6 – High level sensor signal

1. INTRODUCTION

The aim of preheating oil is to raise the oil temperature before starting the engine up to the appropriate minimum value (about 40ºC) that ensures adequate oil viscosity for loading the engine.

2. DESCRIPTION

For this purpose, we use a direct preheating system in which the heating resistance is in straight contact with the fluid, i.e. oil, to warm up.

Direct heating offers the advantage that heaters' efficiency is near 100% because oil directly absorbs all the generated heat. This contributes to faster warming up and suppression of thermal delay. There is no intermediate medium giving rise to heat losses during heat transfer.

The oil preheating system is a monobloc unit that consists of a resistance, a thermostat and a protective cap. According to the engine model and the crankcase capacity, there will be one, two or four resistances. See table 1.

For heating oil, we specify a 1500W resistance with a specific charge of up to 3.9W/cm². Fitting into the tank is with a 1-1/4" gas stamped brass cap nut and a copper gasket to prevent oil leaking through the thread. The tube is made of AISI 316L stainless steel, 8mm in diameter.

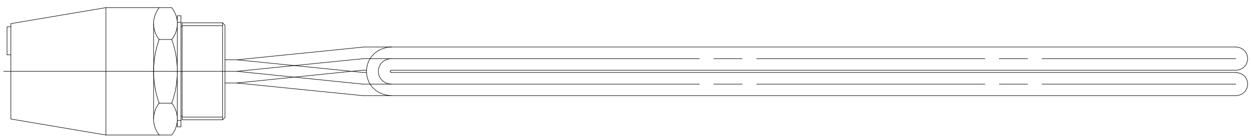


Fig. 1 - Heating resistance

3. ASSEMBLY

These monobloc units lie inside the crankcase (oil sump), in the lower front area. See Fig. 2, 3 and 4.

The resistance is connected to the mains through a plug-in thermostat with the power wires secured to the special-purpose clamping screws.

The resistance must always lie horizontally and submerged in oil. Otherwise, it could break and fail to operate correctly.

These so-called monobloc preheating systems have built-in thermostatic controls with temperature adjustments from 30 to 90ºC. The thermostat must be set at 40ºC. When the preheating system switches on, the resistances start warming up the crankcase and the oil temperature rises progressively. As the oil temperature reaches 40ºC, the thermostat switches off.

ENGINE TYPE	REFERENCE	VOLTAGE	POWER	No. of Units
180/240		230 V/50 Hz	1500 W.	1
360/480				2
SFGLD/SFGM/SFGRD 560				2
HGM 420/560				4
180/240		400 V/50Hz	1500 W.	1
360/480				2
SFGLD/SFGM/SFGRD 560				2
HGM 420/560				4
180/240		480 V/60Hz	1500 W.	2
360/480				
SFGLD/SFGM/SFGRD 560				2
HGM 420/560				4

Table 1 – Oil Preheating System per Type of Engine

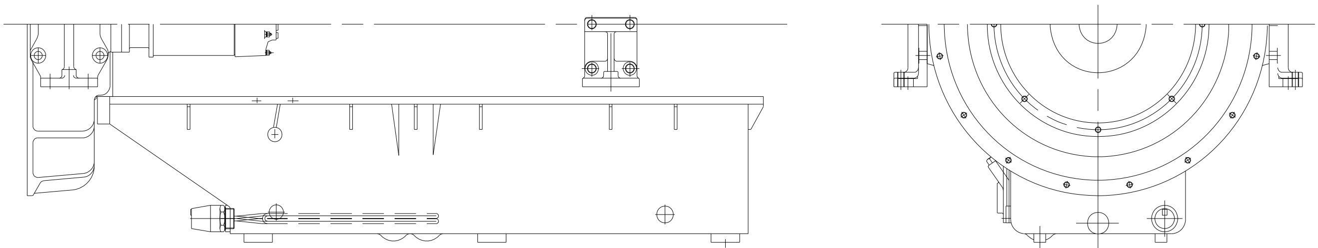


Fig. 2 – General Layout - F/SF/FG/FGLD/SFGLD/SFGM/SFGRD/SFE 180/240 Engines

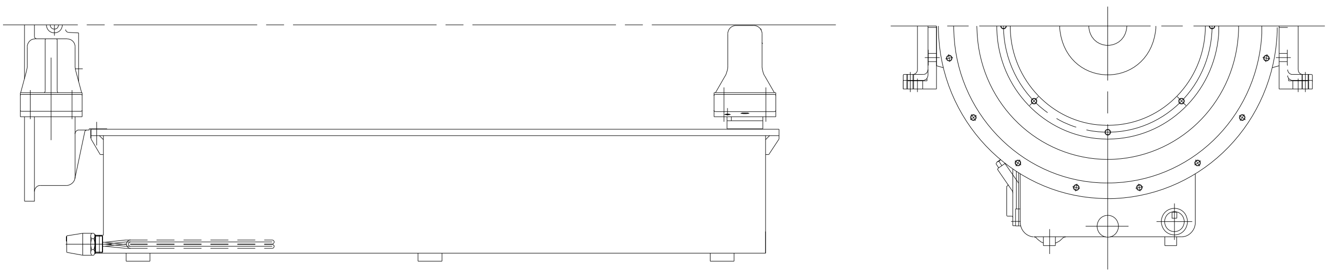


Fig. 3 – General Layout - HGM 240 Engines

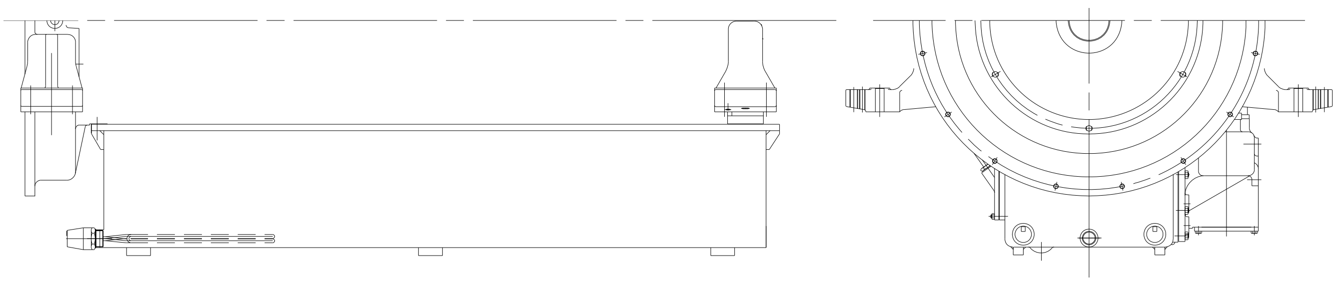


Fig. 4 - General Layout - F/SF/FGLD/SFGLD/SFGM/SFGRD/SFE360/480 – SFGLD/SFGM/SFGRD560 Engines

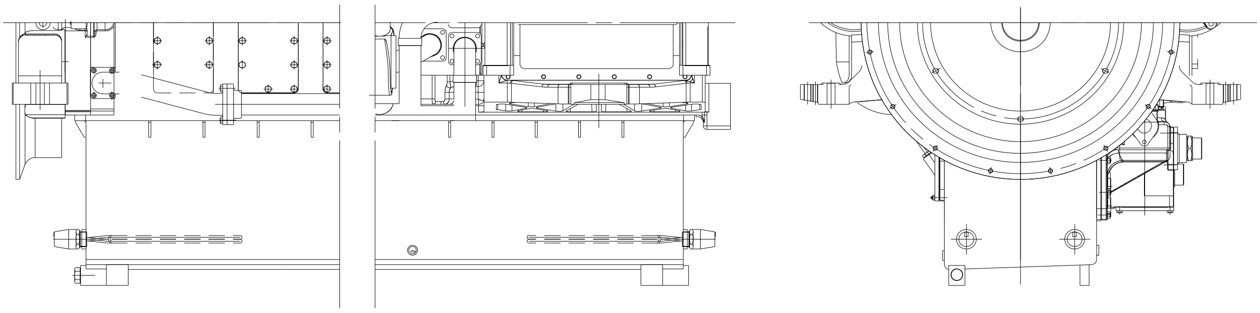


Fig. 5 - General Layout – HGM420/560 Engines

4. PERFORMANCE

Warming expected from the proposed preheating system is 40ºC over 2 hours.

5. OPERATION

Switching on/off of the preheating resistances is through a control integrated into the engine control panels, which assures thermal/magnetic protection of each resistance. The resistance incorporates an on/off thermostat.

DESCRIPTION OF A CRANKCASE GAS RECIRCULATION SYSTEM

O&M_2.002262.810_10_2016

1. INTRODUCTION

The crankcase gas recirculation system of the engine, also called the active system, is intended to feed the flow of engine blow-by gases back into the intake air current in a clean and efficient manner and so:

- to eliminate one source of emissions, by burning these gases inside the engine, and thus to get one single exhaust in accordance with the prevailing legislation in different countries;

- to clean the blow-by gas flow so that it is harmless when reintroduced into the engine;

- to regulate the blow-by gas flow so as to set optimum working conditions, fulfilling both internal criteria of optimum cleanness and engine operation requirements.

Blow-by gases refer to the portion of combustion gases which passes through the combustion chamber sealing rings into the crankcase, generating a higher pressure than the atmospheric one, and which must be released to the outside of the machine room in order to avoid:

- plugging of the inlet filters;
- explosion and fire hazards;
- a polluted atmosphere harmful to the machine operators.

2. CONFIGURATION

A crankcase gas recirculation system (CGR) comprises the following parts:

- A crankcase (1) which collects the gases that escape from the combustion chamber through the interstice between the piston rings and the cylinder liner.

- The blow-by gas breather (2) with drain It is made of one or various wire-mesh separators which separate the gas-borne thick liquid drops and feed them back to the crankcase by gravity.

- Piping between separators and recirculation filter (6).

- Blow-by gas separator filter (3). All the liberated configurations have only one filter, except for terrestrial diesel V-engines with air filters which have two gas separator filters and the HGM420/560, with the HGM filters having the greatest filtering efficiency.
- An oil return pipe from the recirculation filter (5).

- Crankcase pressure control valve (4).

- Blow-by gas feed pipe to air intake (between air filter and carburettor) (6).

NOTE

It is mandatory to follow the installation and assembly instructions defined in product information documents IT-C-A-25-024e and IM-C-C-25-002e in order to ensure correct operation of each component as specified or otherwise to be able to take the necessary corrective steps.

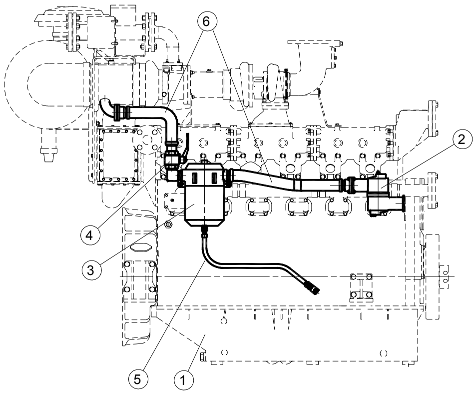


Fig.1: CGR on gas in-line engine FGLD/SFGLD.

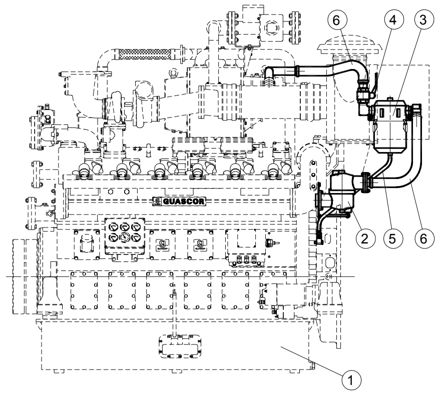


Fig 2: CGR on gas V-engine FGLD/SFGLD.

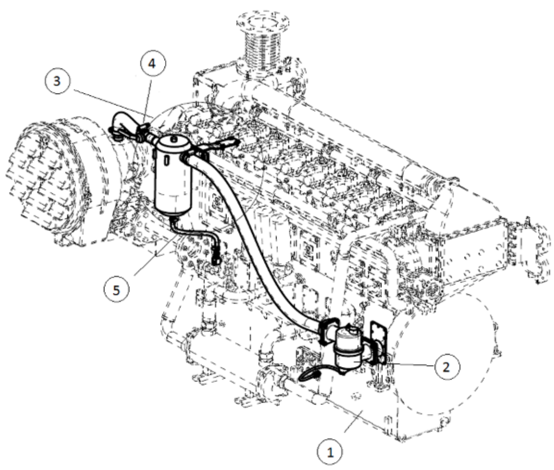


Fig 3: CGR on HGM240 engine

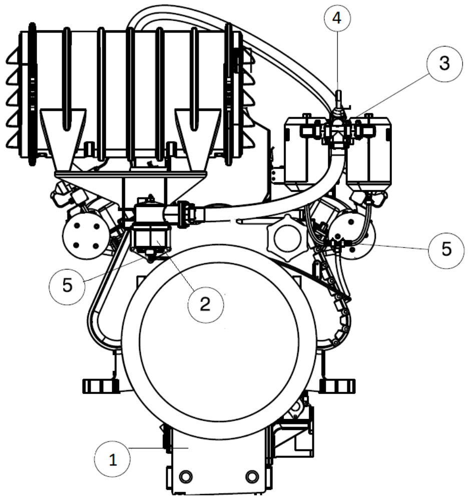


Fig 4: CGR on HGM 420/560 engine

2.1. Crankcase

The crankcase or oil sump is an important component of the engine, which little attention is often paid to. In addition to collecting, storing and recirculating oil that has lubricated and cooled the engine, the crankcase also accumulates the gases leaking from the engine's combustion chambers through small interstices between the rings and liners of each cylinder.

The amount of gas entering the crankcase will depend on the wear condition of the a.m. parts.

Due to crankshaft rotation and oil removal from different places in the engine, an undetermined quantity of oil drops are carried by the blow-by gas flow.

The crankcase gas pressure indicates the status of balance between the amount of blow-by gases removed from the crankcase through the exhaust system and the quantity generated during the engine operation.

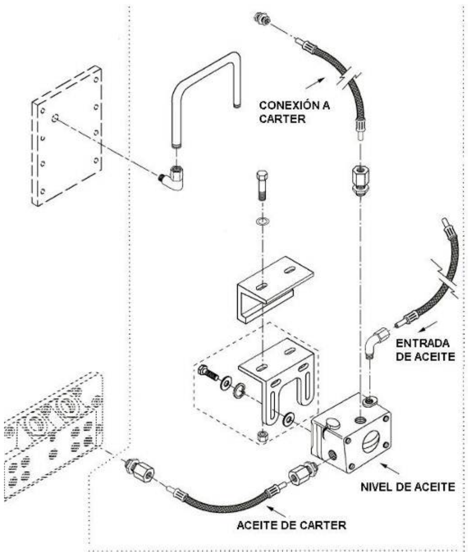
By analysing the crankcase pressure over time, it is possible to anticipate any failure that would offset the said balance in one direction or another, notably wear of piston rings, filter clogging, blocked pipes, etc.

2.2 Oil level controller.

This is an oil level valve with a float that allows oil to pass into the crankcase and fill it when the level is too low, allowing the level to rise until it reaches the correct level before it cuts off the oil supply.

When there is gas recirculation from the crankcase to the intake, given that the pressure in the crankcase does not have to coincide exactly with atmospheric pressure, it is essential to have an effective oil level control device, and this is achieved with the automatic level control. This level control is connected to engine crankcase pressure and not to atmospheric pressure, meaning that we obtain a real measurement of the true level of oil in the crankcase.

When the crankcase pressure does not coincide with the atmospheric pressure, the dipstick will give a false reading, as when crankcase pressure is negative it will indicate low oil levels and high levels when it is negative. The dipstick is a valid means of measuring the oil level when crankcase gases exit to the atmosphere, but not with recirculation.



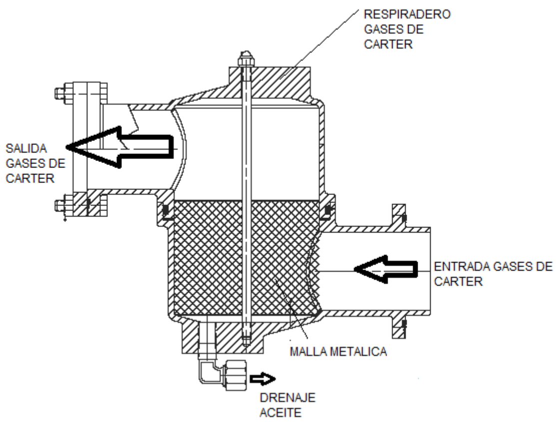
2.3. Crankcase Gas Breather

The blow-by gases exit the engine through the "crankcase breather" made of one cylindrical separator filled with wire-mesh.

The function of the breather is to separate gas-borne oil. This oil is collected it in the lower portion and oil is fed back to the crankcase by gravity.

The breather always lies above the oil level of the engine. It is part of the engine, whether integrated into a blow-by recirculation system or an open venting system.

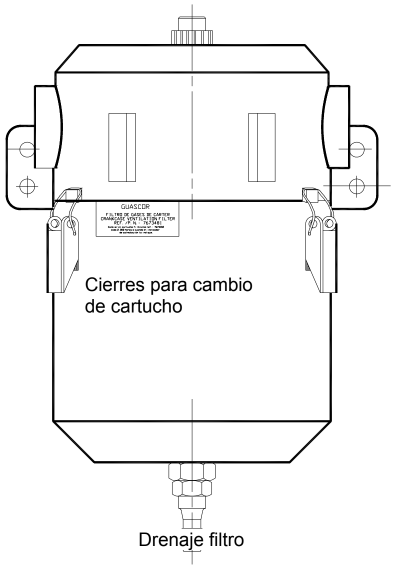
The location of the system in the engine depends on the type of breather and will be such as to prevent or minimise the entrainment of oil by the blow-by gases.



2.4. Blow-by gas recirculation filter

This is the real conditioner of the blow-by gases before entry into the air intake system. Externally, it looks like an upright black cylinder fitted with a blow-by gas inlet pipe, one gas exhaust pipe and a drain for filtered products at the bottom.

FILTRO RECIRCULACION GASES CARTER

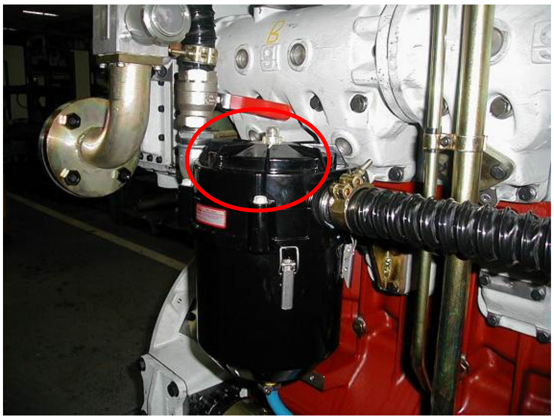


Its function is to completely eliminate gas-borne oil and condensates. For this purpose, it includes a high-performance synthetic fibre filtering cartridge. There are two filter models depending on the engine model, with the HGM filter having the greatest filtering efficiency given the demands for cleaning the turbochargers.

At the top, it has a red light indicator warning that the filter is plugged and must be changed. In any case, the cartridge shall be changed at the intervals specified in the maintenance guidelines. Refer to IO-C-M-25-011e.

At the bottom of the system, there is a non-return valve which prevents blow-by gas from flowing in a direction opposite draining.

The device has marks on the top showing the gas flow direction, by pointing to the in and out ports of the filter.



2.5. Crankcase pressure control valve

This valve checks the balance between the amount of blow-by gas sucked out of the crankcase into the air intake system and the total quantity of blow-by gas produced in the engine.

For correct operation of the valve, it is necessary to measure the pressure in the crankcase with the engine running at nominal power and to set the valve to the specified rating. When done, the valve need not be readjusted until the cartridge is changed, since the crankcase pressure variations provide important information on the system performance and the internal wear of the engine. Tampering with the valve would result in a loss of data and "deceiving" the system.

When changing the filter cartridge, check the valve. If found dirty or full of condensates, flush it with a water jet.

2.6. Oil feedback to crankcase

Oil separated by the recirculation filter shall be fed back through a hose to the crankcase and always above the crankcase oil level.

2.7. Blow-by gas feed pipe to the air intake

Connected downstream of the crankcase pressure control valve, this pipe transports the filtered gas to the engine air intake.

On gas engines, the blow-by gas feed pipe is connected between the air filters and the compressor
(Fig. 1, 2, 3 and 4)

2.8 Crankcase pressure

Monitoring the crankcase pressure will enable you to detect and follow-up the evolution of possible failures due to a malfunction of the recirculation system or the engine.

The crankcase pressure can be measured at the connecting rod cover or oil sump filling plug or crankcase breather cover, using a water gauge.

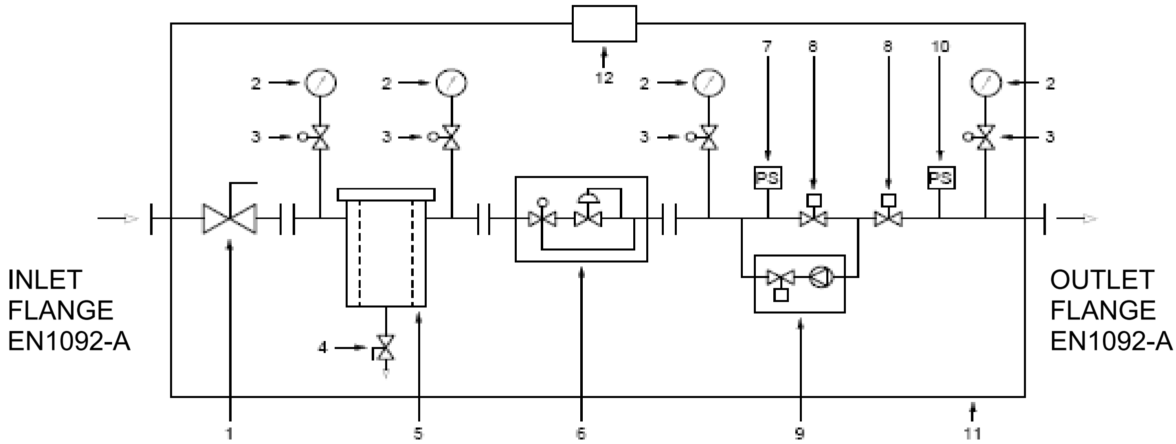
1. INTRODUCTION

The valves train is a set of elements such as a stopcock, filters, valves, etc, configured for various functions, mainly the safety cut-off of the gas supply in a receiving installation..

Conceptually, the gas train will always have the same configuration and is adapted only in the sizing of its components to the gas flow needs and especially to it. Generally, the design of the gas train matches the specifications of the UNE 60670-2005 standard “Installation of natural gas receivers with a pressure equal to or less than 5 bar.”

2. FUNCTIONAL TECHNICAL DESCRIPTION

The gas train is the set of elements that feed, regulate and cut off the gas supply to the internal combustion engine. The gas train consists of the following elements, the functions of which are described below.



1. Cut-off valve.
2. Pressure gauge.
3. Manual press valve to isolate the pressure gauge.
4. Manual purge valve.
5. Gas filter.
6. Pressure regulator (optional).
7. Low pressure switch.
8. Double cut-off solenoid valve.
9. Electronic tightness control.
10. High pressure gauge
11. Self-supporting steel frame.
12. Data plate.

- Manual cut-off valve: the cut-off valve is of the butterfly type and allows the gas to be opened and closed manually.

- Gas filter: the gas filter is of the cage type with a filtering mesh of 1 micron. Its purpose is to clean the gas of any impurities and suspended elements in it. It has a purge valve at its bottom.

- Spherical pressure gauge: there are various connections for measuring pressure in the gas train. These connections consist of a press valve and a pressure gauge. The measurements are taken by pressing the valve. These measurements serve as a visual check of the proper functioning of each of the components in the train.

- Pressure regulator: a pressure regulator is needed in installations in which the inlet gas pressure is higher than 150 mbar. The main function of the pressure regulator is to regulate and stabilise the gas supply pressure, adapting it to the specific needs of each carburation system in Kohler engines. The pressure of the regulated gas is 100-120 mbar.

- Double solenoid valve: the main function of the double solenoid valve is to feed and cut off gas in the feed line to the engine as per the DIN EN 161 standard Class A Group 2, remotely and automatically. It consists of two solenoid valves installed in the same body. The solenoids are for slow opening and quick closing. The valve is opened by powering the solenoids and closure is by cutting off the power supply, always at 24 V DC. The double solenoid valve also has a gas volume adjustment. The body of the solenoid valve has various quick connections for installing various safety elements needed for operations such as pressure switches and/or tightness controllers.

- Pressure switches: two pressure switches are installed directly on the solenoid valve body, for minimum and maximum pressure. The minimum pressure switch ensures that the pressure of the gas supply to the engine exceeds the minimum value, otherwise it provides a power free contact to generate the appropriate alarm on the engine control panel. The maximum pressure switch checks that the gas pressure does not exceed a set value that could damage the engine’s components. If this value is exceeded, the pressure switch provides a power free contact to generate the appropriate alarm on the control panel.

- Tightness control: its fundamental function is to check that the closure of the double solenoid valve is tight. If a failure in the closure of the solenoid is detected, it provides an alarm signal to the panel. The tightness control functions only when the engine is stopped.

- Support or frame: a steel structure on which the gas train components are installed.

3. SIZING

The gas trains are sized according to three fundamental parameters:

- The type of fuel gas.
- The pressure of the gas supply.
- The engine’s consumption.

There are three functioning pressure ranges:

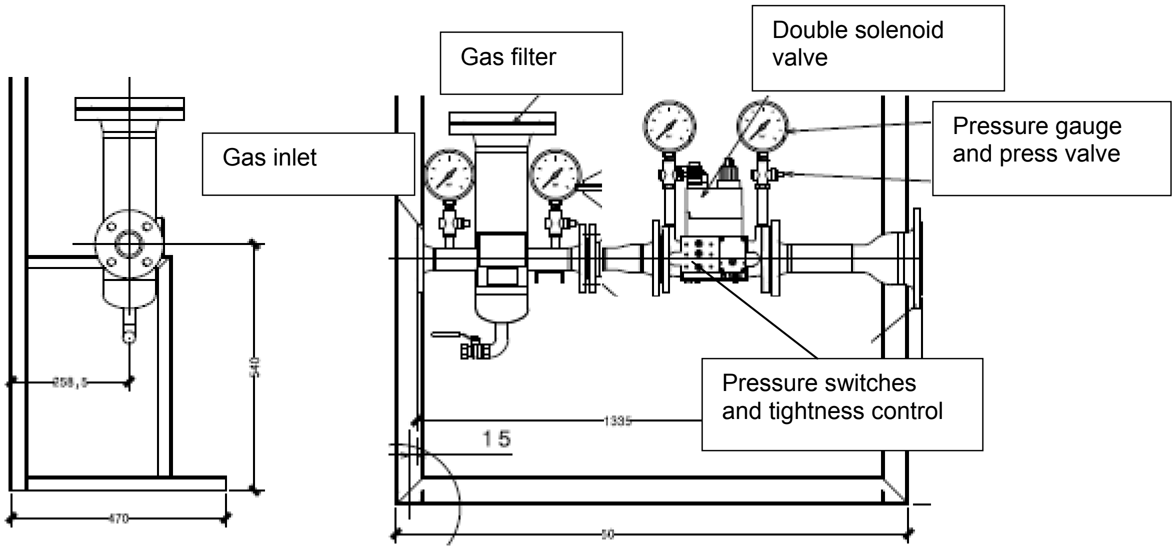
- 100 – 150 mbar
- 150 – 1000 mbar
- 1000 – 4000 mbar

The following types of gas are defined as standard applications:

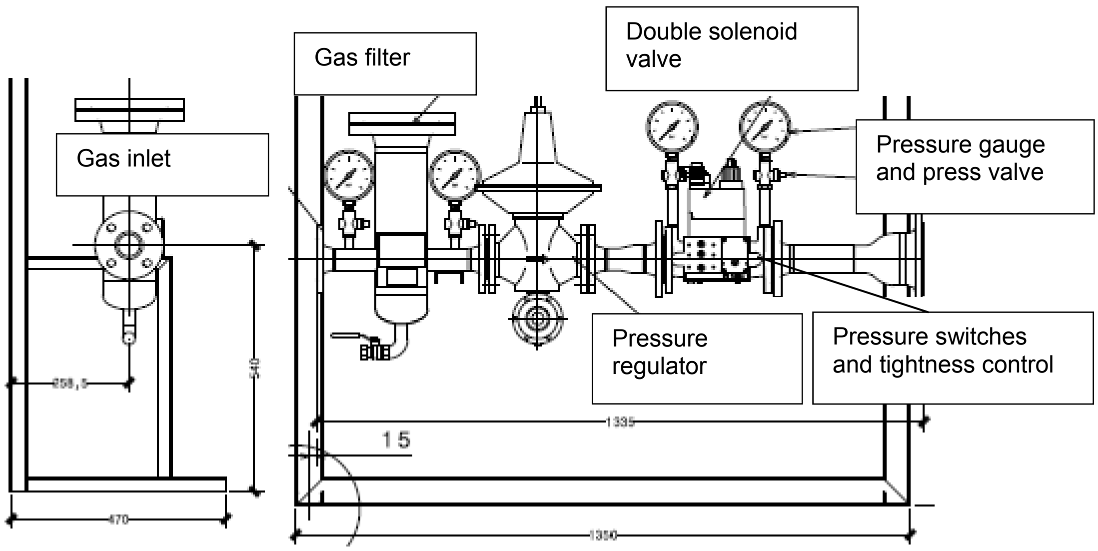
- Natural gas.
- Treatment plant gas (biogas).
- Tip gas (landfill).

4. GAS TRAIN INSTALLATION

The gas train must be installed near the engine although care must be taken to avoid its being affected by the heat radiated from it or from the liquids used in it and protecting it from impacts and with suitable ventilation conditions.



Gas train without pressure regulator (gas pressure range 100-150 mbar man.).



Gas train with pressure regulator.

1. DESCRIPTION

EGS 02 is the new control system for gas engines and it is suitable for the entire range of Kohler gas engines.

These are the major features of the controller:

- Speed control (variable duty and island applications)
- Load control (parallel/mains applications)
- Control of carburetion at different loads
- Control of carburetion for variations of gas quality
- Engine protections
- Communications-based system management.

A complete EGS control system comprises the following items:

- EGS 02.
- TECJET
- AIR/FUEL MIX THROTTLE VALVE
- PICK-UP
- MAT
- MAP

2. FUNCTIONALITIES

2.1 SPEED CONTROL

EGS02 can ensure the engine runs at constant speed regardless of its load. Speed can be pre-programmed in the controller memory or changed externally by means of an analogue signal or through communications.

2.2 LOAD CONTROL

Where EGS02 does not control speed, e.g. when the engine is synchronised with the grid, it can control power according to the required output, by means of an analogue signal or through communications.

2.3 CONTROL OF CARBURATION AT DIFFERENT LOADS

EGS02 can control the required air/gas ratio from tables that depend on power and speed. For this purpose, EGS measures the gas flow as provided by the Tecjet and the mixture volume. This enables controlling emissions according to load.

2.4 CONTROL OF CARBURATION FOR VARIATIONS OF GAS QUALITY

EGS02 will control carburetion, and subsequently emissions, when gas quality variations do not exceed ±10%. Where gas quality is expected to change by more than 10%, it is possible to feed EGS02 with the gas CH4 percentage to enable EGS to make the appropriate corrections.

2.5 COMMUNICATONS-BASED SYSTEM MANAGEMENT

For easier monitoring and control, EGS02 features CanOpen communications that allow operators to read the controller's data and to enter all kinds of settings. For further information about CanOpen communications, please refer to: *IT-G-A-50-010e "Description of EGS02 CanOpen Communications".*

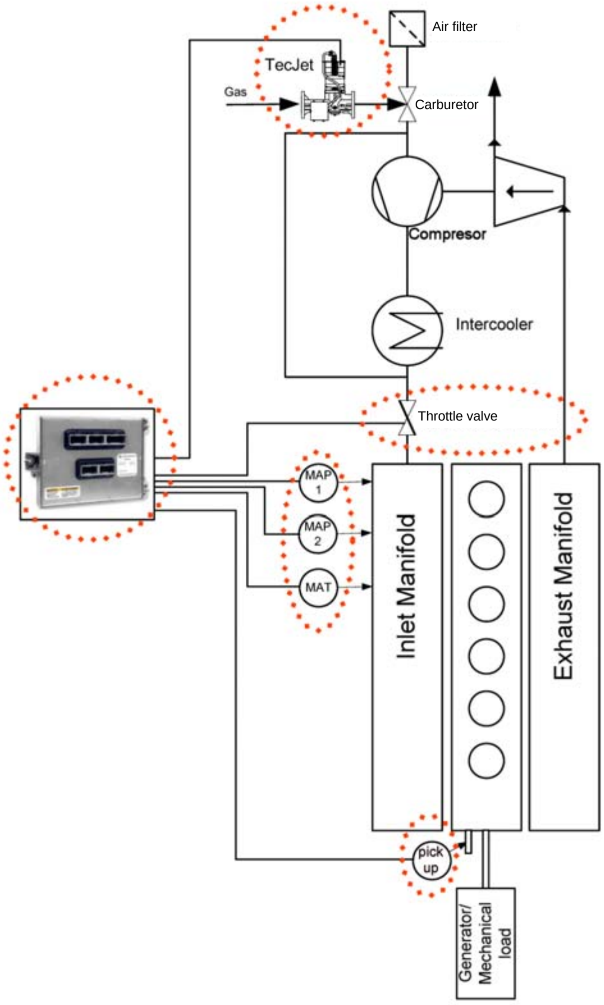
2.6 ENGINE PROTECTIONS

EGS02 provides a number of alarms to protect the engine against mechanical failures:

- Overspeed detection. It is possible to program the maximum speed limit that the engine may not exceed.
- Sensor faults: the controller can detect failing sensors in order to prevent damage to the engine.
- Misfire detection Detecting engine running instability can help detect misfire events. The following are possible causes of engine speed inconsistency that can cause misfire events:
  - Failure of ignition parts (module, coil, high voltage wire, spark plug)
  - Carburetion faults
  - Mechanical breakdowns

3. EGS02 COMPLEMENTARY EQUIPMENT

The EGS02 control system would keep to the following diagram:



3.1 PICK-UP

This sensor detects the teeth of the engine flywheel. From the teeth detection data, EGS02 can calculate the engine rotational speed.

3.2 MAT

This NTC type temperature sensor reads the temperature of the air/fuel gas mixture fed into the engine. The data is necessary for carburetion control.

3.3 MAP

This pressure sensor reads the pressure of the air/fuel gas mixture in the inlet manifold. The data is necessary for carburetion control.

3.4 THROTTLE VALVE

By controlling the throttle valve, the EGS controller adjusts the amount of mixture fed into the engine. Controlling the throttle valve is the way the EGS can control the engine power or speed.

3.5 TECJET

This is a valve controlling the amount of gas supplied to the engine. It incorporates both pressure and temperature sensors before and after the valve chest. Hence the controller receives accurate information on the gas volume entering the engine.

1. INTRODUCTION

A venturi-type carburation system comprises generically the following items:

- Zero Pressure Regulator (ZPR)
- Main Adjustment Screw (MAS)
- Carburettor (Mixer)

CARBURATION SYSTEM

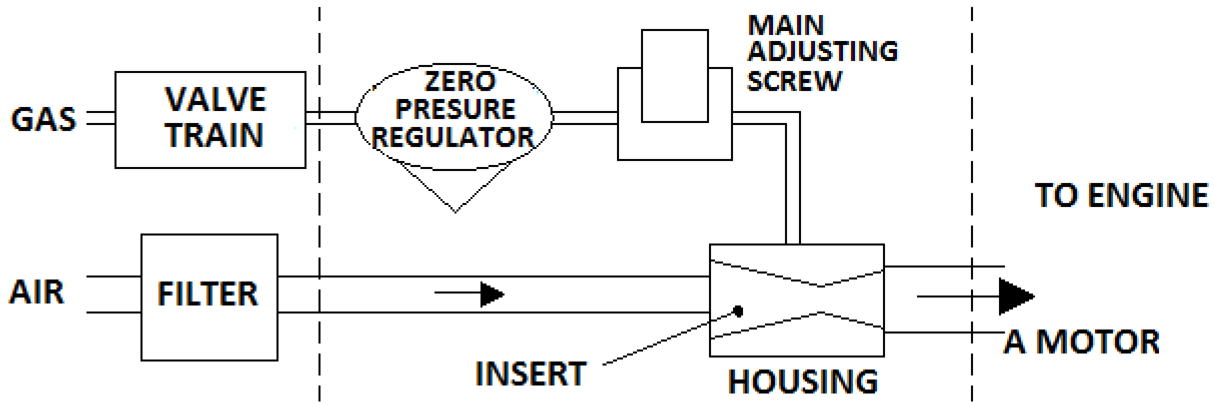


Figure 1 Carburation system scheme

In the case of electronic regulation, for the NOX sensor control or Lambda sensor control regulation, the main adjuxsting screw is changed by an electronic gas control valve.

In the case of electronic regulation, for the lambda close loop control regulation, the zero pressure regulator and the main adjusting screw are changed by a gas inyecction valve.

2. ZERO PRESSURE REGULATOR (ZPR)

It is the pressure regulator's function to reduce the gas supply pressure to the carburettor inlet pressure. This type of regulator is called "zero pressure regulator", because the regulator outlet pressure is zero or almost zero.

For the Zero Pressure Regulator setting, see document IT-G-A-30-001e

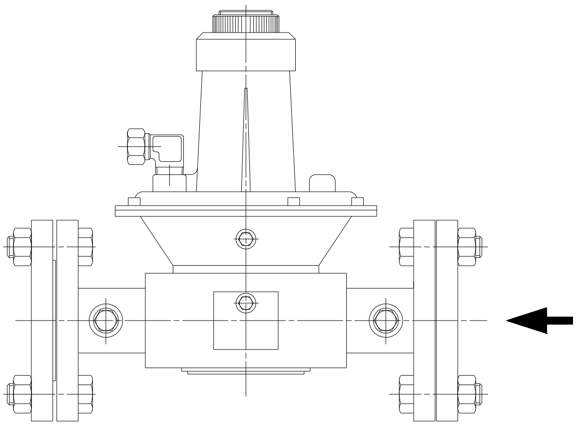


Figure 2 Zero pressure regulator

The ZPR shall be mounted as near the adjustment screw or the gas control valve as possible, respecting the minimum distance specified by the regulator manufacturer, and in such a way as to avoid the engine vibrations Kohler uses two models of pressure regulators:

- FRN: This regulator must always be placed with the outlet pressure adjusting spring facing downwards. It needs an inlet air pressure compensation line downstream of the filters.

- FRNG: This type of regulators can be installed with the outlet pressure adjusting spring facing up or facing downwards. They require no inlet air pressure compensation line downstream of the filters; fitting a compensation line could lead to problems with the engine operation. Since there is no compensation line, they require more frequent monitoring of the exhaust emissions to avoid air-fuel ratio misadjustments due to clogged air filters.

For this type of regulators (supplied by Kohler) , the inlet gas pressure must not exceed 50 mbar.

3. GAS FLOW CONTROL

3.1 MAIN ADJUSTMENT SCREW (MAS)

The main adjustment screw for the mixture ratio lies between regulator and carburettor. It checks the flow of fuel to the carburettor.

For the MAS setting procedure, see IT-G-A-30-001e

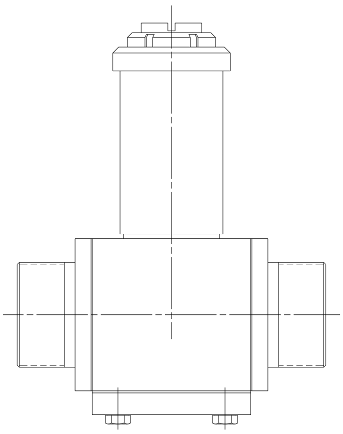


Figure 3 Main Adjusting Screw

3.2 GAS CONTROL VALVE

The gas control valve is a throttle valve, powered by an electric actuator and electronically controlled. It requires a zero pressure regulator before.

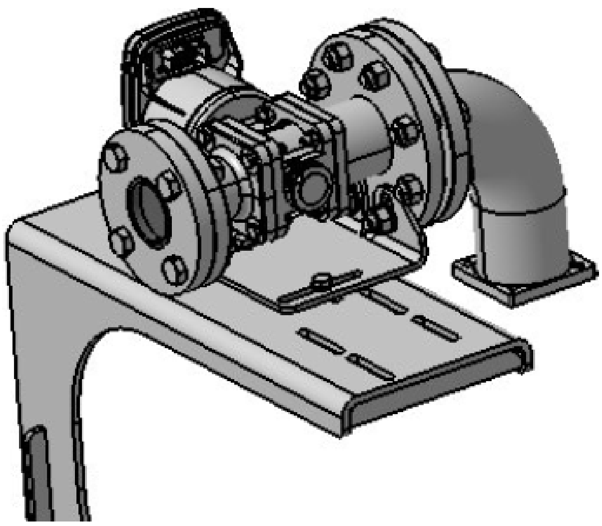


Figure 4 Gas Control Valve

3.3 GAS CONTROL INJECTOR

The gas control injector is a throttle valve, powered by an electric actuator and electronically controlled. Temperature and pressure sensors are used internally for the gas flow control. It works with positive inlet pressure, so it is not necessary a zero pressure regulator installation.

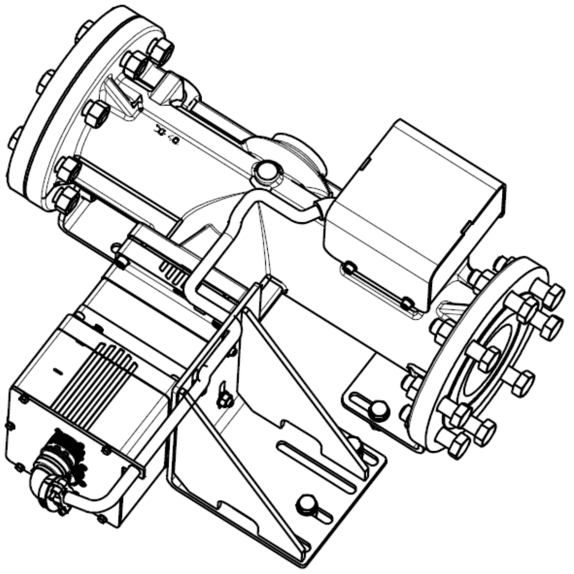


Figure 5 Gas Control Injector

4. CARBURETTOR

A venturi-type carburettor consists of a barrel in a housing, which allows it to be mounted on the air intake manifold.

Complete carburettor | Barrel

Figure 6 Carburettor and barrel

The operating principle is the Venturi effect. As air flows through the barrel, a vacuum proportional to the air velocity develops in the throat of the venturi, causing gas to be drawn into the carburettor, thus giving rise to an air-gas mixture in the venturi.

With a venturi type carburettor, the gas pressure need not be greater than the atmospheric pressure. Accordingly, the system includes a zero pressure regulator upstream of the carburettor. Since air and gas pressures are identical, a constant air-gas ratio is obtained throughout the operating range of the engine.

Using this type of carburation permits easy adjustment of the proper air-fuel mixture to ensure optimum operation of the engine under conditions of maximum efficiency or minimum exhaust emissions.

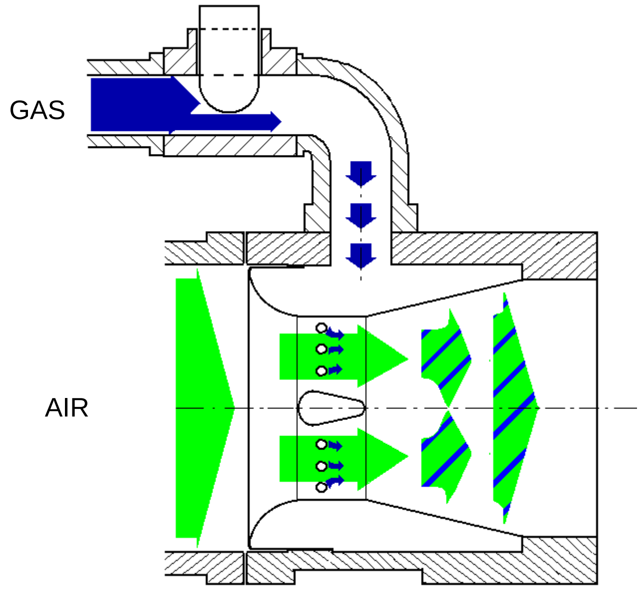


Figure 7 Air-Gas mixteure by venturi effect

For a manual carburation setting procedure using a mechanical carburation (Main Adjusting Screw), refer to document IT-G-A-30-001e.

5. ELECTRONIC CONTROL

An electronically controlled valve uses a valve as shown in 3.2 and 3.3 paragraphs.

See the product information for carburation electronic control:

- IC-G-D-50-003 for EGS 02 system
- IC-G-D-50-004 for GCS system
- IC-G-D-50-005 for E3. DESCRIPCIÓN system

KOHLER Powered by DRESSER-RAND	PRODUCT INFORMATION	INDEX	DATE	Dep. 2
	IC-G-D-30-040e	**A**	*September 2016*	
	SPECIFICATION OF GAS SUPPLY TO TECJET 52			

O&M_2.002262.810_10_2016

1. INTRODUCTION

This Product Information document applies to all the gas engines fitted with a Tecjet 52 valve.

2. GAS PRESSURE RANGE

Correct operation of the Tecjet 52 control valve is directly related to the input gas pressure and the pressure drop in the valve during normal running of the engine.

The input pressure to Tecjet 52 must be in the range from 50 to 275 mbar (as shown on the graph-Fig. 1).

NOTE

For input gas pressure to Tecjet52 less than 50 mbar, consult Kohler. Accuracy may be adversely affected

With the engine running, pressure drop in the Tecjet valve (delta-p) must be in the range 70-345 mbar. Operation below this range is possible at start-up and idling, but on load, accuracy will be affected negatively. At pressures greater than 275 mbar, accuracy decreases as well and the error tolerance increases by about 10% in relation to the normal margin.

The graph below shows the minimum pressure requirements as measured at the inlet to the Tecjet 52 valve related to engine power and gas quality under normal conditions.

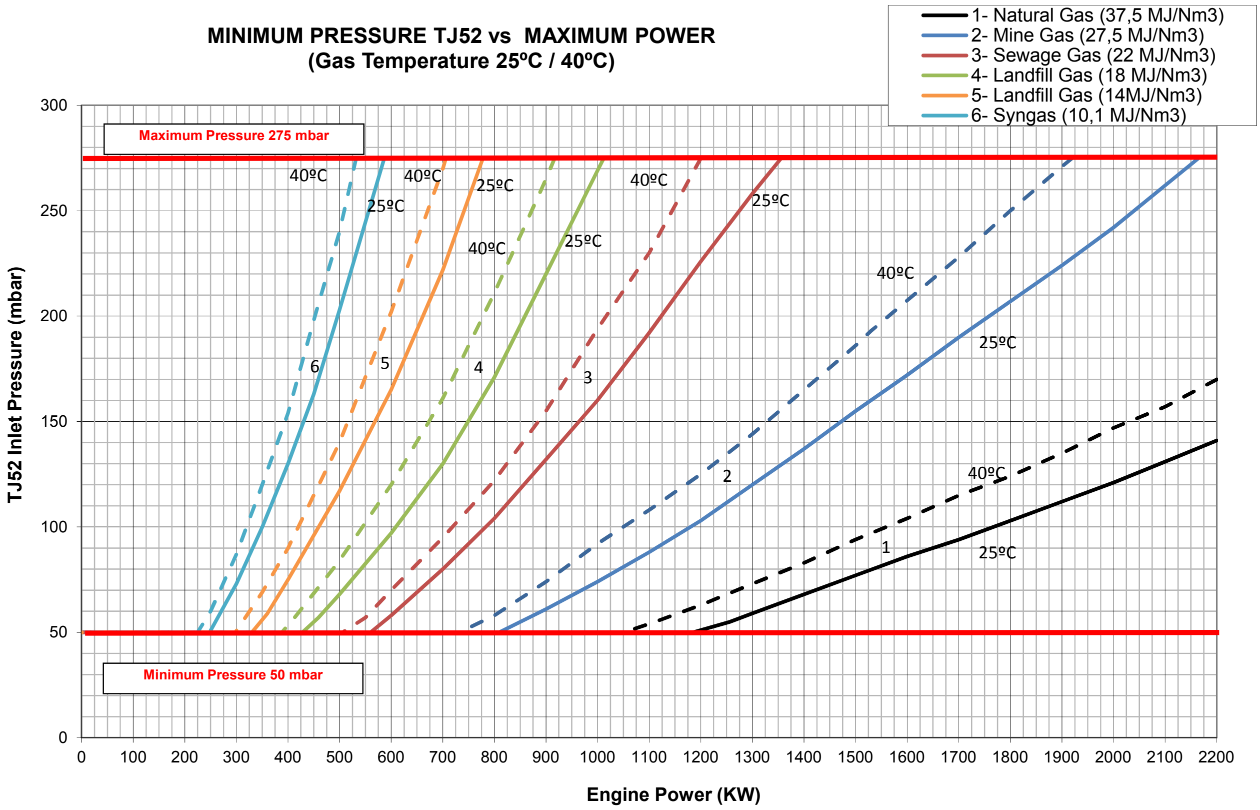


Fig. 1 - Minimum pressure at Tecjet52 vs Maximum Power

SPECIFICATION OF GAS SUPPLY TO TECJET 52

NOTE

Where gas temperatures exceed the value used in the graph, the minimum pressure required for a given power will increase. Consult Kohler.

Using a Tecjet 52 valve with a gas of very high volumetric Low Heat Value (LHV) may affect accuracy negatively, depending on the engine power and the gas pressure at the Tecjet. If the supply pressure is high for a gas of very high LHV, small variations in the valve opening or supply pressure may lead to great variations in the carburetion of the engine. For this reason, we specify a maximum supply pressure to the Tecjet for Natural Gas and propane.

The graph below shows the maximum pressure requirements as measured at the inlet to the Tecjet 52 valve related to engine power and gas quality under normal conditions.

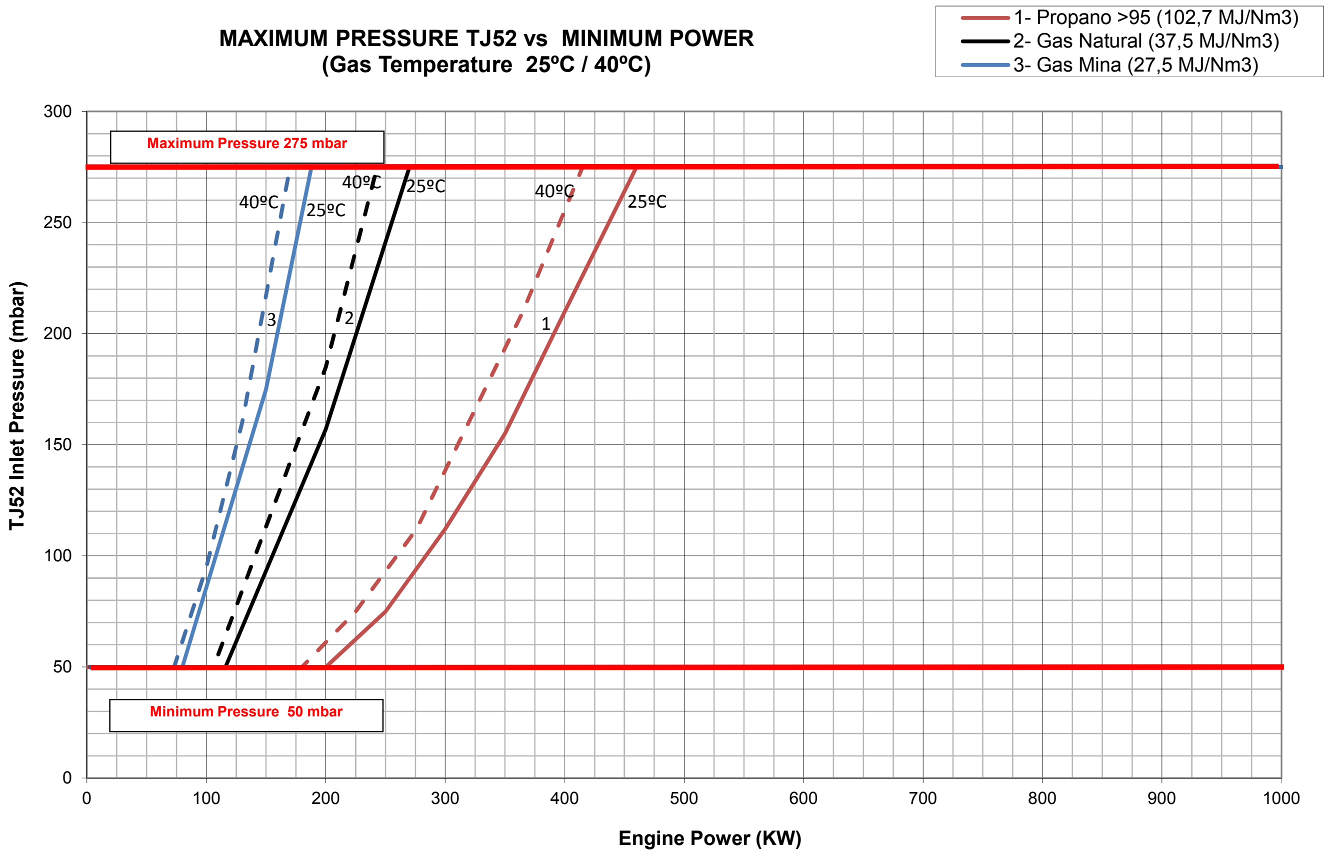


Fig. 2 - Maximum pressure at Tecjet52 vs Maximum Power

Tabulated below are the characteristics of the reference types of gas used in the graph:

	Density (kg/m_n^3)	LHV (kJ/kg)
Propane	2,02	46050
Natural Gas	0,80	47200
Mine gas	0,88	31500
Digester Gas	1,17	18800
Landfill Gas A	1,33	13500
Landfill Gas B	1,38	10200
Syngas	0,89	11400

For optimum performance of the carburetion control, a gas pressure regulator must be installed upstream of the Tecjet 52 valve. We recommend that the volume between both devices be minimized by placing a regulator close to the engine and with a straight fitting of a minimum length equal to 5 times the diameter of the pipe linking the pressure regulator to the Tecjet52. Under stable operation, the input pressure to the Tecjet 52 valve should not fluctuate in more than +/- 2 mbar.

With the engine running at full power, the position of the Tecjet52 valve must lie anywhere between 20 and 85% of its total travel. In the event it is near any of the said limits, then, if the equipment allows and the input pressure and pressure drop requirements are fulfilled, it will be necessary to adjust the pressure regulator so as to work with the valve in the recommended position.

3. WORKING TEMPERATURES

Room temperatures for Tecjet52 operation: - 20 ºC to + 85 ºC

Tecjet52 gas temperature range: - 20 ºC to + 65 ºC

Kohler recommended gas temperature in operation:+10 ºC to + 40 ºC

4. GAS FILTER

To prevent damage, a 1µm or thinner mesh filter must be installed at the Tecjet gas intake.

With regard to the contaminants contents, gases must also meet the specifications set out in Product Information IC-G-D-30-001e, IC-G-D-30-002e, IC-G-D-30-003e, IC-G-D-30-004e, IC-G-D-30-013e, IC-G-D-30-018e and IC-G-D-30-038e.

KOHLER Powered by DRESSER-RAND

PRODUCT INFORMATION	INDEX	DATE	
IC-G-D-33-002e	A	*July 2013*	*Dep. 2*

DESCRIPTION OF THE GIS IGNITION SYSTEM

O&M_2.002262.810_10_2016

1. DESCRIPTION

The ignition system manages and controls the ignition of the mixture in the combustion chamber. Firing must be accurately coordinated with the rotation of the engine and the movement of the valves of each cylinder.

Two GIS ignition unit models are used by Kohler:

- GIS ignition unit
- GIS CSA ignition unit

Both units have the same performance in operation. The only difference of the two units lies in the housing; 76.64.607 up to 60ºC and 76.64.605 up to 70ºC.

The GIS ignition system is made up of the following components:

1. GIS ignition module
2. Display module
3. Hall effect pickup and wiring
4. Two magnetic pickups and wiring.
5. Reset pin
6. Reference magnet
7. Primary wiring
8. Coils
9. Secondary wiring

Fig. 1 – GIS ignition unit

Fig. 2 – GIS coil

Fig. 3 – GIS high voltage lead

Most items on the list are compatible with the CPU 95 electronic ignition system used up to now with SFGLD and HGM engines. The only incompatible items are the coil, the high voltage lead and the ignition rails.
The electrical characteristics of the coil are different to those of the coil used with the CPU 95 electronic ignition system, while the high voltage lead is different in the threaded connection with the coil.

In fact, the basic ignition diagram is the same as that used with the CPU 95 electronic ignition system.

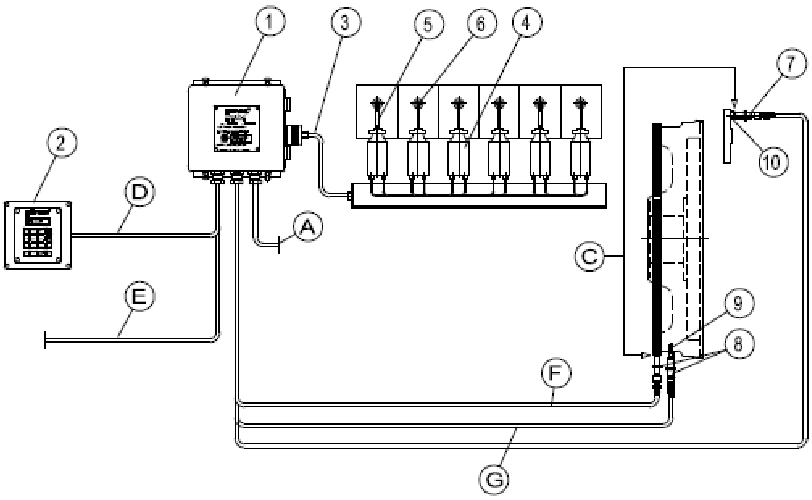


Fig. 4 - Basic layout of the in-line engine ignition system

DESCRIPTION OF THE GIS IGNITION SYSTEM

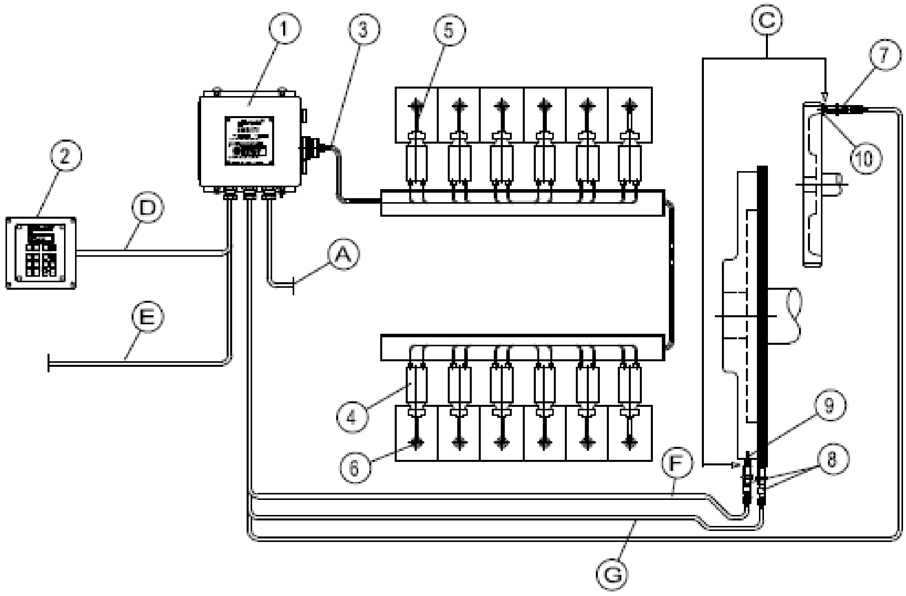


Fig. 5 - Basic layout of the V-engine ignition system

1 GIS ignition module.
2 Display module
3 Primary wiring
4 GIS ignition coils
5 Secondary wiring
6 Spark plugs
7 Hall effect pickup and wiring
8 Magnetic pickups and wiring
9 Reset pin
10 Reference magnet

A 24Vcc power supply.
C Hall effect pickup. Unlike the CPU 95 system, the reference magnet of the camshaft does not have to be lined up with the reset pin during the compression stage of cylinder Nº1 (with 6 and 8 in-line engines), Nº12 (12V engines) and Nº8 (16V engines).
D CAN communications cable for transmission of data from the module to the display
E Communication with external equipment (CAN or RS-485), digital and analogue inputs and outputs for connection to control equipment (PLC)
F Pickup wiring for measuring engine revolutions
G Reset pickup wiring

The ignition system is configured at the factory. Field use of the ignition system may lead to improper engine operation and could cause serious engine damage and/or personal injury to operators and other personnel nearby. Check with Kohler Engineering Department for any queries concerning the ignition module. Do not manipulate the module without prior authorisation.

1.1. GIS IGNITION MODULE

1.1.1. General features

The main features of the GIS ignition module are as follows:

- Microprocessor-based digital system with highly precise distribution of engine ignition, based on crankshaft and camshaft position reference signals.
- Optional programming adjustment to adapt to different engine configurations.
- Optional manual timing adjustment can be configured according to engine speed, analogue signals, potentiometer, digital inputs and/or communications.
- Option to adjust timing per cylinder.
- Option to adjust ignition energy and even configure different energy levels for start-up and normal engine operation.
- High capacity for diagnosis in the primary and secondary ignition system circuits.
- Modbus RTU and CAN 2.0b (CANopen) communications.
- Ability to generate a series of pulses that control other equipment, such as the Detcon, injection system, etc.
- USB connection compatible with USB 1.1 and USB 2.0 for connection to PC.
- CE Marking.
- Certification CSA Class I, Division 2, Group C, D; T4.

All the system options are selected by Kohler on the basis of the requirements and characteristics of each application. All the data required, such as distribution of ignition, configuration of the energy parameters, ignition sequence, number of flywheel teeth, etc. are programmed at the factory.

NOTE

Refer to IT-G-A-33-011 for programming the GIS ignition module. Refer to IO-G-M-33-010 for information on the display module. Refer to IM-G-C-33-006 for installation of the ignition module.

1.1.2. Functions and operation

Configuration of pickup signals

Unlike the CPU 95 module, the GIS ignition system can operate with different pickup signal configurations, making it a more flexible system. With Kohler engines, it can operate with two different configurations:

- 2 PU configuration: The ignition module operates according to the signals received from the magnetic tooth pickup and the camshaft Hall effect pickup.

- 3 PU configuration: The ignition module operates according to the signals received from two magnetic pickups fitted to the crankshaft (teeth and reset) and the camshaft Hall effect pickup.

Analogue/Digital Inputs

The ignition module has an analogue input which, once configured, allows the advance ignition to be adjusted. The analogue signal can be intensity (4-20 mA) or voltage (0-10 V). With Kohler engines, this analogue input is connected to the Detcon and configured so that the ignition unit reduces the advance as the mA of the signal increase.

The module also has three digital inputs to carry out the following functions:

- Start/Stop. This signal allows the ignition to be enabled/disabled. If a high level signal is sent (2.8 – 32 V) the ignition is activated, while if a low level signal is sent (0- 0.8 V) the ignition is deactivated. The signal has a maximum input current of 20 mA.
- Reserved/GPI: The General Purpose Input (GPI) can be configured by software and used for several functions. With Kohler engines, this input allows us to reset the CAN communications module with the engine in operation (1 second pulse at high level) or completely reset the ignition unit when the engine is stopped (5 second pulse at high level).
- Schedule A/B: This digital input allows us to select from two previously configured ignition schedules. The unit allows us to programme two ignition schedules (Schedule A and B) and this digital signal allows us to select one of the other (low level (0 - 0.8 V) for schedule A and high level (2.83 - 2 V) for schedule B). The signal has a maximum input current of 20 mA.
  With Kohler engines, this input is not connected, meaning that the unit allows operates with ignition schedule A.

Analogue/Digital Outputs

The GIS ignition unit has two digital outputs that provide information on the status of the unit. They are potential free contacts with a common return that is not referenced (maximum 32 VDC, 100 mA):

- The Go/NoGo contact closes when the unit is sending ignition signals to the coils. This output can be used to activate the security loop when there is an emergency engine shut-down.
- The GPO (General Purpose Output) contact is totally configurable by software. We can configure both those situations when we want it to be activated and the output logic itself. With Kohler engines, the output is normally configured as closed, to be activated (open) only when the unit shows a serious error that results in ignition shutdown.

The ignition module can generate a pulse sequence signal that allows it to control another piece of equipment, such as the Detcon. This signal is known as the ASO (Auxiliary Signal Output) and can be connected with two wires to the equipment in question. It is a TTL level (5V) with a maximum intensity of +- 10 mA.
With Kohler engines, this signal is used to control the Detcon, meaning that the ignition unit must be connected to the Detcon with a 2-wire screened cable.

Visualisation LEDs

There are 6 LEDs on the front of the ignition module that provide information on the status of the unit:

- The “Status” LED indicates the status of the unit. The LED is always flashing and its colour changes according to the status of the unit. If the unit has an error, the LED is red, if there is a warning, the LED is orange and the LED is green if there is no error or warning. When the LED flashes quickly, the unit has a hardware problem (“critical error”).
- The “Firing” LED always activates when the unit is sending. The light is green.
- The pickup LEDs activate whenever the module receives a signal from a pickup. All the lights are green. With Kohler engines, they are as follows:
  - Pick up 1: Hall effect camshaft pickup
  - Pick up 2: magnetic reset pickup
  - Pick up 3: crankshaft tooth pickup
- The GPO LED activates when the GPO contact is closed. With Kohler engines, due to the fact that this output is normally configured with closed logic, the LED should always be lit unless the unit is in error status.

NOTE

If the module has been configured so that one of the three pickup signals is not used, the LED corresponding to this signal will never be lit.

Communications

The ignition module has two options for communicating with other equipment. Both communications protocols have the same possibilities as regards control and reading capacity:

- 2 CANbus 2.0 communications ports: the unit can communicate with the other equipment by means of two different CAN protocols: CANopen and J1939. We can use the configuration menu to choose one protocol or the other. The CAN connection allows a maximum cable length of 250 metres.
- 1 RS-485 port for connecting to a PC or Modbus communication with other equipment. The RS-485 connection allows a maximum length of 100 metres.

NOTE

With GCS-E panels, communication with the other equipment is carried out through the CAN port using the CANopen protocol.

NOTE

The ignition module can be connected to the PC in two ways: via the USB or RS-485 ports. To activate said port, please contact Kohler.

PC Connection

The ignition module can be connected to the PC in two ways: via the USB or RS-485 ports.
However, the firmware to connect the unit via the USB port does not let us connect it via the RS-485 port and vice versa. This means that the firmware version of the unit has to be changed to change the port used to connect to the PC.

NOTE

With Kohler engines, the units are pre-programmed for connecting to the PC via the USB port. The maximum USB cable length allowed is 5 metres.

Potentiometers and reset button

The unit has two potentiometers to adjust the advance: one for ignition schedule A and the other for ignition schedule B. With Kohler engines, the option of adjusting the advance using these potentiometers is disabled (only A).

The reset button completely resets the unit. With Kohler engines, this reset is carried out via communications, either from the GCS-E panel display or from the GIS unit display.

WARNING

The reset button (in the GIS hardware) should not under any circumstances be pressed when the engine is in operation. Pressing the reset button cuts of ignition, which could lead to detonations in the exhaust and/or inlet manifolds. Said detonations could both cause damage to the engine and serious injury to anyone standing near the engine.

1.1.3. Technical specifications

The following table shows the main technical specifications of the GIS ignition module. Certain data is common to both stock references (and   ), while other details are not:

Power Supply Voltage		24 VDC (nominal)
Consumption		< 7A (depending on the application and power supply voltage)
Number of outlets to cylinders		16
Digital inputs		3
Digital outputs		2 (NC and configurable)
Analogue inputs		1 Configurable: 4-20 mA / 0-10 V
Magnetic pick up		2
Hall effect pick up		1
Communications port		1 x USB 1.1; 2 x CAN 2.0b; 1 x RS-485
Display		Optional
GIS Unit	**Operating Temperature**	-40ºC to 60ºC
	Dimensions	304 x 240 x 95.5 mm
	Weight	5.2 kg
GIS CSA Unit	**Operating Temperature**	-40ºC to 70ºC
	Dimensions	304 x 240 x 115.5 mm
	Weight	6.7 kg

Fig. 6 – Overview of the ignition system for V-engines with 16 cylinders

2. FITTING THE IGNITION MODULE

Depending on the engine type and the application, the ignition module can be installed in three different positions:

- Installed on a bracket on the engine with shock-absorbing systems to minimise the negative effect of vibrations.
- Installed on the nerve of the profile of the engine frame. Shock-absorbing systems are also used in this case to minimise the negative effect of vibrations.
- Installed in the GCS-E panel with those engines fitted with said panel.

For further detail on the installation of the ignition module, refer to IM-G-C-33-006, GIS ignition module installation manual.

1. AIM

The aim of this product information sheet is to describe the elements installed in series to make up the gas engine intake system.

2. INTRODUCTION

The air intake system comprises the following elements mounted on the engine:

- Air filter.
- Carburettor.
- Turbocharger (only in supercharged engines).
- Air Cooler (only in supercharged engines).
- Throttle Valve.
- Intake Manifold.

3. AIR FILTER

It is the air filter's function to remove impurities from the air needed for combustion. The most appropriate type of filter for the operational environment must be defined.

The air filtration system must guarantee 99.7% efficiency. The maximum intake restriction is 38 mbar when the engine is operating at its rated power.

There are two types of filters in use: two-stage cyclone filters and high-rate single-stage filter.

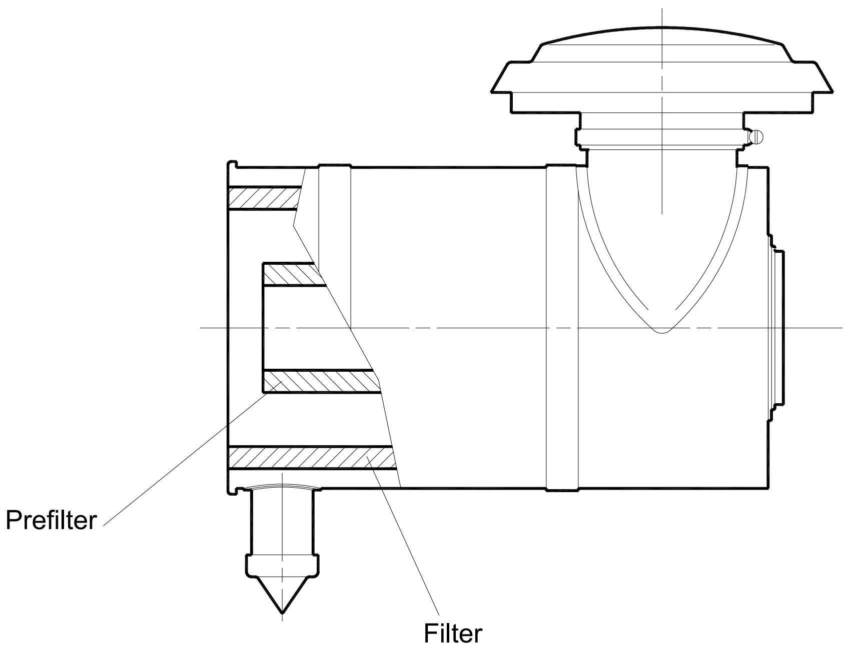


Fig. 1 - Air Filter (two stages)

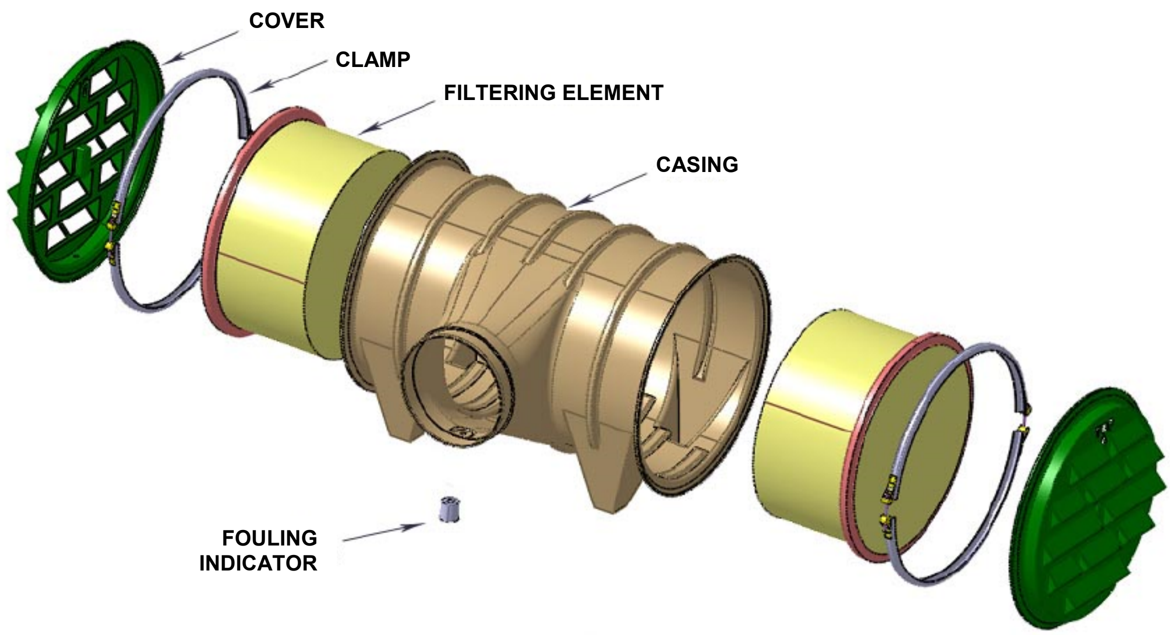


Fig. 2 - High-rate single-stage filter

4. TURBOCHARGER

The turbocharger is installed in order to boost the air pressure fed into the intake manifold so that there is a dense air/fuel mixture in the combustion chamber.

As they are “low gas pressure” engines, the air-fuel mixture is created at atmospheric pressure (carburettor next to the air filter) and later the air-fuel mixture is compressed.

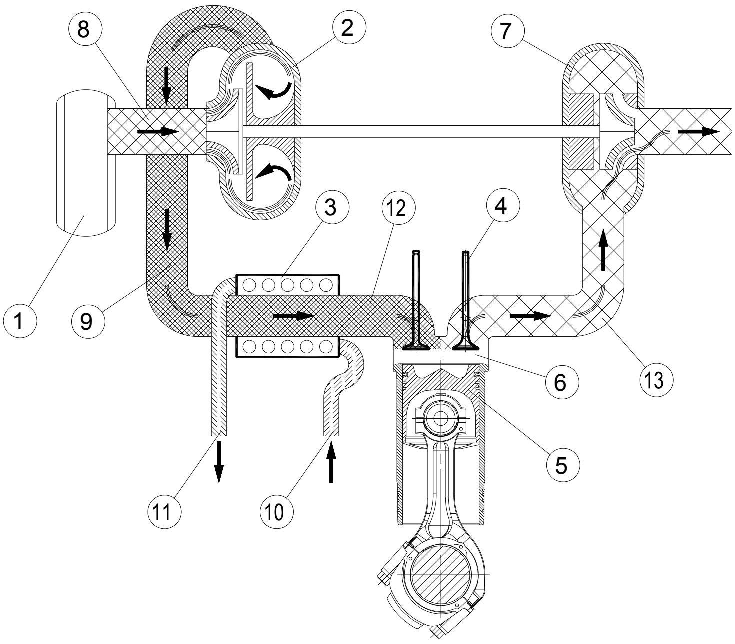
From the turbocharger outlet, the mixture passes through the air cooler to the elbow in the Throttle valve and from there it is diverted towards the intake manifold.

In-line Engines

- They include one (1) turbocharger on their top right-hand side.

V Engines

- They have two (2) turbochargers: one on each cylinder bank. HGM engines however have one single turbocharger.
- They include two (2) intake manifolds



1	Air Filter
2	Air Compressor
3	Air Cooler
4	Valves
5	Piston
6	Combustion Chamber
7	Exhaust Turbine
8	Non Compressed Air
9	Hot Compressed Air
10	Intercooler Water Inlet
11	Intercooler Water Outlet
12	Cold Compressed Air

Fig. 3 - General Drawing - Intake System

The electronic management of the units with a control of the power generated (in kW) regulates and limits the supercharging of the engine, normally being sufficient as a safety limiter.

5. AIR COOLER

The air cooler is integrated into the engine and consist of a tube nest and blades, housed in a reinforced cast-iron body as a pressurised air-fuel mixture circulates between the tubes.

The air cooler is cooled by means of water from the auxiliary circuit (at 55ºC or 80ºC depending on the engine model), which circulates inside the tubes. Two-stage coolers have main circuit water flowing at 82ºC through their first stage.

Water reduces the temperature of the air-fuel mixture once compressed by the turbo. On reducing the temperature of the air-fuel mixture the density of the air load in the engine increases, allowing a larger amount of air-fuel mixture to enter the cylinder. This leads to greater combustion efficiency and indirectly, more power per cylinder.

6. THROTTLE VALVE

The load regulation valve (Throttle valve) lies downstream of the air cooler outlet. By regulating the amount of A/F mixture delivered to the cylinders, it regulates the power output or the speed according as the engine is in grid or island mode.

This valve is driven directly by the load/speed regulator.

In “V” engines, a branch at the outlet of the Throttle valve diverts the flow of mixture toward the two intake manifolds

7. INTAKE MANIFOLD

The design of the intake manifold includes special internal ribs that cause the flow to go in the right direction.

In-Line Engines:

- The intake manifold lies on the left-hand side of the engine and distributes the mixture to the cylinders.

V Engines:

- There are two intake manifolds: one on each side of the engine, distributing the mixture independently to the cylinders on its bank.

1. AIR FILTERS. CHARACTERISTICS

It is the function of an air filter to ensure that air supplied to the engine has optimum cleanness characteristics. Kohler engines can include either of two types of filters: double-stage cyclonic filters and GHF high-flow single-stage filtration filters. The cyclonic air filters used on Kohler engines comprise two filtering elements or cartridges: one so-called main cartridge outside and the other so-called safety element inside. High-flow filters are single-stage filtration systems.

Air filtering is achieved to global efficiency rates of 99.7%. Pressure losses due to filtering are less than 20mbar with a clean filter and the engine running at rated power and full speed. Filter plugging occurs when pressure losses exceed 38mbar.

The air filters fitted to Kohler engines can be used in dust-laden atmospheres of up to 15 mg/m_n^3. In case of greater dust concentration, it will be necessary to install mechanical air prefilters (refer to document IC-G-D-35-001e).

In double-stage filters, this is how filtering occurs:

- Air enters the filter tangentially to the cylindrical casing of the filter.
- Passes through the first filtering element (main element).
- Flows through the second, safety filtering element.
- And finally goes out axially with respect to the filter casing.

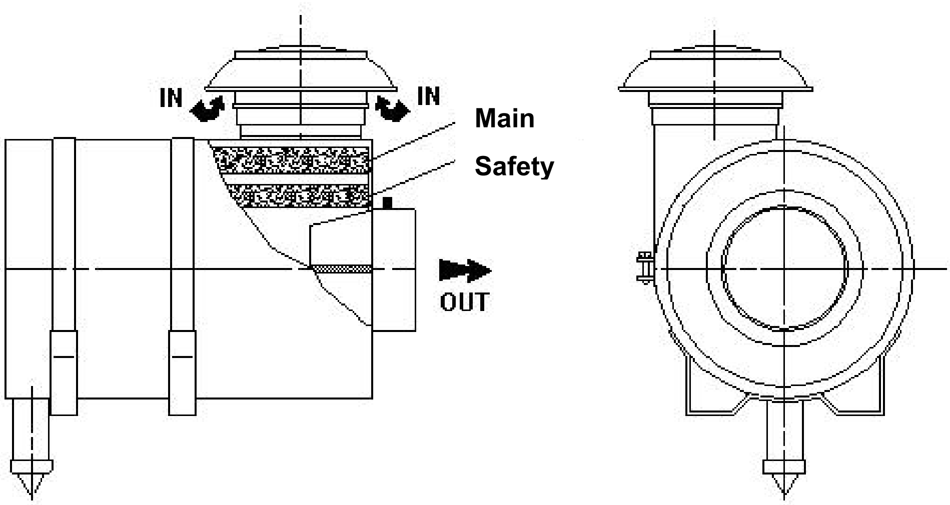
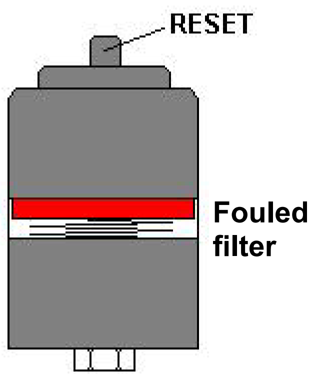


Fig. 1 - General view of double-stage air filters

The airflow restriction created by the air filters increases as the filters get fouled. As already mentioned, the maximum permissible airflow restriction is 38mbar for filters on engines running at their power rating. On reaching this value, the filtering elements are said to be clogged and must be immediately cleaned or changed. For monitoring their fouling level, the Kohler filters include a mechanical air flow restriction detector Ref. 76.50.134 with a red-coloured indicator showing up completely when the maximum permissible pressure drop has been reached. Alternatively, an electric detector Ref. 76.50.321 can be installed, indicating the fouling condition of the filters by means of a light signal or by transmitting an electric signal to the PLC.



The figures below show exploded views of double-stage air filters, identifying their major components.

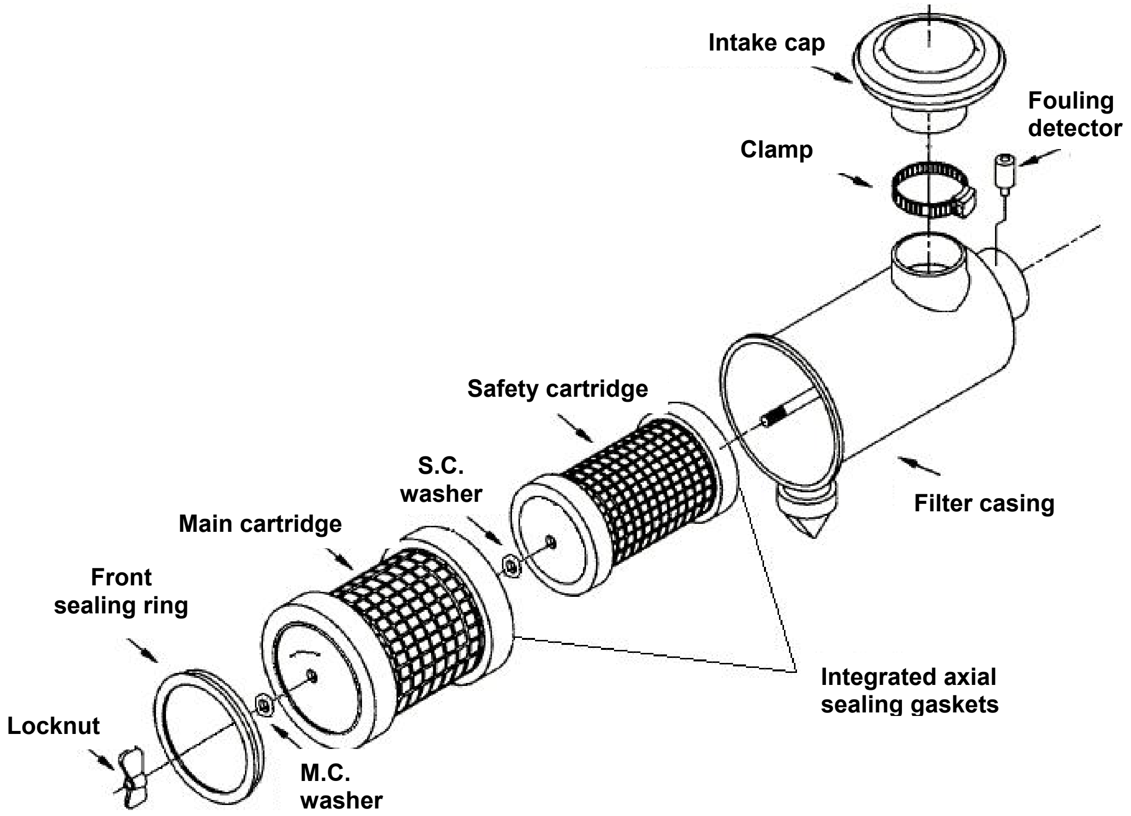


Fig. 2 - Exploded view of a tangentially sealed air filter

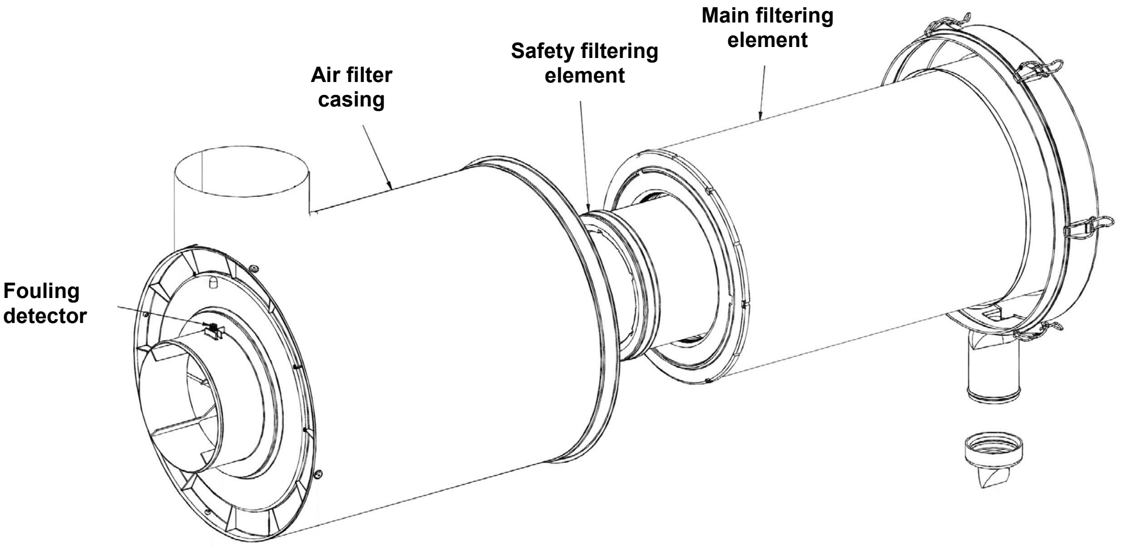


Fig. 3 - Exploded view of a radially sealed air filter

In GHF High-Flow filter, filtering occurs as follows:

- Air enters the filter directly through either one or two of the side intake ports, depending on whether the filter has 1 or 2 filtering cartridges
- Passes through the filtering cartridge,
- And finally flows out to the engine through one port with HGM engines and through two ports on the other engines.

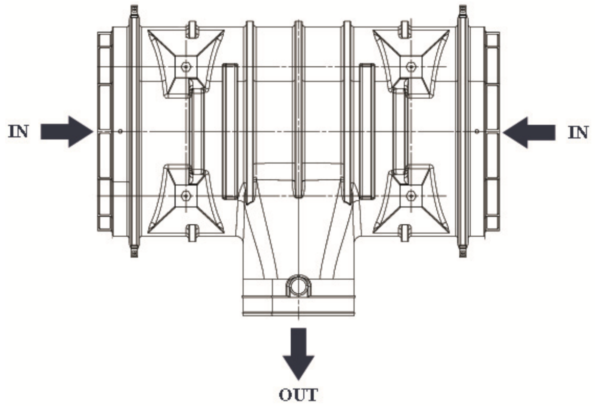


Fig. 4 - General drawing of Kohler High Flow two-cartridge filter

To monitor their fouling level, the GHF filters have a mechanical airflow restriction detector Ref. 76.50.319 with a red-coloured indicator showing up completely when the maximum permissible pressure drop (38 mbar) has been reached at the filter outlet. In this event, depending on the case, either one or two cartridges need to be changed. The fouling detector can alternatively be an electric device Ref. 76.50.266 indicating the fouling condition of the filters by means of a light signal or by transmitting an electric signal to the PLC.

The next figures show exploded views of the GHF air filter.

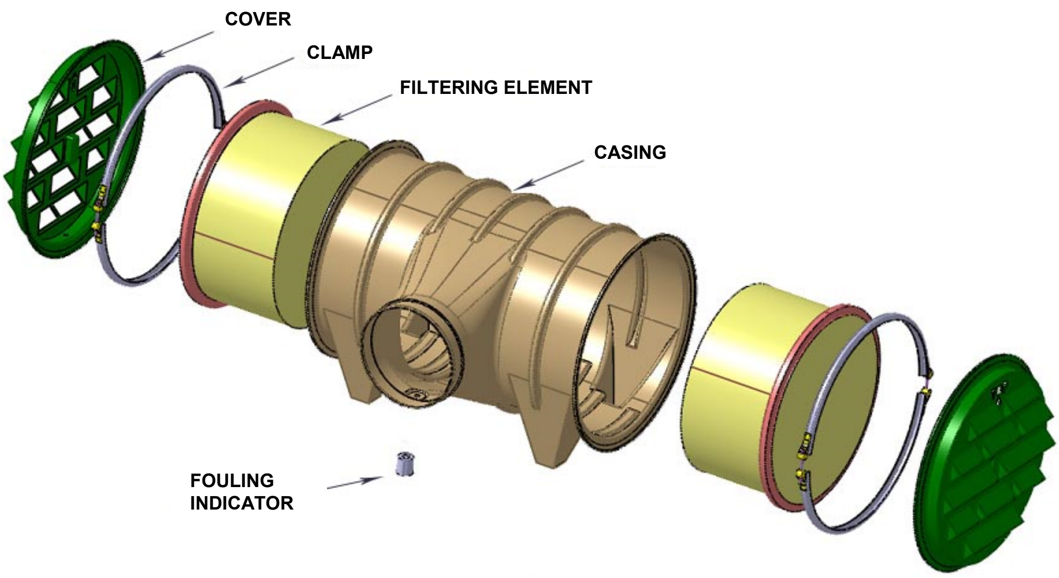


Fig. 5 - Exploded view of Kohler High Flow two-cartridge air filters

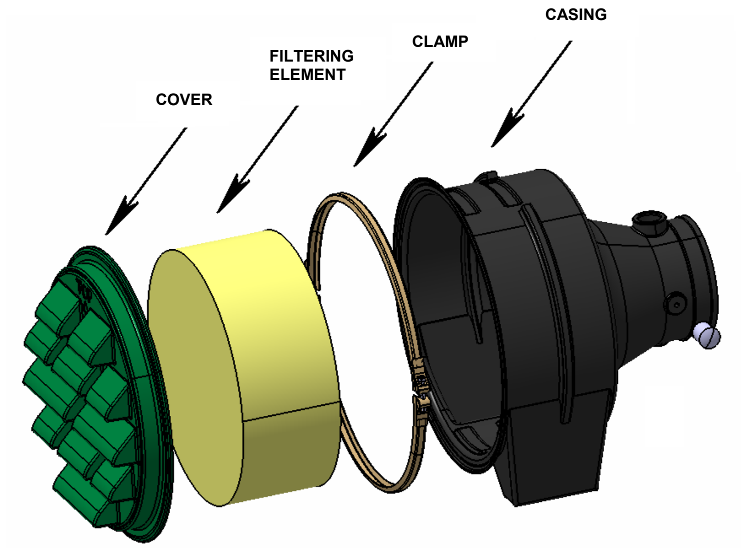
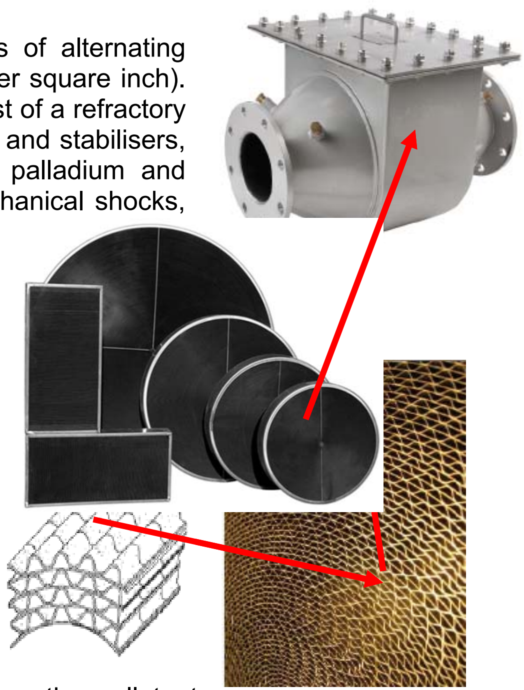


Fig. 6 - Exploded view of Kohler High Flow one-cartridge air filter

1. OXIDATIVE CATALYTIC CONVERTERS



Catalytic substrates consist of high-temperature resistant steel foils of alternating layers of corrugated and flat strips 100, 200, 300 or 400 cpsi (cells per square inch). The catalytic materials coated onto the surfaces of the channels consist of a refractory inorganic oxide, various substances which act as chemical promoters and stabilisers, and a combination of precious metals that can include platinum, palladium and rhodium. The substrates provide high resistance to thermal and mechanical shocks, while at the same time offering customers an economical alternative to ceramic and metal substrates currently on the market.

2. OPERATING THE CATALYTIC CONVERTER

The oxidative catalytic converter is effective in controlling carbon monoxide (CO), non-methane hydrocarbons (NMHC), volatile organic compounds (VOC), formaldehyde (CH2O) and hazardous air pollutants (HAPs) produced by gas engines. The oxidation catalytic converter is also effective for the catalytic combustion of VOC emissions from a variety of exhaust gas streams.

The temperature of the exhaust gases within the catalytic converter is a very important factor with regard to obtaining a high degree of conversion efficiency. In general, the higher the temperature, the greater the efficiency obtained by the catalytic system, depending on the pollutant being treated. The appropriate permissible temperature range should be greater than 400°C and less than 600°C.

These oxidation reactions are exothermic (they produce heat), meaning that the catalyser outlet temperature is higher than the inlet temperature. The ΔT value throughout the catalytic converter depends on several factors, such as the amount of contaminant or the degree of efficiency of the catalytic converter, but the temperature rise is normally below 40ºC.

An oxidative catalytic converter requires a certain amount of oxygen in order to be able to operate correctly, which is why they are not normally used in stoichiometric combustion engines. Due to the high oxygen requirements in the exhaust, it is not viable to carry out NOx reduction reactions in this type of catalytic converter, meaning that the presence of these pollutants in the exhaust flows remains practically the same. The amount of NOx in the exhausts must be adjusted to comply with legal requirements concerning emissions by controlling the parameters of the lean mix engine itself or by incorporating other processing systems.

OXIDATION REACTIONS THAT OCCUR IN THE OXIDATION CATALYTIC CONVERTER

CARBON MONOXIDE	$CO + ½ O2 \rightarrow CO2$	(1)
HYDROCARBONS	$CmHn + (m + n/4) O2 \rightarrow m CO2 + n/2 H2O$	(2)
ALDEHYDES, KETONES, ETC.	$CmHnO + (m + n/4 - 0.5) O2 \rightarrow m CO2 + n/2 H2O$	(3)
HYDROGEN	$H2 + ½ O2 \rightarrow H2O$	(4)

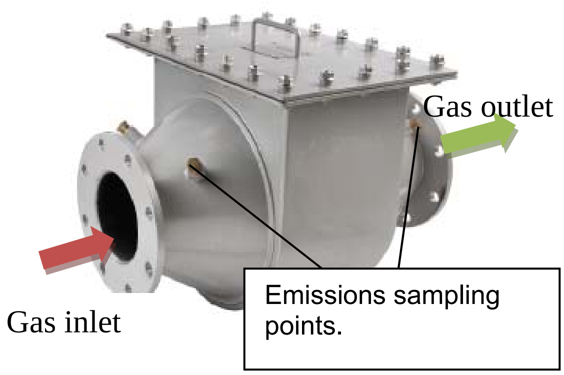
Table 1. Contaminants that are reduced in a oxidative catalytic converter by utilising oxidation reactions.

The conversion efficiency of this type of oxidative catalytic converter is shown in the following table:

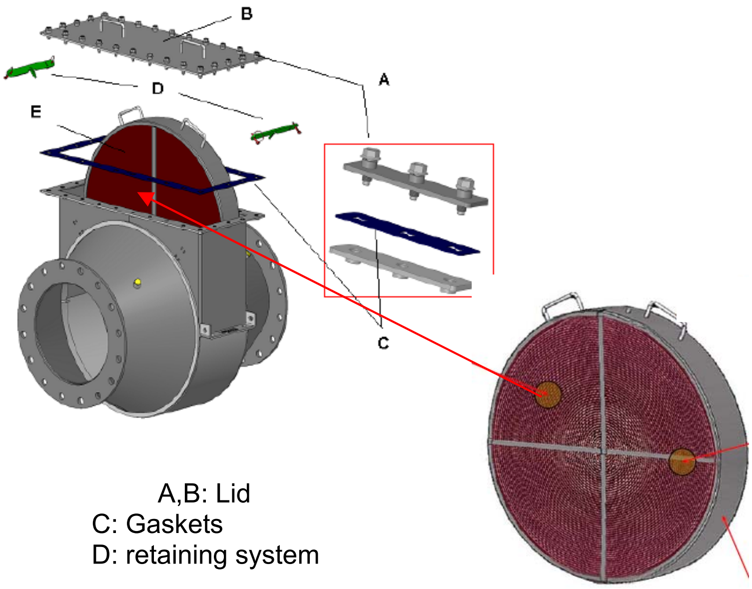
NOx	CO	NMHC	VOC	CH2O	HAPs
Null	70-95%	40-90%	60-99%	60-99%	60-99%

NMHC: Hydrocarbons (no methane)
VOC: Volatile Organic Compounds.
CH2O: Formaldehydes.
HAPs: Polycyclic aromatic hydrocarbons.

Table 2. Reduction efficiencies of each contaminant in an oxidative catalytic converter.



Oxidative catalytic converter



A,B: Lid
C: Gaskets
D: retaining system

E: Catalyst element

Fig. 1 Parts of an oxidative catalytic converter.

2. ENGINE OPERATION

The way in which an engine with an oxidative catalytic converter is operated may cause it not to work properly or even damage or disable it The following requirements should thus be taken into account when operating the engine-catalytic converter unit.

- The engine must be operated and maintained in accordance with the manufacturer’s specifications.
- Maximum inlet temperature to the catalytic converter 600°C.
- Special lubricating oil with less than 0.6% weight of sulphated ash as an additive of the same must be used. Zinc content must be less than 900ppm and phosphorus content less than 400 ppm.
- Substances deposited on the inner surface of the catalytic converter must not lead to an excessive increase in the initial load of the catalytic converter, as it would be covering the reaction points and leading to a progressive reduction in system efficiency. The engine must operate with specific oil consumption in accordance with IO-G-M-25-001 and IO-F-M-25-001.
- The engine can operate with or without recirculation of crankcase gases, in accordance with the systems and specifications defined by the manufacturer.
- Fuel quality should meet the ASTM D975, ASTM D6751 standards and also have a sulphur content of <500 ppm, chlorine compounds of <10ppm and without the presence of silicon compounds.

- The quality of the natural gas must be as specified in documents IP-GD-30 IC-001 and IC-GD-IP 30-002 on natural gas fuel. There must be no leaks from the exhaust system.
- There must be a minimum of 4% by volume of oxygen in the exhaust gas at the oxidative catalytic converter inlet.
- The pressure drop in the catalytic converter should be no more than 0.5 kPa above the initial pressure drop in the catalytic converter. If this occurs ash deposits are being produced on the surface of the catalytic converter and it must be cleaned.

3. OPERATING THE CATALYTIC CONVERTER

The oxidative catalytic converter is designed to convert the main unburnt fractions of the engine exhaust gases: carbon monoxide (CO), hydrocarbons (CxHy) and partially oxidised hydrocarbons (CxHyO) to the typical products of perfect combustion: carbon dioxide (CO2) and water (H2O).

These oxidation reactions are exothermic (they produce heat), meaning that the catalyser outlet temperature is higher than the inlet temperature. The ΔT value throughout the catalytic converter depends on several factors, such as the amount of contaminant available or the degree of efficiency of the catalytic converter, but the temperature rise is normally below 40ºC.

The temperature of the exhaust gases within the catalytic converter is a very important factor with regard to obtaining a high degree of conversion efficiency. In general, the higher the temperature, the greater the efficiency obtained by the catalytic system, depending on the pollutant being treated. Below you can see the typical recommended values and limits for temperature and pollutants in the exhaust gas to optimise the efficiency of oxidative catalytic converters.

Fuel type	Pollutant type	Minimum temperature	Exhaust composition limit
Any fuel	CO	400ºC	-
Natural Gas	NMHCs, including formaldehyde (no methane)	450ºC	Ethane < 40% weight NMHCs Ethane + propane < 50% weight NMHCs
Natural Gas	NMNEHCs (no methane, no ethane)	425ºC	Propane < 10% weight NMNEHCs
Natural Gas	VOCs	425ºC	-
Natural Gas	CH_2O (formaldehyde)	425ºC	-
LPG (Liquid Petroleum Gas)	THCs (totals)	450ºC	Propane < 30% weight THCs
Diesel	THCs	400ºC	

NMHCs: Hydrocarbons (no methane)
NMNEHCs: Hydrocarbons (no methane, no ethane)
VOCs: Volatile Organic Compounds.
THCs: Total hydrocarbons.
CH_2O: Formaldehyde.

Table 2. Optimal working temperatures of the catalytic converter

The following diagram shows the overall trend as regards the degree of conversion of the catalytic converter for the different contaminants according to the exhaust gas temperature at the catalytic converter inlet.

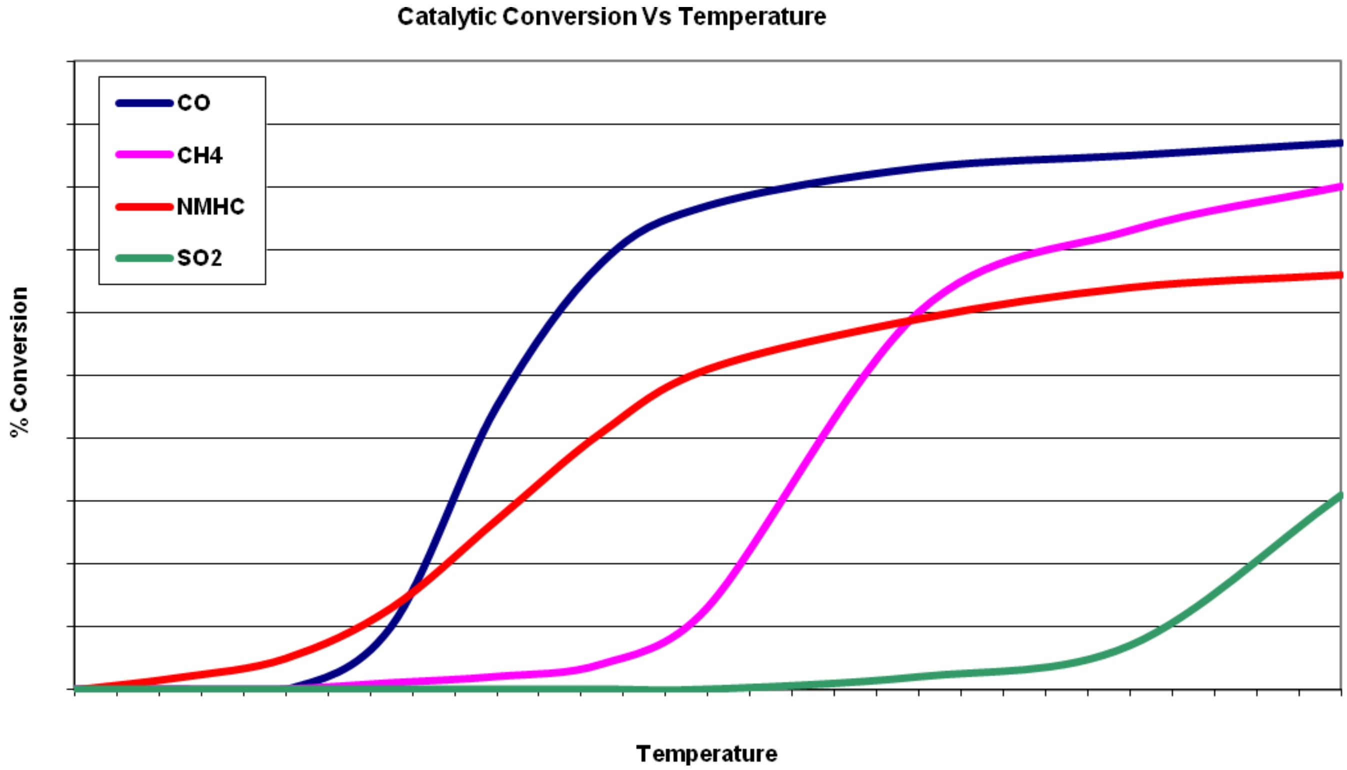


Fig.2 Reduction efficiencies according to contaminant, based on the temperature inside the catalytic converter

These curves show general tendencies for oxidative catalytic converters. However, noble or transition metals that make up the active stage, as well as the coating material and the preparation method determine conversion results at different temperatures. Catalytic converters manufacturers do not usually supply the consumer with this information, but show the conversion vs temperature curves for a specific catalyst. Another important factor is the influence of the spatial speed of exhaust gases in the catalytic converters. The higher the speed, the lower the conversion is

4. TECHNICAL LIMITATIONS OF THE LUBRICATING OIL

The lubricating oil used by an engine with an oxidative catalytic converter in the exhaust must have certain special specifications with regard to maximum additive content and maximum engine consumption. This is because both high specific consumption of motor oil and excessive additive levels therein can lead to the excessive generation of components that are damaging to the catalytic converter, or poisons that reduce its performance and useful life.

As well as these values, the lubricating oil must comply with specifications relating to engines that do not have oxidative catalytic converters fitted to their exhausts.

POISON	MAXIMUM AMOUNT
Zinc	900 ppm
Phosphorous	400 ppm
Sulphated Ash	0.6% weight
Specific consumption	In accordance with KOHLER specification IO-G-M-25-001

Table 3. Limit of harmful compounds entering the catalytic converter in the engine lubricating oil.

5. TECHNICAL LIMITATIONS OF COMBUSTION GAS AND EXHAUST GAS

As with the lubricating oil, certain catalytic converter poisons can mix with the exhaust gas flow as a result of the combustion of the fuel used. The maximum quantity of poison catalytic converters can tolerate, like their performance, depend on the suppliers. By way of example, the following table shows the limits for these types of harmful components for the approved catalytic converter.

POISON	LOCATION	MAXIMUM AMOUNT
Chlorine compounds	Combustion gas	According to fuel IP IP IC-G-D-30-002
Sulphur	Combustion gas	According to fuel IP IP IC-G-D-30-002
Silicon compounds	Combustion gas	Null for both types of fuel.
Calcium Sulphur Phosphorous Zinc Iron Sulphur+Calcium+Phosphorous+Zinc+Iron	Catalytic substrate	< 1 % < 1 % < 1 % < 0.5 % <1 % < 2 % (collectively).
Heavy metals: Pb, Hg, Ar, Sb, Zn, Cu, Sn, Fe, Ba, Ni, Cr, P y S	Exhaust gas	200 ppm weight (collectively)
Ash deposit	Catalytic substrate	< 1g/litre of substrate

Table 4. Limit of harmful compounds entering the catalytic converter present in the engine's exhaust gases.

6. LOSS OF ACTIVITY IN THE CATALYTIC CONVERTER

The activity of a catalytic converter drops progressively over time, although a series of mechanisms can cause said activity to be lost before the end of its useful life, significantly reducing exhaust pollutant reduction efficiency as shown on the following table:

Mechanism	Description
CHEMICAL POISONING	Poisons are those elements or compounds which are present in engine exhaust gases and combine chemically with the materials of the catalytic converter, causing them to lose activity. In most cases when poisoning occurs the damage is irreversible.
CATALYTIC INHIBITION	Inhibitors are those elements that, when present in engine exhaust gases, can make the catalytic converter lose efficiency in certain operating conditions. However, the catalytic converter recovers its normal performance when the inhibitor is not present in the exhaust gases or when operating conditions change. One example of this is sulphur, which does not allow the catalytic converter to operate correctly at low temperatures, and acts as a poison. When the system starts operating at high temperatures it is eliminated and normal efficiency levels are regained.
DIRTYING OR MASKING	The loss of activity by a catalytic converter through dirtying or masking happens when an inert residue or ash from the exhaust gases is deposited on the catalytic surface, blocking it and preventing it from working correctly. In many cases, the residue can be eliminated from the catalytic surface using cleaning methods that allow it to regain normal catalytic converter activity levels.
THERMAL DEACTIVATION	Thermal deactivation of the catalytic converter happens when the creep temperature of the materials that make it up is exceeded. This type of problem can happen as a result of a sudden increase in the pollutants to be eliminated which, when they are converted through exothermic reactions, cause the thermal limits of the materials of the catalytic converter to be exceeded, causing irreversible damage to its structure.
MECHANICAL EROSION AND DEACTIVATION	The erosion of the materials making up the catalytic converter substrate is due to natural causes (time) or to wear caused by an excessive presence of solid materials in the exhaust gas. Mechanical deactivation means that the internal channels of the catalytic converter become blocked or their walls collapse due to mechanical problems (excessive vibration, blows, excessive erosion, etc.). This type of damage to the catalytic converter is irreversible.

Table 5. Causes of loss of activity in the catalytic converter.

1. AIM

This product information sheet describes the exhaust system and crankcase gas breather of GAS engines.

2. EXHAUST SYSTEM

The exhaust system consists of the following components:

- Exhaust Manifold.
  - 1 in "L" engines.
  - 2 in "V" engines.
- Turbocharger Turbine (only in supercharged engines)
  - 1 in "L" and HGM engines.
  - 2 in "V" engines.
- Exhaust Pipe (supplied by customer)
- Crankcase gas exhaust system

3. EXHAUST MANIFOLD

Each exhaust manifold comprises various segments joined together. The exhaust manifolds connect to the cylinder heads to receive the exhaust gases.

- "L" engines: The exhaust manifold lies on the right hand side of the engine.
- "V" engines: The exhaust manifolds are on the inside of the engines and fixed to their respective line of cylinder heads.

A. Water-cooled Exhaust Manifold

Cooled by water from the engine's cooling system, these exhaust manifolds connect to the cylinder heads to receive coolant.

B. Dry Manifold

It is made up of various separate sections joined together with high-temperature expansion joints. The manifold is covered with thermal insulation material.

Fig. 1 Example of dry exhaust manifold on a V-engine

4. TURBOCHARGER (Only in supercharged engines)

A turbocharger is a centrifuge air compressor driven by a turbine that utilises the energy of the exhaust gases. It is an element of the air/fuel mixture system. The turbocharger delivers high-pressure air to the engine; accordingly, the amount of air the piston can take is greater. This increase in the amount of air delivered allows the engine to increase its level of combustion efficiency and power output.

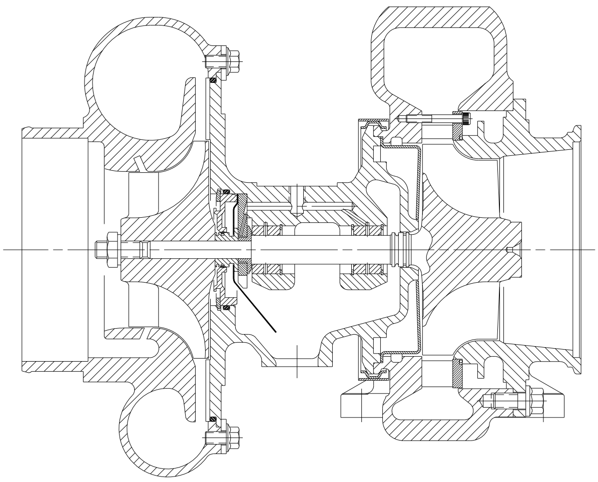


Fig. 2 Turbocharger Section

In “L” engines, the turbocharger is mounted on the right side of the engine.

In “V” engines, the turbochargers are mounted on the right and left of the engine, over the exhaust manifolds.

In HGM engines, the turbocharger lies in the front end, in V engines above the top cover of the air cooler.

5. EXHAUST GASES OUTLET LINE

The exhaust gases produced by combustion leave the cylinders through the exhaust valves in the cylinder heads. They are expelled to the exhaust manifold during the up stroke of the pistons.

In naturally aspirated engines, the exhaust gases go out of the engine through the exhaust directly. Customer has to fit the gas outlet line to this exhaust.

In supercharged engines, the exhaust gases flow from the exhaust manifold into the turbocompressor(s) that make(s) use of the energy of the exhaust gases to compress the intake air.

Finally, the gases go out into the atmosphere through the gas outlet line provided with flexible joints that absorb expansion caused by the high temperatures involved.

The exhaust pipe will also be fitted with an exhaust gas silencer to reduce the noise produced in all internal combustion engines and, where appropriate, with a catalytic converter to reduce polluting emissions.

6. CRANKCASE GAS BREATHER

Crankcase ventilation aims to eliminate the combustion gases that enter the crankcase through the clearance between piston rings and piston liners. Those gases sweep oil along, which must be separated.

Ventilation takes place through a tap in the front or rear cover of the engine block. There, an elbow directs the gases to a gridiron separator.

A. Open System

In an open crankcase ventilation system, gas-borne oil is separated in a separator (and drawn off oil returns to the oil sump), while clean gases are expelled to the outside through a duct or pipeline. Refer to Product Information Sheets IC-C-D-25-007e and IT-C-A-25-016e.

B. Closed System or Gas Recirculation System

In a closed system, the blow-by gases flow first through a separator and then through a specific filter that also directs drawn off oil to the oil sump. Clean gases are fed back into the intake system, at a point located between the intake filter and the carburettor. See specific Product Information Sheet IC-C-D-25-006e.

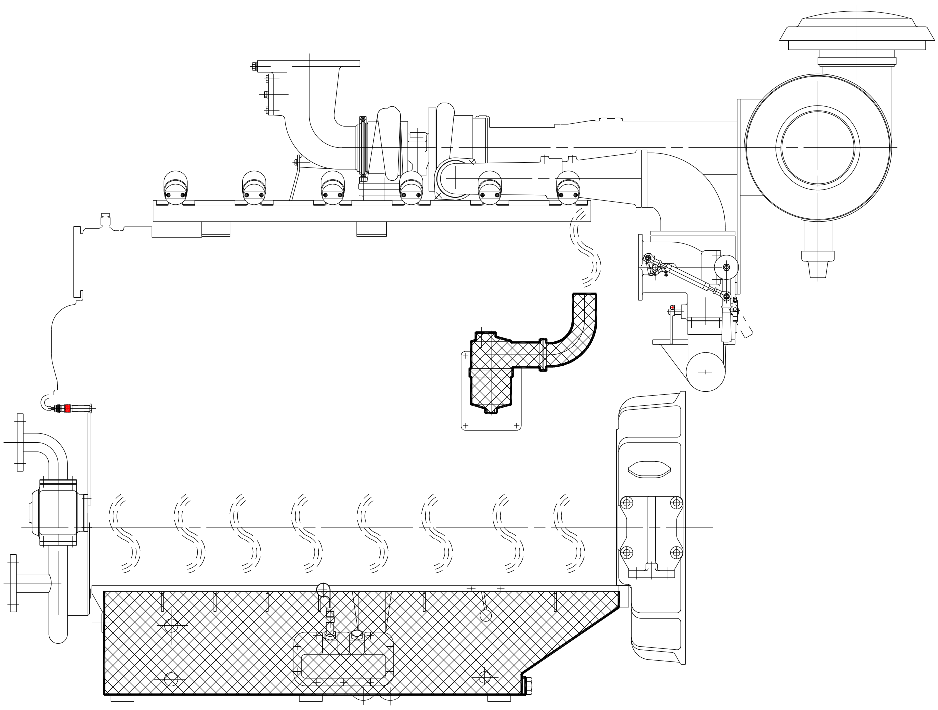


Fig. 3 Arrangement of Crankcase Gas Breather

1. ELECTRIC STARTER

1.1. DESCRIPTION OF THE ELECTRIC STARTER SYSTEM

The electric starters used to start all Kohler engines are standard commercially-available products, with a toothed pinion that moves linearly to engage with the flywheel gear.

The electric starter pinion is operated with a start button. This pinion disengages as soon as the start button is released or when a tachometer relay detects a particular gear mesh frequency and disables the electric starter.

1.2. INSTALLATION

The wiring diagram below shows the installation with starter motor.

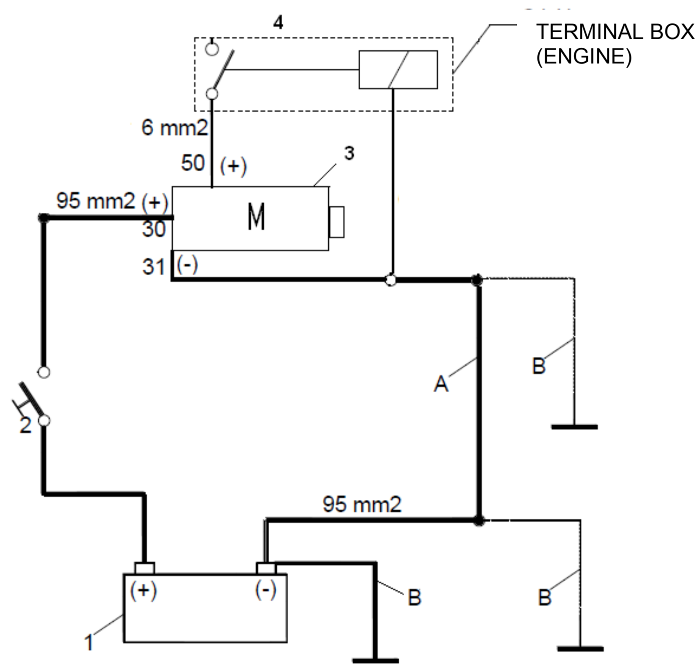


Fig. 1.1 - Overview of electric start with one starter motor

The wiring diagram below shows the installation with two starter motors.

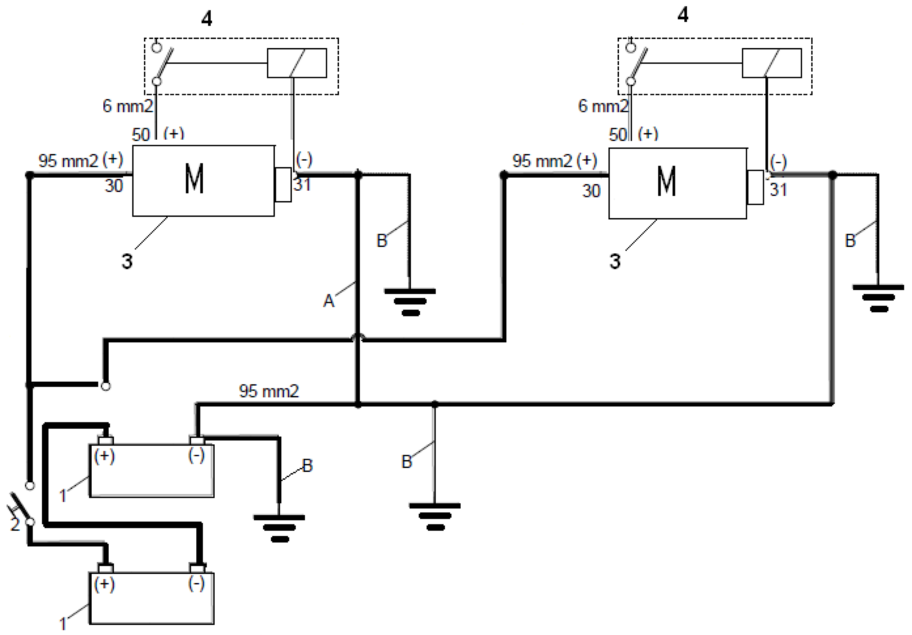


Fig. 1.2 - Overview of electric start with two starter motors

1	Battery (12 V DC)
2	Master switch
3	Starter motor
4	Auxiliary start-up relay
A	Earth insulation
B	Earth connection

Table 1 - Electrical schematic components

The auxiliary start-up relay (4) should be fitted as close as possible to the engine, either in the terminal box or on the starter motor itself.

The system has a series of batteries to power the electric starter. The standard batteries used by Kohler to start its engines are LEAD BATTERIES. The battery capacities are the minimum needed for the maximum current during start-up.

If the batteries are to provide other services apart from engine start-up, the installer should size their capacity to satisfy the services to be provided. A voltage of 24 V DC has been adopted for the starter motor. The batteries are 12 V and two are installed in series.

Engine	Voltage (V)	Capacity 20 h (Ah)	No of batteries in series
H series	12	90	2
E series		180	2
FG/SFGLD/SFGM/SFGRD/HGM		220	2
V engines, remote areas		220	4

Table 2 - Battery properties for engine series

The cross section of the power leads should be chosen according to the capacity of the battery chosen and the maximum length of the lead. The minimum cross section of the lead used should be at least 95 mm2

It is very important for the batteries to be installed as close to the starter motor as possible.

1.3. OPERATION

The system works as follows:

- Connect the batteries to the start-up system using the **Main switch.**
- Connect the **Switch contact** in the start-up panel.
- Start by pressing the **Start button.**

After pressing the start button, start-up consists of three stages:

- Movement of the pinion and slow rotation so that it can engage with the flywheel gear.
- Rotation of the starter motor at maximum torque to start the engine.
- Disengagement of the starter pinion from the flywheel gear after the engine has started.

1.4. START-UP

This start-up sequence must be programmed in the engine PLC as follows.

- Maximum start-up time 20 seconds (1st, 2nd and 3rd attempts) and 30 seconds (4th and 5th attempts).
- Minimum pause between start-up attempts 30 seconds between the first three start-up attempts and 120 seconds between the 4th and 5th start-up attempts.
- After five start-up attempts, the sequence begins again; the time out between sequences is 120 seconds.

The start-up time is a set maximum. Start-up times of less than 20 seconds can be entered as parameters for the first three start-up attempts and less than 30 seconds for the last two attempts. The same is true for the pause, which can be increased between start-up attempts.

The engine speed at which it can be considered running and at which the starter must be released from the crown gear is 400 rpm.

1. INTRODUCTION

This document compiles the different variables that can be recorded on a FG/FGLD/SFGLD/SFGM/SFGRD engine with a view to setting up an operating safety chain. We classify the safety features in order of importance within two groups as follows:

- Minimum or obligatory safety measures
- Additional signals

Of a general nature, this document does not apply to special cases in which the values shown in the next tables may vary due to production requirements, prevailing regulations, characteristics of the plant, or fuel quality, etc.

2. MINIMUM OR OBLIGATORY SAFETY MEASURES

2.1. FAILURE OF THE MEASUREMENT SIGNALS

Failure of the measurement signals of any of the sensors used should be treated as non-compliance with the minimum or obligatory safety measures of the engine. With a failure of this kind, you should initiate a **gradient shutdown** of the engine.

With the 4-20mA analogue signals, the control equipment must be able to detect cable breakage and/or interpret a reading outside the 4-20mA range as a failure of the measurement signal. Gradient shutdown of the engine due to analogue signal failure can be timed as long as the fault is maintained for over 10 seconds.

With potential-free contacts, as all of them are NC (Normally Closed) type in operation without alarm, a broken cable or failure in the signal should initiate a **gradient shutdown** of the engine.

2.2. TABLE OF MINIMUM ENGINE SAFETY MEASURES.

Table 1 shows all the obligatory safety measures that must be configured in the engine control equipment.

WARNING

If the configurations shown in the table are not complied with and said non-compliance leads to a fault in the engine, the client shall be held responsible for all damage caused.

Table 1. Configuration of minimum engine protections.

Measure	Location	Signal type	Protection value	Action	Active
Oil temperature Dual cooling circuit engines	Crankcase	4-20 mA (0-150ºC) (32-302ºF)	> 105ºC (221ºF)	Gradient shutdown	Always
			> 100ºC (212ºF)	Alarm or warning	Always
Oil temperature Single cooling circuit engine			> 107ºC (224,6ºF)	Gradient shutdown	Always
			> 104ºC (219,2ºF)	Alarm or warning	Always
Oil level	Crankcase	NC potential-free contact with the correct oil level	High	Alarm or warning	Always
			Low	Emergency shutdown	Always
Oil pressure	Gallery	4-20mA (0-10 bar) (0-145 psi)	< 3,9 bar (56,6 psi)	Alarm or warning	In operation + 20 s
			< 3,6 bar (52,2 psi)	Emergency shutdown	In operation + 20 s
	Before filters (only V engines)	NC potential-free contact	> 6 bar (87 psi)	Alarm or warning	In operation + 20 s
Oil pressure Explosive areas engines		Does not apply			
Water temperature Engines 90/80,90/55 and 90/40 (194/176ºF 194/131ºF y 194/104ºF)	Main Circuit Outlet	4-20 mA (0-150ºC) (32-302ºF)	> 92ºC (197,6ºF)	Alarm or warning	Always
			> 96ºC (204,8ºF)	Emergency shutdown	Always
Water temperature Engines 120/80, 120/55 and 120/40 (248/176ºF 248/131ºF y 248/104ºF)			> 122ºC (251,6ºF)	Alarm or warning	Always
			> 126ºC (258,8ºF)	Emergency shutdown	Always
Water temperature	Auxiliary Circuit Inlet		-	Display	Always
Water pressure Engines 120/80, 120/55 and 120/40 (248/176ºF 248/131ºF y 248/104ºF)	Main Circuit Outlet	NC potential-free contact in operation without alarm	< 2,6 bar (37,7 psi)	Gradient shutdown	Under load
Water pressure Engines 120/80, 120/55 and 120/40 (248/176ºF 248/131ºF y 248/104ºF) Explosive areas engines		4-20mA (0-10 bar) (0-145 psi)			
Water pressure	Discharge Main Circuit pump	NC potential-free contact in operation without alarm	< 0.5 bar (7,3 psi)	Alarm or warning	Under load
	Discharge Auxiliary Circuit pump				
Water pressure Explosive areas engines	Discharge Main Circuit pump	4-20mA (0-10 bar) (0-145 psi)			
	Discharge Auxiliary Circuit pump				
Air Temperature	Engine inlet	4-20 mA (0-150ºC) (32-302ºF)	-	Power correction. (See IC-G-B-00-001e)	Always

Measure	Location	Signal type	Protection value	Action	Active
Mixture Temperature Engines 90/55 and 120/55 (194/131ºF y 248/131ºF)	Intake manifold	4-20 mA (0-150ºC) (32-302ºF)	> 63ºC (145,4ºF)	Alarm or warning	Always
			> 65ºC (149ºF)	Emergency shutdown	Always
Mixture Temperature Engines 90/80 and 120/80 (194/176ºF y 248/176ºF)			> 85ºC (185ºF)	Alarm or warning	Always
			> 87ºC (188.6ºF)	Emergency shutdown	Always
Mixture Temperature Engines 90/40 and 120/40 (194/104ºF y 248/104ºF)			> 52ºC (125,6ºF)	Alarm or warning	Always
			> 65ºC (149ºF)	Emergency shutdown	Always
Mixture Temperature Single cooling circuit engines			> 105 ºC (221ºF)	Alarm or warning	Always
			> 107 ºC (224,6ºF)	Emergency shutdown	Always
Mixture pressure Explosive areas engines	Intake manifold	4-20mA (0-4 bar abs) (0-58 psi) Mechanical regulation	-	Display	Always
		Control unit parameter Electronic regulation			
Crankcase gas pressure Engines 120/80, 120/55 and 120/40 (248/176ºF 248/131ºF y 248/104ºF)	Gallery	NC potential-free contact	> 3mbar (0,044 psi)	Alarm or warning	In operation. Timed 5 sec.
				Emergency shutdown	Refer to (*) Timed 5 sec.
Exhaust temperature	After turbo	4-20 mA (0-800ºC) (32-1472ºF)	> T + 50ºC (122ºF)	Alarm or warning (T = temperature balance)	Always
			Difference between lines > 30ºC V Engines	Alarm or warning	Under stable load
Exhaust temperature (SFGRD)	After catalyst		> 700ºC (1292ºF)	Emergency shutdown	Always
Overspeed Engines 1200 rpm	Engine control equipment	Signal type according to control equipment used for said protection	> 1500 rpm (25%)	Emergency shutdown	Always
Overspeed Engines 1500 rpm			> 1875 rpm (25%)	Emergency shutdown	Always
Overspeed Engines 1800 rpm			> 2160 rpm (20%)	Emergency shutdown	Always
Emergency stop button	On Engine	NC potential-free contact	-	Emergency shutdown	Always

(*) Activates when the engine has been running for several minutes. This time depends on the oil temperature:

- <60ºC (140ºF) Cannot be activated for oil temperatures of less than 60ºC (140ºF)
- Activates and engine shutdown 20 minutes after temperature has been > 60ºC (140ºF)
- Activates and engine shutdown 15 minutes after temperature has been > 70ºC (158ºF)
- Activates and engine shutdown 10 minutes after temperature has been > 80ºC (176ºF)
- Activates and engine shutdown 5 minutes after temperature has been > 90ºC (194ºF)

3. ADDITIONAL INSTRUMENTATION

The following signals and/or protections can be included with the engine on express request of the client. .

Table 2. Configuration of additional engine signals and/or protections

Measure	Location	Signal type	Protection value	Action	Active
Exhaust manifold temperature (SFGM560)	Exhaust outlet of each cylinder	Type K thermocouple	-	Informative	Always
Crankcase gas pressure Engines 90/80,90/55 and 90/40 (194/176ºF 194/131ºF y 194/104ºF)	Gallery	NC potential-free contact	>3mbar (0,044 psi)	Alarm or warning	In operation. Timed 5 sec.
Crankcase gas pressure Engines 90/80,90/55 and 90/40 (194/176ºF 194/131ºF y 194/104ºF) Explosive areas engines		4-20mA (-50 - 50 mbar) (-0.73 – 0,73 psi)			
				Emergency shutdown	Refer to (*) Timed 5 sec.
Air filter blockages	Air filter	Visual	> 38 mbar (0,055 psi)	Alarm or warning	Always
		NC potential-free contact			
Air filter blockages Explosive areas engines	Air filter	4-20mA (-50 - 50 mbar) (-0.73 – 0,73 psi)	> 38 mbar (0,055 psi)	Alarm or warning	Always
Catalyst blockage SFGRD engines	Catalyst inlet	4-20mA (-50 - 50 mbar) (-0.73 – 0,73 psi)	< 45 mbar (0,065 psi)	Alarm or warning	Always
Water pressure Engines 90/80, 90/55 and 90/40 (194/176ºF 194/131ºF y 194/104ºF)	Discharge Auxiliary Circuit pump	4-20mA (0-10 bar) (0-145 psi)	< 1 bar (14,5 psi)	Alarm or warning	In operation + 10 s
			< 0,5 bar (7,3 psi)	Gradient shutdown	In operation + 10 s
Water pressure Engines 120/80.120/55 and 120/40 (248/176ºF 248/131ºF y 248/104ºF)			< 2 bar (29 psi)	Alarm or warning	In operation + 10 s and water temp. > 100ºC (212ºF)
			< 1,5 bar (21,8 psi)	Gradient shutdown	In operation + 10 s and water temp. > 100ºC (212ºF)

(*) Activates when the engine has been running for several minutes. This time depends on the oil temperature:

- <60ºC (140ºF) Cannot be activated for oil temperatures of less than 60ºC (140ºF)
- Activates and engine shutdown 20 minutes after temperature has been > 60ºC (140ºF)
- Activates and engine shutdown 15 minutes after temperature has been > 70ºC (158ºF)
- Activates and engine shutdown 10 minutes after temperature has been > 80ºC (176ºF)
- Activates and engine shutdown 5 minutes after temperature has been > 90ºC (194ºF)

4. POWER REGULATION

4.1. OBLIGATORY

Depending on ambient temperature, the power correction described in IC-G-B-00-001e should be made.

4.2. RECOMMENDED

It is advisable to regulate the engine power according to reachable values (below the shutdown-triggering values) to avoid sudden shutdowns of the engine at facilities short of cooling.

The recommended regulations to be made with the signals of the minimum safety measures installed are shown below.

Table 3. Configuration of power regulations

Measure	Location	Signal type	Protection value	Action	Active
Water temperature Engines 90/80, 90/55 and 90/40 (194/176ºF 194/131ºF y 194/104ºF)	Main Circuit Outlet	4-20 mA (0-150ºC) (32-302ºF)	> 92ºC (197,6ºF)	Linear power regulation. • 92ºC(197,6ºF):100% load • 95ºC(203ºF): :20% load	Always
Water temperature Engines 120/80.120/55 and 120/40 (248/176ºF 248/131ºF y 248/104ºF)			> 121ºC (249,8ºF)	Linear power regulation • 121ºC (249,8ºF): 100% load • 124ºC (255,2ºF): 20% load	Always
Mixture Temperature Engines 120/40 and 90/40 (248/104ºF y 194/104ºF).	Intake manifold	4-20 mA (0-150ºC) (32-302ºF)	> 51ºC (123,8ºF)	Linear power regulation. • 51ºC (123,8ºF): 100% load • 64ºC (147,2ºF): 40% load	Always
Mixture Temperature Engines 120/55 and 90/55 (248/131ºF y 194/131ºF)			> 62ºC (143,6ºF)	Linear power regulation. • 62ºC (143,6ºF): 100% load • 64ºC (147,2ºF): 20% load	Always
Mixture temperature Engine 120/80 and 90/80 (248/176ºF y 194/176ºF)			> 84ºC (183,2ºF)	Linear power regulation • 84ºC (183,2ºF): 100% load • 86ºC (186,8ºF): 20% load	Always

CHAPTER 3 – HANDLING AND STORAGE INSTRUCTIONS

GENERAL STANDARDS FOR THE CORRECT LIFTING OF GAS AND ETHANOL ENGINES

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1. INTRODUCTION

The purpose of this product information sheet is to provide the general standards for the correct lifting of Kohler gas engines and ethanol engines, as well as the points where the engine must be lifted.

2. GENERAL STANDARDS

CAUTION

- Always be careful when the lifting the engine or its components.
- Keep all the personnel away and do not walk under or around the engine when is lifted.

WARNING

- Inspect all anchoring points to make sure that there are no faulty welds, loose bolts, etc., which could make the lifting of the engines dangerous.
- Be sure that the apparatus used for the lifting has been inspected, that it is in good condition and that it can bear the weight of the engine plus 10%. If you are not sure, weight the engine before raising it.

KOHLER GAS ENGINES AND ETHANOL ENGINES ORIENTATIVE WEIGHT TABLE

MODEL	WEIGHT (KG)	WEIGHT (LB)
180	2700	6000
240	3500	7800
HGM240	4200	9300
360	4200	9300
480	5500	12000
SFGLD/SFGM 560	5800	12800
HGM420	6250	13778
HGM560	7500	16500

- The use of cloth slings is recommended in order to prevent damage to the engine with sharp movements.
- Ensure that the slings do not make contact with sensitive parts of the engine.
- Before raising the engine, make sure that it is a balanced as possible. If necessary, use slings of different lengths.
- Do not raise the engine higher than necessary.

3. ENGINE RAISING

The engines in line are raised at two points, one at the front of the engine and the other at the rear of the block. (See Fig.1)

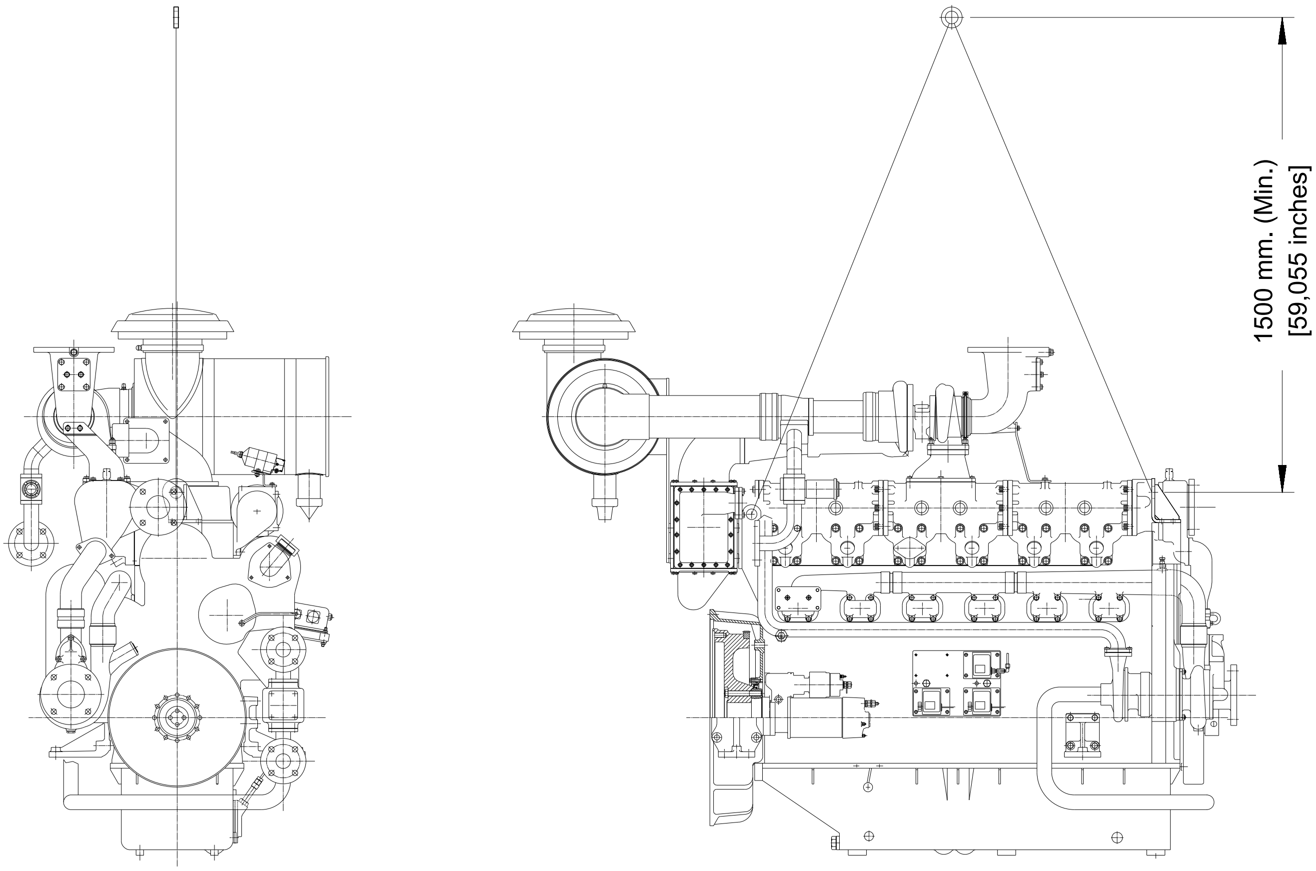


Fig. 1 – “In line” Engines Lifting.

The engines in V are lifted at 4 points, two in the front of the engine block and two on the rear of the block.

To make its lifting it is necessary to use a perch.

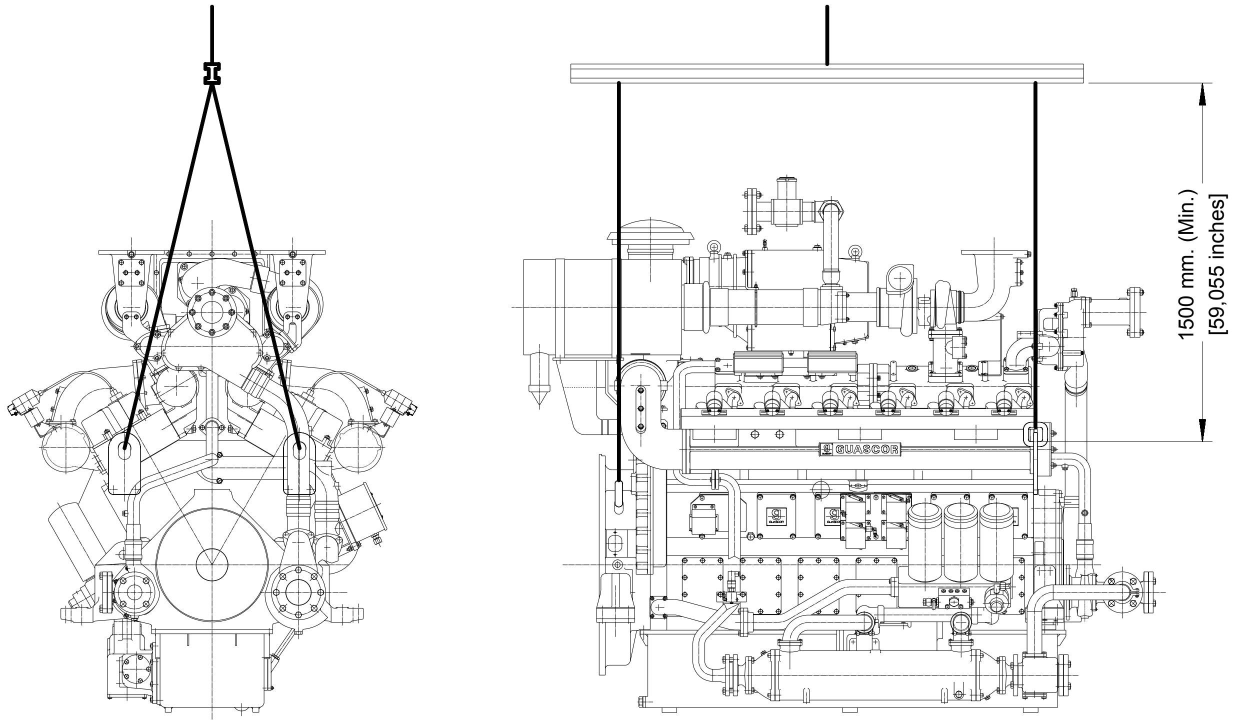


Fig. 2 -360/480 and SFGLD/SFGM560 Engines Lifting

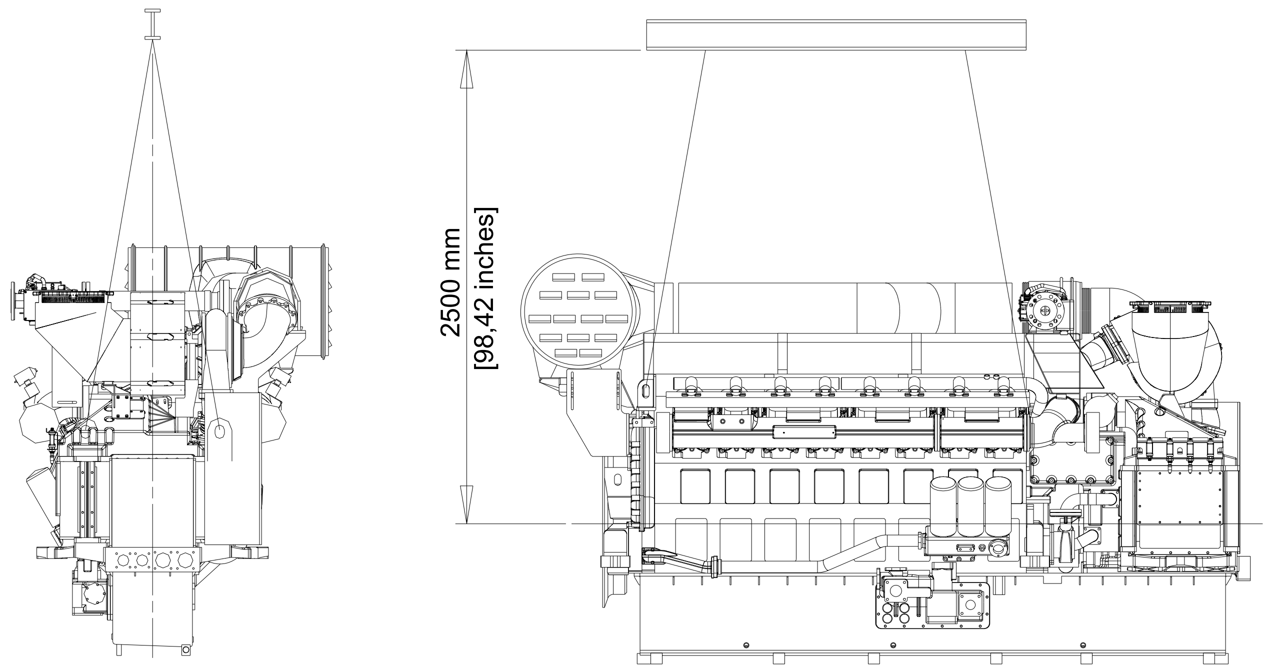


Fig. 3 - “HGM 420/560” Engines Lifting

DEFERRED START-UP ENGINE INSPECTION AND PROTECTION

O&M_2.002262.810_10_2016

1. INTRODUCTION

The deferred start-up status aims to keep Kohler Basic Warranty valid for any new engine that is going to be stored for more than 6 months from factory dispatch before its initial start-up.

Kohler will grant the deferred start-up status to an engine if all of Kohler requirements as specified in this Product Information Sheet are met.

2. DEFERRED START-UP STATUS APPLICATION REQUIREMENTS

When planning to store a new engine for more than 6 months, the owner shall apply to Kohler for the deferred start-up status. In this event, Kohler authorised staff shall inspect and protect the engine fulfilling all the herein defined obligations.

An engine subject to deferred start-up shall be put into operation within the next 12 months from the date of being recognised the deferred start-up status.

Kohler will accept a maximum of two requests for deferred start-up status, the second application having to be filed no more than 12 months after the first inspection and protection of the engine provided however that the first request had been made.

As a result of said deferred start-up status, the initial start-up of an engine may occur up to 30 months after the date of dispatch from factory, with Kohler Basic Warranty remaining valid. The total storage and warranty period shall by no means exceed 42 months from the date the equipment is at the customer's disposal.

If an engine is tested after dispatch from factory and is not started at the operating site within one month from said testing, then it will be necessary to protect it and to apply for deferred start-up status in order to withhold its warranty; it will be further requisite to renew said protection once a year.

Engines stored at the mercy of the elements or in humid or corrosive atmospheres may need protections and inspections more often than specified herein. In those events, consult Kohler.

Since the deferred start-up status is no extension of the standard Basic Warranty, there is no cost charged for it, except for the costs of the inspection made and protective lube oil used by the Authorised Technical Service Workshop.

The Basic Warranty will become effective from the engine start-up date, provided that the duly filled start-up report is submitted within thirty days from said start-up, the requests for deferred start-up status had been filed and the protections implemented. If the owner did not apply for the deferred start-up status, the warranty period will not be extended as stated in this section.

3. RELATED DOCUMENTS

- GLPI_09 Kohler Limited Warranty for Industrial Products
- GLPM_09 Kohler Limited Warranty for Marine Products

4. CONDITION OF ENGINES SUBJECT TO DEFERRED START-UP

At the time Customer applies for the deferred start-up status, the engine can be in any of these conditions: stored in its original packaging; unpacked and stored under conditions differing from the original ones, or mounted on the Customer's equipment.

- If ***packed in its original packaging***, the engine shall be inspected and protected by the Workshop according to the instructions contained in this Product Information Sheet.
- When the engine is ***unpacked and stored in conditions differing from the original ones***, the Workshop shall inspect the engine in order to assess its storage conditions and shall pack the engine again in original packaging in order to ensure a good state of preservation. Such inspection, protection and packaging of the engine shall conform to these specifications.
- In the event of the engine being ***mounted on the Customer's equipment, but not put into operation,*** the Workshop shall inspect, protect and pack the engine as specified herein.

CAUTION

If the engine exhaust is piped to the outside, the Workshop shall check to ensure these connections are perfectly sealed, impeding rainwater from getting inside the engine and causing serious damage to it.

- In the event of the engine having been ***started up and its commissioning being incomplete*** and not expected to be completed at once (within one to six or more months), the Workshop shall recommend that Customer should start the engine periodically (weekly) and operate it at least for one hour, idling or on low load. In addition to the items described in this Product Information Sheet, the following points shall be checked during the engine inspection:
  - Draining of cooling circuits
  - Oil and coolant levels and pressures
  - Air filters
  - Starter motor
  - Unusual noise during operation
  - Draining of condensates or water ingress from exhaust system
  - Repair of fuel, coolant or lube oil leaks, if any.

  Finally, the Workshop shall protect the engine according to the specifications contained in this document.

5. DEFERRED START-UP ENGINE INSPECTION

The Authorised Technical Service Workshop shall inspect the equipment in accordance with the following guidelines, recording findings and results on form G-19-31 “Deferred Start-up Engine Inspection”.

Engine inspection comprises the following steps:

- Check **packaging and protection** of the engine as per document IM-C-C-00-001e and record whether the engine has been installed and whether it has been started but not completely commissioned.
- **Turn the engine by hand** to check that it rotates freely and has not seized up.
- Inspect the unpainted machined surfaces for rust. Also, check to see if all inlets and outlets of the engine (such as pump elbows, exhaust fume ducts, etc.) are adequately sealed and whether there is any part of the engine missing. If you observed any defect or fault, report on the condition of the equipment.
- Remove all the **rocker arms covers**. Check pushrods, rocker arms, adjusting screws, valve springs for rust, corrosion or contamination. If you observed any defect or fault, report on the condition of the equipment.

- Boroscope the **combustion chambers** of all the engine cylinders to see if there is water or moisture inside. Also, check the cylinder liners or walls, cylinder head firing deck and valves for rust. If you observed any defect or fault, report on the condition of the equipment.
- Remove the covers from the **exhaust manifold** (water-cooled exhaust manifold) and from the **intake manifold**. Check to see if there is moisture or corrosion inside. If you observed any defect or fault, report on the condition of the equipment.
- Remove the **camshaft** covers. Inspect camshafts and auxiliary rocker arms for moisture or rust. If you observed any defect or fault, report on the condition of the equipment.
- Remove the **crankshaft** covers. Inspect crankshaft, connecting rods, main bearing caps and crankcase for moisture or rust. If you observed any defect or fault, report on the condition of the equipment.
- Remove the inspection covers from the **gear covers** (front and rear). Check the timing gears for moisture or rust. If you observed any defect or fault, report on the condition of the equipment.
- Check **turbochargers** to see if their shafts rotate freely, if there is any blade damaged and if the axial bearings are correctly lubricated. If you observed any defect or fault, report on the condition of the equipment.
- Check the **water pumps** of the engine to determine whether they rotate freely and their belts (in the case of belt-driven pumps) are in good condition. If you observed any defect or fault, report on the condition of the equipment.
- Check the **injectors (jets)** of the engine to make sure they inject fuel correctly. If you observed any defect or fault, report on the condition of the equipment.
- Inspect **wiring and electric and electronic devices** (e.g. pickups, connectors, coils, HV leads, actuators, etc.) to see if they are rusty, if they are adequately protected, if leads are coiled and packed in plastic bags. If you observed any defect or fault, report on the condition of the equipment.

Record all findings and results on form G-19-31 “Deferred Start-up Engine Inspection” included at the end of this document.

6. DEFERRED START-UP ENGINE PROTECTION

The Authorised Technical Service Workshop, after checking the equipment, shall protect or preserve it in accordance with the following guidelines.

⚠ CAUTION

For engine protection, use only KOHLER **MOTOROIL PROTECTOR**.

⚠ DANGER

The recommended protector contains oil distillates. Read the Material Safety Datasheet before use.

- Spray KOHLER MOTOROIL PROTECTOR inside all of the **rocker arms covers** while turning the engine manually. Apply said protector to push rods, rocker arms, adjusting screws and valve springs.
- Spray KOHLER MOTOROIL PROTECTOR inside the **combustion chambers** through the jet or spark plug housings while turning the engine manually. Spray when the piston is at TDC.

CAUTION

Before starting up engines that have been protected this way (especially gas engines), it will be necessary to inspect the combustion chambers and drain waste protective oil.

- Dry the inside of the **exhaust manifold** and the **camshaft** housing, if found humid during inspection. Spray KOHLER MOTOROIL PROTECTOR on the camshaft and, only in case of humidity, into the exhaust manifold.
- Spray a thin coat of TECTYL 506 or similar rust-preventive oil on the **unpainted machined surfaces** that will remain exposed, out of the engine (such as, for instance, the flywheel, etc.).
- Hermetically seal all the flanged elbows or inlet and outlet ports of the **intake, exhaust, cooling and lubricating** systems with plastic, rubber or similar plugs or films.
- Apply KOHLER MOTOROIL PROTECTOR with a brush to the **control linkage and ball joints**.
- Fit the **electric and electronic components** with connectors, protectors and caps, if missing. Put **all leads and cables** in plastic bags. Also, apply TECTYL 506 or any similar substance to any components showing signs of rust damage.

7. PACKING OF DEFERRED START-UP ENGINES

These instructions apply to engines with damaged packaging or unpacked. Packing deferred start-up engines implies the steps that follow.

- Spread **bags of desiccant** evenly over the surface to be packed. The number of bags will be proportional to the volume of the package.
- Cover the engine with **heat-shrinkable plastic film** and heat-seal it. Protect all sharp edges to prevent damage to the plastic film. The wrapping must cover the machine entirely and be sealed at the bottom.
- The wrapping must enable lifting the engine without breaking; for this purpose, make **holes** in the wrapping as follows. In the event of 6 or 12-cylinder engines, make two holes on both sides and one hole at each end; in the event of 8 or 16-cylinder engines, make three holes on both sides and one hole at each end. Additionally, the wrapping must have a **window** to gain access to the engine **nameplate**.
- Write the date inspected, protected and packed on the engine's packaging sticker.

8. APPLICABLE FORMS

Form G-19-31 – Deferred Start-up Engine Inspection

DRESSER-RAND. A Siemens Business	INSPECCIÓN DE MOTORES PARA ARRANQUE DIFERIDO *DEFERRED START-UP ENGINE INSPECTION*	Doc.: G-19-31 Rev.: 3 Asistencia Técnica *Technical Assistance* Página 1 de 2 / *Page 1 of 2*

Modelo motor: *Engine Model*	Nº serie: *Serial Number*	Fecha Suministro: *Delivery date*

Datos del Cliente / *Customer data*

Empresa: *Company*

Persona de contacto: *Key person*

Dirección: *Address*

Localidad: *City*

País: *Country*

Teléfono: *Phone number*

Fax: *Fax number*

E-mail: *E-mail*

Inspección del Motor / *Engine Inspection*

0. Instalación del motor
Engine installation

¿Esta montado en la instalación? _____ ¿Está arrancado sin terminar Puesta en Marcha? _____
Is it assembled in the installation or vessel? *Has it been started up without finishing the commissioning?*

1. Embalaje y preparación del motor de fábrica
Engine factory packaging and protection

¿Está embalado según IM-C-C-00-001? _____ ¿Está protegido según IM-C-C-00-001? _____
Is the engine packed according to IM-C-C-00-001? *Is the engine preserved according to IM-C-C-00-001?*

En la operación de virado, ¿Gira el motor libremente sin esfuerzo anormal? _____
In the engine manual rotation operation, does the engine rotate freely without abnormal effort?

En caso negativo, explicar el estado: _____
If not, explain the status:

¿Están las superficies metálicas no pintadas oxidadas? _____ ¿Faltan piezas del motor? _____
Are the non painted machined surfaces rusted? *Are there any part missing from the engine?*

¿Faltan los sellos o cerramientos de cualquier parte abierta del motor (incluidos escapes)? _____
Is there any engine seal or duct closing devices missing (included exhaust fumes outlet)?

En caso afirmativo, explicar el estado: _____
If yes, explain the status:

2. Desmontar las Tapas de Balancines
Remove Rocker Arms Covers

Verificar los siguientes componentes en busca de oxidación o corrosión (indicar estado de los componentes)
Check for oxidation or rust in the following components (indicate component conditions)

_____ Empujadores y varillas _____ Balancines _____ Tornillos reglaje _____ Muelles de válvula
Push rods and pushers *Rocker Arms* *Valve lash adjustment screws* *Valve springs*

En caso afirmativo, explicar el estado: _____
If yes, explain the status:

3. Revisar con endoscopio las cámaras de combustión
Boroscope combustion chambers (cylinders)

Verificar los siguientes componentes en busca de oxidación o corrosión (indicar estado de los componentes)
Check for oxidation or rust in the following components (indicate component conditions)

_____ Paredes camisas cilindro _____ Cara de fuego de la culata _____ Válvulas
Cylinder liner or Cylinder walls *Cylinder Head Firing Deck* *Valves*

En caso afirmativo, explicar el estado: _____
If yes, explain the status:

4. Desmontar las Tapas del Colector de Escape (refrigerado) y del Colector de Admisión
Remove the Exhaust Manifold Covers (Water Cooled Manifolds) and the Intake Manifold

¿Hay presencia de humedad en su interior? _____ ¿Hay corrosión en su interior? _____
Is there any moisture present? *Is there any rust present?*

En caso afirmativo, explicar el estado: _____
If yes, explain the status:

DRESSER-RAND. A Siemens Business

INSPECCIÓN DE MOTORES PARA ARRANQUE DIFERIDO
DEFERRED START-UP ENGINE INSPECTION

Doc.: G-19-31 Rev.: 3
Asistencia Técnica
Technical Assistance
Página 2 de 2 / *Page 2 of 2*

Modelo motor: *Engine Model*	**Nº serie:** *Serial Number*	**Fecha Suministro:** *Delivery date*

5. Desmontar las Tapas de Visita del Árbol de Levas / *Remove Camshaft Covers*

¿Hay presencia de humedad en su interior? _____ ¿Hay corrosión en su interior? _____
Is there any moisture present? *Is there any rust present?*

En caso afirmativo, explicar el estado: _____
If yes, explain the status:

6. Desmontar las Tapas de Visita del Cigüeñal / *Remove Crankshaft Covers*

Verificar los siguientes componentes en busca de oxidación o corrosión (indicar estado de los componentes)
Check for oxidation or rust in the following components (indicate component conditions)

_____ Cigüeñal *Crankshaft* _____ Bielas *Connecting rods* _____ Sombreretes *Main Bearing Caps* _____ Bloque motor *Crankcase*

En caso afirmativo, explicar el estado: _____
If yes, explain the status:

7. Desmontar la Tapa de Inspección de las Puertas de Distribución (Delanteras y Traseras)
Remove the Inspection Cover of the Gear Covers (Front and Rear)

¿Hay presencia de humedad en su interior? _____ ¿Hay corrosión en su interior? _____
Is there any moisture present? *Is there any rust present?*

En caso afirmativo, explicar el estado: _____
If yes, explain the status:

Accesorios del Motor y Varios / *Engine Accessories and miscellaneous*

8. Turbocompresores / *Turbocharger*

¿No giran libremente sus partes móviles? _____ ¿Está alguna de las palas dañada? _____
Do their mobile components not spin freely? *Any blade damage?*

En caso afirmativo, explicar el estado: _____
If yes, explain the status:

9. Bombas de Agua / *Water pumps*

¿No giran libremente sus partes móviles? _____ ¿Las correas están flojas? _____
Do their mobile components not spin freely? *Are the belts loose?*

En caso afirmativo, explicar el estado: _____
If yes, explain the status:

10. Inyectores / injectors

¿No inyectan correctamente? _________

En caso afirmativo, explicar el estado: _________
If yes, explain the status:

11. Cableados, conexiones eléctricas, etc. / *Wirings, electrical connections, etc.*

¿Hay corrosión? _____ ¿Mal protegidos? _____ Faltan bolsas de recogida de cableados _____
Is there any rust present? *Are they badly protected?* *Wiring bags lack*

En caso afirmativo, explicar el estado: _____
If yes, explain the status:

12. Observaciones sobre otros equipos del suministro: _____
Observations about other elements included in the supply

Realizado por / *Performed by*

Taller de Servicio Técnico Autorizado: _____
Authorized Technical Service Workshop

Nombre y Apellidos del Técnico: _____
Technician Name

Firma:
Signature

Lugar de la Inspección: _____
Inspection location

Fecha: _____
Date

CHAPTER 4 – OPERATING INSTRUCTIONS

MINIMUM ROOM TEMPERATURE FOR OPERATING GAS ENGINES

O&M_2.002262.810_10_2016

1. INTRODUCTION

This product information document is applicable to all gas engines installed in covered facilities and not outdoors. This document is designed to limit the minimum engine air inlet temperature, whether it is installed in a room or a container, to avoid condensation inside the same.

This document is aimed at all gas, natural gas, syngas, landfill, digester, propane and low methane number gas engines.

This document is designed to identify the minimum air inlet temperature at its installation site in order to prevent the appearance of any condensates in the same when site conditions mean that the engine will have to operate at low temperatures.

2. TEMPERATURE LIMIT IN THE ROOM OR CONTAINER ON START-UP

The gas engines air inlet temperature, should be no lower than 0ºC at start-up and the engines with injected pre-chamber 10ºC. If lower temperatures are expected, the room, container or inlet air should be pre-heated to achieve the minimum temperature indicated.

You should take into account the “Criteria for application of pre-lubrication, post-lubrication and oil and water pre-heating” described in document IC-C-D-00-008e.

For lower room temperatures, check with Kohler.

NOTE

This limitation does not apply to the engine with single cooling circuit, like the emergency engines.

RECOMENDATION

In these engines with single cooling circuit, it is recommended not to start up the external cooling system of the facility until the engine water temperature is higher than 50ºC, in order to avoid the engine water temperature to drop below than 35 ºC (obtained temperature due to the preheating system of the engine).

3. TEMPERATURE LIMIT IN THE ROOM OR CONTAINER ON OPERATION

The engine air inlet temperature -air filter- should be maintained over 0ºC for the engines FGLD/SFGLD/SFGM when the engine runs over 30 % of nominal load to avoid surge problems or turbocompressor pumping. Below of 30% the load the engine can run without problems with air inlet temperature below 0ºC.

In the applications where the air inlet temperature could be below 0ºC, is suggested not to run the engine at higher load than 30% until the room temperature has been accommodated with the heat of the engine itself during the operation at low load.

If it is required to run the engine above of 30% of load with air inlet temperatures to the engine below 0ºC, it will be necessary to consult it with Kohler. In order to change the supply scope of
these engines (out of standard).

If the fuel gas has a high concentration of moisture or heavy hydrocarbons (like usually have biogases, syngases or well gas), the minimum temperature of the gas could be limited to avoid condensates in the carburetor due to the contact of the gas with the cold air. In this cases it is required a dew point calculation of the gas taking in account the temperature of the air and the mixture in the carburetor.

KOHLER Powered by DRESSER-RAND	PRODUCT INFORMATION	INDEX	DATE	
	IO-C-M-15-002e	**A**	*March 2008*	*Dep. 2*
	KOHLER ENGINE BARRING GEAR OPERATING INSTRUCTIONS			

O&M_2.002262.810_10_2016

1. USE OF THE BARRING GEAR

The barring gear is located on the flywheel housing on the left side of the engine. It serves to turn the crankshaft during maintenance operations (valve setting, bore scoping, etc.).

To use the barring gear:

1. Remove the barring gear cover.

2. Place the drive socket over the hex nut.

3. Push the barring gear shaft, until the pinion engages the ring gear.

4. Rotate the socket to turn the flywheel.

5. Upon completion of the maintenance operations, replace the barring gear cover.

CAUTION

NEVER TRY TO START THE ENGINE WITH THE SOCKET CONNECTED TO THE BARRING GEAR. THE BARRING GEAR COULD SPIN, CAUSING THE SOCKET WRENCH TO BE THROWN, CAUSING SEVERE INJURY OR DEATH!

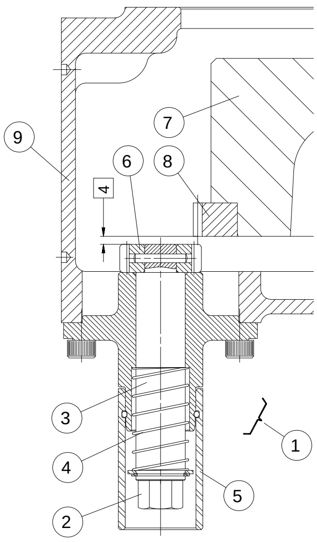


Fig. 1 – Location on in-line engines

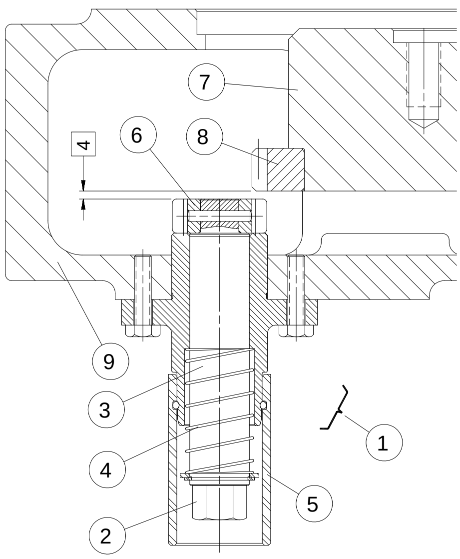


Fig. 2 – Location on Vee engines

1	Complete barring gear	**6**	Pinion
2	Hexagonal nut (size 22)	**7**	Flywheel
3	Barring gear shaft	**8**	Ring gear
4	Spring (inspect periodically to insure that it is not broken)	**9**	Flywheel housing
5	Barring gear cover		

1. GENERAL INFORMATION

When installing the engine, one point to bear in mind is the quality of the cooling water that will be used, in order to prevent heat transfer problems.

Any water treatment programme mainly aims at protecting the cooling system from corrosion, deposit or scale which might impair the continuous flow of the coolant.

The most common problems with an engine cooling system are as a result of corrosion, cavitation, microbiological growth, deposits and scale.

Corrosion

This is a metal degrading process arising from oxygen-triggered chemical or electrochemical reactions. As for cooling systems, the reactive medium is water that attacks the metallic materials of piping and heat exchangers.

Corrosion is dependent upon the effect of temperature, high salinity (especially of chlorides), high water speed, alkalinity or acidity, dissolved solids, dissolved gas traces, microbial growth and pollution by manufacturing process waste. The major negative effect of corrosion is a decrease in the engine components' fatigue strength.

The following are the most frequently occurring types of corrosion:

Electrochemical:	Bonding of metals of varying electrochemical properties.
Chemical:	pH and salinity
Physical:	Abrasion and cavitation
Differential aeration:	Low deposits
Bacterial:	Sulphate-reducing bacteria, ferrobacteria, nitrifying bacteria, denitrifying bacteria.

Cavitation

Cavitation is the creation of bubbles within a liquid when it passes through a high pressure area at high speed and increases when the pressure is low in the cooling system and/or when there are leaks. In addition, as the vibration increases, so the number of bubbles in the coolant also increases. These bubbles cause erosive corrosion of the cylinder wall and frequently lead to pitting of cylinder walls.

To solve cavitation problems, purge the cooling circuit thoroughly and, for applications requiring high temperature, keep the circuit under pressure. Also add coolant additives that will cover the metal surfaces and limit cavitation-induced erosion and pinholes.

Scale

This is the crystallisation and deposition in their solid form of different combined ions present in water, due to oversaturation of the solution at a given temperature. It usually appears as compact, hard and adhering deposits of predominantly inorganic matters, but may occasionally take soft, non-adhesive forms and be a mixture of organic and inorganic components.

The major compositions of scale include, but are not limited to: calcium carbonate, calcium sulphate, calcium phosphate, magnesian salts, silica, and iron and manganese compounds. Scale forming depends on multiple factors such as temperature, salt concentration, pH and alkalinity, dissolved solids content, fluid-dynamic and thermostatic conditions of the system, etc.

One of the most typical reactions is:

$$Ca(HCO_3)_2 \quad + \quad heat \longrightarrow CO_2 \quad + \quad H_2O \quad + \quad Ca\,CO_3$$

Calcium bicarbonate highly soluble (760 mg/l. approx.) — Carbon dioxide — Calcium carbonate (hardly soluble 30 mg/l. approx.)

The presence of scale has a significant impact on the performance and operation of the equipment, since some of its effects are:

- Reduction in heat transfer
- Non-scheduled outages
- Maintenance costs
- Deterioration and overheating of exchangers
- Decrease in the quantity of circulating water

Microbiological growth

This basically originates in algae, fungi, bacteria and other micro-organisms to a lower extent, all of which avail themselves of light, heat, sludge and contamination by the manufacturing process or otherwise, nutrients and pH to keep growing. Special consideration is to be given to autotrophic bacteria (ferrobacteria and sulphate-reducing bacteria) which can give rise to localised corrosion.

A product of this activity is sludge that builds up in the system, reducing its efficiency in addition to limiting the water passage and decreasing the flow rate, which in turn results in an increase in temperature. Both observing the colour, feel and smell of sludge and analysing it will provide information about its origin.

2. COOLING WATER QUALITY

In general, an engine coolant consists of water, additives and antifreeze.

There are several basic parameters that ensure optimum coolant quality and, thus, a trouble-free operation of the equipment.

This is why, it is strongly advisable to have cooling water analysed at the planning stage or before commissioning, so that should results fail to match the values in Table 1, the user can contact a water treatment specialist in order to take the necessary actions to ensure compliance with those specifications.

According to information provided by the equipment and the available water analysis results, it is essential to determine the optimum concentration and any appropriate external and internal treatment which will maintain the above issues under control and ensure the lowest possible water consumption.

These are the most common chemical treatments:

- Sludge dispersants or conditioners.
- Scale inhibitors.
- Corrosion inhibitors.
- Algicides
- Microbicides/biocides
- Biodispersants

In the market, there exist combined products suitable for treating different problems simultaneously.

Minimum coolant requirements.

PARAMETERS	VALUE	UNITS
Aspect and odour	Transparent, neutral odour, free from sediments	
pH value 25ºC	7-9	
Total hardness	35-170 / 2-9.5	ppm CO_3Ca / ºd
Sulphates SO_4^{-2}	Max 100	ppm or mg/l
Chlorides Cl^-	Max 40	ppm or mg/l
Nitrates	Max 10	ppm or mg/l
Total dissolved solids (TDS)	Max 300	ppm or mg/l
Conductivity @ 25ºC	Max 400	µS/cm
Total alkalinity	Max 150	ppm CO_3Ca
Iron Fe	Max 0.5	ppm or mg/l

Aspect and Odour: Water-borne chemical compounds like phenols, several hydrocarbons, chlorine, organic matters in any state of decomposition or the products of outgassing algae and fungi can give water a very strong odour and taste, even if said compounds exist only in very small concentrations. Salts or minerals give water a salty or metallic taste, but not always an odour.

Particles such as clay and silt, a.o., although not dissolved, are transported by water in either of two ways: as a colloidal solution or in a dissolved condition that only persists while these particles are carried away by the flow of water. Colloids will settle only if undergoing coagulation or flocculation (clumping of particles).

Ph: The pH value expresses the acidity or alkalinity of an aqueous system. To be precise, it is the measurement of the hydrogen ion "activity" in a given sample; in practical terms, it is a measure of the hydrogen ion concentration in a sample Since the pH scale is logarithmic and inverse, any increase in pH by one unit corresponds to a tenfold decrease in the hydrogen ion molar concentration. The lower end of the scale (pH = 0) defines the acidity equivalent to a solution of 1.0 M HCl whereas the upper end of the scale (pH = 14) represents the alkalinity equivalent to a solution of NaOH 1.0 M.

Total hardness: The sum of temporary and permanent hardness. This is the sum of water dissolved metallic ions. It is always stated in mg /l CO3Ca
Temporary hardness: caused by acid calcium or magnesium carbonate. These bicarbonates precipitate, as water warms up, to form insoluble carbonates.
Permanent hardness: due to the contents of sulphates, nitrates and calcium, magnesium, sodium and iron chlorides. These salts do not precipitate as solutions.

Sulphates: Salts that dissociate in an aqueous solution and form ions which combine with calcium and magnesium. These compounds combine with hydrogen to form acids which turn water corrosive.

Chlorides: The amount of chloride ions present in the system enhances the conductivity of water and affects the protective film on the metallic surface, creating a favourable atmosphere for corrosion.

Nitrates: Salts that, in an aqueous solution, combine with hydrogen to form aggressive corrosive acids that may damage the cooling system.

Total alkalinity: Water alkalinity may be defined either as the water capacity to neutralise acids, react with hydrogen ions, or accept protons or as a measure of the water total contents of alkaline substances (OH-).
Determining total alkalinity and different forms of alkalinity is important in chemical coagulation, softening and corrosion control processes.

Natural water alkalinity generally derives from the presence of three types of ions: bicarbonates, carbonates and hydroxides.
Some waters will contain other compounds (borates, silicates, phosphates, etc.) which contribute to their alkalinity; but, in practice, the effect of these compounds is insignificant and can be disregarded.

Total dissolved solids: Solid substances appear in most waters as suspended materials or colloidal solutions. They are measured in laboratory by the filtration method. Fine solids generate turbidity (NTU and JTU). Turbidity is measured by the effect of light on these particles.

Conductivity. Electrical conductivity is the capacity of inorganic salts in solution (electrolytes) to conduct electricity. Pure water hardly conducts electricity which is however conducted by water containing dissolved salts. Positively and negatively charged ions are the elements that conduct electricity; the amount of conduction depends on the number of existing ions and their mobility.

Iron (Fe). Iron dissolved in groundwater to its iron form II. This form is soluble and usually causes no problem by itself but iron II is oxidized to form iron III which are hydroxides and are insoluble in water. These are corrosive red dyeing compounds and cause blockage of screens, pumps, pipes and recirculation systems etc.

The use of distilled or de-ionised water increases the risk of corrosion and it is therefore necessary to add corrosion inhibitors. Such additives can be rust-preventive products used alone or diluted in the antifreeze.

Additives. Antifreeze

The best way of avoiding problems due to corrosion, oxidation, scale, deposits, etc. in the cooling system is to treat water with adequate additives which will protect the metallic surfaces of the system. These products form a rust-proofing film on the surfaces of the cooling system, preventing corrosion and inhibiting settlements.

Thus, engine corrosion and rust can be minimised using different types of anticorrosion additives.

Additive	**Protection / Purpose**	**Disadvantage**
Phosphates (PO4)	Steel, iron, aluminium	Unstable, fast wearing, deposits (caused by hard water).
Borates (BO4)	Iron	Corrode aluminium at high temperature.
Tolytriazol (TT)	Copper	
Nitrites NO2	Iron (cavitation) and steel	Fast wearing. They expand welds. Dangerous if combined with amines.
Silicates SiO3	Aluminium, Iron, general, relative neutralisation	Fast wearing. Form films and, if excessive, they produce a "green paste" that impairs heat transfer.
Carboxylic acids	Aluminium, general, stable, neutralisers	

Antifreeze products are glycol-based water-soluble liquids (e.g. ethylene glycol, propylene glycol), which generally contain the above mentioned additives whose object is to prevent the effects of corrosion, deposits, foam, etc.

Therefore, in order to prevent cooling water from freezing, it is recommended to add good quality commercial antifreeze, even in hot climate areas, because such product raises the boiling point of cooling water, which impedes that water boils and evaporates.

An inadequate concentration will not only reduce frost protection or the boiling risk, but also increase cooling water corrosiveness.

The antifreeze-coolant ratio depends on the ambient temperature at the place of installation of the engine and it is the antifreeze supplier who should state the concentration based on its product specifications and take responsibility for any secondary effects.

The figure below can be used to check the recommended glycol ratio according to the ambient temperature.

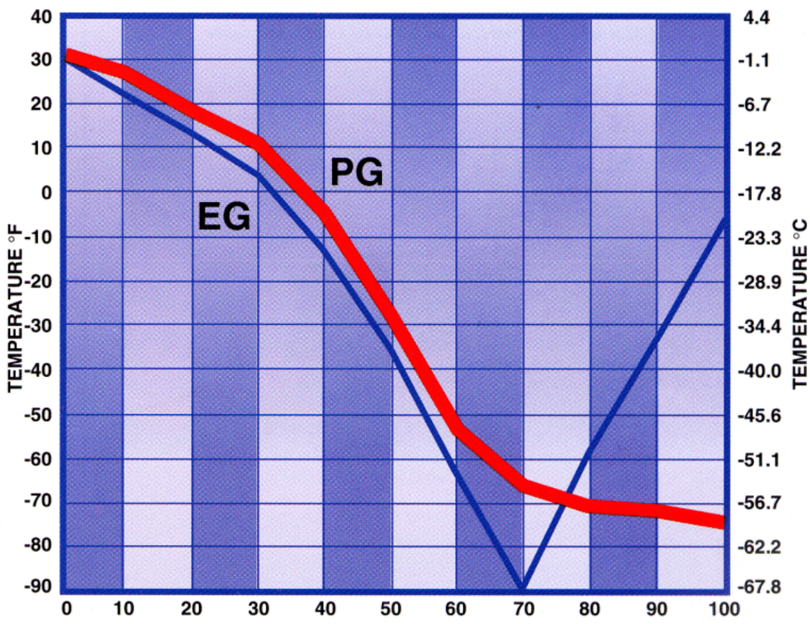
As a rule, where the objective is to increase the boiling temperature of water without it evaporating, Kohler recommends adding around 10% of glycol to the water, not only where there is risk of freezing. The antifreeze will not only prevent the possibility of the water boiling but it will also protect against possible corrosion thanks to its anticorrosive additives which antifreeze normally contains.

In the case of ambient temperatures being very low and there is a risk of freezing, the maximum permitted amount of glycol, and for use only in engines, is 50%. The use of incorrect quantities of antifreeze in the cooling circuit can lead to a reduction in heat transfer from the cooling fluid and can affect the performance of the engine.

Here we can find ourselves faced with:

- Increased internal temperature of head and shroud
- Increased intake temperature.
- Increased exhaust temperature

Therefore, and in order to maintain the best possible performance, if the content of glycol is more than 30% then a change should be made at the end of the cold season to use coolant with % glycol in accordance with the indications of the following chart; in any case a minimum of about 10% antifreeze is recommended.



Glycol Concentration, % weight

3. COOLANT TREATMENT

Maintaining cooling water in good condition will avoid the aforementioned trouble with and failure of the cooling system, as well as helping us to detect possible engine malfunction.

For instance, a decrease of the pH value together with an increase in the sulphate contents may be symptomatic of water pollution by exhaust gases. On the other hand, a rise in chloride contents may be due to contamination by seawater, and in this event, it would be advisable to inspect the engine and look for the source of the leak.

In closed circuits, where fluid refilling is infrequent, a complete corrective treatment can be applied initially, while cooling water properties can be checked subsequently on refilling large amounts of water, but at least once a year.

It is advisable to clean the engine cooling circuit as described below:

Prepare a concentrated detergent solution (for cooling circuits) in warm fresh water (40-50°C) and shake until the detergent is completely dissolved and there is no sediment. The maximum concentration should be 2%.

Insert said solution into the engine cooling circuit and start the engine up until it is hot. The engine must be operating at full load for approximately two hours. Once this time has elapsed, stop the engine.

Then clean the cleaning fluid using fresh water. Once rinsed and clean, immediately fill the water circuit with treated antifreeze.

In open systems that operate on large volumes of water, water treatment is very expensive. Input treatments are usual practice or, if the installation allows, chemical cleaning will be undertaken periodically. For this type of system, water tests must be made at least once a month, both at the cooling tower and in the water circuit to the engine.

Companies specialising in water analysis and treatment have test kits available so users can check the cooling system periodically.

If the results of periodic checks fail to match the values shown in Table 1, the customer must contact the water treatment specialist, who has to participate actively in preparing and in defining the protection method most suitable for the installation concerned.

Antifreeze decomposes into corrosive acids due to the cooling system's temperature cycles; contamination can build up in the system and the corrosion inhibitors will eventually get exhausted. It is therefore recommended that the antifreeze concentration in the system should be checked with a refractometer or hydrometer when testing the water quality. This will aid to ensure that the glycol concentration remains within adequate limits. By measuring the coolant density as shown below, you can determine whether the antifreeze concentration is correct:

Glycol Concentration % weight	Coolant density @ 20ºC	Freezing point of coolant
10%	1.02 g/l	-3.4 ºC
20%	1.03 g/l	-7.9 ºC
30%	1.04 g/l	-13.7 ºC
40%	1.06 g/l	-23.5 ºC
50%	1.07 g/l	-36.8 ºC

KOHLER MOTOROIL 3040 PLUS LUBE OIL FOR NATURAL GAS-FUELLED AND ETHANOL ENGINES

1. INTRODUCTION

There are currently no standard procedures for classifying lube oils to be used in gas-fuelled and ethanol-fuelled engines. It is therefore necessary to perform exhaustive field tests in order to approve a suitable lubricant. Along with the ash content, there are several other parameters to bear in mind. These include phosphorus content, resistance to oxidation and nitration (often produced by the high working temperatures), neutralising capacity and corrosion inhibition (particularly in the presence of aggressive gases).

2. DESCRIPTION

KOHLER MOTOROIL 3040 PLUS is a lubricant designed by Kohler division in collaboration with the most prestigious lubricant manufacturers. It has been specially formulated for use in Kohler engines that operate on gas or ethanol. See documents IP IC-G-D-30-002e, IC-G-D-30-013e, IC-L-D-30-001e.

KOHLER MOTOROIL 3040 PLUS is a high-performance oil with a medium ash content. It is formulated with prime quality paraffin bases that provide it with exceptional oxidation and nitration stability, great thermal resistance, and a very low tendency to carbon deposit and residue build-up. Maintaining excellent performance after a long period of operation is thus ensured. Additionally, this oil has a low foam-forming tendency, good emulsibility and corrosion protection for cylinders and bearings, while considerably reducing wear on piston rings, liners and valve seats. All this means the oil has a long service life and filters withstand extended maintenance intervals.

Given its advanced formulation, KOHLER MOTOROIL 3040 PLUS is specially suitable for modern four-stroke engines with low oil consumption. It has been specially developed to ensure extended intervals between oil changes in engines whose usability is limited by the oil lifespan.

Its detergency and dispersancy system controls the build-up of carbon deposits and sludge, which results in cleaner engines, longer lasting oils and lower filter costs.

This oil has also been designed to provide exceptional protection against piston abrasion and wear of cylinder liners and piston rings.

3. APPLICATIONS

KOHLER MOTOROIL 3040 PLUS has been specially designed and is recommended for providing the highest performance in Kohler engines that operate on natural gas and ethanol. It can however be used in all kinds of naturally-aspirated or supercharged four-stroke engines, whether high or medium rated, that require a lubricant having a medium ash content. It is designed to ensure optimum engine life and lower maintenance costs. Its scope of application encompasses stoichiometric combustion and lean-burn engines as well, ensuring low oil consumption in both cases.

Given its low zinc and phosphorus content, this lube oil can be used in engines fitted with a catalytic converter, which require lube oil having a medium ash content.

Its advanced technology means any wear on the valve train components can be monitored as well as reducing the risk of abrasion, scoring and accelerated wear of pistons and piston rings. The end result means lower engine operating and maintenance costs.

4. ADVANTAGES AND BENEFITS

- Excellent resistance in the presence of oxidation and nitration.
- Very high protection of cylinder head valve seats and guides.
- Excellent protection against piston scoring and liner surface wear.
- Excellent engine cleanliness.
- Minimum deposit build-up.
- High foam-forming and corrosion resistance.
- Excellent performance of the alkaline reserve.
- Longer oil and filter life.
- Lower maintenance costs.

5. HEALTH AND SAFETY

No special precautions are required for its use, except good personal hygiene and avoiding contact with the skin for extended periods of time. There is a Safety Data Sheet available on request.

TYPICAL CHARACTERISTICS

PROPERTY	ASTM KOHLER	MOTOROIL 3040 PLUS
Viscosity, SAE grade		**40**
Flashpoint, Open Cup method, ^{o}C	D-92	240
Freezing point, ^{o}C	D-97	-21
Density @ 15^{o} C, g/cc	D-4052	0.895
Viscosity, cSt @ 100 oC	D-445	13.6
Viscosity, cSt @ 40 oC	D-445	124.3
TBN, mg KOH/gr	D-2896	9.0

The values of typical properties shown in the table are mean values given for information purposes only. They do not constitute any guarantee These values are subject to change without prior notice.

1. AIM

This product datasheet defines the conditions a gas must comply with in order for it to be used as a fuel in Kohler gas engines. **Every parameter or component out of this specification should be consulted to and authorized by Kohler, else Kohler won't take any malfunctioning responsibilities.**

2. GASES USED AS ENGINE FUELS

The gaseous fuels used in internal combustion engines are available in a large variety of compositions and conditions of supply, which will affect the configuration, design, life expectancy and performance of the engine to a greater or lesser extent,. The gaseous fuels used in Kohler engines may range from "dry" natural gas to different kinds of synthesis gases resulting from thermochemical processes or the anaerobic digestion of organic matters.

In all cases, the gas is a mixture of major constituents, some combustible and others inert, and a number of minor or low-concentration components which may however play an important role for the correct operation of the engine, since they could be very harmful in quantities exceeding the manufacturer-specified limits.

As a consequence, it is necessary to assess the fitness of a given type of gas for its use in internal combustion engines. Where appropriate, the gas must be cleaned or filtered, to make it match the specifications required for its use in IC engines, by limiting its contents of corrosive and abrasive components, in order to guarantee a reasonable service life of the engine.

Depending on the type of constituents to be completely or partly eliminated from the gas so as to adjust their concentration to the specifications, one of several filtering techniques may be used. Kohler does not wish to make any recommendation with respect to any of them, provided that the limit values specified in this document are complied with. However, Kohler has experience in this field and may be consulted for advice by the customer, on the understanding that Kohler will not assume any responsibility for the effectiveness or performance of the recommended equipment or systems. Any such responsibility being directly incumbent upon the system's supplier.

2.1. BASIC PARAMETERS OF GASEOUS FUELS

There are several basic parameters to bear in mind when specifying or selecting a gas-fueled engine. Those parameters, which are listed below, can be calculated with reference to the chemical analysis of the fuel mixture:

- **LHV (Lower Heat Value):** This indicates the amount of energy available per unit volume or mass of gas. Its SI units are kJ/m_n^3 or kJ/kg.
- **Methane number:** Is an indicator of a gas mixture's pro-knock tendency. The higher the methane number, the smaller the pro-knock tendency. This is a dimensionless number.
- **Density:** This is the mass per unit volume of combustible gas. It depends on pressure and temperature. So, for its measurement, standardized values of pressure and temperature are normally used, namely 101325 Pa (1 atm) and 0ºC. The SI unit of density is kg/m_n^3.
- **Stoichiometric A/F ratio:** Indicates the minimum amount of air necessary for a complete combustion of the fuel gas mixture. It is a dimensionless number representing the ratio of air volumes or masses per unit of fuel gas.

3. ANALYSIS OF FUEL GAS

For the characterization of the gas to be used as a fuel, it will be necessary to carry out a chemical analysis of the same. Such an analysis will be made first in order to select the type of engine required and to check the gas conformity with the specifications for its use as an engine fuel. Additionally, gas analysis shall be conducted whenever harmful constituents are suspected to be present in the gas as well as from time to time as part of the installation monitoring.

3.1. SAMPLING FREQUENCY

For all the specified types of gas, the sampling frequency will be determined as follows:

Project Phase: At least one complete analysis shall be made for each application.

Start-up Phase: During the first year, analysis shall be made at least every six months for natural gas, every three months for landfill and digester gas, and every month for gases resulting from thermochemical processes.

Operation Phase: Once the gas properties have been found stable (one year without relevant variations), the following minimum analysis program can be established: once a year for natural gas, once every six months for landfill and digester gas, once every three months for gas from thermochemical processes.
The intervals of the above analysis program may be increased, provided the stability of the supplied fuel gas has been demonstrated.

3.2. ANALYSIS LABORATORIES.

Kohler can advice the customer on the availability of laboratories where to make the required gas composition analysis.

In any case, Kohler reserves the right to carry out its own analysis on fuel gas fed to the engine.

4. CONTAMINANTS AND FACTORS AFFECTING THE ENGINE OPERATION

The fuel gas contaminants and factors affecting the engine operation fall within these categories:

- **Important variations in the fuel gas composition and conditions of supply.** In case there are variations in the composition, pressure, temperature and humidity of the fuel gas affecting its basic specification parameters (see point 2.1), their effect can be the engine breakdown or operation in conditions beyond those advisable. By important variations, we mean also those which are within the fuel specifications but differ by ±5% from the design value given to the manufacturer or the engine start-up conditions. At times, a small adjustment will suffice to adapt the engine to the new conditions; but any change whatsoever in the supplied gas conditions over the aforesaid limit must be reported to the engine manufacturer or maintenance staff who will come to tune the engine as necessary.
- **Contaminants that cause abrasive wear to the engine components.** These include all the substances contained in the gas, which circulate at high speed inside the engine, either upstream or downstream of the combustion chamber, and may therefore cause abrasive wear to different parts of the engine, leading to engine failure or to a reduction of its life expectancy. Belonging to this category are such compounds as siloxanes, gas combustion salts, metal particles, oils, tar, etc.
- **Contaminants that corrode the engine components.** This category refers to those substances which, due to their chemical nature, are capable of attacking both the metallic parts and the fluids of an engine, and thus leading to engine failure or to a reduction of its life expectancy. Within this group are acids compounds,

ammonia, and even condensation water that sometimes contributes to increasing the harmful effects of the contaminants, etc.

Although not explicitly referred to in this document, any gas constituent which has any of the described effects on the engine components, should be considered as included in the list of harmful contaminants and it will be the customer's responsibility to follow the engine manufacturer's recommendations specific to each case of application.

5. Kohler **SPECIFICATIONS FOR FUEL GASES**

5.1. LOWER HEAT VALUE

Lower heat values of fuel gases may be within the following ranges:

NATURAL GAS:	30 / 43 MJ/m_n^3 equal to 7165 / 10270 $kcal/m_n^3$ (See IC-G-D-30-002)
DIGESTER GAS:	23 / 30 MJ/m_n^3 equal to 5490 / 7165 $kcal/m_n^3$ (See IC-G-D-30-003)
LANDFILL GAS:	17 / 23 MJ/m_n^3 equal to 4060 / 5490 $kcal/m_n^3$ (See IC-G-D-30-003)
LEAN LANDFILL GAS:	14 / 17 MJ/m_n^3 equal to 3350 / 4060 $kcal/m_n^3$ (See IC-G-D-30-003)
RICH SYNGAS:	7.0 / 14 MJ/m_n^3 equal to 1670 / 3350 $kcal/m_n^3$ (See IC-G-D-30-004)
LEAN SYNGAS:	4.6 / 7.0 MJ/m_n^3 equal to 1100 / 1670 $kcal/m_n^3$ (See IC-G-D-30-004)
LOW METHAN NUMBER GAS:	40 / 47 MJ/m_n^3 equal to 9560 / 11230 $kcal/m_n^3$ (See IC-G-D-30-013)
VERY LOW METHAN NUMBER GAS:	40 / 93 MJ/m_n^3 equal to 9600 / 22250 $kcal/m_n^3$ (See IC-G-D-30-038)
PROPANE:	93 / 100 MJ/m_n^3 equal to 22200 / 23900 $kcal/m_n^3$ (See IC-G-D-30-018)

5.2. CONTAMINANTS OF FUEL GAS

Listed below are the contaminants that are normally found in gases used as fuel in Kohler engines. **Contaminants other than those listed are not allowed in the fuel gas.**

The permissible amounts of those contaminants in each type of fuel are stated in the relevant Product Information sheets. Refer to IC-G-D-30-002e for natural gas, to IC-G-D-30-003e for digester and landfill gas, to IC-G-D-30-004e for gases from thermochemical processes, IC-G-D-30-013 for low methane number gases and to IC-G-D-30-018 for propane.

5.2.1. SULFUR COMPOUNDS LIKE H_2S.

Among the sulfur compounds present in fuel gases, hydrogen sulfide (H_2S) is the most common one. Hydrogen sulfide is a corrosive compound that is normally contained in gases resulting from the decomposition of organic matter. There are limitations to its concentration in fuel gases because:

- H_2S attacks the metal parts of the engine - above all those containing copper - reducing their service life and performance.
- H_2S leads to premature degradation of lubricating oil. Indeed, an acidic constituent, H_2S will attack the oil additives, reducing the life of oil, if its concentration is out of the specifications.
- H_2S generates sulfur oxide releases at the exhaust. Emissions of sulfur oxides are limited by law and also attack the exhaust gas piping, silencers, turbochargers, valves, etc.

5.2.2. HALOGENATED COMPOUNDS (F, CL, BR, I) SUCH AS CL^-

Halogenated compounds may be very harmful to the engine, if they are present in the form of acidic elements in the fuel gas or in the combustion products. They normally develop in landfill gases, and to a lesser extent, in digester gases and in gases from thermochemical processes. Due to their chemical nature, the acids of this type of constituents are extremely corrosive, they attack almost all the metallic parts of the engine and destroy the additives of lubricating oil, thus reducing its life.

5.2.3. SILICON COMPOUNDS

Silicon compounds appear in fuel gases in either of two type groups:

a) inorganic silicon compounds, having their origin in mineral material introduced in the gas flow, such as silicates and silica, and which can be classified in the group of gas-borne solid particles; or
b) organic silicon compounds, which include siloxanes as the most frequent ones, are hard to detect because they require special analysis techniques, generally have their origin in the degradation of the many silicon-based products used in the industry for manufacturing general-purpose products, paints, cosmetics, cleaning products, etc.

Those compounds are present in the form of gas or vapor in the fuel flow and, generally, are harmless to the engine until their combustion. Combustion transforms the silicon they contain into silicon dioxide, silicates and other crystalline compounds that precipitate, forming abrasive particles inside the engine and jamming valves, pistons and other parts essential to the operation of the engine.

Moreover, a portion of the silicon content migrates from the combustion chamber to the lubricating oil, reducing the oil properties, which in turn affects engine parts that are not in direct contact with the combustion chamber.

5.2.4. AMMONIA (NH_3)

Ammonia is a chemical compound that can either attack different elements of an engine alone or combine with other more acidic constituents to form ammonia salts that will abrade the engine components. Also, the NO_x emissions of the engine may increase, as ammonia compounds pass through the combustion chamber, where ammonia transforms itself into nitrogen oxides.

5.2.5. RESIDUAL OILS AND TAR

Oils and tar are usually carried along by the fuel gas. They are in the liquid phase or they condense when the gas temperature decreases. Their presence is attributable to lubricant leaks in the gas compression equipment. However, they are also present in large quantities in gases from thermochemical processes. Their effects on the engine include plugging of filters and regulators, as well as a lower performance of the turbochargers and dirtying of air coolers, etc.

5.2.6. SOLID PARTICLES

Solid particles act as abrasives on the engine components and they also give rise to failure when they accumulate and block certain items of equipment impeding them to operate correctly. Solid particles are the major source of inorganic silicon entering the engine with the fuel gas.

5.3. ENGINES WITH A CATALYTIC CONVERTER

The Kohler engines with a catalytic converter to reduce emissions deserve a special treatment within this document. Catalytic converters require the fulfillment of several special requisites in terms of fuel gas contaminants and lubricating oils used in the engine. This is why the fuel gas specifications must be checked by Kohler in accordance with the type and brand of catalytic converter whenever one is installed on the engine. (See IC-G-D-45-001)

Catalytic converters may be reliably used only on natural gas-fueled engines. All other types of gas do not meet the specifications required by the catalytic converter manufacturers.

6. ENGINE LUBE OIL ANALYSIS AS AN INDICATOR OF THE FUEL GAS CHARACTERISTICS.

On certain occasions, lubricating oil analysis may serve as a relative measure of the quantities of contaminants that may show up in a fuel gas fed to the engine.

Lubricating oil is one of the engine consumables that permit to rapidly notice a deterioration of their properties due to the increase in the amounts of contaminants in the fuel gas.

In those installations where there are no continuous sampling of gas contaminants and where it is thus possible to have periods of time in which the limits specified in this document could be surpassed, we recommend, for a reliable operation of the engine, that the lubricating oil of the engine should be analyzed frequently according to the criteria set forth in Product Information Sheet IO-G-M-25-001e. Those analysis would allow to predict the type of contaminants entering the engine or which components of the engine are getting deteriorated, before any breakdown occurs.

Depending on the oil analysis results, it might be decided to make a specific analysis of the fuel gas contaminants which might be affecting the engine, so as to be able to take any appropriate actions rapidly and effectively.

1. ANALYSIS OF FUEL GAS

For the characterization of the gas to be used as a fuel, it will be necessary to carry out a chemical analysis of the same. Such an analysis will be made first in order to select the type of engine required and to check the gas conformity with the specifications for its use as an engine fuel. Additionally, gas analysis shall be conducted whenever harmful constituents are suspected to be present in the gas as well as from time to time as part of the installation monitoring.

Below are the basic parameters of the fuel gas which need be checked, according to the gas origin.

1.1. NATURAL GAS

Natural gas consists in a mixture of light hydrocarbons and inert constituents. It is of mineral origin. Its composition will be determined by analyzing at least the following parameters:

1. Description of the place where the analysis is conducted (within an installation or at a location)
2. Date/time of sampling
3. Date/time of analysis
4. Analysis procedures employed
5. Gas temperature and pressure
6. CH_4 concentration (Vol %)
7. C_2H_6 concentration (Vol %)
8. C_3H_8 concentration (Vol %)
9. C_4H_{10} concentration (Vol %)
10. C_5H_{12} concentration (Vol %)
11. $+C_6$ concentration (Vol %)
12. CO_2 concentration (Vol %)
13. N_2 concentration (Vol %)
14. O_2 concentration (Vol %)
15. CO concentration (Vol %)
16. H_2 concentration (Vol %)
17. H_2S concentration (ppm or mg/m_n^3)
18. Gas relative humidity (%)

As a general rule, the above elements are the usual constituents of natural gas and their measurement is by gas chromatography. However, where there are doubts about the total gas composition, it will be necessary to check additionally for the presence of the following compounds:

19. Halides concentration (ppm or mg/m_n^3)
20. Siloxanes concentration (mg/m_n^3): at least TMOH, TMS, L2, L3, L4, D3, D4, D5
21. NH_3 concentration (ppm or mg/m_n^3)
22. BTEX concentration (ppm or mg/m_n^3)
23. Oils and tar concentration (mg/m_n^3)
24. Solid particles concentration (mg/m_n^3)

2. Kohler SPECIFICATIONS FOR FUEL GASES

2.1. LOWER HEAT VALUE

Lower heat values of natural gas may be within the following range:

– 37.5 / 42 MJ/m_n^3 equal to 950 / 1050 Btu/SFC natural gas

As for engines with a mechanical carburetion system, the maximum permissible variation in the gas LHV is ±5% with regard to the carburetion point. Greater variations would mean that carburetion must be readjusted.
Engines with an electronic carburetion system must be used where LHV variations can be as high as ±10%; above this limit, the gas composition has to be continually monitored with an analyzer.

LHV variation in excess of 1%/min. absolute value shall not be allowed over time.

2.2. METHANE NUMBER

The **minimum value for the methane number (AVL) of natural gas** is fixed at 75. For lower values, contact Kohler.

2.3. SUPPLIED GAS CONDITIONS

In this respect, the following applies:

2.3.1. SUPPLIED GAS PRESSURE AND TEMPERATURE

Since the acceptable gas pressure and temperature at the inlet to the engine depend on the carburetion system the engine is equipped with, refer to the following Product Information documents for the applicable ranges:

- IC-G-D-30-007e: Engines with a TECJET 50+ type electronic carburetion system
- IC-G-D-30-040e: Engines with a TECJET 52 type electronic carburetion system
- IC-G-D-30-008e: Engines with a mechanical carburetion system
- IC-G-D-30-015e: Engines with a ELEKTRA 50 type electronic carburetion system
- IT-G-A-00-011e : Minimum room temperature for operating gas engines

2.3.2. GAS HUMIDITY

The gas relative humidity at the inlet to the gas ramp shall always be less than 80% and by no means shall water be allowed to condense over the engine components. Therefore, we recommend that gas is fed to the engine at a temperature exceeding the water dew point by at least 15ºC. Natural gas does not usually imply serious humidity problems.

2.3.3. OXYGEN IN GAS

For engines with a mechanical carburetion system, the maximum permissible quantity of oxygen (O_2) in the gas is 2% vol. For higher values or fluctuations greater than ±1% in relation to the carburetion point, it will be necessary to use engines with an electronic carburetion system and continuous monitoring of the gas composition by an analyzer.

2.3.4. HYDROGEN IN GAS

The maximum permissible hydrogen (H_2) content in a fuel gas is 12% vol. H_2.

2.3.5. HIGHER HYDROCARBONS IN GAS

The maximum permissible quantity of C4+ hydrocarbons (butane and higher) shall not exceed 2% of the total gas mixture volume. For greater percentages, contact Kohler.

Therefore, we recommend that gas is fed to the engine at a temperature exceeding the gas dew point by at least 15ºC.

2.4. CONTAMINANTS OF FUEL GAS

Listed below are the maximum permissible values of the contaminants that are normally found in natural gas used as fuel in Kohler engines. The stated limits may not be exceeded; neither are contaminants - other than those listed below - allowed in the fuel gas.

2.4.1. SULFUR COMPOUNDS STATED AS H_2S.

For Kohler engines, the maximum permissible limit of H_2S equivalent* is set at:

- 300 ppm ---- 455 mg /m_n^3 ENGINES WITHOUT CATALYTIC CONVERTER
- 100 ppm------- 150 mg /m_n^3 ENGINES WITH A CATALYTIC CONVERTER

*: In order to calculate the H_2S equivalent in other sulfur compounds, the mass of S present in the sulfur compound may be taken as a basis for the mass of H_2S, considering organic and inorganic compounds.

2.4.2. HALOGENATED COMPOUNDS (F, Cl, Br, I) STATED AS Cl^-

HF and HCl are the most harmful acids; therefore, their concentration is specified in mg of Cl^- equivalent /m_n^3 and the remaining constituents are considered as if they were chlorine, using the following equations:

Fluor = 2 Chlorine Bromine = 0.5 Chlorine Iodine = 0.25 Chlorine

Accordingly, for Kohler engines, the maximum permissible level of halides, expressed as chloride equivalent, is set at:

- 80 ppm ---- 100 mg Cl^- equivalent* / m_n^3 ENGINES WITHOUT CATALYTIC CONVERTER
- 6.5 ppm ----8 mg Cl^- equivalent* / m_n^3 ENGINES WITH A CATALYTIC CONVERTER

*: Organic and inorganic halides must be taken into consideration.

2.4.3. SILICON COMPOUNDS

Kohler has set the maximum permissible content of silicon in a fuel gas at:

- 7 mg / m_n^3 * ENGINES WITHOUT CATALYTIC CONVERTER
- NIL ENGINES WITH A CATALYTIC CONVERTER

In calculating the proportion of silicon in siloxanes, it is reasonable to take an average of 37% of silicon per total siloxanes.

*: Given the difficulties in analyzing and quantifying the silicon compounds in a fuel gas (Contact Kohler for information on reference laboratories), it is generally agreed that the silicon content in the oil of the engine should not exceed 75 ppm during the contracted maintenance period of the engine concerned. Accordingly, this value may also be deemed to be the maximum relative limit of silicon in the fuel.

2.4.4. AMMONIA (NH_3)

For Kohler engines, the maximum permissible content of ammonia in the fuel gas is set at:

- 60 ppm ---- 45 mg / m_n^3

2.4.5. RESIDUAL OILS AND TAR

Condensation is not allowed.

Consult Kohler about analysis methods.

2.4.6. SOLID PARTICLES

Kohler has established the following limits in connection with the presence of solid particles in fuel gas:

Maximum permissible particle size: 5 microns (μm)

Maximum concentration of particles 1 to 5μm in size:

- 10 mg / m_n^3

3. SUMMARY TABLE

Symbol	Parameter	Limit value	Engine/application	Comments
LHV	Lower heat value	37.5 – 42 MJ/m_n^3	All Natural gas engines	Natural gas
ΔLHV	LHV variation	<±5%	Mechanical carburetion	Readjust carburetion
		<±10%	Electronic carburetion	
		>±10%	Electronic carburetion Continuous gas analyzer	Continuous gas analyzer required
∇LHV	LHV gradient	<1%PCI/min	All Natural gas engines	
MN	Methane number	>75	All Natural gas engines	
P & T	Supplied gas pressure and temperature	IC-G-D-30-007e	Electronic carburetion	TECJET 50+
		IC-G-D-30-040e	Electronic carburetion	TECJET 52
		IC-G-D-30-008e	Mechanical carburetion	Zero pressure regulator and screw
		IC-G-D-30-015e	Electronic carburetion	ELEKTRA 50
		IT-G-A-00-011e	All Natural gas engines	Minimum room temperature
φ	Gas humidity	<80%	All Natural gas engines	No condensation
WetDewT	Wet gas dew point	>15º less than Tgas	All Natural gas engines	Recommended
O_2	Oxygen in gas	<2% vol.	Mechanical carburetion	Readjust carburetion
		<±1% carb. point		
O_2	Oxygen in gas	>2% vol.	Electronic carburetion	Continuous methane meter for automatic setting of carburetion
		>±1% carb. point		
H_2	Hydrogen in gas	<12% vol.	All Natural gas engines	
C4+	Higher hydrocarbons	<2% vol.	All Natural gas engines	
DryDewT	Dry gas dew point	>15º less than Tamb	All Natural gas engines	@ max. supplied gas P. Recommended
H_2S	hydrogen sulfide equivalent	<300 ppm	W/o catalytic converter	Total sulfur: H_2S equivalent
		<100 ppm	W/ catalytic converter	
Cl^-	Chlorine equivalent	<80 ppm	W/o catalytic converter	F, Cl, Br, I organic and inorganic
		<6.5 ppm	W/ catalytic converter	
Si	Silicon and siloxanes	<7 mg/m_n^3	W/o catalytic converter	Analyze: TMOH,TMS,L2,L3,L4,D3,D4,D5 Besides, <75ppm of Si in engine oil
		Nil	W/ catalytic converter	
NH_3	Ammonia	<60 ppm	All Natural gas engines	
Tar	Oils and tar	Condensations not allowed	All Natural gas engines	Condensable oil vapors
Dust	Solid particles	<5 μm	All Natural gas engines	Larger size not allowed.
		<10 mg/m_n^3 (1-5μm)	All Natural gas engines	

Summary table of natural gas fuel specifications for Kohler engines

1. INTRODUCTION

Once the display has been properly connected in accordance with the guidelines set out in IM-G-C-33-004, it is then ready for use.
This document lists the steps required to configure the display and also sets out the different features provided: data visualization, parameter settings.

2. DISPLAY CONFIGURATION

Configuration is divided into two steps:

- In order to connect the ignition unit to the display, first you have to configure the unit.
- Screen configuration

For both steps, you have to access the *Device Menu* display

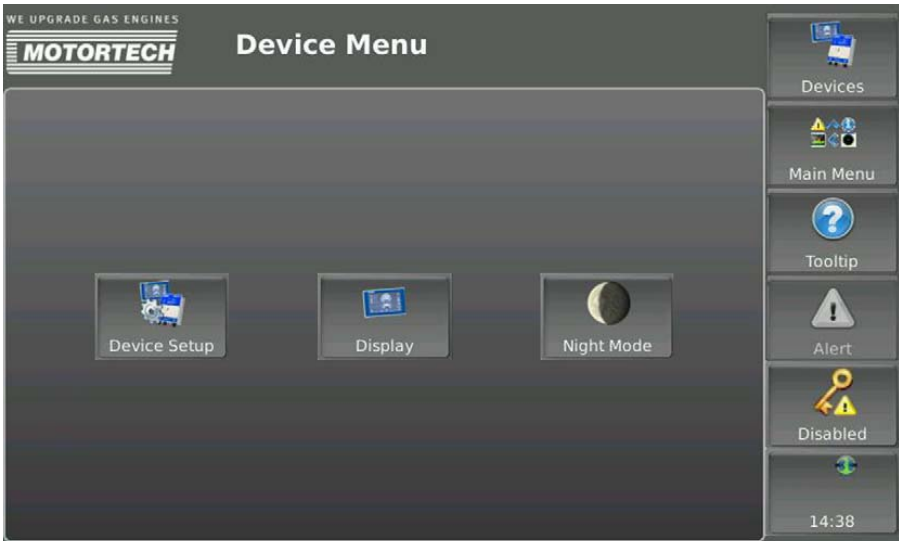


Fig. 1 – Screenshot of Device Menu

2.1. DEVICE CONFIGURATION

To configure the devices you wish to view, you have to access the *Device Setup* menu within the *Device Menu* view via the display.

The steps for including data related to the GIS ignition unit on the display are outlined below:

1. Clicking the *Add New* button displays the following window shown in Figure 2

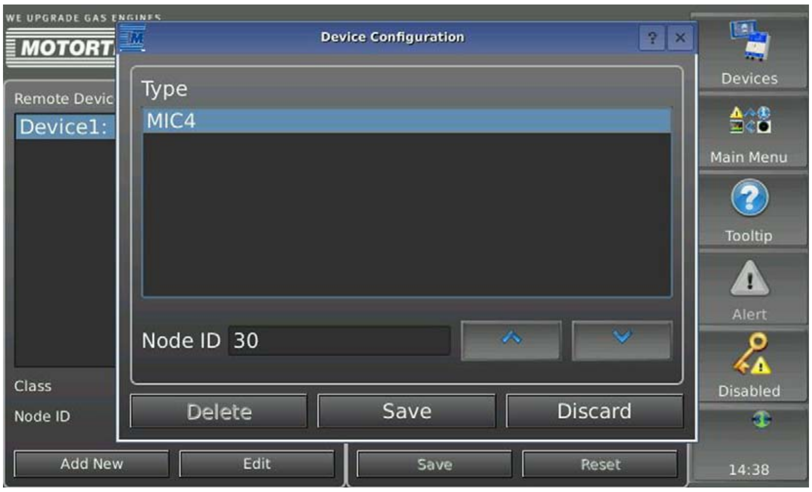


Fig. 2 – Selecting a new device

2. Then, select the device you want to connect. In this case, choose the MIC4 option.
3. The node number must be entered. All KOHLER GIS units have Node ID 30 set as default.

After completing these steps, press the *Save* button to save the settings on the display.

Once this has been done, the new device will be shown in the *Device Menu* (see the MIC4 icon in Figure 3)

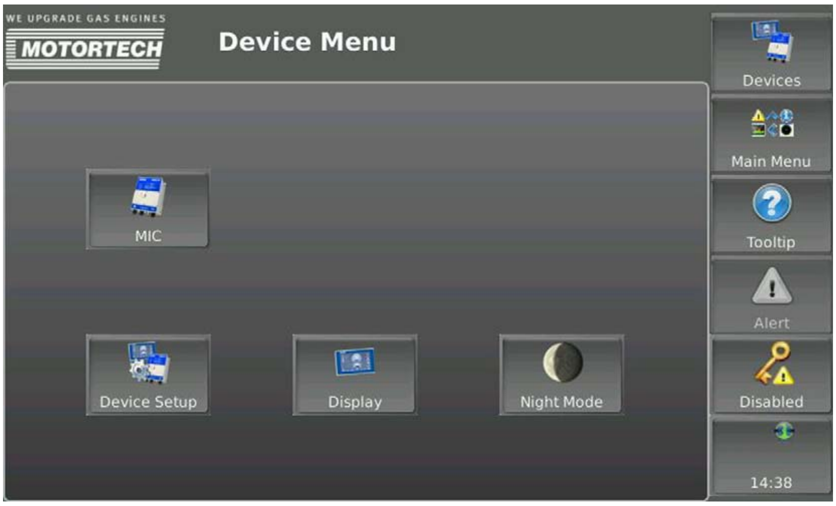


Fig. 3 - Device Menu view, once the device has been configured

2.2. SCREEN CONFIGURATION

By clicking the *Display* button in the *Device Menu* view, you access the next screen where you can configure the various display options.

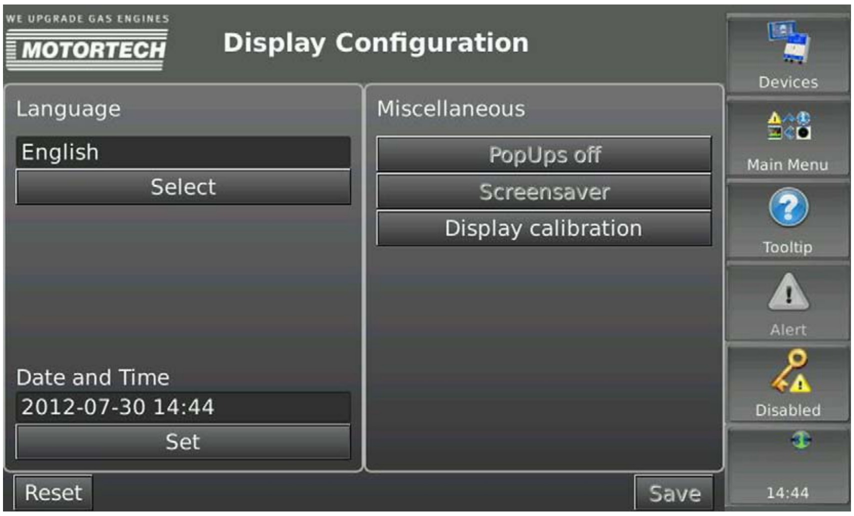


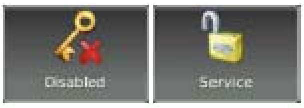
Fig. 4 – Display settings

- Select language: Press the *Select* button to set German, English or French as system language.
- Adjusting the date and time: Click the *Set* button and change the date and time.
- Screen calibration: If the touch screen is not responding properly to touch, click the *Display Calibration* button. Then, tip the midpoint of the Xs displayed on the screen. This will automatically calibrate the screen.

2.3. ACCESS CONTROL CONFIGURATION

The display on the GIS ignition unit can be configured to assign different levels of access to different user types.

To access the access control configuration menu, simply click the button that appears on the left of the display:



By clicking this button, you can access the following menu:

Fig. 5 - Access control

In the dropdown menu at the top left, select the access level you want to configure. Once you select the access level, several options are at your disposal:

- **Login/Logout:** Login/Logout to a specific operating level with the access level selected
- **Change Pin:** Change PIN access code. This can only be accessed at *Master* access level.
- **Enable/Disable Control:** Enable/disable access control. This can only be accessed at *Master* access level.

NOTE

As a default setting, all Pins for all users are set to 0000.

The following table describes the different user levels and rights available for each level:

ACCESS	PERMISSION	
Read only	Read access to all data provided	
Operator	Perimosos Read only	
	Display configuration	
	Recording of device data	
	GIS ignition	
		Reset errors
		Reset warnings
		Reset misfires
Service	Operator rights	
	Configure Node ID	
	Configure device	
	GIS ignition	
		Energy adjustments
		Ignition timing adjustments
		Self Test
		Operating hours adjustment
		Spark plug operating hours adjustment
Master	Service rights	
	Enabling/Disabling access control	
	Reset all PINs	
	Firmware update	

3. USE OF GIS UNIT DISPLAY

The following briefly describes each of the sessions related to the GIS ignition unit.

Once the devices have been configured, you can access the *Main Menu* for each one. To do this, select the icon for the device you wish to view in the *Device Menu* view.

The following screenshot shows the Main Menu of the GIS ignition unit.

Fig. 6 – Main menu on GIS ignition unit

3.1. READING PARAMETERS

The following briefly explains each of the screen views where data is displayed on the ignition unit:

3.1.1. Overview

This view shows global operating parameters

Fig. 7 – Menu Overview

- *Pick up*: the green status display indicates that pickup signals are being recorded (engine running). If no signal is detected, the LED remains grey.
- *Ignition Output*: we get different information on the ignition outputs depending on the colour:Grey: the firing is not active
  - Green: There are no misfires. Everything is working correctly.
  - Yellow: There were previously misfires, but currently there are no more misfires.
  - Red: There are misfires.

  Further details on the information this led provides can be found in the *Ignition* view.
- *Ignition Enabled:* This LED indicates whether the ignition unit has received a spark enabled command or not.
  - Grey: the firing is not activated
  - Green. The firing is activated
- *System*: this LED displays the system status. Equivalent to Status LED on the front of the ignition unit:
  - Grey: the display is not communicating with the ignition unit (the ignition unit is not powered on, the unit-screen communication is not working...)
  - Green: the ignition unit is recording no errors.
  - Yellow. The ignition unit is giving warnings/alerts (which do not lead to stopping the unit)
  - Red: There are errors, which lead to shut down.
- *Speed:* the pointer shows the engine speed.
- *Ignition Time:* shows the global timing of the engine.

3.1.2. Timing

This view provides information on how to calculate the ignition timing the engine operates on.

Fig. 8 – Ignition timing display menu

The following parameters are related to the global timing of the engine:

- *Base Timing*: Shows the base ignition timing programmed in the unit. The value for this parameter is set to 21° in all KOHLER engines. This base timing is corrected in "Timing correction" depending on the engine balance
- *Potentiometer Timing*: Displays the correction applied by the potentiometers in the unit. The value for this parameter is always set to 0 in KOHLER engines as potentiometers are not used.
- *Analogue Current Input Timing*: Displays the correction applied by 4-20 mA signal from the Detcon.
- *Analogue Voltage Input Timing:* Displays the correction applied by an analogue voltage signal. The value for this parameter is always set to 0 in KOHLER engines as no analogue voltage signal is used to adjust the advance.
- *Speed Curve Correction*: Displays the correction applied based on the engine speed.
- *Timing Correction*: Displays the external correction the unit receives via communications (CAN, Modbus). This timing correction can come from several devices:
    - From the display itself
    - From the PLC that controls the engine
    - From the ECU

NOTE

Depending on the engine balance, the required timing advance is entered via the display. Therefore, the timing correction value is always different to 0. (It is only set to 0 for disengaged engines with an advance of 21).

- *Global Timing:* Displays the currently set global timing which all cylinders are running on. This value is the result of the sum of all the above parameters.

The following parameters relate to the individual timings for each cylinder. There may be cylinders that are not working with the global timing because some kind of cylinder-specific individual correction is being applied:

- *Minimum Relative Firing Angle:* This is the lowest of the individual timings (the most retarded) of all engine cylinders.
- *Maximum Relative Firing Angle:* This is the largest of the individual timings (the most advanced) of all engine cylinders.
- *Average Relative Firing Angle:* Displays the average value of the different cylinder-specific advances in the engine. This value does not have to coincide with the *Global Timing.*

3.1.3. Ignition

This view provides information related to the firing in each cylinder

Fig. 9 – Screenshot of secondary voltage

- *Secondary Voltage:* it is an estimate value of the voltage required to generate the spark in the spark plug gap.
- *Misfire Indicator:* This LED gives information on where the misfires have occurred in the different cylinders:
  - Grey: There are no misfires.
  - Yellow: has previously been misfiring but currently there are none.
  - Red: There are misfires.

3.1.4. Energy

This view displays cylinder-specific spark characteristics. The value of two parameters is shown for each cylinder:

- *Spark Duration*: spark duration in microseconds
- *Energy Output*: firing energy applied to each cylinder to generate the spark

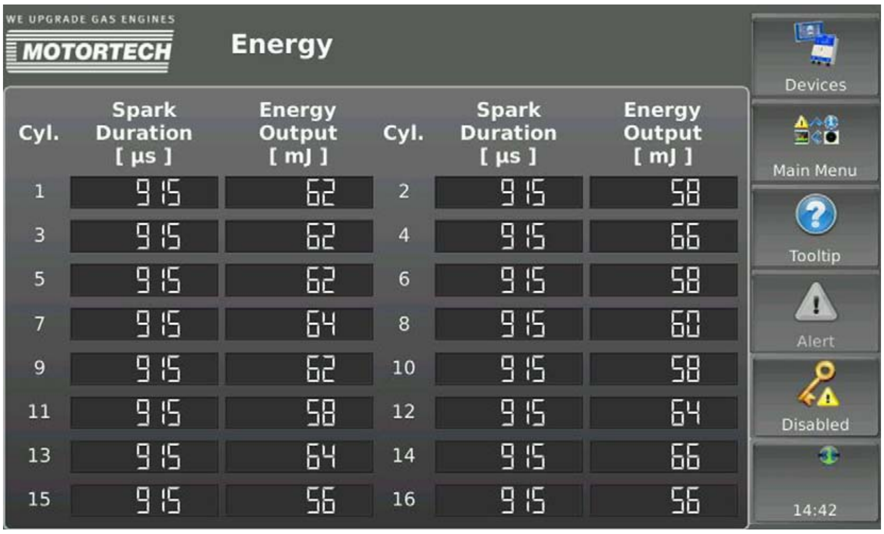


Fig. 10 – Screenshot of energy parameters

3.1.5. Firing Angle

This view displays the individual timings per cylinder

Fig. 11 – Screenshot of ignition timing per cylinder

3.1.6. Message Log

This view displays a record of al alarms, warnings and errors. In addition, lines are also included reporting on how the on system status and operation.

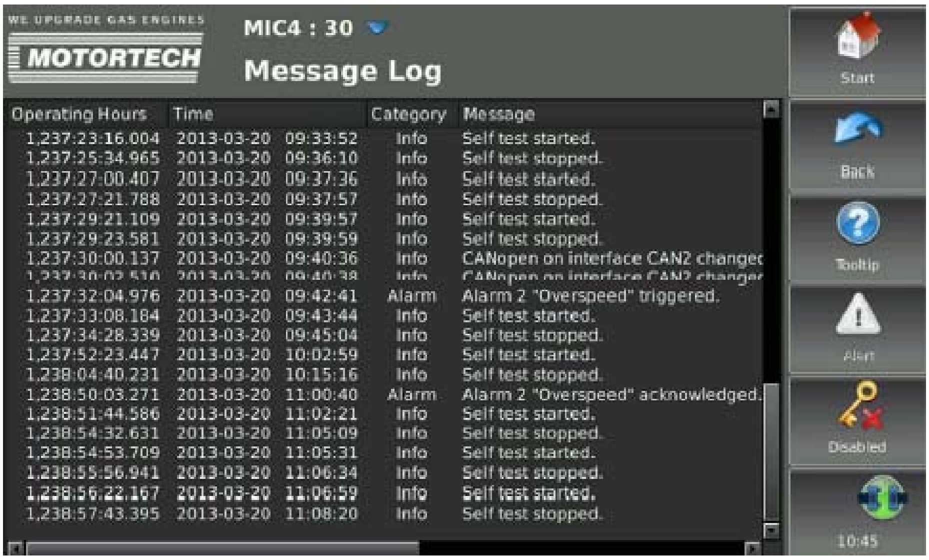


Fig. 12 – Screenshot of list of errors and warnings

Clicking the button, you can access the actions menu where you can perform the following functions:

- Confirm Alarms
- Confirm Runtime Errors
- Activate and deactivate automatic scrolling

A list of errors and warnings are outlined below.

ERROR CODE	DESCRIPTION
Trigger number	Number of teeth does not coincide with the set number
Trigger missing	Number of teeth counted is smaller than expected number
Cycle signal missing	Cam signal was not detected in time. More events were counted than expected per cycle.
Trigger period	Event period between two teeth was outside the expected range.
Reset number	Number of reset signals per cycle is outside expected range
Pre-processor pickup	Pre-processor pickup is causing an error
Overspeed	Overspeed
Output board missing	Output board could not be detected
Output or HV error	Error occurred in output board Possible problems with primary high voltage generator (185 V)
Misfire rate	Misfire rate exceeded
Low-power	Voltage too low
General	General warning
Temperature	The maximum permissible device temperature was exceeded
Reset by watchdog	The device was restarted by the watchdog

WARNING	DESCRIPTION
Trigger number	Number of teeth does not coincide with the set number
Trigger missing	Number of teeth counted is smaller than expected number
Cycle signal missing	Cam signal was not detected in time. More events were counted than expected per cycle.
Trigger period	Event period between two teeth was outside the expected range.
Wrong trigger	Tooth event recognised as fault
Wrong reset	Reset event recognised as fault
Reset number	Number of reset signals per cycle is outside expected range
Pre-processor pickup trigger number	Number of events detected in the pre-processor pickup is outside the expected range
Pre-processor trigger missing	Event period of pre-processor pickup is outside the expected range
Pre-processor pickup Index missing	The pre-processor pickup has not been able to detect the reset/cam signal
Pre-processor pickup	Pre-processor pickup causes warning
Misfire rate	Limit of misfire events exceeded
Overspeed	Overspeed
Low-power	Voltage too low
General	General warning
Configuration data CRC error	The configuration could not be read due to a CRC error

NOTE

There are a number of errors and warnings that match the description. The difference is that when such failures occur below a rotation speed threshold, it is considered a warning and the unit continues firing. When failure occurs above this threshold, it is considered an error and the unit cuts out the ignition. This rotation speed threshold depends on the rated operating conditions the unit is configured to.

3.1.7. Information

This view displays an overview of the ignition unit

Fig. 13 – Screenshot of device information

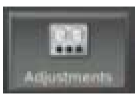
3.1.8. Diagnostics

This view includes further information on unit operation: board temperature, voltage.

Fig. 16 – Screenshot of the unit's operating parameters

3.2. ADJUSTING PARAMETERS

Adjusting and writing parameters is carried out in the "Adjustments" session in the Main Menu.



3.2.1. Adjusting the ignition timing

You can adjust the ignition timing on the next screen. Adjustments can be made in increments of +- 0,1 º o +- 0,5 º.

Fig. 14 – Adjusting the ignition timing

3.2.2. Adjusting energy parameters

Both the spark duration and the level of intensity can be changed on the next screen.

Fig. 15 – Adjusting energy parameters

WARNING

KOHLER recommends that you do not change the energy parameters previously configured in the ignition unit Changing these can cause an engine malfunction.

3.2.3. Operational hours

The spark plug burn time duration and operating hours of the unit can be adjusted on the next screen.

Fig. 16 – Adjusting operating hours counter

1 AIM

The aim of this product information sheet is to define an SFGLD emergency gas engine starting and stopping procedure.

2 PREPARATIONS FOR STARTING UP FOR THE FIRST TIME

Before starting up for the first time, the following operations shall be carried out:

2.1 PRE-START INSPECTION

General checks:

- Ensure that there are no power transmitting devices connected (clutches, brakes, etc.).
- Also inspect drive belts. Examine for good condition and correct tension. If a cooling fan is used, be sure it is free to turn, the journal bearings are properly lubricated and the belt tension is correct.
- Make certain that all guards and shields are secure on engine and equipment. Remove all loose tools, rags, fittings or other equipment, which may be picked up by external moving parts of the engine.
- Use a starter bar to turn over the engine several revolutions to be sure that nothing will interfere with the turning of moving parts. Do not forget to remove the bar when this has been checked.
- Ensure that there are no oil, fuel or coolant leaks on all joined surfaces.

Refrigeration (engine coolant circuit):

- Check the coolant level and concentration. Add additional quantity if necessary. If the amount of coolant to be added is large, open the drainage valves to allow the removal of air bubbles. It is advisable to check the entire coolant circuit in order to find out the cause of any significant leaks of coolant.
- Check the entire water circuit checking that all the control valves are open and all the drainage valves are closed.

Lubrication (oil circuit):

- Check the lubricant oil levels daily; adding more oil is required to maintain the level above the minimum indicated with the dipstick, unless an automatic oil level regulator has been installed. It is advisable to check the oil level regulator periodically to make sure it works properly.
- Start the prelube system (if any) until the indicator shows a positive oil pressure.

NOTE

The engines are supplied without oil. It is necessary to disassemble the drainage plugs to allow a small amount of oil and condensate to drip, accumulating in the bottom of the sump during the storage. Tighten the plugs firmly after this operation. Fill with oil in accordance with the instructions given in the chapter on maintenance.

Fuel:

- Make sure that the fuel is supplied at the right pressure. If the motor is equipped with fuel cut-off valve, ensure that it is active.

Air filter:

- Check the status of the clogged air filter indicator. If the indicator is red, press the button at the top of the indicator to reset it. If the indicator turns red again when the engine reaches full load, change the main filter and the safety filter.

Batteries:

- Check connections and batteries voltage.

2.2 OPERATION

Compliance with these regulations will have a decisive influence on the life of the engine:

- Avoid sudden load increases when the engine is cold.
- Avoid prolonged operations when the engine is running with no load or a very light load.

3 PRECAUTIONS TO BE TAKEN AT EACH START-UP

The procedure for starting up an engine is described below:

3.1 Before engine start-up

1. Before starting up, locate the manual stop lever, in order to operate this if necessary.
2. Activate engine pre-lubrication to distribute the oil to all parts of the engine, IT-C-A-25-040. When necessary, activate oil and coolant pre-heating as well. See IC-C-D-00-008.
3. Carry out the pre-start-up check: purge circuits, check levels and pressures.

3.2. Engine start-up

1. Initiate the start-up sequence.
2. Monitor the oil pressure gauge when the engine has started.

CAUTION

If, within a period of 10 seconds, no oil pressure has been indicated, stop the engine immediately. Never keep the engine in operation without an oil pressure indication.

NOTE

The oil pressure may reach 7 bar (100 psi) with cold oil at start-up

3. The generator switch can be closed once the rated speed is ready. Normally, the idle speed can be get . in 20 or 30 seconds after pressing the start button. This time depends on the batteries conditions and ambient temperature mainly.

   In case of generated connected to the grid, the synchronize process must be carried out to close the switch. The synchronization time will dependo n the stability of the grid parameters.

4. Load applications must be according to the product information:
   - IC-G-B-00-002 for engines at 1500 rpm
   - IC-G-B-00-003 for engines at1800 rpm

   Minimum time between loads application of 5 seconds.

CAUTION

Do not operate a turbocharged engine for prolonged periods (fifteen minutes or above) at light load or idle. Under this condition the turbocharger may be damaged by the accumulation of carbon, which does not have a chance to burn off completely.

5. *Operating inspection: There are series of important aspects, which must be checked while the engine is in operation*:

- Examine the water, fuel and oil conduits in case of leaks, mechanical damage or corrosion.
- Inspect the level and status of coolant. The presence of rust, foam or oil in the coolant indicates the need to overhaul the circuit.
- Observe and note down the operating parameters. Variations with regard to the normal values may indicate that anomalies are occurring.
- Listen to the sound of the engine. Some problems such an occasional false explosions, failures of the turbocharger bearings or problems with the water pumps, may be detected at the outset by unusual sounds from the engine.

3.3. Engine Shut-down

1. Reduce the load gradually.
2. Open the generator switch once the load is off.
3. Before stopping an engine after having been operating in severe loading conditions, you should make spinning without charge or idle for 5 to 10 minutes to stabilize at moderate levels the temperatures of the various components of the turbocharger, valves and other engine parts

CAUTION

Before doing anything to the engine, let it cool for at least ten minutes after shut-down.

4. Check the fuel supply has been cut off at the engine.

5. Post-lubricate the engine during five minutes after shut-down (when fitted with a pre-lube/post-lubrication system),

The exhaust pipe must be blocked off when the engine is shut down for long periods of time, to prevent rainwater or condensation from getting into the engine should be exposed to these elements.

4 NORMAL START AND STOP PROCEDURE

During normal operation, **the start-up procedure shall be as follows**:

1. Start the engine with both the ignition system and the fuel supply off, in order to eliminate any residual fuel from the intake and exhaust lines.
2. First turn the ignition system on and next the fuel supply.

During normal operation, **the shut-down procedure shall be as follows**:

1. Turn the fuel supply to the engine off.
2. Allow the engine to turn over several times and then disconnect the ignition system. Any residual fuel will get out of the system or will burn in the cylinders before the ignition system is off.

5 EMERGENCY START AND SHUT-DOWN

In case of an emergency, shut down the engine by turning the fuel supply and ignition system off at the same time. Failure to comply with this rule may lead to irreparable damage, injury or death.

CAUTION

Before restarting the engine after an emergency shutdown, wait for 10 minutes until the engine temperatures have stabilised. Do not restart the engine, unless the causes of the shutdown have been completely identified and the problems solved. Failing to do this may lead to irreparable damage, injury or death. Once the problems have been identified and solved, you can restart the engine according to the normal start-up procedure described in point 4.

GAS ENGINES AND ETHANOL ENGINES CARBURATION

1. INTRODUCTION

Tuning of an engine in order to ensure its correct operation means that different elements or parameters of the same, namely ignition timing and the air/fuel ratio, are adjusted.

Depending on the application of the engine and on the specifications or regulations to be complied with, tuning will be the most appropriate to meet these requirements, e.g. maximum thermal efficiency, lowest emissions, etc.

As for compliance with the regulations on permissible emission levels, it is essential to determine the proper air/fuel ratio and to this effect, the Kohler engines include adequate tuning capabilities.

2. SPECIFICATIONS

The thermal balance-sheets of Kohler for gas engines and ethanol engines (lean burn in both cases) specify the NOx emission level that can be achieved for each engine, based on the preset ignition timing and the different cooling water temperature settings. The engine carburation is adjusted so that the specified NOx level is complied with in each case. Normally, the NOx value is related to 5% Oxygen (provided the applicable legislation does not specify another reference oxygen level for correction).

ATTENTION

Never carburet an engine, taking the percentage value of oxygen in the exhaust as a reference, but the NO_x referred to above.

In rich burn engines, the target is to maximize the emissions' reduction; therefore, a 3 Way catalyst is used. In these cases the carburetion must be done in order to get the conjunction of the minimum possible NOx and CO emissions.

NOTE

To calculate the emissions, refer to doc. IC-C-D-40-001e "Emission Units Conversion".

3. REMARKS

1- Compliance with this specification is conditional upon correct tuning and adequate maintenance of the engine, in particular with regard to ignition timing and spark plugs.

2- On gas engines with mechanical controller, engine carburation faults may occur mainly due to any of the following circumstances:

- Change in the gas supply conditions (pressure, temperature, humidity and composition of gas).
- Change in room temperature or in the temperature of the intake manifold.
- Plugging of air filters.

As a result, it is necessary to increase exhaust emission controls with a view to making any correction of the air/fuel ratio that may be required to prevent the engine from running at risk.

3- Unusual emission values can denote any of different problems with the engine, according to the component of the exhaust gases which is out of standard and the engine behaviour. For instance:

- High oxygen level: denotes ignition problems (old spark plugs, broken or defective spark plug, faulty connection of a wire, failure of the ignition unit...). It is associated with a high level of Total Hydrocarbons (THC), if measured. Also, the exhaust temperatures will be lower on the affected cylinder bank and possible unbalance will be observed between the two banks of Vee engines.

- The engine will not reach its rated power, although the emission levels show a good mixture: This can be caused by air filter plugging or by problems with the throttle valve.

- The engine will not reach its rated power and the emission levels denote a very poor mixture: This is due to engine carburation faults or problems with the fuel system (low fuel pressure, dirty fuel filter, valves not opening correctly, ...). Also, the exhaust temperatures will be lightly lower and the throttle valve will be fully open.

1. EMISSION UNITS CONVERSION

For further information on emission computation and units conversion, refer to ISO 8178-1 (2006).

Exhaust emissions are usually stated in any of the following units:

Parts per million	- ppm (1)
Milligrams per cubic meter (normal)	- mg/m_n^3 (2)
Grams per kilowatt-hour	- g/kWh

Generally analyzers measure volume, in ppm or %, in wet basis (considering the water of the exhaust gases) or in dry basis (water not considered). Some analyzers can give results in other units after making internal calculations.

In case of mg/m3 units, the pressure and temperature conditions as reference must be taken into account. This can suppose differences between the values from different equipments. To compare different equipments measurement in this unit, they have to reference to the same pressure and temperature conditions. Legislations use to indicate the reference conditions to be taken. In general normal conditions, 0ºC and 1013 mbar (100 KPa) are the usual reference.

Below are bases of unit conversion for a number of components:

1.1. Converting ppm to mg/m_n^3 (2)

Multiply the ppm value by the density of the gas to be measured under normal conditions (2), which is, in kg/m_n^3:

Nitrogen Oxides, NOx such as NO_2	2.053	
Sulfur Dioxide, SO_2	2.85	
Carbon monoxide, CO	1.250	
Total Hydrocarbon, THC (C/H RATIO 1.85)	0.619	(0.716 in case of natural gas)
Methane, CH_4	0.716	
Formaldehyde, CH_2O	1.34	

NMHC (Non Methane HydroCarbons) are calculated by subtracting CH4 (methane) from THC (Total HydroCarbons).

When measuring ppm or mg/Nm^3, the usual practice is to take a reference exhaust oxygen value; in this event, the result must be multiplied by:

$$\frac{20.95 - O_{2\ ref}\ (\%)}{20.95 - O_2\ \text{measured}\ (\%)}$$

Generally, the most frequent $O_{2\ ref}$ (%) values are 3, 5, 7, 12 and 15, and they are specified by the applicable legislation.

(1) Parts per milion by volume, sometimes noted ppmv, 1 ppm = 0.0001%

(2) (Normal conditions: Temperature 273 K and Pressure 1013 mbar)

1.2. Converting ppm to g/kWh

The formula reproduced below is approximate; the exact computation method is defined in ISO 8178-1.

$q_{m\ gas}$ (g/h) = Emis $(ppm)_w$ x $factor_{gas}$ x Flow rate of wet exhaust gas (kg/h) / 1000

Emis (g/kWh) = $q_{m\ gas}$ (g/h) / Power (kW)

where:

- factor $_{gas}$ is the relative density-to-air ratio (or molecular weight ratio):

	Diesel	Natural Gas	Propane	Ethanol
Nitrogen Oxides, NOx	1.586	1.621	1.603	1,609
Sulfur Dioxide, SO_2	2.21			
Carbon Monoxide, CO	0.966	0.987	0.976	0.98
THC (C/H ratio 1.85)	0.479	0.565	0.512	0.805
Methane, CH_4	0.553	0.565	0.559	0.561
Formaldehyde, CH_2O	1.035	1.058	1.046	1.050

- the exhaust gas flowrate appears on the thermal balance sheets; it is a wet basis concentration value. The emission value in ppm used in the formulae must be a wet basis value (usually NOx, SO2 and CO are measured in dry basis) and the calculation of NOx requires correction to account for the ambient humidity, defined in ISO 8178-1 (2006).
  For Kohler gas engines, the Qexh / Power factor normally lies between 5 - 6.

- To change from a dry basis concentration "Emis $(ppm)_d$" to a wet basis concentration "Emis $(ppm)_w$" use the following equation:

  Emis $(ppm)_w$ = Emis $(ppm)_d$ x $factor_{W/D}$

  where $factor_{W/D}$ is in the order of:
  - Diesel engines: 0.92 (± 0.03)
  - Lean gas engines: 0.88 (± 0.03)
  - Rich gas engines: 0.81 (± 0.01)
  - Methanol engines: 0.84 (± 0.03) (3)

  The $factor_{W/D}$ in the above equation can be calculated accurately, by applying the definition in ISO 8178-1 (2006).

When using g/bHPh units, the equivalence is 1 bHP = 0.7457 kW.

In the case of ISO 8178-4 cycle performance, see paragraph 1.3

(3) Hydrated Ethanol, 5% of water

1.3. ISO Cycles

On many occasions (e.g. Marine engines), emissions are calculated by taking measurements under various operating conditions of the engine and applying weighting factors for each checkpoint. Legislations specify which cycle must be applied to calculate the emissions. These are the most common cycles:

- C1 Cycle

Speed	Rated Speed				Intermediate Speed			Idling
Torque (%)	100	75	50	10	100	75	50	0
Weighting Factor	0.15	0.15	0.15	0.1	0.1	0.1	0.1	0.15

- D1 Cycle

Speed	Rated Speed		
Torque (%)	100	75	50
Weighting Factor	0.3	0.5	0.2

- D2 Cycle

Speed	Rated Speed				
Torque (%)	100	75	50	25	10
Weighting Factor	0.05	0.25	0.3	0.3	0.1

- E2 Cycle

Speed	Rated Speed			
Torque (%)	100	75	50	25
Weighting Factor	0.2	0.5	0.15	0.15

- E3 Cycle

Speed (%)	100	91	80	63
Torque (%)	100	75	50	25
Weighting Factor	0.2	0.5	0.15	0.15

- E5 Cycle

Speed (%)	100	91	80	63	Idling
Torque (%)	100	75	50	25	0
Weighting Factor	0.08	0.13	0.17	0.32	0.3

Formula for the specific emissions calculation:

$$\text{Emissions} = \frac{\sum_{i=1}^{i=n} q_{m\,gas\,i} \times W_i}{\sum_{i=1}^{i=n} P_i \times W_i}$$

Where $q_{m\,gas\,i}$ is the pollutant flow (g/h) as 1.2 paragraph formula, P_i is the power and W_i is the weighting factor

1. DESCRIPTION

A level indicator is a device that combines an oil level display with high and low alarms. It provides protection against any high oil level due to possible water or fuel ingress as well as against a low level arising from high oil consumption or leakage. An oil level indicator with dial means the condition of the lubricant as well as the level can be checked without having to stop the equipment. When the float hits the high or low limit switch, it activates the alarm on the equipment.

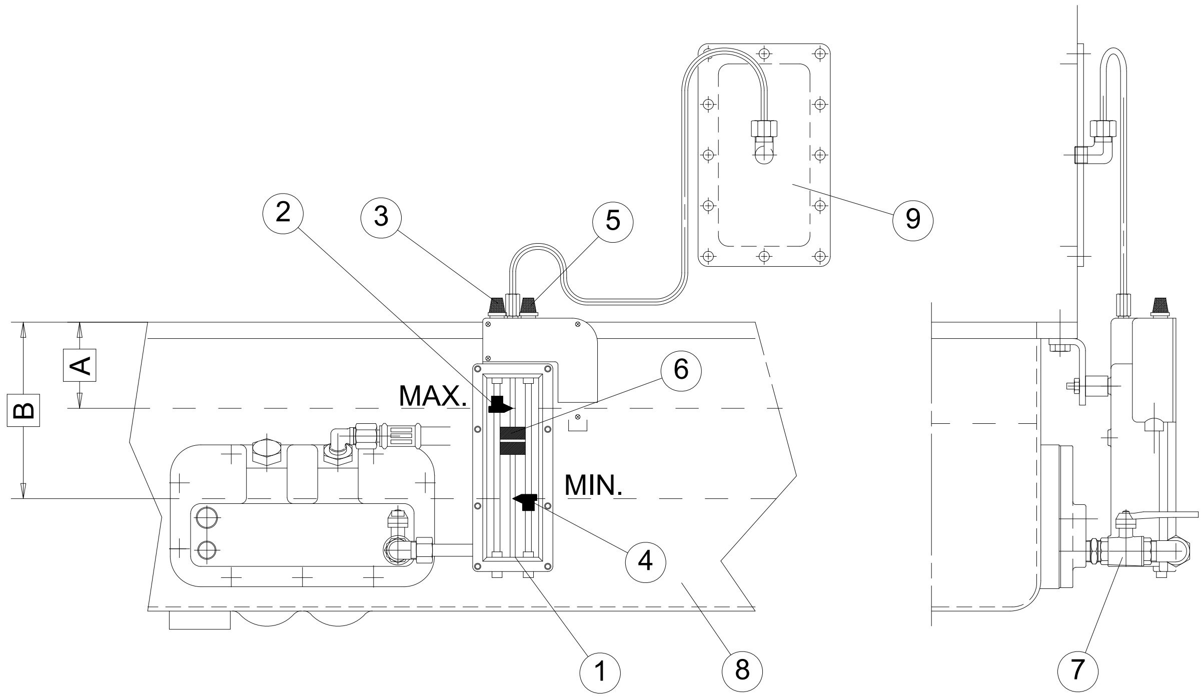
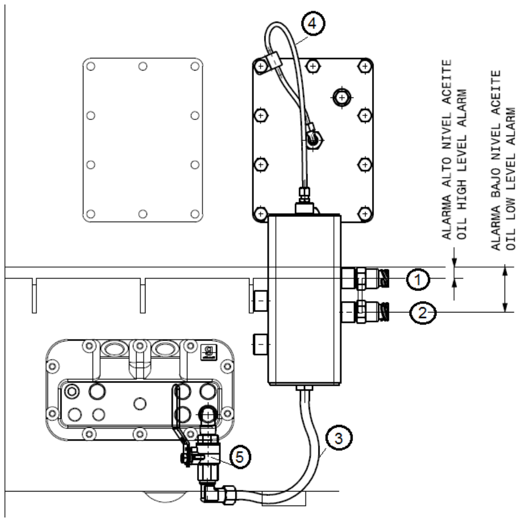


Fig.1 – Oil level indicator

1	Oil level indicator
2	High level indicator
3	High level adjuster
4	Low level indicator
5	Low level adjuster
6	Float
7	2-way valve
8	Oil sump
9	Connecting rods inspection cover

In place of this oil level indicator with high and low alarms, and if UL certification is required, the engines may be equipped with another alarm system but without an oil level indicator. Refer to IT-G-A-25-009e.



1	High level alarm indicator
2	Low level alarm indicator
3	Oil controller hose to oil sump
4	Venting hose
5	2-way valve

Fig.2 – UL Oil level indicator

With the engine at rest, the oil level in the indicator may rise up to the high limit, occasionally indicating a situation of excess oil. This results from backflow, i.e. oil flows back from the lubricating circuit to the sump, when the engine has stopped.

2. MAINTENANCE

There have been cases reported when, due to a lack of cleaning, the oil level indicator showed a normal level, whereas the amount of oil in the equipment was above or below the permissible limits due to obstruction in the pipe that connects the oil level indicator to the oil sump in the engine.

Cleaning the oil level indicator is a simple process that requires little time and must be included in the engine maintenance programme. It is advisable to clean the equipment when the oil is being changed, and do so at least once a year. Cleaning involves removing the pipes, both the sump-venting pipe and the connection pipe to the oil sump, and checking to ensure they are not blocked.

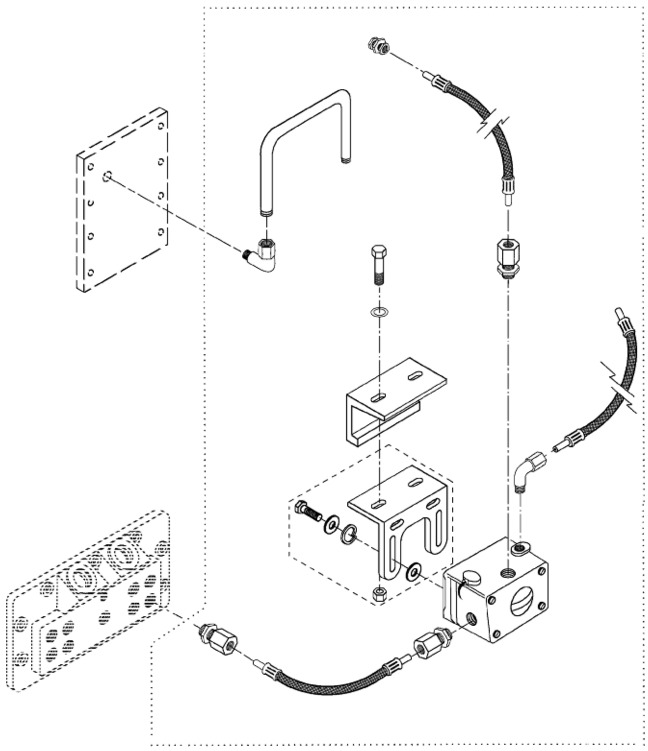
1. DESCRIPTION

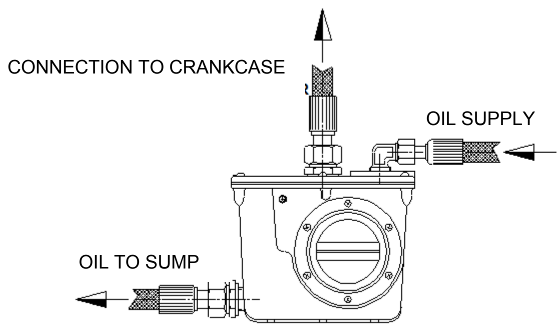
In engine-driven facilities that operate 24 hours a day or similar, it is advisable to mount an oil level controller. Diesel engines for industrial applications usually incorporate such a device, while engines for marine applications are not normally equipped with one.

The oil level controller is a mechanical actuator fitted on the oil sump in the lower part of the engine. It is equipped with a floater inside a small reservoir which opens or closes the oil flow into the engine crankcase based on the oil level in the oil sump at that time.

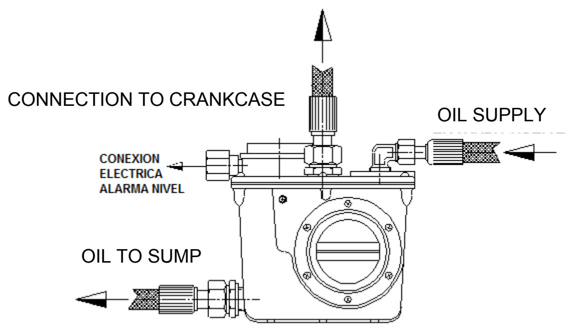
KOHLER engines do not use this latter function of the actuator, since they incorporate another system that monitors the high and low oil levels in the crankcase (Refer to IO-C-M-25-006e, IT-C-A-25-002e or IT-G-A-25-009e)

For CSA-certified engines, the filling unit is equipped with sensors, a maximum and a minimum sensor, in order to send alarm signals and/or stop signals to a control panel. (Refer to IT-G-A-25-008e)



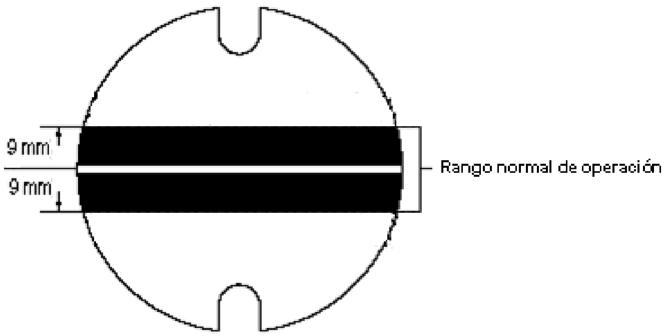


Automatic oil level controller



Automatic CSA oil level controller

When the engine is running, the oil level in the display must be within the normal operating range.



With the engine at rest, the oil level will go beyond this range due to oil flow back from the oil circuit, causing overfills. However, after restarting the engine, the oil level will lie again in the normal range.

2. MAINTENANCE

Cleaning the controller indicator and checking correct operation thereof is a very simple process. It is advisable to clean the equipment when changing the oil, doing so at least once a year. Cleaning involves removing both the venting hose and the connection hose to the oil sump, and checking that they are not blocked.

1. INTRODUCTION

According to the United States Environmental Protection Agency (EPA) Ref. code of Federal Regulations 1048.130, these instructions are intended to give the installer of the engine all of the information that is necessary to properly install the engine.

SFGLD series engines are stationary engines that fulfill the requirements described in 40 CFR 60 subpart JJJJ.

The SFGLD series engines are constant speed only engines, and no variable speed applications are allowed.

The maximum mechanical power is the value defined in the corresponding Heat Balance sheet as nominal power (100% Load) and no overloads are allowed. The mechanical power is given without mechanical water pumps. If the mechanical pumps are installed in the engine the corresponding power required by pumps must be subtracted from the nominal value.

- V engines. Water pumps power: 7 kW.
- Line engines Water pumps power: 4 kW.

In order to obtain the best engine performance and maintain the engine emissions levels the maintenance schedule for each application and engine configuration must be followed.

ATTENTION

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

ATTENTION

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

2. INSTRUCTIONS FOR INSTALLATION OF THE EXHAUST PIPE

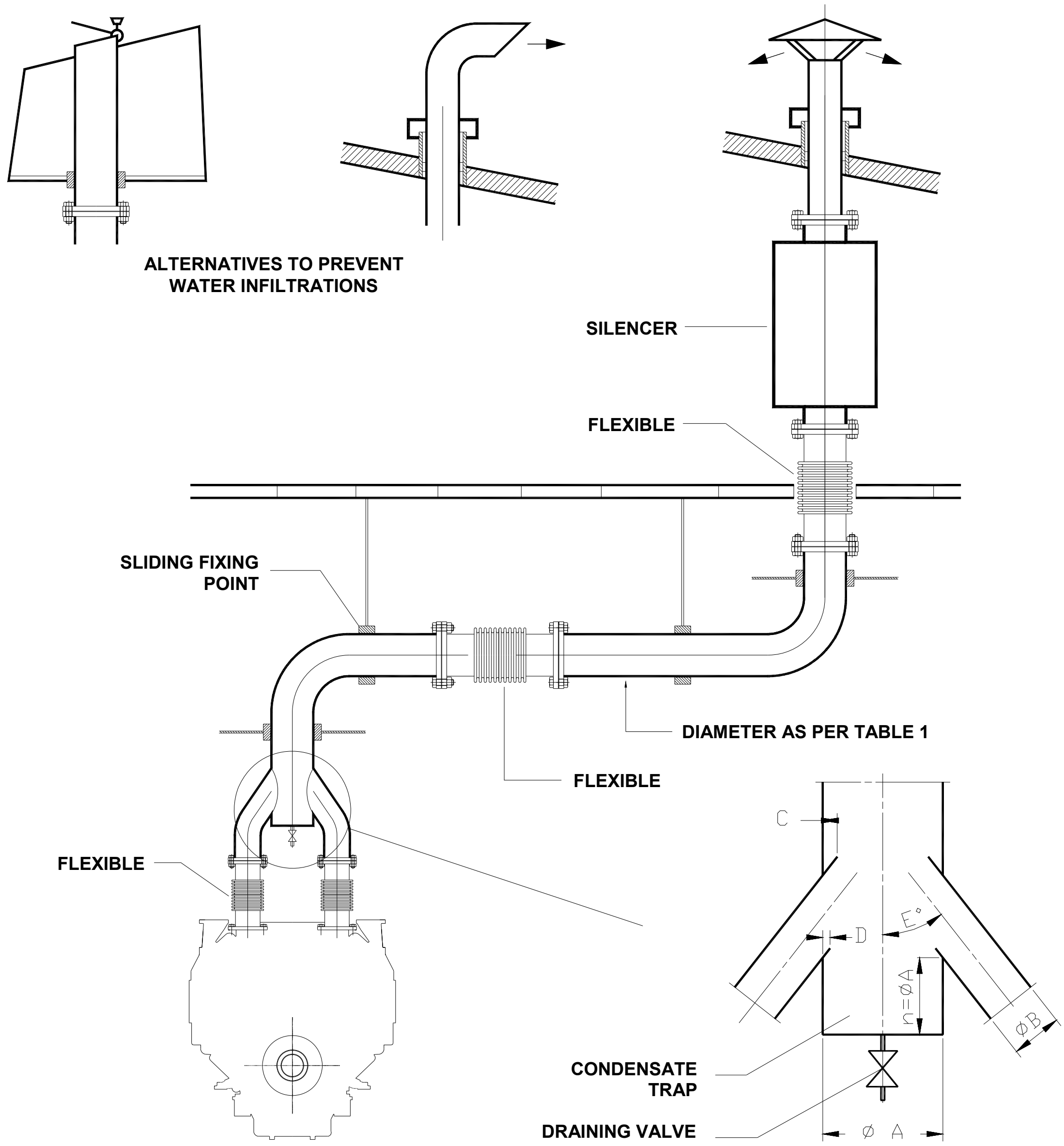
The maximum backpressure allowed is defined in the Heat Balance sheet and to exceed this value is not allowed.

The exhaust pipeline shall be made up of as few bends as possible and no unnecessary pipe lengths, in order to reduce pressure losses to a minimum.

Below are some aspects to be borne in mind when designing the installation:

- Insert the appropriate number of expansion joints into the exhaust pipeline, as will enable free expansion and contraction of the pipes under temperature changes.
- The rigid fixing of the exhaust pipes to the engine room structure usually is a source of noise and vibrations. Additionally, it may be the cause for exhaust pipeline breakage.

- The exhaust pipeline shall be secured by means of collars through which it can slide and properly distributed fixed anchorage points.
- The exhaust pipeline and silencer shall be protected and heat-insulated to avoid big heat radiations into the engine room and the subsequent reduction in the engine performance.
- The exhaust pipeline must be laid for each engine individually. Never put together the gas outlets of various engines in a single collector.
- For completion of the exhaust pipeline, there must be a condensate trap installed at the lower end of the last vertical run of exhaust pipe as well as one draining valve (*see Figure 1*).



∅ A	Inner Diameter		D	10 mm (0.39 inch)
∅ B	Exhaust Flexible Diameter		E	30º (86ºF)
C	20 mm (0.78 inch)		n	∅ A

Fig. 1 – “V” Engine Installation of Exhaust Pipeline

Although there is no problem for installing expansion joints or flexible exhaust pipes, the following should be taken into consideration:

- The expansion joints are basically designed to make good any longitudinal extension of the exhaust pipes.
- To prevent exhaust pipes from moving crosswise, the pipes should be guided and attached to the engine room structure in such a way that their longitudinal movement only is permitted to avoid damage to the expansion joints.
- The expansion joints have one single assembly position in accordance with the direction of the exhaust gas.
- The number of joints to be installed is determined by the length and layout of the exhaust pipeline.

Figures 2 and 3 show the admissible axial shift and cross travel as well as the direction of exhaust gas escape for standard Kohler flexible pipes.

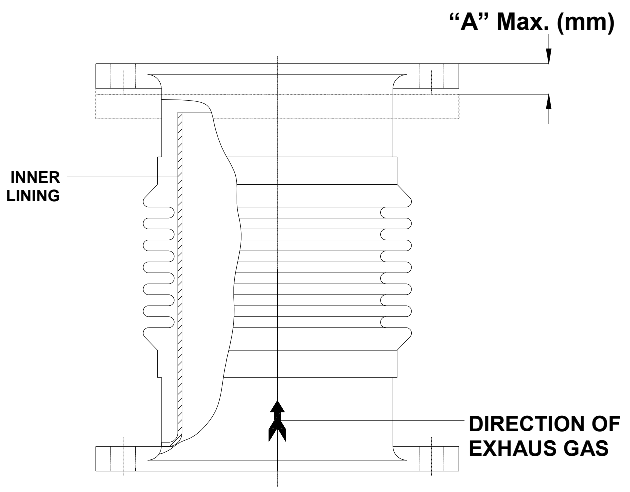


Fig. 3 – Axial Shift (Compression)

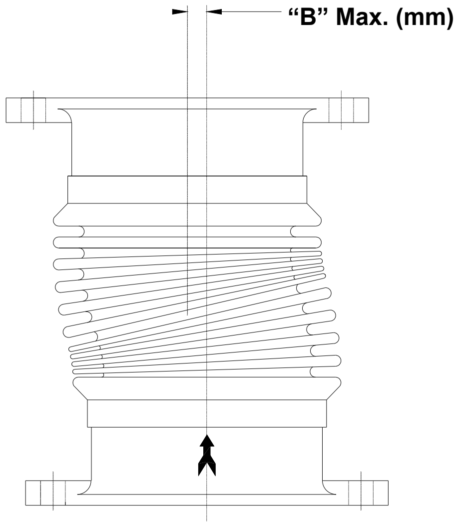


Fig. 4 – Cross Travel

The dimensions of the engine exhaust connections for V engines are given in IT-G-A-40-002e. In line engines don't require special connections.

3. INSTRUCTIONS FOR INSTALLATION OF THE FUEL PIPE

In order to control emissions efficiently the elements and dimensions of the pipes and components must be in such way to comply the gas specifications for the fuel supply described in IC-G-D-30-007e (TECJET 50+ gas injector) or IC-G-D-30-012e (TECJET 110 gas injector).

The gas ramp must include, at least, the following elements in the same order: manual shutoff valve, filter, pressure regulator (if required) and valve train.

The fuel gas must comply with the specifications described in IC-G-D-30-002e (Gas Natural) or IC-G-D-30-003e (Biogas) or IC-G-D-00-04e (syngas). Other gas qualities or failures in the specifications meeting can affect emissions levels, being out of the emissions levels according to the 40 CFR 60 subpart JJJJ standards. Kohler is not responsible for the emission level compliance in these situations

Check leakages before engine first start.

4. ENGINE-ROOM VENTILATION

The correct ventilation of the engine room allows the correct engine performance; especially in the case the engine takes the air from the room.

In designing a ventilation system, the same importance should be given to the necessary volume of air as to the flow direction.
The ventilation system must be able to provide sufficient combustion air and to remove radiation heat from the rest of the facility.

For an estimated thermal difference of 5ºC (9ºF) between inlet and outlet air temperatures, the air inflow must be in the region of 70 m^3/h per 1kW installed power. See the following table for air flow rates.

ENGINE TYPE	EXHAUST MANIFOLD		AIR FLOW RATE					
			AIR INTAKE ENGINE		ENGINE ROOM VENTILATION		TOTAL	
			ft^3/hHP	m^3/hkW	ft^3/hHP	m^3/hkW	ft^3/hHP	m^3/hkW
TURBOCHARGED	WATER-COOLED	EXTERNAL FILTER	0	0	1580	60	1580	60
		INTERNAL FILTER	263	10	1580	60	1843	70
	DRY	EXTERNAL FILTER	0	0	1580	60	1580	60
		INTERNAL FILTER	263	10	1580	60	1843	70

Generally, the air flow direction in an engine room will match the following pattern:

- The entry of air in the engine room should be from the area furthest away from any sources of heat.
- The fresh air should be able to flow freely from the point of entry to the sources of heat, in its circulation towards the point of exit.
- The expulsion of hot air should be at a point directly above the most important sources of heat, avoiding the intake of the exhaust gas.
- Where the temperature of the engine room or, in particular, of the crankcase gases return lines to the intake manifold is too low, the said lines must be heat-insulated so as to prevent condensation in the said piping section.

In all cases, the hot air should be forced out of the engine room by means of an outlet duct, without allowing it to mix with the fresh ventilation air.

5.2 INSTALLATION OF AIR FILTERS

- The filters should be installed in every case in the most optimum place according to the layout of the engine room.
- A sufficient quantity of combustion air should be guaranteed.
- In case of an external air inlet, avoid any risk of water entering into the filter.
- The minimum cross section area (S) of air flow through the filter protector derives from the following equation:

S = S1 x 2
(where S1 = developed area of the filter)

- The air duct between the filter and the engine should be made of metal with a circular or rectangular section.
- The maximum admissible pressure drop after filter, measured in the air intake duct, should not be bigger than 381 mm.w.c. relative to external atmosphere. It is recommended to keep approximately 81 mm.w.c. in reserve, that is to say that with clean filter the maximum pressure drop shouldn't exceed 300 mm.w.c.

- The fitting of the air intake duct should be studied by the installer and should eliminate all the abnormal forces due to the sheer weight of the air intake duct and all the vibrations which could be produced, as both these factors could result in problems for the correct functioning of the engine.
- The air intake duct connection to engine should be made by means of a flexible rubber hose.
- Fit a drain cock at the lowest point of the air intake duct. This point is generally as near as possible to the turbochargers. It is important and necessary that, if the air intake duct were over hot parts it would be well isolated. *(See fig.4)*

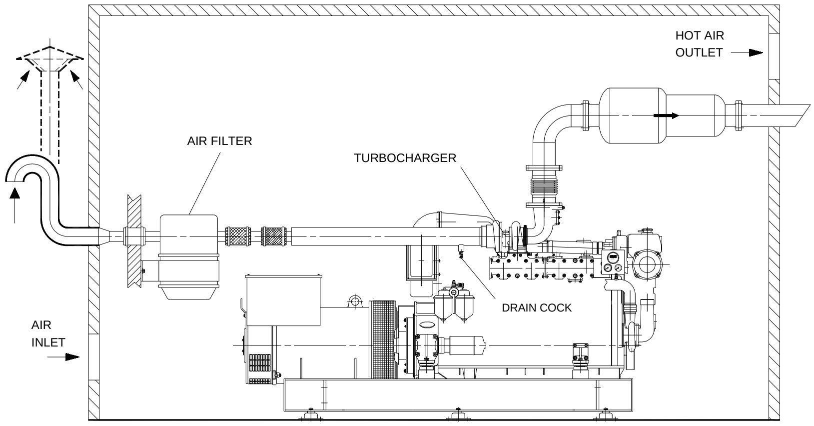


Fig 4

- In any case, the air temperature for combustion should not exceed in general 25°C (77ºF) at the filter entry point, otherwise it will be necessary to reduce the engine power.

6. ENGINE INSTRUMENTATION

The instrumentation is defined in IO-G-M-60-002e. In this Product Information sheet you can find the engine running parameters that must be monitored, the limit values for this parameters and the alarm logic operation.

7. IN USE TESTING

The U.S. EPA certification regulations for LSI engines require the engine manufacturer (Dresser-Rand A Siemens Business) to notify the equipment manufacturer that sampling of exhaust emissions must be possible after engines are installed in equipment and placed in service. If this cannot be done by simply adding a 20-centimeter extension to the exhaust pipe, you, as the equipment manufacturer, must demonstrate to Dresser-Rand A Siemens Business how to sample exhaust emissions in a way that prevents diluting the exhaust sample with ambient air.

8. ADJUST FUEL AIR RATIO

The carburetion control systems are designed to maintain the emissions level during all typical operating conditions. Under extreme or unusual operating conditions (gas quality, gas pollutant, dusty ambient, extreme season temperatures) carburetion settings need to be confirmed and potentially adjusted. To “check / adjust fuel air ratio” the exhaust emissions and actual A/F ratios are confirmed. If adjustments are necessary, they are performed using Kohler proprietary software interface and only performed by Kohler authorized service technicians.

CHAPTER 5 – MAINTENANCE INSTRUCTIONS

5.1 Maintenance Procedures

5.2 Description of Maintenance Operations Type E

1. MAINTENANCE INTERVALS

The satisfactory performance of engines depends on many factors, the most significant being:

- Mode of operation
- Humidity, barometric pressure and air temperature
- Number of hours operating at full load
- Number of hours operating at full speed
- Engine parameters: ignition timing, cooling temperatures, water flows,…
- Fuel and lubrication oil quality
- Proper loading of engine after start sequence
- Oil and filters changes intervals
- Use of Kohler products and original spare parts
- Care taken to ensure that engines are adjusted to factory settings in inspections and maintenance operations

Because of these as well as other similar factors not mentioned, it is difficult to set a precise number of hours of operation for each engine, before normal servicing becomes necessary.

The maintenance intervals listed in this section do not in any way imply an obligation on behalf of Kohler, and are given only as a guide to users for maintenance scheduling. Users must take into account operating conditions and demands to determine the maintenance operations that should be carried out more frequently than stated on the schedule. In all cases, the number of hours specified are reasonable limits, which should not be exceeded in order to ensure that the engine works correctly. If the engine maintenance schedule is not adhered to then the warranty of the same may be cancelled. This document should be studied carefully before the engine is started up for the first time.

ATTENTION

These circumstances can modify the intervals of maintenance operations:

- Excessive exhaust back-pressure
- Insufficient air supply to intake. Air quality
- High crankcase pressure
- Low oil pressure
- Over heating of the jacket water system (boiling)
- Changes in fuel quality
- High air temperature
- Sudden stops and alarms
- Incorrect realization of maintenance operations
- Deficient installation or ventilation
- Incorrect air/fuel ratio
- Use of non-approved oil

2. DAILY MAINTENANCE

2.1. CONTROL OF COOLANT LEVEL

The coolant level must be checked daily. It is necessary to ensure that there aren't air or steam bubbles in the system. In that case the system must be purged by hand or automatic vent valves must be installed in the top of the circuit.

The quality of the cooling water must comply with **IO-C-M-20-001**, which specifies not only the water quality but recommends the percentage of glycol to be used.

CAUTION

NEVER USE DIRTY, HARD OR SALT WATER. COOLANT NOT ONLY PRESERVES ENGINE AGAINST FREEZING, BUT ALSO PRESERVES ENGINE AGAINST CORROSION AND OXIDATION. SEE IO-C-M-20-001.

2.2. CONTROL OF OIL LEVEL

Check the engine oil level every day under identical conditions. This is to be done with the engine idling, after running for several minutes.

The oil level should never be below the lower indicator mark, nor above the high limit on the dipstick.

Note: If the engine has crankcase gases recirculation system, the oil level on the dipstick could be erroneous because the pressure in the crankcase is not at atmospheric pressure. Therefore, the oil level must be checked when crankcase pressure is at atmospheric pressure or the reading must be done in the devices not influenced by these pressure differences: lubrication oil level indicator or oil level regulator (with the filling valve closed).

2.3. DAILY RECORDING OF THE ENGINE DATA

It is necessary to record pressures, temperatures, levels, energy outputs... in order to be able to detect possible engine operation failures by analysing the evolution of the aforementioned parameter values.

Note: Daily records may help you to solve performance problems before they arise, because of that, it is recommendable to record a high number of parameters of engine performance.

2.4. CLEANING OF THE ENGINE

Several reasons make it desirable to keep the exterior of the engine clean. Dirt from the outside can be drawn into the intake filters. Further, exterior dirt can get into the engine during normal maintenance in cylinder heads, crankcase…

A number of products for cleaning the engine exterior can be used, such as pressurized steam or degreasing agents. It is necessary to be extremely careful with the electrical components of the engine.

2.5. CLEAN AND KEEP WATCH OVER ELECTRICAL CONNECTORS

Clean the electrical connectors if necessary, but before be sure that there is no tension on them.

ATTENTION

NEVER BRING A FLAME OR MAKE SPARKS NEAR THE BATTERIES. FLAMMABLE STEAM CAN BE PRODUCED.

2.6. LUBRICATION OIL LEAKS

Inspect plant lubrication piping for oil leaks. Tighten hardware or change seals and gaskets if necessary.

In addition, make sure the dipstick and filling plug on the inspection cover are tight.

2.7. COOLANT LEAKS

Inspect plant water piping for water leaks. Tighten hardware or change seals and gaskets if necessary.

Verify that the drain holes on the water pumps are unobstructed, as their plugging could lead to serious damage.

2.8. GAS LEAKS

Inspect gas piping for leaks using a gas detector or water with soap. Tighten hardware or change gaskets if necessary.

CAUTION

NEVER USE A FLAME TO DETECT GAS LEAKS BECAUSE THIS CAN PRODUCE AN EXPLOSION AND PERSONS CAN BE HURT.

2.9. SPEED CONTROL LINKAGE (NOT NECESSARY FOR ELECTRONIC CONTROL ENGINES)

It is necessary to check the ball joints of the speed control linkage for clearances (greased and readjusted where appropriate).

2.10. CHECK FOR SENSORS

Temperature and pressure measures must be checked in order to detect deviations or broken sensors on engine. It is also necessary to inspect pressure and temperature sensors of the control system.

2.11. INTAKE AND EXHAUST LEAKS

Check that there are no leaks in the intake and exhaust circuits.

1. MAINTENANCE PROGRAM

The information in this maintenance program is complemented with product information document **IO-G-M-00-060e**, General Maintenance Guidelines for Gas Engines. This maintenance program have been defined for Prime application, as indicated in the product information IC-C-D-00-002.

KOHLER has developed this maintenance program to ensure optimum performance of your engine. Given that strict adherence to this program will benefit you, it is essential that you follow the instructions detailed in this manual. Failure to do so may not only jeopardize KOHLER's warranty, but also restrict you from obtaining the best performance for equipment.

The maintenance intervals listed in this section do not in any way imply an obligation on behalf of KOHLER, and are given only as a guide to users for maintenance scheduling. Users will take into account operating conditions and demands to determine the maintenance operations that should be carried out more frequently than stated on the schedule. In all cases, the number of hours specified are reasonable limits, which should not be exceeded in order to ensure that the engine works correctly. If the engine maintenance schedule is not adhered to then the warranty of the same may be cancelled. This document and product information document **IO-G-M-00-060e** should be studied carefully before the engine is started up for the first time.

IMPORTANT

The maintenance jobs described below (identified with as an "E" type task) must be regarded as "additive" to each other. Accordingly, the performance of every "E_i" job implies that all previous "E_{i-1}", every time as the frequency indicates it.

This will require the availability of such materials and labour as may be necessary at each stage.

NOTE Any Check-Inspection may require a corrective operation if the element in question requires one.

1.1. Basic maintenance operations:

NEW ENGINE OR MAJOR SERVICE WORK START-UP MAINTENANCE

Jobs to be done during the initial start-up of a new engine or during the break-in phases following major overhauls (change of cylinder liners, pistons, piston rings, cylinder heads,...). They must be carried out by KOHLER authorized Repair Shop.

Job	Interval	Job Description
NA	**0 h**	**(Operation before starting up the engine)**
		- General inspection and set-up of the engine
N1	**100 h**	**(Operations after starting up or break-in phase)**
		- Change oil KOHLER MOTOROIL (oil sump and cooler)
		- Change oil filters
		- Analyze waste oil
		- Clean the oil centrifuge filter and change the paper filter
		- Inspection of the gas ramp filter
		- Adjustment of rocker arms and valve lifters. Measure valve height
		- Check air/fuel ratio
		- Adjust air/fuel ratio to full load, if necessary
		- Measure the exhaust back-pressure
		- Check damper temperature
		- Inspect for leaks in all coolant, oil, gas and exhaust gases system
		- Check the cleaning of carburetion system and admission (compressor, intercooler and inlet manifold)
		- Inspection and retightening of flanges and clamps, battery terminals, connectors, flexible couplings, air filter supports, exhaust piping, oil pipes, etc.

ROUTINE MAINTENANCE (Type "E")

Minor Jobs

Job	Interval	Job Description
EO	Daily	**(Operations to be performed with the engine stopped)**
		- Vent the coolant circuit. Check automatic vent valves
		- Drain condensates out of the exhaust Y-pipe
		- Check oil pressure and temperature during the pre-lubrication phase
		- With the dipstick, check for a possible increase of the oil level in the oil pan due to coolant leaks
		- Verify oil heating with the pre-heater, if necessary
		- Check the oil level of the pneumatic starter lubricator, if necessary
		- Clean the engine and its surrounding
		(Operations to be carried out with the engine idling)
		- Check oil level
		(Operations to be carried out with the engine stabilized)
		- Check coolant level / pressure. Vent circuits
		- Check oil pressure
		- Inspect the air filter plugging level (reset the pilot first)
		- Check oil, coolant and exhaust gases temperature
		- Check the filter cleaning state pilot of the crankcase gases recirculation system. Control the crankcase pressure (*A*)
		- Record engine parameters on a regular basis
		- Revision of the operational stability and unusual noise
		- Inspect for leaks in fuel, coolant, oil and exhaust gases

Job	Interval	Job Description
E1	1.200 h	- Analyse waste oil
		- Change oil filters
		- Change oil KOHLER MOTOROIL (oil sump and cooler)
		- Clean the oil centrifuge filter, film-thickness measurement and change the paper filter
		- Clean the metallic sponge of the oil purifier
		- Measure crankcase pressure
		- Check air/fuel ratio
		- Adjust air/fuel ratio to full load (*), if necessary
		- Inspect the air filters
		- Adjustment of rocker arms and valve lifters. Measure valve height
		- Check safety devices and connections: temperature and pressure switches and probes
		- Check battery acid level
		- Check battery and starter connections
		- Inspection of high voltage wires of the ignition system
		- Change the filter of crankcase gases recirculation system and clean this circuit (*A*)
E3	4,800 h or once a year	- Verify the ignition timing
		- Check damper temperature
		- Change air filters
		- Check gaskets in the rocker arm covers
		- Disassemble, clean and adjust all the speed and ignition pick-ups
		- Measure the exhaust back-pressure
		- Change coolant
		- Verify the tightening torque of knocking sensors on stud head (20 Nm)
		- Check the axial clearance, radial clearance and condition of the turbocharger vanes

NOTE	- The spark plugs change must be made attending the IO-G-M-33-007 product information*. *It's recommend to carry out a borescope inspection and do a compression test when changing spark plugs
	- Ask Kohler to use another oil that it is not KOHLER MOTOROIL.

Periodic interventions (Type "R")

major interventions

Job	Interval	Job Description
R1	11,200 h	- Recondition cylinder heads.
		- Clean pistons, cylinder liners and cylinder head seating on block
		- Check valves driving system: valve lifters, rocker arms, push-rods, roller rocker arms and cams
		- Measure cylinder liners wear
		- Clean oil sump
		- Check and clean the cooling system. Clean pipe bundles and change gaskets on heat exchanger and coolers
		- Change oil thermostat (only V engine)
		- Test thermostats of coolant circuit.
		- Clean filters of coolant circuit. Change filter cartridge
		- Retighten connections in knocking detection system unit.
		- Check-up of electric or pneumatic starting motor.
		- Check-up of battery charging alternator
		- Change hoses and clamps.
		- Check safety valves in intake manifold
		- Check and clean the intake circuit, from the air filters outlet to the intercooler (*[A]*)
		- Test control and safety devices: temperature and pressure switches and probes
		- Change high voltage wires of the ignition system
		- Recondition turbochargers

Job	Interval	Job Description
R2	22,400 h	- Change complete pistons (Piston, piston rings, pin, circlips)
		- Change cylinder head springs
		- Change cylinder liners
		- Change flexible coupling condition engine-alternator
		- Inspection of elastic suspensions and alignments
		- Check axial and Radial allowance of Crankshaft
		- Check connecting rods
		- Change conrod bearings
		- Change the connecting rod bolts (maximum of 3 retightenings). Mark number of retightenings on the bolt
		- Change thermostats of coolant circuit
		- Recondition water pumps of main coolant circuit
R3	44,800 h	- Engine Overhaul, including its major components and systems:
		Inspection of Cylinder block, change main crankshaft bearing shells, camshaft thrust drive discs and bushings
		Inspection of Crankshaft
		- Inspect camshafts
		- Inspect timing gears and change ball-bearings
		- Recondition oil pump: check gears and change bushings
		- Change crankshaft counterweights fixing screws and washers
		- Change damper
		- Overall inspection and cleaning of coolant, oil, fuel, intake air, exhaust gas, automation systems, wiring.
		- Change turbochargers
		- Change connecting rods
		- Change coils
		- Change engine gaskets

This maintenance program is specified for dry natural gas. The natural gas specifications are detailed in the last version of Product Information Sheet **IC-G-D-30-002e: "Fuel specifications – natural gas"**. Minimum methane number is specified in the Power Rating of the engine for this application. If methane number is less than the specified, consult with KOHLER.	
(*)	For installations where the gas composition is variable, it's recommended to reduce the periods between carburetion adjustments
(*A*)	Make this maintenance job only if the engine has crankcase gases recirculation system

2. ENGINE LONG TERM STORAGE

When a customer has specified in advance that the engine is going to be stored, the instructions contained in Product Information Sheets **IM-C-C-00-001e** (storage for less than 6 months) and **IO-C-M-00-001e** (storage for more than 6 months) apply.

In that case, the engine is supplied perfectly packed and sealed against external agents.

It is however very important that the temperature in the warehouse used for storing the engine should remain at all times above the outside temperature to prevent condensation.

1. MAINTENANCE PROGRAM

The information in this maintenance program is complemented with product information document **IO-G-M-00-060e**, General Maintenance Guidelines for Gas Engines.

KOHLER has developed this maintenance program to ensure optimum performance of your engine. Given that strict adherence to this program will benefit you, it is essential that you follow the instructions detailed in this manual. Failure to do so may not only jeopardize KOHLER's warranty, but also restrict you from obtaining the best performance for equipment.

The maintenance intervals listed in this section do not in any way imply an obligation on behalf of KOHLER, and are given only as a guide to users for maintenance scheduling. Users will take into account operating conditions and demands to determine the maintenance operations that should be carried out more frequently than stated on the schedule. In all cases, the number of hours specified are reasonable limits, which should not be exceeded in order to ensure that the engine works correctly. If the engine maintenance schedule is not adhered to then the warranty of the same may be cancelled. This document and product information document **IO-G-M-00-060e** should be studied carefully before the engine is started up for the first time.

IMPORTANT

The maintenance jobs described below (identified with as an "E" type task) must be regarded as "additive" to each other. Accordingly, the performance of every "E_i" job implies that all previous "E_{i-1}", every time as the frequency indicates it.

This will require the availability of such materials and labour as may be necessary at each stage.

NOTE	Any Check-Inspection may require a corrective operation if the element in question requires one.

1.1. Basic maintenance operations:

NEW ENGINE OR MAJOR SERVICE WORK START-UP MAINTENANCE Jobs to be done during the initial start-up of a new engine or during the break-in phases following major overhauls (change of cylinder liners, pistons, piston rings, cylinder heads,...). They must be carried out by KOHLER authorized Repair Shop.		
Job	**Interval**	**Job Description**
NA	**0 h**	**(Operation before starting up the engine)**
		- General inspection and set-up of the engine

1.2 Daily maintenance:

ROUTINE MAINTENANCE (Type "E") Minor Jobs		
Job	**Interval**	**Job Description**
ED	**24 h**	- Check oil pressure and temperature during the pre-lubrication phase
		- Verify oil heating with the pre-heater
		- Check battery acid level
		- Verify water heating with the pre-heater

1.2.1 Continuous Pre-lubrication

In order to ensure perfect lubrication of all circuits of the engine, it is necessary to operate the pre-lube pump in the correct conditions, see IT-C-A-25-040.

1.2.2 Continuous Pre-heating

In order to guarantee a suitable oil viscosity before the start up of the engine preheating must be used according to instruction IC-C-D-00-008. The use of water preheating improves the engine start conditions, see IC-C-D-00-008.

1.2.3 Battery Charger

The correct function of the battery charger must be checked every day.

1.3 Monthly maintenance

Job	Interval	Job Description
EM	Monthly	**(Operations to be performed with the engine stopped)**
		- Vent the coolant circuit. Check automatic vent valves.
		- Drain condensates out of the exhaust Y-pipe
		- With the dipstick, check for a possible increase of the oil level in the oil pan due to coolant leaks
		- Check the oil level of the pneumatic starter lubricator, if necessary
		- Check battery acid level
		- Clean the engine and its surrounding
		(Operations to be carried out with the engine stabilized)
		- Check coolant level / pressure. Vent circuits.
		- Check oil level / pressure
		- Inspect the air filter plugging level
		- Check oil and coolant temperature
		- Check exhaust gases temperature
		- Record engine parameters on a regular basis
		- Revision of the operational stability and unusual noise
		- Inspect for leaks in fuel, coolant, oil and exhaust gases

1.3.1 Engine Start-up

Every month, the engine must be started and correct performance of the following items should be checked:

- Start-up process and increase in speed.
- Loading of the engine.
- Switch: making and breaking.

The start-up test must be made with a load equal to at least 40% of the engine's rated power. The engine shall run during a minimum of one hour.

These recommendations figure in the ISO 8528-12 standard on standby sets for security duty.

Job	Interval	Job Description
E0	250 h or 6 months	- Analyse waste oil
		- Check and refill additive level in coolant
E1	500 h or once a year	- Change oil KOHLER MOTOROIL (oil sump and cooler)
		- Change oil filters
		- Clean the oil centrifuge filter, film-thickness measurement and change the paper filter
		- Clean the metallic sponge of the oil purifier
		- Measure crankcase pressure
		- Check air/fuel ratio
		- Adjust air/fuel ratio to full load (*), if necessary
		- Inspect the air filters
		- Adjustment of rocker arms and valve lifters. Measure valve height
		- Verify the ignition timing
		- Check battery and starter connections
		- Inspection of high voltage wires of the ignition system
		- Change the filter of crankcase gases recirculation system and clean this circuit (*A*)
E2	1,500 h or 3 years	- Check gas filters
		- Change hoses and clamps.
		- Test thermostats of coolant circuit.
		- Test control and safety devices: temperature and pressure switches and probes
		- Check damper temperature
		- Change air filters
		- Check gaskets in the rocker arm covers
		- Disassemble, clean and adjust all the speed and ignition pick-ups
		- Measure the exhaust back-pressure
		- Change coolant
		- Verify the tightening torque of knocking sensors on stud head (20 Nm)
		- Check axial and Radial allowance of turbochargers

NOTE	- The spark plugs change must be made attending the IO-G-M-33-007 product information. *It is recommended cylinder endoscope revision and compression test when the spark-plug change
	- Ask Kohler to use another oil that it is not KOHLER MOTOROIL.

Job	Interval	Job Description
R1	6,000 h or 12 years	- Recondition cylinder heads.
		- Clean pistons, cylinder liners and cylinder head seating on block
		- Check valves driving system: valve lifters, rocker arms, push-rods, roller rocker arms and cams
		- Measure cylinder liners wear
		- Clean oil sump
		- Check and clean the cooling system. Clean pipe bundles and change gaskets on heat exchanger and coolers
		- Change thermostats of oil(only V engine)
		- Change thermostats of coolant circuit
		- Clean filters of coolant circuit. Change filter cartridge
		- Retighten connections in knocking detection system unit.
		- Check-up of electric or pneumatic starting motor.
		- Check-up of battery charging alternator
		- Check safety valves in intake manifold
		- Change high voltage wires of the ignition system
		- Recondition turbochargers
		- Check and clean the intake circuit, from the air filters outlet to the intercooler (*A*)
		- Change flexible coupling condition engine-alternator
		- Inspection of elastic suspensions and alignments
		- Recondition water pumps of main coolant circuit
		- Change damper

Table title: **Periodic interventions (Type "R")** — major interventions

This maintenance program is specified for dry natural gas. The natural gas specifications are detailed in the last version of Product Information Sheet **IC-G-D-30-002e: "Fuel specifications – natural gas"**. Minimum methane number is specified in the Power Rating of the engine for this application. If methane number is less than the specified, consult with KOHLER.	
(*)	For installations where the gas composition is variable, it's recommended to reduce the periods between carburetion adjustments
(*A*)	Make this maintenance job only if the engine has crankcase gases recirculation system

2. ENGINE LONG TERM STORAGE

When a customer has specified in advance that the engine is going to be stored, the instructions contained in Product Information Sheets **IM-C-C-00-001e** (storage for less than 6 months) and **IO-C-M-00-001e** (storage for more than 6 months) apply.

In that case, the engine is supplied perfectly packed and sealed against external agents.

It is however very important that the temperature in the warehouse used for storing the engine should remain at all times above the outside temperature to prevent condensation.

1. DESCRIPTION

This Product Information document clearly explains an oil monitoring procedure in order to determine oil change intervals for gas-fueled engines whose specifications are defined in Product Information IC-G-D-25-003e and IC-G-D-25-002e.

2. OIL CONSUMPTION

A small amount of lube oil is consumed in the combustion process. In general, oil consumption decreases with the operation of the engine or any rise in temperature. After the first 600 hours of operation, the oil demand should be considered constant. From then on, it is advisable to check the oil consumption, which should be as follow:

Engine	Standard consumption g/kwh	Maximum consumption g/kwh
FGLD/SFGLD/SFGM/HGM 180/240/360/480	0.35	< 0.5
SFGLD 560	0.20	<0.3
SFGM/HGM 420/560	0.15	<0.2

In order to calculate an engine's oil consumption, the following formula applies:

Specific consumption (g/kWh) = [897 x Consumption (liters)] / [Power (kW) x Hours of operation]

3. OIL ANALYSIS

As a reference, Kohler recommends that oil analysis should be conducted as specified in the maintenance instructions in respect of lubricant for use in gas engines.

Product Information sheet IO-C-M-25-001e describes the oil sampling procedure for its subsequent analysis, while document IO-C-M-25-004e deals with the oil change procedure.

NOTE

Changing oil from an engine does not only consist in draining the crankcase and cooler, but it also implies changing the oil filters.

Oil change intervals should not exceed the recommendations (due to the deterioration of the additives), unless there is a careful oil analysis program established. Even in this latter event, however, remember that rather than predicting the exact moment additives will fail, laboratory analyses normally aim at detecting engine malfunctions. It is therefore important to inspect the engine before deciding on any modification of the oil change intervals.

Besides on oil consumption, the useful life of oil is highly dependent upon the thermal and mechanical stress oil is subjected to, the volume of circulating oil, the engine wear and tear, and most importantly the fuel gas composition and quality, since the oil change intervals will vary as a function of the quality of the biogas or biomass gas used as fuel.

With those analyses, wear and tear of the engine can be efficiently monitored and actions taken in order to ensure good performance at a minimum cost, before serious and costly failures occur.

When requesting an oil analysis, always state the type of oil used as well as the time (number of hours) the oil charge has been in service, and the engine specific oil consumption. We recommend the following properties are checked:

- Viscosity
- TBN / TAN
- Oxidation / Nitration
- Water content
- Insoluble substances
- Metals
- Chlorine
- Observations

4. INTERPRETATION OF RESULTS

Oil degrades throughout its useful life due to oxidation, loss of effectiveness of the additives, and pollution by combustion products, fuel, water or solids. This can be checked by reviewing the evolution of the periodical test results.

Those analyses serve to check the oil contamination levels and to detect potential ill performance of oil. The most significant test results may be interpreted in the following manner:

- **Viscosity**

Oil viscosity is a very important feature, since it gives an idea of the working conditions of the oil that coats the bearings with a lubricating film ensuring the lowest friction and leakage.
An increase in oil viscosity is generally attributable to the presence of oxidation products, dirt, insoluble substances or wear elements.

Generally, the established oil change frequency prevents reaching the point where oil can no longer accept any increase in contaminants.

- **TBN**

It is the function of the alkaline additives contained in oil to neutralize the acidic products that develop during combustion (mainly strong sulfuric and nitric acids) as well as weak organic acids resulting from oil oxidation through aging.
TBN is a measure of the oil capacity to neutralize strong acids produced by the fuel combustion. It does not measure the oil alkalinity, but the alkaline reserve of oil or its acid-neutralizing capacity.

A sharp fall of the TBN may occur due to a low consumption of oil, the use of a fuel rich in sulfur or a small volume of the oil pan. Oil with a low TBN does not have enough capacity to neutralize the acids which corrode the engine parts.

- **TAN**

By measuring the oil acidity, it is possible to prejudge and determine the quantity of products of an acidic nature contained in the oil. Such acidic products may originate both in the natural oxidation of oil and in its contamination by sulfur compounds or halogen acids formed during combustion.

- **Chlorine**

Halogenated compounds, if present in the form of acidic components, may prove very harmful to the engine. Given their chemical nature, acids of this type of elements are very aggressive, attack almost all the metallic components of an engine and shorten the working life of lube oil by destroying its reserve of additives.

- **Oxidation / Nitration**

Oxidation is a chemical reaction of oil with oxygen. Oil oxidation can be fought by adding inhibitors, however, it will always develop when oil is mixed with air and it will accelerate under the effect of the combustion gas temperature, contaminants and oxidizing agents. As oxidation grows, the oil loses its lubricating properties and thickens, organic acids build up, forming deposits and gum.

Nitration occurs in all engines, but reaches high levels in natural gas engines. Nitrogen compounds, formed during the combustion, make oil thicken and lose its lubricating properties.

- **Water Content**

The presence of water in oil means there is contamination either through the cooling circuit or due to combustion steam condensation. Any small amount of water - in particular from the cooling system - which has been treated with chemical inhibitors will have a harmful effect on oil. It will bring about a reduction of the oil lubricating capacities and the build up of sludge; also it may induce corrosion.
If Na or B is found in a metals analysis, this means water an/or anti-freeze is present. This will be the case, if water has leaked out of the cooling system. Both sodium silicate and potassium metaborate are typical inhibitors and responsible for introducing Si, K or N and B into oil. Another way of detecting the presence of coolant consists in determining the glycol level in oil.

- **Insoluble Substances**

A check for insoluble substances will indicate if there are carbonaceous matter, powders, wear-induced particles and oxidation products present in oil.
The presence of solids in oil affects the oil detergency and dispersancy, giving rise to a fast-growing tendency of deposit formation in several engine components. Generally, the quantity of insoluble substances is greater when wear intensifies.
A high content of solids leads to an increase in oil viscosity, wear of bearings and moving parts, and clogging of filters.

- **Content of Metallic Particles**

The test includes a measurement of oil-borne metal particles, like:

- Fe: Iron	- Pb: Lead
- Cr: Chromium	- Na: Sodium
- Al: Aluminium	- Sn: Tin
- Cu: Copper	- Si: Silicon

Other elements may be added to the above list. It is essential to compare the test results with previous ones before drawing final conclusions on their meaning.

Metal concentrations in oil are initially low and increase with the operating time of the engine. A sudden rise would mean abnormal wear and operating conditions. Consequently, it is important to take into account not only the metals content but also the engine operating conditions and the mechanical interventions carried out on the engine.

An increase in the content of any metal indicates wear or damage of an engine component. The metal present in oil can identify the engine part concerned. For example:

- An increase in the content of lead and copper should lead to an inspection of the bearings, bushings...
- An increase in the iron content should bring about an inspection both of the cylinder liners and of the timing gears.
- A higher content of aluminium may be caused by an incipient peeling of the piston material.
- The presence of silicon is, generally, due to poor filtering of inlet air; however, in biogas applications, this element originates in the gas fuel itself.

For all those reasons, in determining the oil service life, it will be necessary to implement an analysis program that provides information on the oil performance tendency or specific details on its evolution.

Initially and until the oil change frequency has been fixed, it is advisable to take oil samples for subsequent analysis by a specialist laboratory every 100h. Depending on the test results, sampling intervals may then change. Based on our knowledge and experience, for natural gas fuelled engines, we would recommend sampling oil at least at the oil's half-life and at oil change.

The high limits of acceptability of an oil for natural gas, biogas or biomass gas engines have been established from a database obtained through the use of the lubricant in real operating conditions and tests of waste oil.

These are the properties to be analyzed and their high limits of acceptability:

Property	Oil from natural gas engines	Oil from landfill or digester gas engines
Viscosity	+ - 25%	+ - 25%
TBN	-50% fresh oil	-50% fresh oil
TAN	+2 mgKOH/g fresh oil	+2 mgKOH/g fresh oil
pH	4,5	4,5
Oxidation	20 Abs/cm	20 Abs/cm
Nitration	20 Abs/cm	20 Abs/cm
Water content	Max. 0.5%	Max. 0.5%
Insoluble substances	Max. 1.0%	Max. 1.0%
Metals	Fe<100 ppm Cu<40 ppm Cr<25 ppm Sn< 25ppm Al<20ppm Pb<40ppm Na<40ppm	Fe<100 ppm Cu<40 ppm Cr<25 ppm Sn< 25ppm Al<20ppm Pb<40ppm Na<40ppm
Silicon	Si< 30 ppm	Si<75, provided it comes from the gas *.
Chlorine		< 800 ppm

* Reaching this limit before the time interval specified in the oil servicing Instruction Sheet will probably be due to a poor quality of the gas.

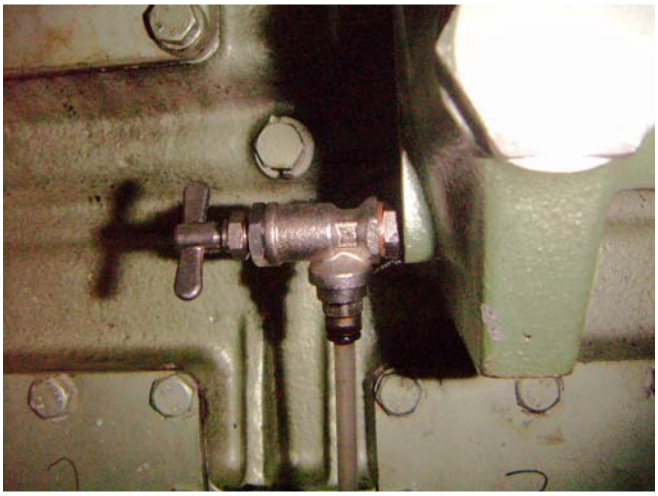
The frequency of analysis and the test results determine the oil changing requirements in each individual case. When altering the oil change intervals, bear in mind not only the test results, but also the engine condition and operating temperature. If oil and water temperatures are kept within the manufacturer-specified range, in particular during lengthy periods of operation at low load, the probability of corrosive vapor condensation will be minimized. This, in turn, will reduce the TBN depletion rate and consequently increase the time oil can be used.

1. OBJECT

This Product Information sheet clearly specifies a procedure for collecting oil samples from all Kohler engines, for their subsequent analyses.

2. SAMPLING ROCEDURE

- The oil sample for analysis must be representative of the entire operating load. Therefore, always do the sampling when oil is circulating in the engine, since this ensures product homogenization.
- When collecting oil, take great care to avoid external contamination. In particular, check that the sample containers are perfectly clean and dry.
- You may sample oil during an oil change, but bear in mind that you should not take samples at the beginning or end of the oil sump draining process.
- To take samples for analysing the oil condition when there is a sampling valve (unit ref. 31.25.920) available, remove the cap from the sampling valve.
- Where there is no such sampling valve available, we recommend sampling on a pressure oil line or, failing this, direct from the oil sump.
- NEVER take samples from the first jet of oil coming out when you open the sampling valve; always drain about 400ml of oil to eliminate any contaminating residues present in the circuit. When done, reset the valve cap.
- Finally, stick a label on the sample, stating all the relevant data: date, engine, type of oil, operating time of engine, operating time of oil, engine oil consumption.



In-line engines

V-engines

KOHLER ENGINE OIL CHANGE INSTRUCTIONS

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1. INTRODUCTION

The useful life of a lube oil charge depends on many and varied factors. Determinants are the oil working time, engine oil consumption, type and grade of fuel, volume of circulating oil, lubricant quality, engine condition, oil temperature, etc.

Oil change frequencies should not exceed the recommendations (due to the degradation of the additives) unless a careful oil analysis programme is previously implemented. But, even in this event, remember that lab analysis are normally intended to detect troubles with the engine, rather than predicting the exact time additives will fail. It is therefore important to inspect the engine before making a decision of modifying the oil change intervals.

Accordingly, when determining the oil life, it is necessary to make a series of analysis in order to obtain information on the oil performance tendency or specific details on its evolution.

Changing the oil charge must be made either in accordance with the maintenance instructions for each type of engine and application or when the values of the tested parameters have reached their maximum permissible limits as specified in the oil maintenance instructions in respect of each application, or else when the operating conditions require that oil be changed before the limit values are reached.

Check the sump oil level daily to detect possible contamination by water or fuel and to make yourself an idea of the oil condition.

If this visual inspection reveals that oil on the dipstick has lost consistency, flows quickly, is muddy, milky or thick, then oil must be changed.

Changing the oil of an engine is not limited to draining oil from the sump and cooler, but also implies changing the oil filters.

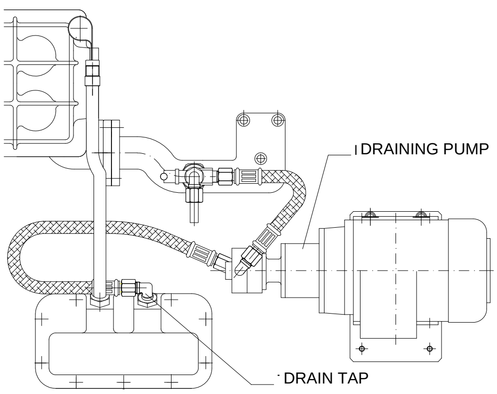
2. OIL CHANGE PROCEDURE

The oil change procedure is identical for all types of engines and must always be performed after stopping the engine, with the oil still hot, since in this state, oil drains better and faster.

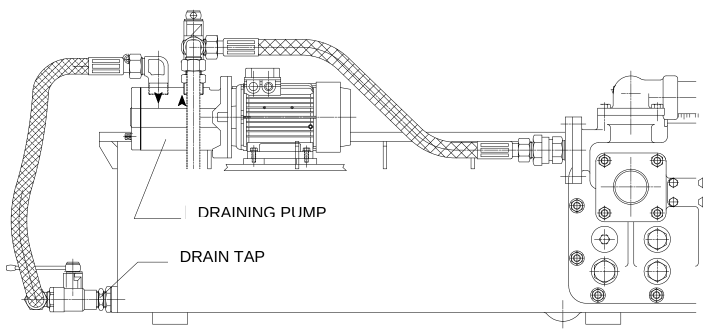
Procedure:

1. Drain the sump. To do so, open the oil sump drain plug or use a draining pump.

   If the engine incorporates a the pre-lubricating pump, you can use it as a draining pump.



Line Engine



V Engine

It is essential that the amount of oil which remains in the sump be as small as possible, since the useful life of the next oil charge may be shortened due to the presence and quality of this oil quantity.

CAUTION

Contact with hot oil may cause severe burns.

2. Open the drain plug of the oil cooler and remove the waste oil. Make sure the cooler body is drained.
3. Clean the oil sump through the inspection cover provided for this purpose on one side of the sump.

CAUTION

Do not use any cleaning product likely to leave residues.

4. Set and tighten the drain plugs thoroughly.

5. Now, through the filling plug pour new oil, according to Kohler specifications, until the oil level is **two centimetres** above the maximum limit on the dipstick.

6. Perform a pre-lubrication cycle, idle the engine and check that the oil level is between the maximum and minimum marks on the dipstick.

7. Inspect for possible oil leakage in the engine.

8. Check the oil level every day. With the engine at rest and cold oil, the level must reach the maximum mark on the dipstick. When the engine is idling, the level must be within the max. and min. marks on the dipstick. If necessary, add oil as per Kohler specification for each application.

On engines with an automatic oil level controller, oil makeup is continuous.

WARNING

Dispose of waste oil in a controlled manner in compliance with the prevailing legislation on waste oil collection and management.

We do not recommend adding extra additives because the oils used in Kohler engines have been formulated and produced with state-of-the-art technology so that nothing need be added to the original formulation. Besides, the use of additives other than those contained in a given oil is likely to modify its balance, resulting in an unfavourable performance of oil.

If you cannot use any of the recommended types of oil for the application concerned, you should consult

Kohler before choosing another type of oil.

3. CHANGING OF THE OIL FILTER CARTRIDGE

The oil filter cartridges must be replaced each time you **change oil** in the engine or when the filters are clogged, a condition that generates such a low oil pressure in the gallery that the oil pressure alarm is near the setting value.

To dismount the filter:

1. unscrew the filter body with your hand or with the special-purpose spanner;
2. make sure the old gasket comes out with the filter cartridge..

Mounting the filter:

1. Oil the gasket.
2. Screw on the filter and tighten it slightly. Once the filter is in contact with the sealing gasket, give it 3/4 of a turn.
3. Start the engine and check the filter tightness.
4. Tighten further where applicable.

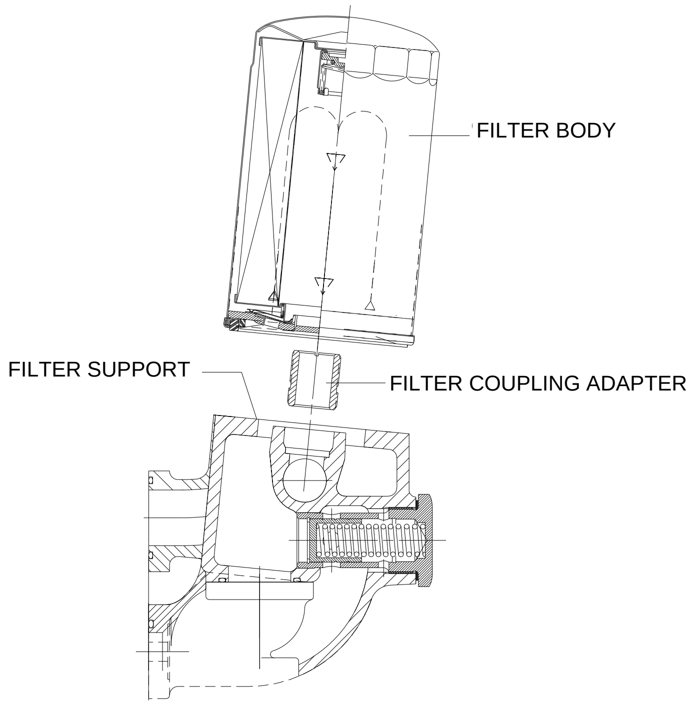


Fig. 1 - Oil filter

1. CLEANING OF FILTER

After stopping the engine completely or isolating the filter from the lubrication system by means of a valve:

1.1. Loosen and remove clamp (*8*).

1.2. Remove the cover and check the top bearing for wear or damage. Check the O-ring (*17*) and replace it if necessary.

1.3. Lift the rotor unit and allow oil to flow out through the nozzles before removing the rotor from the filter body. Hold the rotor body securely and back off the rotor nut (*15*). Separate the rotor cover from its body and remove the central support tube (*9-11*).

1.4. If there is a sheet of paper at the bottom of the rotor, remove it, since it contains accumulated impurities. If there is no sheet of paper, remove sludge from the rotor inside with a wooden spatula or an adequate wooden object and clean the interior of the rotor with a cloth. Put a new filtering paper (*14*).

1.5 Clean the nozzles with a bronze wire to verify that oil can circulate freely. Make sure the inside of the shaft is free from impurities. Check the shaft bearings for damage and excessive wear. Check the O-ring (*12*) and replace it if necessary.

1.6. Clean and wash the central support tube and make sure the filter holes are unobstructed.

1.7. Re-assemble the whole rotor and torque the nut (*15*) to 9.5 to 10.8 Nm (1 to 1.10 kg).

1.8. Check the bottom bearings housed in the filter body for wear or damage.

1.9. Remove the cap of the shutoff valve (*3*) and take out the whole unit. Verify that the spring and valve are not damaged and move freely. Inspect the seal (*4*) for good condition. Replace it if necessary.

1.10. Re-assemble the shutoff valve.

1.11. Re-assemble the whole filter, check for free rotation of the rotor unit and then place the filter cover and fix it with the clamp.

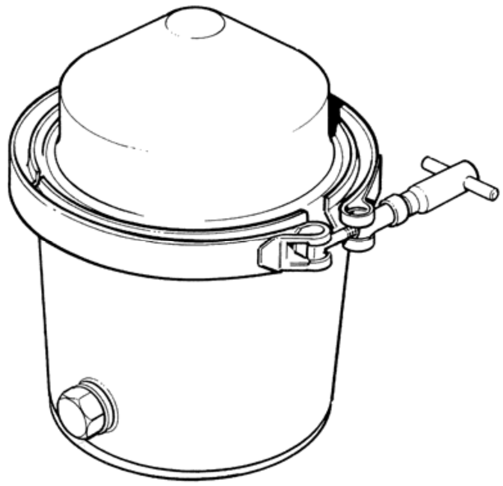


Fig. 1 - Centrifugal filter

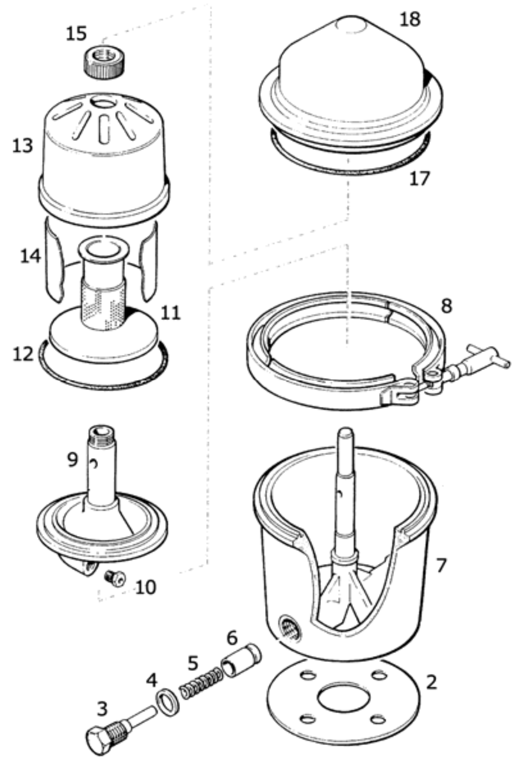


Fig. 2 - Quartering

1. MAINTENANCE OF THE RECIRCULATION SYSTEM

Maintaining the crankcase gas recirculation system basically consists in changing the filtering cartridge, inspecting the installation and performing the start-up procedure after changing the cartridge.

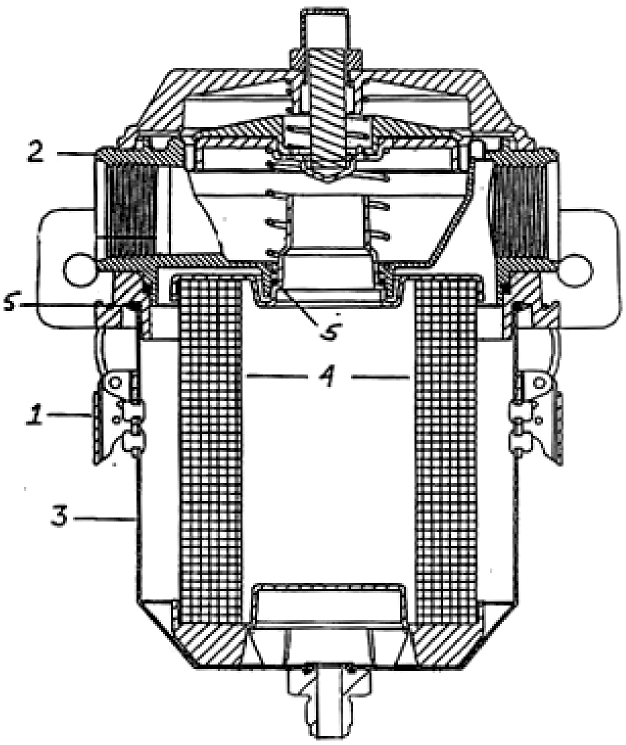
The filtering cartridges must be changed when the hours of operation specified in the maintenance guidelines have been reached or when the filter is clogged (the red indicator at the top of the filter being completely extended), whichever first occurs.

NOTE

Make sure you use spare filtering cartridges of model reference: .

Check to see that, with the cartridge, you receive one O-ring for the top of the filter cartridge and another for the upper part of the body.

1.1. Changing the filtering cartridge



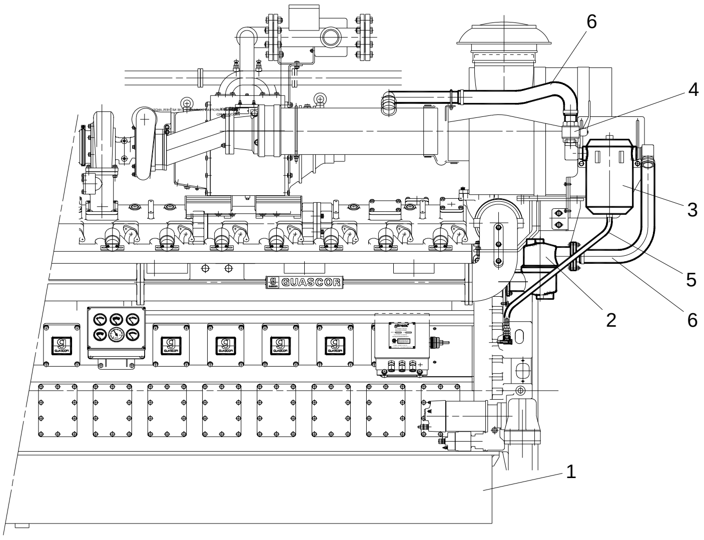
- Release the 4 filtering cartridge locks (1).
- Pull the lower body (3) slightly downwards and the upper body (2) upwards to separate them. Take care of possible oil splashing.
- Remove the waste filtering cartridge (4) pulling downwards smoothly; again oil splashing may occur.
- Remove the O-ring (5) from the top of the external body of the filter and set a new one.
- Set another O-ring (5) into the upper body and the new filtering cartridge in the same position as the used one was.
- Slightly push the new cartridge upwards for a perfect fit into its housing.
- Replace the external body of the filter, taking care that the locks match.
- Tighten the locks, fastening all the parts together.

1.2. Inspecting the installation

- Detach the hose clamps and wash any oil condensate and water out of the hose.
- Clean the pressure control valve.

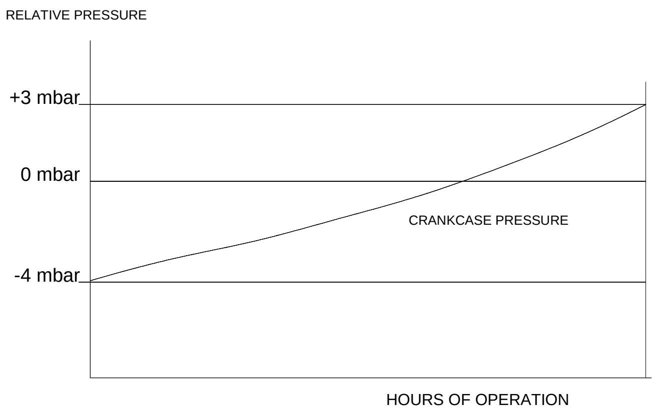
1.3. Performing the start-up procedure

- Carry out the operations of a normal start-up (see IT-C-A-25-024e). If the red indicator is fully extended, push it down with your finger, before starting the engine.
- Record the crankcase pressure with the engine on load and the time (number of hours of operation) for the next filter change. Set the control valve at an initial crankcase pressure of minus 4mbar. This valve shall not be readjusted until the filtering cartridge is changed again; therefore, we recommend removing its operating lever.



1	Crankcase	4	Pressure control valve
2	Blow-by gas breather	5	Oil return line
3	Gas recirculation filter	6	Connecting hoses

The graph below shows the crankcase pressure variation in relation to the hours of operation of the filtering cartridge.



2. TROUBLESHOOTING

At times, the filter clogging indicator will rise when starting the engine after a certain period shut down. This occurs because the cooling of oil in the outside of the filter leads to an increase in head losses. Once warm, oil drips and the system operates correctly again.

To check that the filter works alright, remove the cap from the indicator and push the indicator downwards with your finger, when the engine has warmed up. If the indicator does not rise again, the filter is in good condition. If after pushing the indicator down, it rises again, change the filtering cartridge even if the specified hours of operation for maintenance have not been reached.

When the engine is fitted with a crankcase gas recirculation system, it is advisable to measure the crankcase pressure periodically (every 200 hours). This pressure, being indicative of the balance between the amount of engine-generated blow-by gas and the exhausted quantity, may denote the occurrence of a failure.

The following table shows the relation between the crankcase pressure and the engine components, suggesting corrective actions.

Crankcase pressure	**CAUSE**	**ACTIONS**
from –4 to +3 mbar	System ok. Pressure varies from -4 to +3 mbar in time	None
Greater than +3 mbar	Filter clogged. Possible high blow-by (rings and liners)	Check clogging indicator. Change filtering cartridge. Check to see if the valve has been closed by mistake. Inspect the pipeline of the system to detect any plug or undesired throttling of the gas flow. Measure the crankcase pressure level, after disconnecting the recirculation system, i.e. at atmospheric pressure (by opening the oil filling plug). See IT-C-A-25-016.
Less than –4 mbar	Pressure control valve wide open. High exhaust of blow-by gases.	Check the valve condition. Check the air filters for good condition.
Many fluctuations	Condensate build-up in the system.	Make sure the entire run of pipes of the system is free from spots where condensates could gather. Verify if the hoses of the system are subject to excessive ventilation, leading to large amounts of condensate developing in the hoses. If yes, lag the cold spots.

CLEANING THE OIL SEPARATOR FILTER OF THE CRANKCASE GAS BREATHER

O&M_2.002262.810_10_2016

1. DISASSEMBLY

Follow the instructions referring to Figure 1 that shows the different parts of the crankcase gas breather.

1. Remove the bolts and nuts nº10 & 4, taking care that the O-ring nº8 does not fall out.
2. Separate the hose from the upper body.
3. Undo nut nº6 and remove washer nº7. Next, detach the lower body nº1 from the upper body nº5, taking care that the O-ring nº2 does not fall out.

2. CLEANING AND INSPECTION

1. Remove wire mesh nº3 from its housing and clean it with a solution of water, detergent and rust-preventer, eliminating all accumulated dirt and residues. If the wire mesh is badly damaged, change it.
2. Clean bodies nº 1 & 5 and check to see if the O-rings nº2 & 8 are in perfect condition, flexible and free from cracks. Otherwise, fit new O-rings.

3. ASSEMBLY

1. Set O-ring nº2 in its seat on lower body nº1. Next, set wire mesh nº3 surrounding the stud that lies inside the lower body nº1.
2. Fit the upper body nº5 onto the lower body nº1, fixing them with washer nº7 and nut nº6. Take care that the O-ring does not come off its seat.
3. Connect the outlet of upper body nº5 to discharge pipe nº9, fitting O-ring nº8 in-between and fastening them with bolts nº4 and nuts nº 10.

4. CHECK FOR LEAKS

1. After starting the system, check there are no leaks; if there are, repair them.

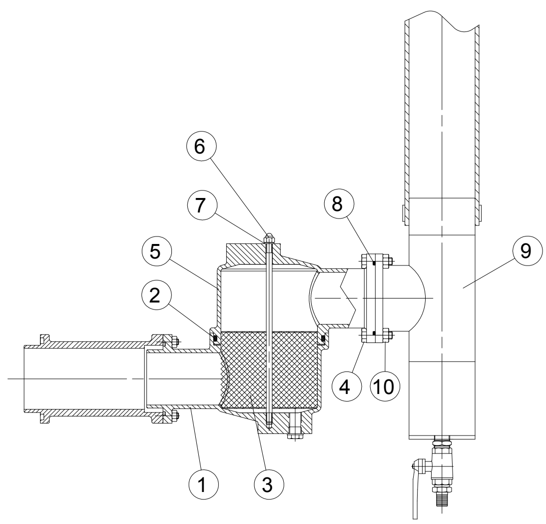


Fig. 1 – Crankcase Gas Breather

5. ALTERNATIVE FOR FV GAS ENGINES

In cases where the upper body nº5 cannot be removed, due to interference with the air filter bracket (gas FV engines), remove the full gas vent and follow the instructions in point 1 to open it and then clean the metal mesh following the instructions in point 2.

Loosen the nuts on the cap and remove the complete assembly to open it

Photo. 1 – Crankcase Gas Breather

Once the outside of the engine has been cleaned, mount the gas breather assembly as per instructions in point 3 before mounting the entire assembly on the engine.

KOHLER Powered by DRESSER-RAND	PRODUCT INFORMATION	INDEX	DATE	
	IO-C-M-00-006e	A	*February 2012*	*Dep.2*

KOHLER ENGINE
CYLINDER COMPRESSION TEST

O&M_2.002262.810_10_2016

1. AIM

For a correct measurement, you will need both the special tool that fits into the injector or spark plug hole and a pressure gauge, which is a commercial product (Moto Meter, Facom, etc.), adapting to the said tool.

Whenever you measure the compression pressure of one cylinder, always check all the remaining cylinders as well. If the fault diagnostic indicates that only one cylinder should be compression-tested, then you can perform the test, by removing the spark plug from the cylinder and operating the starter motor without turning on ignition.

Compression pressure gauge

Compression pressure recording card

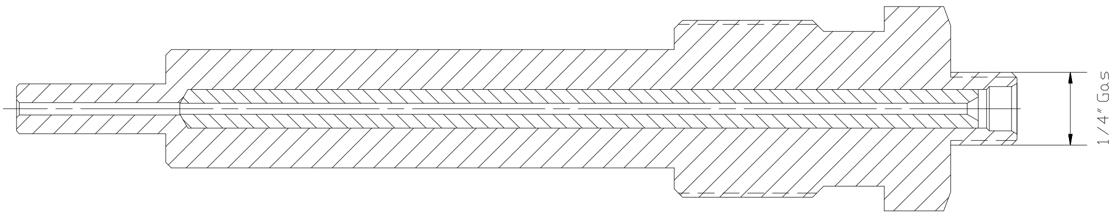
2. TEST PROCEDURE

Before starting the test, make sure the engine is warm and

- Diesel and Dual Fuel Engines: all the injection pipes are loose and all the rocker covers removed, thus preventing the engine from starting while measuring the pressure. Moreover, cut off the fuel supply.
- Gas and Ethanol Engines: disconnect all of spark plug wires, so that the engine will not start while checking the compression pressure. For safety's sake, close the gas supply valve and disable the ignition system. Also, remove all the spark plugs, so the engine can rotate easily.

Next, do the following:

- Diesel and Dual Fuel Engines: Insert the tool (Kohler ref.: 19.75.065) with a copper washer in the place of the jet, to ensure adequate cylinder sealing.



Special tool - Kohler
Ref.: 16.75.065

Gas and Ethanol Engines: Insert the tool (Kohler ref.: 19.75.014) with a copper washer in the place of the spark plug, to ensure adequate cylinder sealing (Fig. 1).

RG ¼” – 19 threads

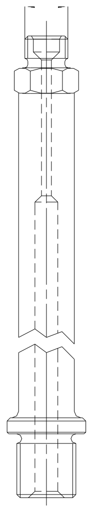


Fig.1 - Special tool - Kohler Ref.: 19.75.014

Mount the compression pressure gauge on the tool in the cylinder.

- Rotate the engine with the starter, until the line marking on the pressure-recording card stops (normally this takes 4 to 6 seconds). If unsure, repeat this step. We recommend writing down the number of the cylinder tested.

- Press the discharge valve of the pressure gauge until the pointer indicates zero.

- Test the remaining cylinders similarly, in correlative order.

ATTENTION

The table below shows compression test values for Kohler engines: These values are for guidance only, since compression checks differ if performed on a hot or cold engine; therefore what really matters is the reading variation among all the cylinders. So, if the compression pressure difference of one cylinder is 2-3 kg/cm^2 lower than for the rest of cylinders, then this cylinder needs servicing.

GAS ENGINES	LCR	12-15 kg/cm^2
	FGLD	14-18 kg/cm^2
	SFGLD	
	SFGM	21-24 kg/cm^2
	HGM	
ETHANOL	SFE	14-18 kg/cm^2
DIESEL DUALFUEL ENGINES	TA Y TAB	19-23 kg/cm^2
	F180	

Pay special attention to the starter motor, to prevent overheating after a number of operations. Also, ensure that the rotational speed is similar, during the test.

3. CONDITIONS CAUSING LOW ENGINE COMPRESSION

The following conditions principally can cause low engine compression:

- Scratched liner; which also implies high oil consumption
- Damaged rings
- Insufficient valve-to-seat sealing due to:
  - dirt between valve head and seat;
  - abnormal wear of the seat caused by worn / stuck valve guide / rod;
  - deposits resulting from combustion problems.

1. INTRODUCTION

Changing spark plugs correctly is extremely important, because otherwise ignition failure would take place, affecting the performance of the engine or influencing the engine overhaul routine.

This document thus describes the basic procedure for changing spark plugs in conformity with Kohler recommendations.

2. PRELIMINARY CHECKS

Before installing a new set of spark plugs in an engine, check the following points:

- The spark plugs you are going to install are those specified by Kohler for the application concerned.
- You have the appropriate tools, i.e. socket wrench, torque wrench.
- Handling of the parts was correct, no hitting or fall having occurred, which would have damaged the new elements.
- Each plug has been visually checked and found free from imperfections and mill defects which could impair its proper operation. You can measure and adjust only some of the Kohler -referenced spark plugs. In particular, the spark gap will be measured against the values tabulated below, using thickness gauges (in the event of one-electrode spark plugs) and a special gap setting tool ref. 19.75.016 (in the event of four-electrode spark plugs).

ATTENTION

It may happen that the actual spark gap differs from the specified value even on new spark plugs. In this event, adjust the gap with the special tool by separating or approaching the electrodes. Refer to Kohler for spark gap for each spark plug.

3. CHANGING THE SPARK PLUGS

Having completed the above preliminary checks, change the spark plugs of the engine according to the following steps:

1. Stop the engine, then disconnect all the wires of the secondary, taking care to soil the Teflon section of the same as little as possible and clean this section with an absorbent degreasing paper if stained with oil or any other substance. Check for electric continuity of any wire suspected of being damaged. If any of the wires is so damaged or soiled that it would not operate correctly, change it for a new one.

WARNING

Under certain circumstances, the failure of a spark plug to operate properly may be due to problems with the wire: either dirt on the wire deviates the spark to earth or the wire contacts are cracked or sulphated, impeding the electric potential to reach the spark plug.

2. Remove the used spark plugs from the engine with a socket wrench.

3. Insert the new spark plugs (dry, without MOLIKOTE) into their housings in the engine, avoiding as far as possible to touch the ceramic portion of the same and remove any residual dirt from the surface of this portion, using an absorbent paper. You can start screwing on the spark plugs manually, making sure the washer is correctly placed in its seat. Finally, use the torque wrench to fasten the spark plug to the appropriate nominal tightening torque, i.e. 4.8kgm.

4. Reconnect the wires of the secondary to the spark plugs, using light pressure to click them in place. Now, you can restart the engine.

5. To prevent the formation of corrosion or sulphation, apply silicone grease onto the connectors and terminals, which prevents moisture from getting in. Such types of grease include: Dow Corning DC-4, G.E. G-623 or GC Electronics Z5. Also apply a small amount of grease onto the wire connector and coil.

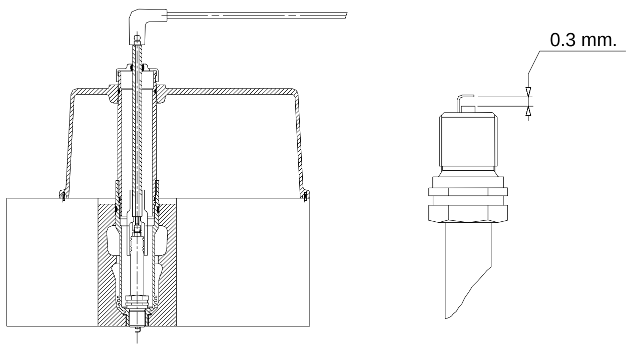


Fig.1 - Disposición de Bujía de un electrodo.

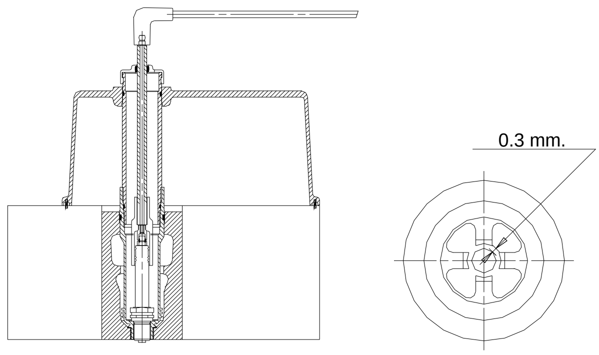


Fig.2 - Disposición de Bujía de 4 electrodos.

5. VISUAL INSPECTION OF THE SPARK PLUG CONDITION

ID	CONDITION	POSSIBLE CAUSE
1	Small deposits of white ashes on the electrodes	NORMAL
2	Electrodes or casing fused	PREMATURE DETONATION OR IGNITION (Possible faulty carburetion, ignition timing or poor quality of the gas used)
3	Orange-colour residues on spark plug end	ANTIFREEZE RESIDUES (Possible entry of cooling water into the chamber)
4	Granular red deposits on insulator or spark plug end	IRON OXIDE DEPOSITS
5	White-yellowish deposits on the electrodes	SILICON DIOXIDE DEPOSITS (Possible content of silicon in the fuel gas or intake air)
6	Rough white deposits on spark plug end	DEPOSITS OF CALCIUM OR BARIUM (These elements normally proceed from oil, but calcium also exists in water)
7	Hard whitish deposits on the spark plug	DEPOSITS OF BURNT OIL (Possible wear or scratching of cyl. liner and/or piston rings. Generally associated with high blow-by)
8	Black specks on the spark plug end	CINDER DEPOSITS (Probably due to incomplete combustion or problems with oil in the chamber)

In many occasions, the forming of those deposits on the spark plugs is associated with the contamination of a given motor oil component. It is therefore recommended that oil analysis should be made in order to determine the oil components out of tolerance.

ID	Representative oil component	ID	Representative oil component
1	Normal oil	5	Silicon
2	Aluminium	6	Water
3	Water, glycol	7	Total solids, iron
4	Iron	8	Total solids, iron

When detecting any of the above mentioned conditions, eliminate the root cause before installing a new spark plug.

CONVENTIONAL SPARK PLUG REPLACEMENT CRITERIA IN GAS ENGINES

O&M_2.002262.810_10_2016

1. INTRODUCTION

This document describes the various methods for detecting spark plug failure to set usable criteria for determining when the spark plugs in the engine should be replaced.

2. SCOPE OF APPLICATION

Fuel:	Gas
Spark plugs:	Spark plugs without prechamber (4 electrodes, J-type, circular electrode, etc). See IO-G-M-33-007e: Spark plug maintenance. Overview.

Coils:
High voltage ignition leads:
Extenders:

Any change to the spark plug, wire or coil may involve a change to the values used in this document.

Either criterion can be used depending on the engine's ignition system.

3. USE OF THE CPU 95 IGNITION UNIT DIAGNOSIS CAPABILITY

There are values in the CPU 95 for the voltage needed to produce a spark in each of the engine's spark plugs with a dimensionless number called the "spark plug reference voltage." Its usefulness lies in how it changes according to spark plug wear.

The reference values in the CPU95 increase as the electrodes wear. High values mean greater electrode wear. These values can be used as a reference to determine when the spark plugs fail.

The "spark plug reference voltage" value has an initial value which basically depends on the coil used, but may also vary according to the types of wires and spark plugs.

This value is typically about 100 when the spark plug is new and increases as the spark plug wears (its gap growing wider). This "spark plug reference voltage" increases slowly to values of nearly 130 – 135, above which the spark loses consistency, causing misfiring in the engine.

There is a maximum CAVG (average cylinder value) value above which the CPU 95 issues a HI SPARK VOLT warning to replace the spark plugs.

There are other limits in the CPU-95 for detecting problems in a specific cylinder:

- Minimum CAVG (average cylinder value) limit: most probably due to a short circuit in the spark plug (centre electrode and ground joined). In this case, readjust the gap.

- Difference between the EAVG (average engine value) and CAVG (average cylinder value) readings. If the difference is much less than the EAVG value, this may be due to a short circuit in the spark plug in that cylinder. If the difference is greater, this may be the result of too large a gap or a fault in the spark plug lead. In the event of a fault in the spark plug, readjust the gap or change the spark plug. If the fault is in the spark plug lead, replace the lead.

The values set in the CPU-95 unit program for the engines to which this document applies are:

Energy level: E3

Minimum CAVG value: 90

Maximum CAVG value of the high voltage level in the secondary circuit: 130 (alarm on display: HI SPARK VOLT).

Limit CAVG value setting for detecting an ignition failure in the secondary circuit: 135 (alarm on display: NO SEC. SPARK).

Maximum CAVG-EAVG difference: 15

Maximum EAVG-CAVG difference: 15

The remaining values that refer to changes in energy levels are not necessary, since the system does not use them.

4. USE OF THE GIS IGNITION UNIT DIAGNOSIS CAPABILITY

The GIS ignition unit has secondary voltage values (kV) which are used to determine if the spark plugs are reaching the end of their service life. The secondary voltage value increases as the spark plug gap increases and greater electric arc to generate the ignition spark is required.

The limit values may vary in different engines.

Fig. 1 - Secondary voltage values on the GIS ignition unit screen

5. USE OF THE GCS UNIT DIAGNOSIS CAPABILITY

The GCS unit displays estimated secondary voltage values (kV) for determining if the spark plugs are reaching the end of their service life. The secondary voltage value increases as the spark plug gap increases and a greater electrical arc is needed to generate the ignition spark.

The limit values may vary in different engines. If the values are near to 30 – 35 kV, this means that the spark plugs must soon be changed.

If the engine is misfiring and the estimated secondary voltage value in a cylinder is very high or very low, this may mean an ignition failure (in some cases a spark plug failure).

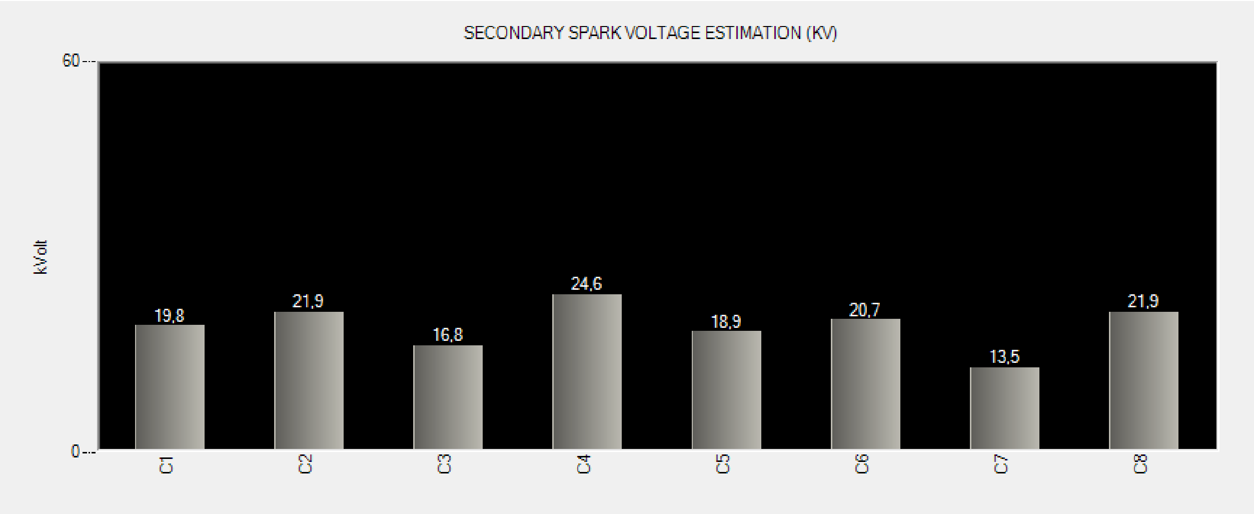


Fig. 2 - Secondary voltage values on the GCS unit screen.

6. USE OF EXHAUST TEMPERATURES PER CYLINDER

After a stoppage due to engine misfire, measuring the exhaust temperature of each cylinder can reveal which one is failing. A much lower temperature than the rest of the cylinders and a much lower temperature for the cylinder than when in normal operation means a combustion failure.

In some cases the failure is due to an ignition failure and, more specifically, to the spark plug.

This method is recommended for engines with exhaust thermocouples on each cylinder. On engines without these, the exhaust temperature for each cylinder can be measured with a potable laser thermometer.

KOHLER® Powered by DRESSER-RAND®

PRODUCT INFORMATION	INDEX	DATE	
IM-G-C-33-001e	**D**	*June 2013*	*Dep.2*

CONVENTIONAL SPARK PLUG INSTALLATION INSTRUCTIONS

O&M_2.002262.810_10_2016

1. FITTING THE SPARK PLUGS

This document describes the basic procedure for fitting spark plugs and connectors in conformity with the criteria established by Kohler.

1. To prevent the formation of corrosion or sulphation, apply silicone grease onto the connectors and terminals, which prevents moisture from getting in. Such types of grease include: Dow Corning DC-4, G.E. G-623 or GC Electronics Z5. Also apply a small amount of grease onto the wire connector and coil.

2. You can measure and adjust the spark plug gap of some of the Kohler - referenced spark plugs. Check the spark gap for each spark plug reference.

- Measure the spark plug gap using thickness gauges.

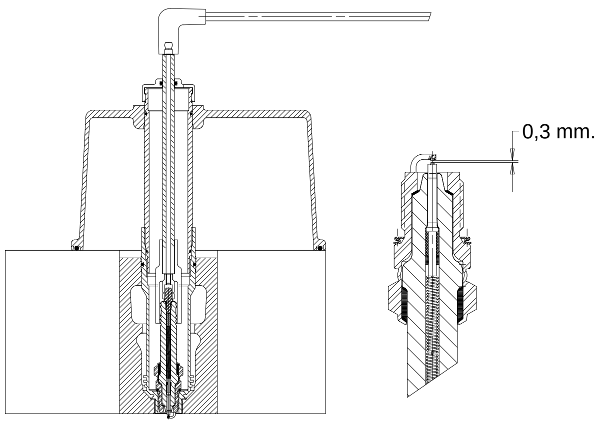


Fig.1: *Example:* 0.3mm gap 1-electrode spark plug

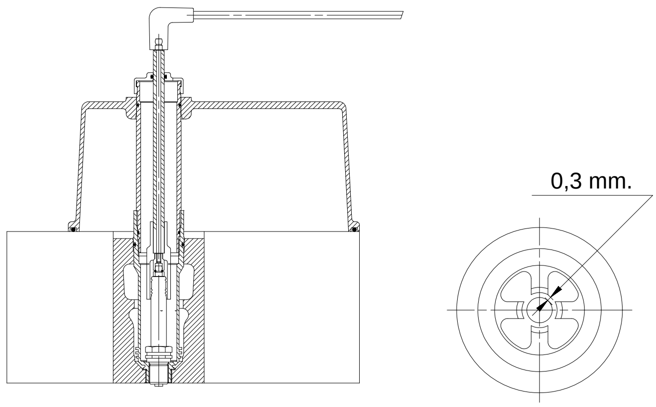


Fig.2: Example: 4-electrode spark plug.

2. In the case of four-electrode spark plugs, a special spark gap setting tool as shown in figure 3 ref. 19.75.016 is used.

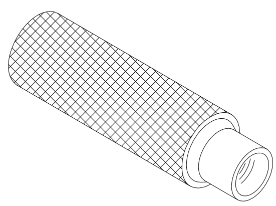


Fig. 3

3. The tightening torque should be 4.8 Kgm.

1. INTRODUCTION

This Product Information Sheet aims to establish a procedure for checking Kohler gas engine ignition components, namely the ignition coils and spark plug wires.

The coils and spark plug wires are the following::

Coils:
Spark plug wires:

A quick coupling system is very easy to fit, but is subject to oxidation/sulfation in the contact area between coil and high-voltage wire.

A screwed coupling system is not so easy to fit as a quick coupling, but it ensures improved ignition due to a stronger electrical connection.

2. COILS

The ignition coil is an electric transformer that transforms a low voltage into a high voltage impulse. The coil is a component of the engine that barely needs any maintenance. In case of failure, it is necessary to change the coil for a new one, since it is beyond repair.

Checking consists in measuring the resistance of the primary and secondary windings with a multitester before fitting the coils into the engine. For references and , **resistance must be in the range of 0.3 to 0.9 Ω for the primary and between 4 and 8 kΩ for the secondary winding.** With reference , **the value of the primary winding must be in the range of 0.45-0.65Ω and the secondary winding must lie between 9 and 11 kΩ**The photos show how to measure resistance properly, indicating its value as an example. We do not recommend making this test on coils already fitted in the engine.

When checking the coils, sulphated compounds may develop and must be removed.

Fig. 1 - Measuring the resistance of the primary winding of an ignition coil ref. 76.64.302

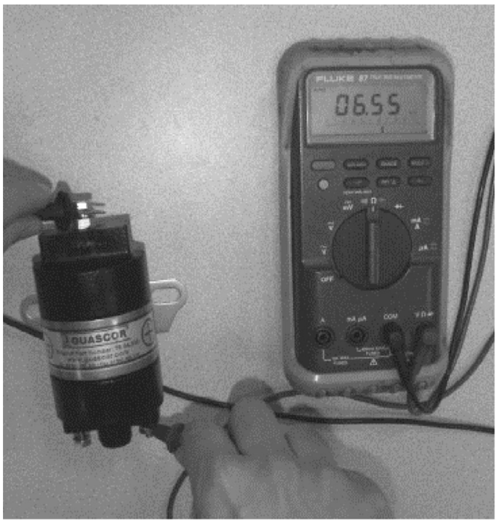


Fig. 2 - Measuring the resistance of the secondary winding of an ignition coil ref. 76.64.302

3. SPARK PLUG WIRES

The high voltage or spark plug wire conveys the high-voltage impulse produced by the coil to the spark plug. The spark plug generates the spark between its electrodes. For proper operation, the contacts between the high-voltage wire from the coil and the high-voltage wire to the spark plug must be perfect.

During the inspection according to the maintenance guidelines, check the following before fitting new wires into the engine:

- The condition of the connection between the high voltage wire and the coil, removing sulphated compounds if any.
- The tightening torque of the coil fixing screws in the event of a screwed coupling.
- **The resistance of the high voltage wire is 5kΩ; therefore, it must be in the range of 4 to 6kΩ**. Otherwise, change the wire for a new one.

Fig. 3 - Measuring the resistance of a spark plug wire ref. 76.64.303

MAINTENANCE OF SPARK PLUGS. OVERVIEW

O&M_2.002262.810_10_2016

1. INTRODUCTION

This document establishes the maintenance intervals for the spark plugs fitted into the different KOHLER engines.

It is worth reminding that spark plug performance, like the behaviour of other components, depends on a number of factors, including without limitation:

- Engine duty
- Full load running time
- Full rate running time
- Fuel quality

Accordingly, it is hard to specify a rigorous number of hours a spark plug can be in service before needing replacement.

Average intervals stated below shall by no means commit Kohlerto any liability. They are provided only as a guide to the servicing needs. According to the operating conditions, requirements, and fuel properties, user has to define whether replacing the spark plugs is necessary before or after the working times suggested in this document.

2. OPERATIONS SIMULTANEOUS WITH SPARK PLUG REPLACEMENT

Changing spark plugs will take place at the same time as other operations, namely:

- Boroscoping of cylinders to check for absence of polish, scratch, unusual coloration or deposits on the components of the combustion chamber (liner, cylinder head, valves, pistons and piston rings).

- Check of cylinder compression.

- Inspection of high voltage wires of the ignition system and replacement if necessary. See IO-G-M-33-003.

- Verification and cleaning of the spark plug extender (for engines with the coil on the rocker arm cover - ignition system defined for explosive environments).

3. GUIDELINES ON SPARK PLUG REPLACEMENT

		1200rpm		1500rpm		1800rpm	
	REF	HOURS	REFERENCE DOCUMENT	HOURS	REFERENCE DOCUMENT	HOURS	REFERENCE DOCUMENT
FG/ FGLD natural gas				1250	IO-G-M-00-073	1000	IO-G-M-00-074
				5000		4000	
FG/ FGLD biogas (*)				1250	IO-G-M-00-073	1000	IO-G-M-00-074
				5000		4000	
SFGLD natural gas		4500	IO-G-M-00-067	3750	IO-G-M-00-065	3000	IO-G-M-00-066
SFGLD natural gas ISLAND		7500	IO-G-M-00-057	6000	IO-G-M-00-038	4500	IO-G-M-00-058
SFGLD natural gas PRIME						1000	IO-G-M-00-061
SFGLD natural gas STAND-BY						1000	IO-G-M-00-019
SFGLD biogas (*)		1250	IO-G-M-00-067	1000	IO-G-M-00-065	1000	IO-G-M-00-066
		4500		3750		3000	
SFGLD natural gas LCR 9,3:1		2500	IO-G-M-00-034	2000	IO-G-M-00-024	1600	IO-G-M-00-035
		5000		4000		3200	
SFGLD natural gas LCR 9,3:1 ISLAND				2500	IO-G-M-00-079	2000	IO-G-M-00-078
				7500		6000	
SFGLD natural gas LCR 8:1				2000	IO-G-M-00-024	1600	IO-G-M-00-035
SFGLD natural gas LCR 8:1 ISLAND				2500	IO-G-M-00-079	2000	IO-G-M-00-078
SFGLD syngas (**)		800	IO-G-M-00-042	700	IO-G-M-00-003	600	IO-G-M-00-043
		4000		3500		3000	
SFGRD natural gas						1000	IO-G-M-00-062
SFGRD natural gas PRIME						1200	IO-G-M-00-063
SFGRD natural gas STAND-BY						1000	IO-G-M-00-064
HGM natural gas		3500	IO-G-M-00-072	3500	IO-G-M-00-070	3500	IO-G-M-00-071
HGM biogas		3500	IO-G-M-00-072	3500	IO-G-M-00-070	3500	IO-G-M-00-071
SFGM natural gas				3000	IO-G-M-00-068	3000	IO-G-M-00-069
SFGM natural gas ISLAND				4800	IO-G-M-00-051	4800	IO-G-M-00-059
SFGM biogas				3000	IO-G-M-00-068	3000	IO-G-M-00-069
SFGM propane				3000	IO-G-M-00-040	3000	IO-G-M-00-041
SFE ethanol						4800	IO-L-M-00-001

NOTE: In most cases, the times specified in this document have been defined to coincide with maintenance activities E.

In the cases of engines operating at variable speed, it must be apply the value of the highest speed.

(*) If the variation of biogas (LHV) is higher than 10%, it is recommended use the spark plug reference

(**) If the gas is very dirty, it is recommended use the spark plug reference

1. DESCRIPTION

This document describes how to check the engine ignition timing.
The timing gun can be connected with the engine running or stopped.

2. CHECKING THE IGNITION TIMING

The cylinders of Line engines and those from 1 to 8 for 16V (or 1 to 6 for 12V) are on the opposite side of the engine to the timing measurement port. In such cases, the strobe timing gun cables are laid over the engine. In order to avoid any risk due to moving parts, the strobe gun cables should not be passed from one side to the other with the engine running.
The following explains how to connect the strobe gun with the engine stopped or running.

2.1. Engine stopped

For Line and V-Engines

1. Connect the gun earth to the ignition rail, engine block or coil earth.
2. Connect the clamp to the secondary of the cylinder where the timing is to be measured. The clamp must be connected in the right way (See photo)

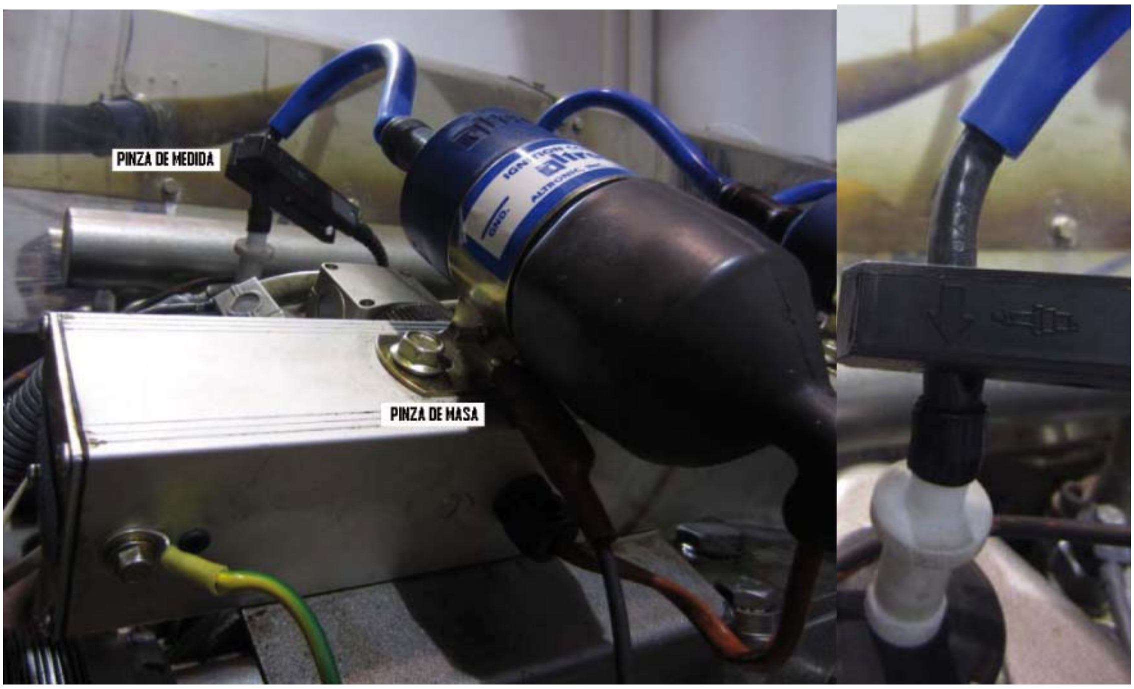


Image 1 – Strobe gun earth and measurement clamps.

3. Connect earth to the negative terminal of the battery

Image 2 – Earth clamp on battery negative terminal

4. Start engine and go to the operating point chosen to measure the ignition timing.

5. Connect to the + terminal of the battery to make the strobe gun work.

Image 3 – Red clamp on positive terminal of the battery

6. It is normal to connect and disconnect so as not to drain the batteries.

7. Check with the timing gun in the flywheel window.

Image 4 – Measuring the timing

8. Disconnect everything when the engine has stopped. Once the engine has stopped the coils are not active. In addition, the coils discharge very quickly so there is no risk of them being live as long as they are well earthed.

2.2. Engine running

1. Only for measuring the timing with V-Engines in cylinders 9 to 16 (16V) or 7 to 12 (12V). These cylinders are on the same side as the measurement port. This means that you do not have to pass the strobe gun cables from one side to another. Connect the gun earth to the ignition rail, engine block or coil earth.

2. Stand on an insulated stool, wearing a high voltage glove and helmet with electrical protection screen, connect the clamp to the secondary of the cylinder where the timing is to be measured.

Image 5 – Connecting the clamp wearing high voltage gloves

3. Connect the earth to the battery

4. Connect to the + terminal of the battery. It is normal to connect and disconnect so as not to drain the batteries.

To disconnect everything:

1. Disconnect from the + terminal of the battery.

2. Using the insulated stool , wearing a high voltage glove and helmet with electrical protection, disconnect the clamp from the secondary of the cylinder.

3. Disconnect the timing gun earth.

4. Disconnect the battery earth.

ADJUSTMENT OF GAS AND ETHANOL ENGINE VALVES. VALVE CLEARANCE

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1. ADJUSTING THE VALVES

This operation aims to set the clearance between the valve lifter and the overhead-valve rocker.

With the engine cold and the cylinder being adjusted at TDC (Top Dead Center) in the compression stroke, the clearance between the rocker arms and the valve lifters must be:

ENGINE	180/240/360/480 - HGM 240 SFGLD/SFGM/SFGRD 560	HGM420 / HGM 560
Intake	0.3 mm / 0.012 in.	0.3 mm / 0.012 in.
Exhaust	0.8 mm / 0.031 in.	0.5 mm / 0.02 in.

Adjustment procedure sequence:

1. Use the barring device to rotate the engine until cylinder #1 in the firing order is at Top Dead Center (TDC) of the compression stroke. Watch the flywheel marks through the hole in the flywheel housing (see page 3 for location marks on the flywheel).

   NOTE: Rotate until cylinder #1 is in the position corresponding to maximum compression, provided that the rocker arms do NOT act on the lifters (cylinder is not in valve crossover position). Otherwise, rotate the crankshaft one complete revolution and set the cylinder in the compression stroke.

2. At the cylinder #1 rocker arm, loosen the ball joint nut (2) and the rocker arm ball joint (3) until the rocker arm (1) moves freely (see figure 1 on page 2).

3. Loosen the valve lifter lock nut (6) and adjusting screw on the valve lifter (7) (see figure 1 on page 2).

4. Check for proper contact between the valve lifter and the valve stems. The valve lifter should contact both valves at the same time.

5. While applying pressure on the fixed side of the lifter, carefully rotate the adjusting screw clockwise until it contacts the valve stem. Tighten the valve lifter lock nut (6) while keeping the adjusting screw from turning. Be sure the valve lifter is contacting both valves evenly.

6. Inset the proper size feeler gauge between the valve lifter (5) and the rocker arm (1) (see table above). The valve lifter should contact both valves at the same time.

7. Tighten the ball joint (3) of rocker arm (1) until it contacts the push rod socket (4) and produces a slight drag on the feeler gauge when it is slid back and forth between the valve lifter and rocker arm.

8. Hold the push rod socket (4) with a screwdriver and tighten the ball joint nut (2).

9. Repeat the same procedure for the other set of valves.

10. Repeat the same procedure for all other cylinders by rotating the engine to bring the next cylinder to the TDC, in the compression stroke.

ADJUSTMENT OF GAS AND ETHANOL ENGINE VALVES. VALVE CLEARANCE

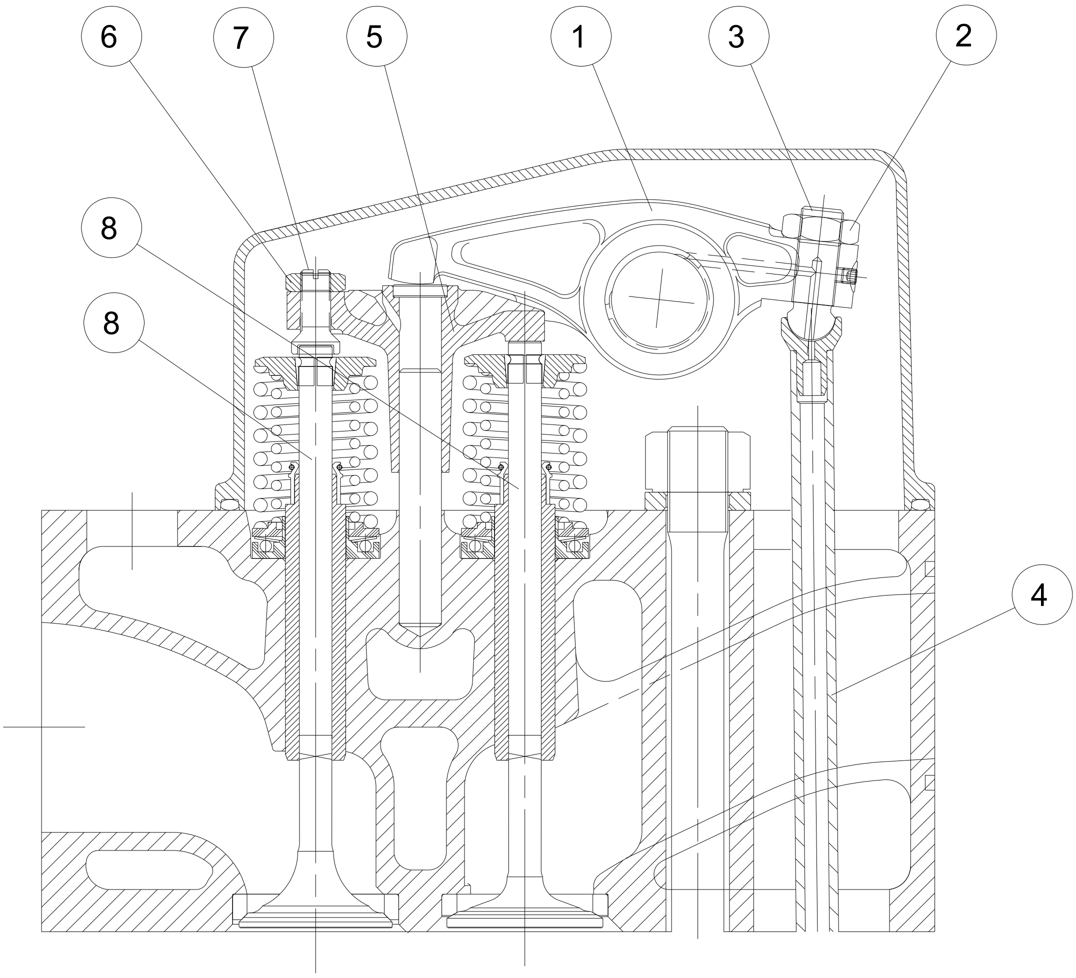
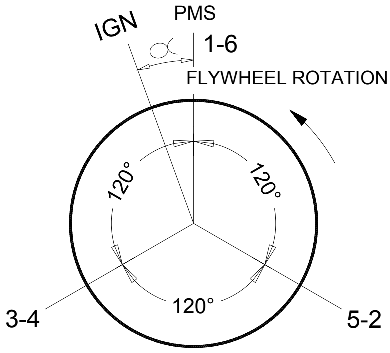


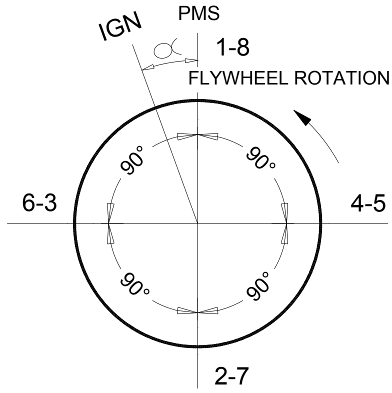
Fig. 1 - Valve Adjustment

1	Rocker arm
2	Ball joint nut
3	Rocker arm ball joint
4	Rocker arm pushrod
5	Valve lifter
6	Valve lifter lock nut
7	Adjusting screw
8	Valves

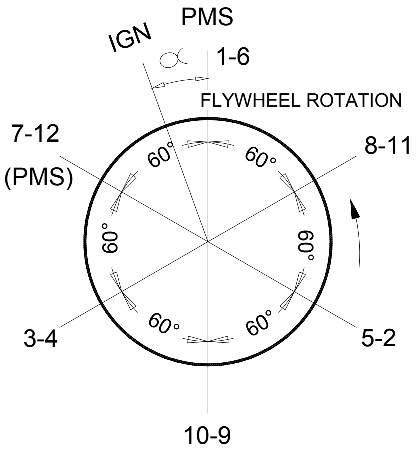
ADJUSTMENT OF GAS AND ETHANOL ENGINE VALVES. VALVE CLEARANCE



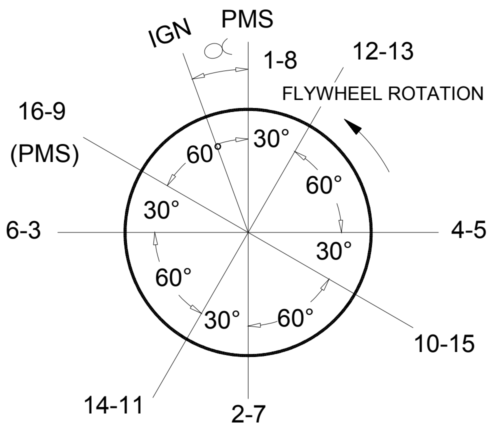
Marks on flywheel
180



Marks on flywheel
240



Marks on flywheel
360/420



Marks on flywheel
480/560

Pairing of Cylinders at Top Dead Center																
180	**1**	**5**	**3**	**6**	**2**	**4**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
	6	**2**	**4**	**1**	**5**	**3**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
240	**1**	**4**	**2**	**6**	**8**	**5**	**7**	**3**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
	8	**5**	**7**	**3**	**1**	**4**	**2**	**6**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
360	**1**	**8**	**5**	**10**	**3**	**7**	**6**	**11**	**2**	**9**	**4**	**12**	**-**	**-**	**-**	**-**
	6	**11**	**2**	**9**	**4**	**12**	**1**	**8**	**5**	**10**	**3**	**7**	**-**	**-**	**-**	**-**
480/560	**1**	**12**	**4**	**10**	**2**	**14**	**6**	**16**	**8**	**13**	**5**	**15**	**7**	**11**	**3**	**9**
	8	**13**	**5**	**15**	**7**	**11**	**3**	**9**	**1**	**12**	**4**	**10**	**2**	**14**	**6**	**16**

NOTE

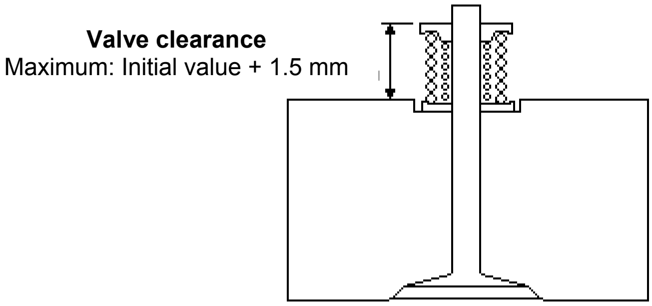
In all cases, when both valves of one cylinder are depressed (open, crossing stroke), the valves of the paired cylinder are released (closed, on compression stroke) and can be adjusted.

2. VALVE CLEARANCE

The valve clearance control allows assessment of wear on the contact points between valve and seat. The operation is explained below.

Valve clearance: use the caliper to measure the distance between the upper disk face and the mechanized upper face of the cylinder head.

Evaluation: the reference value is the initial measurement after 100 hours of operation of the cylinder head. If this value increases over time by more than 1 mm, the wear should be carefully monitored. If this value increases by more than 1.5 mm, it indicates excessive wear and the valve and seat should be replaced.



Measurement of valve clearance

The guiding reference values of initial valve clearance are:

Engine / cylinder head type	Initial reference valve clearance (+0.3/-0.2) (mm)	
Diesel F/SF	Intake	Exhaust
	52.90	51.90
Gas FG/SFG/HGM240	52.1	
Gas HGM420/HGM560	43.6	

1. MAINTENANCE OF AIR FILTERS

For higher efficiency, it is essential that air filters be always in perfect conditions. Therefore, it is necessary to clean or change the filtering cartridges when the appropriate maintenance schedule so specifies or when static pressure loss at filter outlet exceeds 38mbar.

2. DOUBLE-STAGE AIR FILTER MAINTENANCE OPERATIONS

Servicing double-stage air filters imply the following commonest operations.

- **Inspection, cleaning and (where appropriate) substitution of the core components** of the air filters. Generally, the main filter cartridge can be cleaned three times before its replacement. By contrast, NEVER clean the safety component, but replace it, as a rule, at the same time as the main cartridge.

- **Replacement of the core components** of air filters. This operation shall be performed in accordance with the specified maintenance programme or if found damaged or when cartridge cleaning has reached the a.m. limit.

- **Substitution of safety components** of air filters. This operation shall be performed according to the specified maintenance programme or in case of cartridge damage or fouling. NEVER clean the safety cartridge, always change it when fouled or specified in the maintenance schedule.

2.1. INSPECTION OF THE MAIN FILTER CARTRIDGE

The parameter that determines the fouling level of an air filter is the airflow restriction at the air filter outlet. On Kohler engines, the maximum permissible air flow restriction or pressure loss is 38 mbar and it is measured with the engine running at rated power and load.

For monitoring their fouling level, the Kohler engines' double-stage filters include either a mechanical air flow restriction detector or an electric detector. The mechanical detector has a red-coloured indicator showing up completely when the maximum permissible pressure drop has been reached. The electric detector consists of a normally open contact that closes when the airflow restriction reaches the a.m. specification and indicates the fouling condition of the filters by means of a light signal or by transmitting an electric signal to the PLC. The system shall be serviced, when the membrane indicator is completely red or the fouling alarm is given. After servicing a filter with a mechanical fouling indicator, it is necessary to push the "Reset" button on the indicator to relocate the membrane at its initial position.

Other signs can help detect the plugging of the air filters. A gas engine may be unable to reach its rated power, or will see its efficiency decrease or even can present carburetion problems (fuel-air mixture becoming richer), if the air filter does not work properly. A diesel engine with failing air filters will have greater specific fuel consumption and darker exhaust gases.

Always perform filter maintenance with the engine at rest.

For **tangentially sealed filters**, inspecting the main filtering cartridge will imply the following sequence of operations:

1. Back off the air filter locknut and remove the front sealing ring. Also, remove the washer from the main cartridge.

2. Extract the main filter cartridge from engine's filter, avoiding impacts of the cartridge against the casing.

3. Inspect the inside of the filter casing and clean it with a moistened rag. Also check the exhaust valve at the bottom of the filter and eliminate possible dirt build-ups or condensates

4. Verify the condition and appearance of the main filter cartridge: the filtering paper should be free from excessive dirt or breakage. Check the paper folds for homogeneous distribution and absence of deformation.

IMPORTANT

Clean the filter cartridge in case of high dust concentration or if specified by the maintenance programme (see point 2.2).

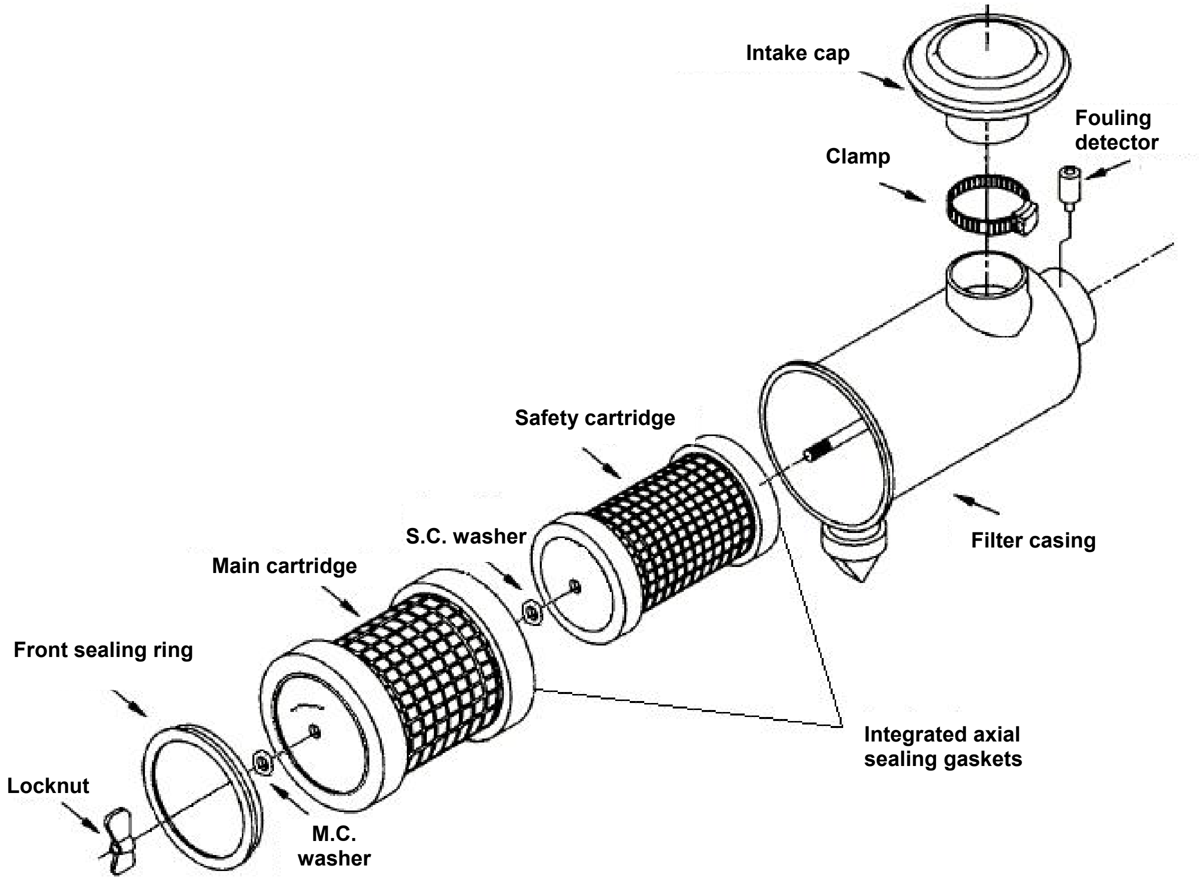


Fig. 1 - Exploded view of a tangentially sealed air filter

For **radially sealed filters**, inspecting the main filtering cartridge will imply the following sequence of operations:

1. Release the metal latches and remove the cover.

2. Extract the main filter cartridge from the filter, avoiding impacts of the cartridge against the casing.

3. Inspect the inside of the filter casing and clean it with a moistened rag. Also check the exhaust valve at the bottom of the filter and eliminate possible dirt build-ups or condensates.

4. Verify the condition and appearance of the main filter cartridge: the filtering paper should be free from excessive dirt or breakage. Check the paper folds for homogeneous distribution and absence of deformation.

IMPORTANT

Clean the filter cartridge in case of high dust concentration or if specified by the maintenance programme (see point 2.2).

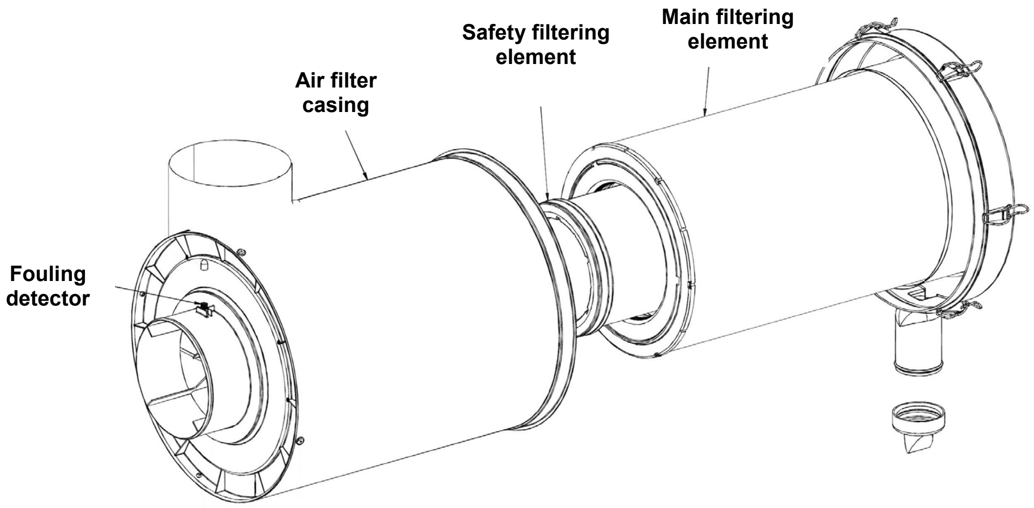


Fig. 2 - Exploded view of a radially sealed air filter

Both **tangentially** and **radially sealed** filters shall undergo other checks of their main cartridge, as follows:

1. Check the elasticity of the sealing gaskets, mounted on the cartridge, by pressing with your finger and watching the gaskets recover their original form. Wipe the gaskets clean with a moistened cloth.
2. After checking the condition of the cartridge and cleaning or changing the filter if necessary or specified by the maintenance programme, reassemble the filter, proceeding in reverse order of its disassembly.
3. Reset the mechanical fouling detector and check the general performance of the engine when restarted. For gas engines, also check for correct carburetion, since the mixture could be leaner.

2.2. CLEANING THE MAIN FILTER CARTRIDGE

Before cleaning the main cartridge of air filters, the inspection process described in the previous section should have been carried out.

ATTENTION

Only the main cartridge may be cleaned (up to three times according to the maintenance schedule). The safety cartridge has to be changed as and when specified in the maintenance programme; it may not be cleaned using the procedures described below because they would damage the safety cartridge.

There are two methods for cleaning the main filter cartridge: Blow-through and Washing.

2.2.1. BLOW-THROUGH

NEVER clean the filter cartridge mounted in the filter or on the engine or in the engine room. Moreover, it is advisable to carry out this operation at a safe distance from any object susceptible to be damaged by blown out dust. Wear respiratory mask, eye and hand protection.

Maximum recommended compressed air pressure to avoid damage to the cartridge: 6 kg/cm^2
Blow through in the direction opposite the cartridge's use, from inside out and from top to bottom, turning the cartridge. Keep the gun nozzle at least 5cm away from the internal perforated plate.

2.2.2. WASHING

Washing is recommendable only if the filter cartridge has been fouled by contaminants mixing with dust to form dirt that compressed air will be unable to remove.
This method should not be used more than twice before replacing the cartridge.

1. Detach the major portion of dirt with compressed air or a water jet.
2. Soak the cartridge in water with a solvent for not less than 15 minutes.
3. Rinse with a water jet until clear water comes out. Maximum recommended pressure: 2.5 kg/cm^2.
4. Let the cartridge dry

IMPORTANT

Do not use compressed air for drying.
Do not re-assemble the filter until the cartridge is completely dry and has been checked again.

2.3 SUBSTITUTION OF FILTER CARTRIDGES

Changing the cartridges of air filters must take place, with the engine at rest, in a ventilated room, following these instructions:

1. For tangentially sealed filters, back off the air filter locknut and remove the front sealing ring. Also, remove the washer from the main cartridge. For radially sealed filters, release the metal latches and remove the cover.
2. Extract the main filter cartridge from the engine's filter, avoiding impacts of the cartridge against the casing.
3. For tangentially sealed filters, remove the washer from the safety cartridge, if this has to be changed, and take out the safety cartridge.
4. Inspect the inside of the filter casing and clean it with a moistened rag. Also, check the exhaust valve at the bottom of the filter and eliminate possible dirt build-ups or condensates.
5. Check the elasticity of the sealing gaskets, mounted on the cartridges, by pressing with your finger and watching the gaskets recover their original form. Wipe the gaskets clean with a moistened cloth
6. Change old cartridges by new ones, making sure their references coincide.
7. Reassemble the filter, proceeding in reverse order of its disassembly. For tangentially sealed filters, verify that the axial sealing gaskets lean correctly against the filter casing. Take special care when fitting the front sealing ring, to ensure total tightness. For radially sealed filters, insert the main and safety cartridges into the casing, as you would put a cork into a bottle; the two cartridges will centre and align themselves automatically.
8. Make sure that all fittings and ducts close hermetically.

9. Reset the mechanical fouling detector and check the general performance of the engine when restarted. For gas engines, also check for correct carburetion.

3. MAINTENANCE OF GHF AIR FILTERS

The parameter that determines the fouling level of an air filter is the air flow restriction at the air filter outlet. On Kohler engines, the maximum permissible airflow restriction or pressure loss is 38 mbar and it is measured with the engine running at rated power and load.

The GHF air filter on Kohler engines includes either a mechanical airflow restriction detector or an electric detector. The mechanical detector has a red-coloured indicator showing up completely when the maximum permissible pressure drop has been reached. The electric detector indicates the fouling condition of the filters by means of a light signal or by transmitting an electric signal to the PLC.

Always service the GHF filter, i.e. replace the two filtering cartridges, with the engine at rest.

3.1 CHANGING THE GHF FILTERING CARTRIDGES

Changing the cartridges of a GHF filter must take place with the engine at rest, in a ventilated room, following these instructions:

1. Undo the clamp form one side of the filter.

2. Remove the cover.

3. Disassemble the fouled cartridge.

4. Install a new filtering cartridge. Do this operation as fast as you can to prevent dust and/or particles from entering the engine.

5. Fit the cover correctly, observing the direction specified on it.

6. Secure the clamp.

7. Repeat the same operation for the second cartridge of the filter, depending on whether the filter has 1 or 2 cartridges.

8. Reset the mechanical fouling detector and check the general performance of the engine when restarted. For gas engines, also check for correct carburetion, since the mixture could be leaner.

ATTENTION

NEVER clean a filtering cartridge

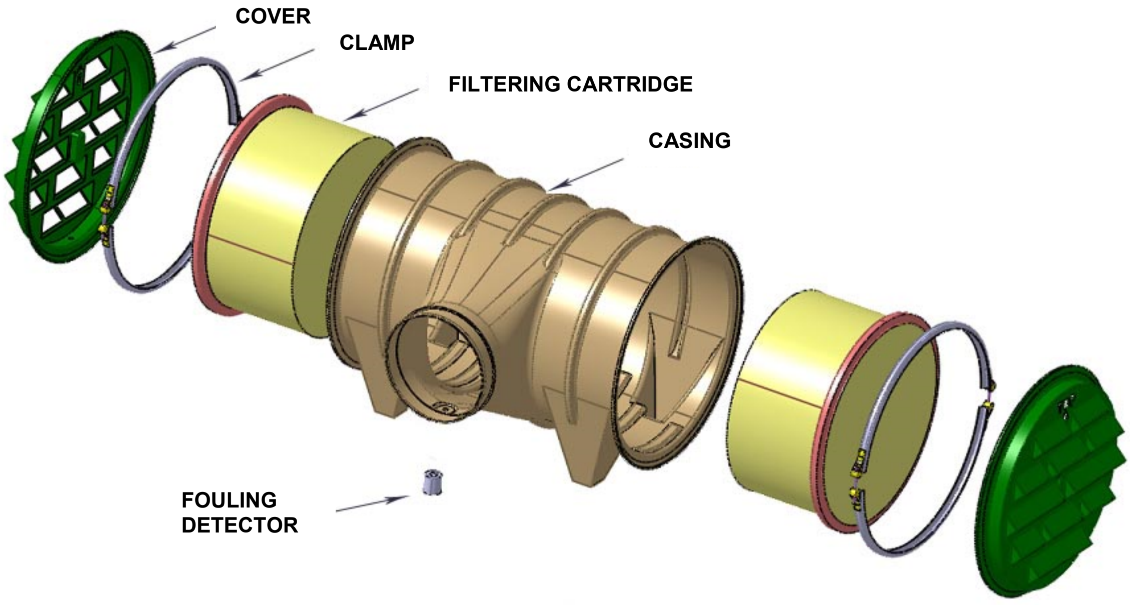


Fig. 3 - Exploded view of Kohler High Flow two-cartridge air filter

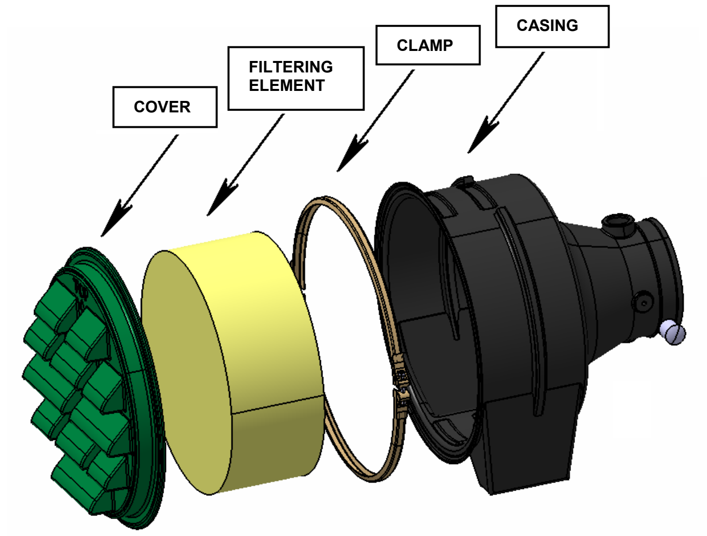


Fig. 4 - Exploded view of Kohler High Flow one-cartridge air filter

	PRODUCT INFORMATION	INDEX	DATE	
KOHLER Powered by DRESSER-RAND	IO-C-M-15-001e	B	September 2013	Dep.2
	DAMPER CONDITION MONITORING			

O&M_2.002262.810_10_2016

1. INTRODUCTION

It is the damper's function to minimize the impact of the torsional vibrations developing in the crankshaft. These vibrations originate in the successive explosions that take place in the combustion chambers and are transmitted to the crankshaft through the pistons and connecting rods.

Damping is achieved as a viscous fluid (silicone) contained in a housing or idle flywheel spreads between the internal plates secured to the end of the crankshaft. As silicone oil deteriorates in time, servicing becomes necessary.

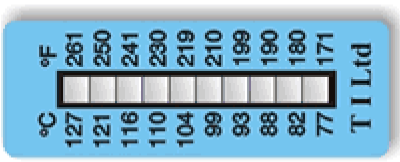
There are two methods for monitoring the condition of a damper:

- controlling its temperature
- analyzing the silicone oil.

Whatever the method used, the control frequency shall be established in accordance with the specifications contained in the Engine Maintenance Guidelines.

2. DAMPER TEMPERATURE CONTROL

Dampers have been fitted with a self-adhesive temperature indicator (ref.16.15.369) for controlling their operating temperature.



Self-adhesive temperature indicator

This indicator enables an approximate control of the maximum permissible temperature on the damper surface. It is to be noted, however, that this indicator only records discrete jumps of temperature. The self-adhesive indicator has ten graduations between the two temperature limits that, in our case, are fixed at 71°C and 110°C. When the temperature reaches or exceeds a reference value, the colour of the corresponding section or graduation changes and turns black.

Temperature should be measured at least after one hour of operation at full power. Ideally, **the equilibrium operating temperature of the damper should not exceed 100°C**. Above this temperature, silicone loses its dampening properties and, consequently, the damper stops to operate correctly, which may give rise to an increase in torsional vibrations, finally leading to severe failures of moving components, including the breaking of crankshaft, gears, couplings, etc.

Damper Temperature	Condition
T = Room Temperature	Damper inoperative. Silicone in bad condition: solid.
40ºC < T < 100ºC	Ok.
T > 100ºC	Overheating. Possible failure of the engine.

It is important that the indicator does not come into contact with such elements as oil, grease, water, etc. Also, it may happen that the indicator looses its thermal properties and the reagent turns grey after a certain time of operation. This is why, for permanent temperature monitoring, the indicators should be changed from time to time. An alternative of this monitoring system consists in measuring the temperature with an infrared thermometer that permits measurements of the existing or instantaneous temperature.

3. SILICONE SAMPLING METHOD

An analysis of the damper silicone is essential to determine whether its properties are optimum or not. The sampling kit to be used for this purpose is Kohler part number .

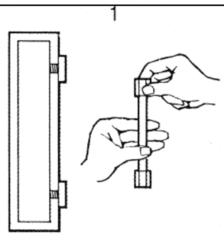
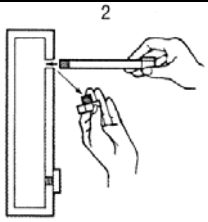
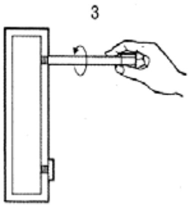
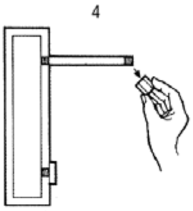
The filling plugs will be found, diametrically opposed, on the damper cover. If there is a reasonably easy access to one of those plugs, sampling can be done with the damper installed on the engine. Otherwise, put the damper in a normal vertical position during the sampling process. As for engines with double damper, both dampers must be checked.

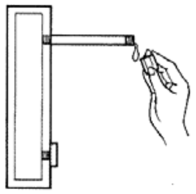
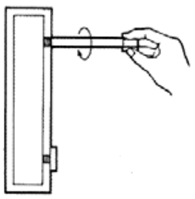
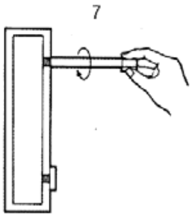
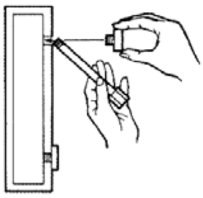
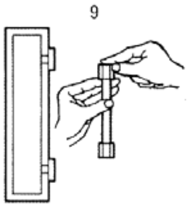
NOTE

For HGM series it is not necessary to take a periodical silicone sample for analysis. The damper must only be changed when the schedule program sets it.

It is recommended to place the damper so that both filling plugs are roughly in a horizontal position and to leave it in that position for at least one hour before starting to take samples. Depending on the damper model, any of various thread sizes are used for the filling holes and, consequently, the threads vary at either end of the sample container.

The silicone fluid sampling procedure is described below:

1 	Assuming you know the thread size of the damper plug hole, prepare a sample container and remove its screw-on cap from the end to be introduced into the damper.
2 	Remove the filling plug from the damper cover, while holding the container ready to be inserted immediately.
3 	Screw the container totally into the hole of the filling plug.
4 	Remove the second screw-on cap from the container.

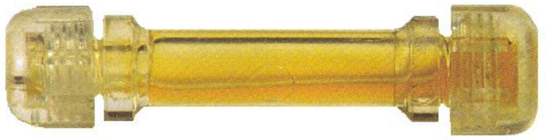
5 	Allow silicone fluid to reach the open end of the sample container. This may take a few seconds or hours depending on the fluid conditions and other factors: the higher the temperature, the shorter the time required.
6 	As soon as the fluid flows out through the open end of the container, replace the screw-on cap. Warning! In order to perform the analysis of a silicone sample, at least 3/4 of the container must be filled up.
7 	Having a filling plug ready for its relocation on the damper cover, unscrew the sample container.
8 	Immediately replace the filling plug and torque to 2.5kg (18lb/ft), and seal it with a punch mark. It is advisable to insert a new O-ring (included in the kit) and to tighten the plug until matching the previously existing marks.
9 	Screw the cap on to the end of the container and check that both caps are fully screwed on, but not forced. (Do not use any wrench.)

IMPORTANT

Cleanness of sample container, filling plugs and areas around the filling hole is essential. It is very important to limit fluid spillage as much as possible during this process. Excess loss would alter the characteristics of the damper as well as reduce the possibilities of taking more samples in future. If fluid spillage is null, at least 10 samples can be taken, when using 'Standard' 1cc containers.

3.1. On-site analysis of the silicone sample

A rapid analysis of the silicone condition can be made by observing the color of the sample. The meaning of possible colors is defined below.

	**Normal Condition**: The original fluid is completely clean and free from impurities.
	**Intermediate Condition**: The sample has a lightly darkened color and may contained particles.
	**Critical Condition**: The sample has a dark brown or black color and has been contaminated by metallic particles.

3.2. Silicone sample analysis performed by the manufacturer

If there is any doubt about the silicone condition, it is recommended to perform a more exhaustive analysis. In this case it must send a sample to Kohler in order to perform that analysis.

1. PROCEDURE FOR FILLING AND DRAINING THE COOLING CIRCUIT WITH ANTIFREEZE

This section describes the method of filling the cooling circuits in Kohler engines, and is suitable for engines and containerized units.

Prior to filling, the **bleed valves** on the water circuits have to be opened. On the engine side, the purge in the main circuit is located in the thermostat housing or on the inlet pipe to the latter. If there is no thermostat housing, look for it at the highest point of the circuit. In general, for the auxiliary circuit, it is fitted to the highest part of the dry-cooler or at a high point on the pipe.

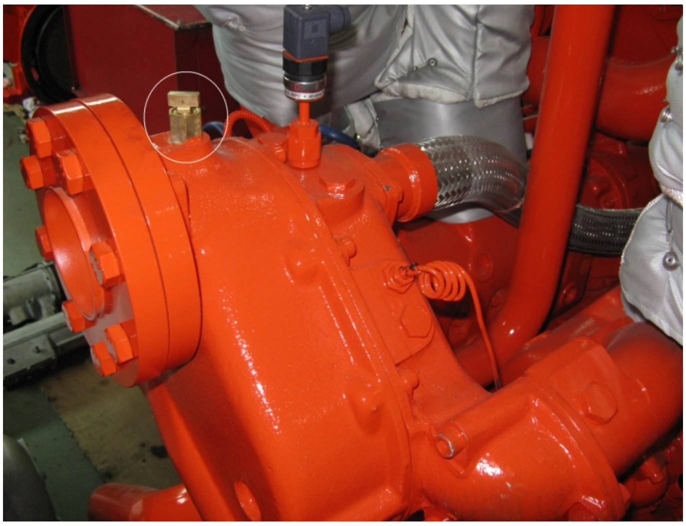


Fig. 1 - Air bleed valve in thermostat housing

For the HGM 420/560 it should be purged both in the thermostat housing and at the highest point of the main circuit, which is in the cylinder head water outlet manifold.

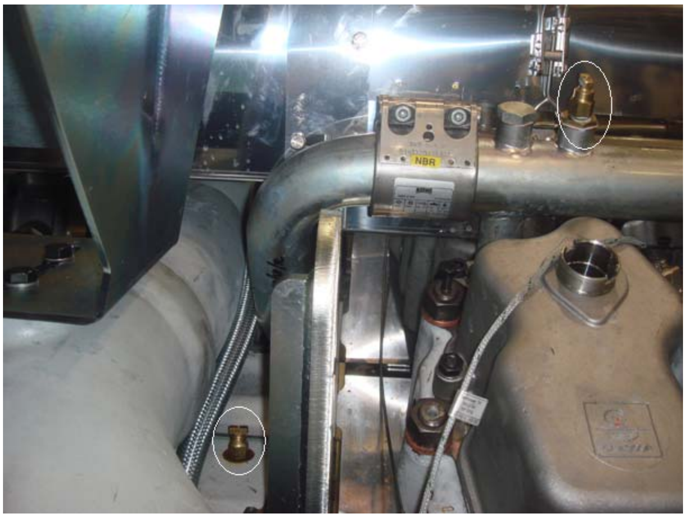


Fig. 2 - Air bleed valve in thermostat housing and cylinder head water outlet manifold, HGM 420/560

The main and secondary circuits on dry-coolers, radiators or heat exchangers, are usually equipped with **automatic air bleed valves.** Some come with a shut-off valve for overriding, but you must ensure they are open during operation. To fill quickly, leave the shut-off valve open and remove the automatic bleed valves until only liquid begins to flow out with no air, at which point you have to close the valve, without forgetting to refit the automatic bleed valves and open said shut-off valve.

Fig. 3 - Automatic air bleed valve

It is, in turn, both important and necessary that automatic bleed valves are installed at the highest, intermediate points on the circuit, where there is a probability that air pockets (loops in the circuit) may occur. This way, purging air pockets located at different points throughout the installation is ensured.

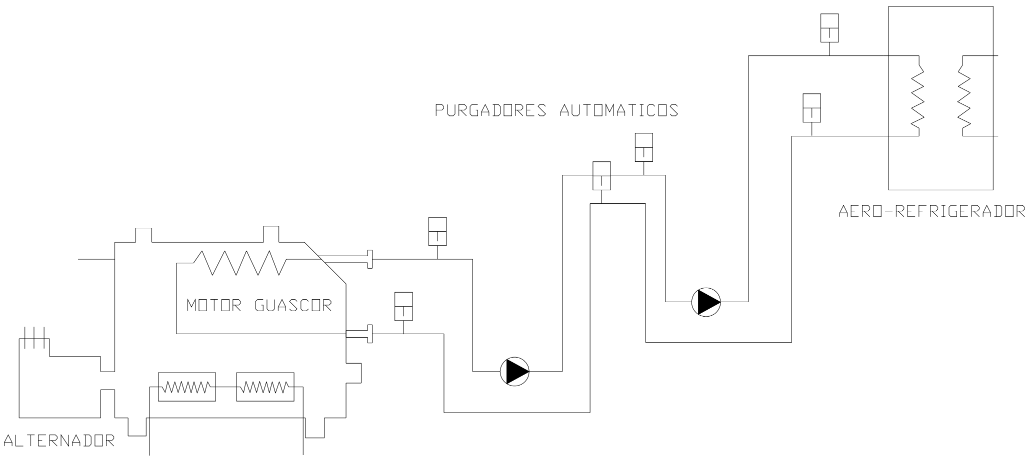


Fig. 4 - Diagram and fitting of automatic air bleed valves at high, intermediate points on the circuit

There are two ways to **fill the circuit**:

1. **Fill with water previously mixed with antifreeze.** This is the best system to use for filling the cooling circuits. Water with antifreeze in the right proportion is premixed in a tank (*refer to IP IO-CM-20-001*), so what we feed into the engine is a homogeneous mixture of water and glycol. Filling is done using an electric pump or by gravity until the right pressure is achieved.

2. **Fill with water and subsequently add antifreeze**. This method is not recommended because the mixture will not be homogeneous until the water pumps are started, which if after adding antifreeze we do not operate the pumps at specific points in the circuit, we only have water that can freeze after a certain period of time. Therefore, when filling it is important to make sure that after starting the engine, we reach a sufficient load to open the thermostats and recirculate water and antifreeze around the circuit, such that after stopping the circuit, it is full and there is no risk of freezing.

In both cases ensure that the ratio of water to antifreeze is correct *(refer to IP IO-C-M-20-001)*. A **hydrometer** is used to determine the concentration of glycol in the water, which will give the density of the water/antifreeze mixture. The supplier of the antifreeze is required to provide the table that correlates density and concentration. A **refractometer** can also be used to get an immediate reading for the concentration value. IP IO-C-M-20-001 displays a graph indicating, based on the concentration and, if the antifreeze is ethylene glycol or propylene glycol, the temperature at which the mixture freezes, in addition to the recommendations on the additive to be used.

The air bleed valves must be opened until no further air bleeds out. For closed, pressurized circuits, the circuit is filled to a pressure slightly above 1 bar.

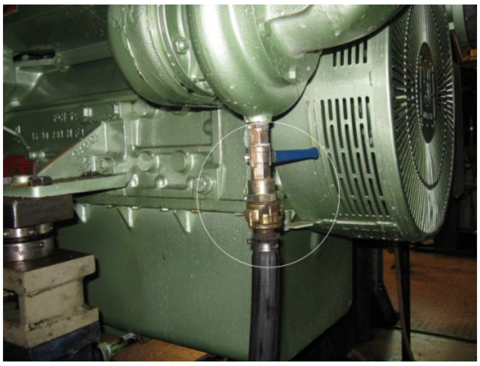


Fig. 5 - Typical hose/circuit connection for filling and draining the cooling system

During the first engine start-up and when the water is a little hot again, open the purge valves to ensure only water flows out. If air comes out, leave them open until the air is completely released. If the pressure in the circuit has lowered a lot, it has to be filled up sufficiently.

ATTENTION

It is very important to ensure that there is no air in the circuit, since this greatly reduces the cooling capacity, causing explosions in the cylinders, cavitation in the water pumps and a considerable decrease in the flow of water that is circulating through the engine circuits.

IMPORTANT

This is particularly true for engines that operate with water in the main circuit 120ºC when this temperature is reached, it is necessary to re-purge the circuit as the capacity to dissolve air in water decreases significantly with temperature, such that on filling the circuit with cold water, we may not have air and have significant air pockets in the entire circuit at the operating temperature. The same occurs in engines where the secondary circuit water is at 80°C.

To **drain** the cooling circuits, water intakes for filling and emptying should be at the lowest point of the circuit. If not, release a flange in the lower area to completely empty the circuit by placing a container underneath to collect the water with antifreeze. Emptying can be done by gravity or by using an electric pump. The hose is connected to the water intake and after starting up the pump, once the pressure permits, open all the purges in the circuit that are being emptied, so the water allows the air to flow through after it has been discharged. If the circuit is equipped with another water intake on the side of the dry-coolers, radiators or heat exchangers, we connect the hose or pump to that intake after draining the water from the engine and check whether water still comes out. Then, close all the bleed valves.

ATTENTION

Since antifreeze is a pollutant, it must be collected in a suitable container for subsequent treatment or reuse.

To fully drain the **dry-coolers, radiators or heat exchangers** (as may occur in the case of containerized units), they have to be separated from the rest of the circuit by disconnecting the associated piping. A number of covers that have been designed for draining are fitted to the pipes: the one at the highest pipe have an outlet for compressed air and located on the lowest pipe to connect a hose that after injecting compressed air discharges all water with antifreeze into a suitable container.

CAREFUL

Before draining, wait for the water contained in the circuits to cool, as the temperatures reached in the engine after it has been operating are dangerous if they come into contact with the body.

2. COOLING SYSTEM MONITORING AND CLEANING

The cooling system has to be regularly monitored, paying particular attention to any leaks that may occur in the hoses, clamping flanges, seals, etc.

To prevent any overheating of the engine, the cooling system must be kept clean. All conduits in the engine and in the heat exchanger (if any) must be free from deposits and impurities contained in the cooling water *(refer to IP IO-C-M-20-001e).*

A chemical is used to clean the circuit (usually dilute hydrochloric acid), recirculating it by using an auxiliary pump to eliminate all possible scaling in pipes and component ducts in the system.

ATTENTION

Particular attention should be paid to the specifications of this product and the supplier's recommendations as excessive recirculation may damage some components. In addition, before refilling the circuit, it must be cleaned with water to remove all traces of hydrochloric acid in the installation.

This cleaning product should be used with the appropriate security measures to avoid contact with any part of the body because it can be very dangerous.

CAREFUL

If you notice a decrease in the thermal efficiency of the **intercooler** or when the operating hours set out in the guidelines for maintenance are reached, it can be disassembled for cleaning. The tubes are thoroughly cleaned using a nylon brush that has been dampened. They are then rinsed with plenty of water until no further deposit exits. The water seals have to be changed before assembling the intercooler. Cleaning can be done using high pressure water and using equipment designed for it, like the rest of the cooling system, by recirculating a suitable cleaning. We can do the same with the **oil cooler.**

The **water thermostat** is another component that has to be checked, which is built in to the corresponding casting housings. To verify proper operation, they are periodically placed into a bowl of water, heating it and controlling the temperature from the start and end of opening. The opening start temperature is marked on the base of the capsule in which the wax is enclosed which enables the thermostat to operate, while the opening end temperature is 13ºC greater than the previous temperature. If the data obtained deviates significantly from the specified values, the thermostat needs to be changed.

KOHLER Powered by DRESSER-RAND	PRODUCT INFORMATION	INDEX	DATE	
	IO-C-M-45-001e	**B**	*June 2008*	*Dep.2*
	MAINTENANCE OF TURBOCHARGER			

O&M_2.002262.810_10_2016

1. INTRODUCTION

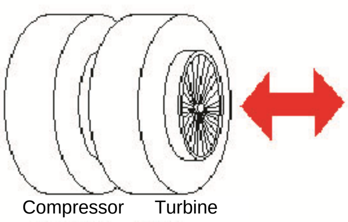
This Product Information Sheet aims to provide guidance on how to maintain the turbocharger of Kohler engines.

2. INSPECTION OF THE TURBOCHARGER

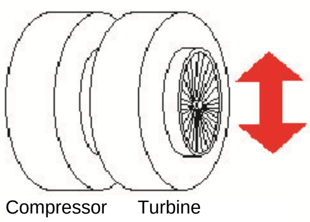
The inspection and possible repair of turbochargers must be carried out by one of Kohler official or authorised Repair Shops.

A turbocharger is a critical component to ensure correct operation of the engine. If the turbocharger does not work correctly, the engine will not perform as initially specified. Therefore, the turbocharger must undergo a simple inspection consisting of four checks (that do not require removing the turbocharger), namely:

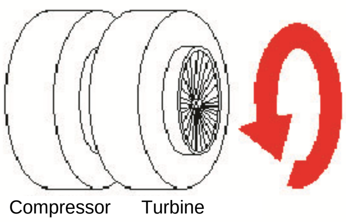
- ***Check for axial play***: Apply force axially on the shaft and check that there is no axial clearance.
- ***Check for radial play:*** Apply force radially on the shaft and check that there is no radial clearance.
- ***Rotation***: Push one of the wheels inwards, while turning it with your hand at the same time in order to detect friction or seizure. Repeat this process on the opposite side. The wheels must rotate freely, without touching the casing, turbo plate or turbine insert.
- ***Blade condition***: Visually inspect the blades of compressor and turbine, with a lamp, to see if they are very dirty or contain foreign materials. Check the wheels, casings and turbine inserts for scratches. Verify if there are blade edges bent, cracked or indented. Check clearance between blade and casing.



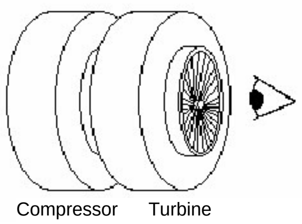
Step 1: Axial Clearance



Step 2: Radial Clearance



Step 3: Rotation



Step 4: Visual Inspection

ATTENTION

If you find any fault during this inspection, you will have to check the turbocompressor completely in order to solve the problem. In this event, ask Kohler for the instruction manual specific to the turbocompressor that needs overhauling or have the turbocompressor checked by one of Kohler official or authorised Repair Shop.

After assembling the turbocompressor, do the following:

- Check the turbo assembly and connections for security problems and air or lubricant leaks.
- Check the manifold connections to the turbine as well as the exhaust manifold gasket.
- Remove the oil drainage tube from the turbo. Look if there is oil inside and check the oil circuit for proper operation (if your engine comes with a pre-lubrication system, you can use it). Once you have finished the inspection, refit the drainage tube.
- Lubricate the new turbos before starting them. To do so, add oil into the oil inlet and turn the turbo by hand a few revolutions.
- Verify that lube oil is clean and that the oil strainers are in good working conditions.

After starting the engine, do the following:

- Refrain from increasing the load excessively, while the coolant temperature in the fresh water circuit remains below 37ºC.
- Test the engine under full loaded conditions.
- Inspect all air, oil and exhaust gas pipes for leaks.
- Check the turbochargers for unusual noise or vibration when the engine runs at rated load and output. If noting any excessive noise or vibration, stop the engine immediately and contact your local Kohler Technical Assistance Service.
- Keep the engine idling for 3 or 4 minutes before shutting it off.

3. CLEANING THE TURBOCHARGER

Dust particles entering the intake air pipe may cause damage to the compressor of the supercharging system. Bearing in mind that even the most efficient air filter allows a small amount of dirt to pass through, dirt will adhere to the compressor blades if there is oil or similar substances on them.

This will unbalance the blades and reduce the efficiency of the turbo. Therefore, it is advisable to set up a compressor cleaning plan based on the operating conditions and to remove periodically any dirt particles adhering to the blade surface. To eliminate dirt, avoid inadequate methods like scraping with a screwdriver, sandpaper, emery cloth or steel wool.

To clean the turbocharger effectively, proceed as follows:

- Disassemble the turbocharger following the instructions in its maintenance manual. The parts to be cleaned are: the compressor housing, the turbine casing, the shaft with compressor wheel, turbine runner, central bearing body, and the turbine plate.
- Dip the components in a container with a solvent (e.g. trichloroethylene) until they are free from grease or oil residues. Neutral household soap can be used instead of solvent, provided it has no chemical effect on the components.
- Dry the components thoroughly with compressed air. There should be no traces of solvent on the parts.
- Remove any dirt or scale left with a non-metallic brush or plastic scraper. Next, dip the components again into the solvent.
- After cleaning the components, apply clean motor oil to the friction areas: shaft and bearing body.

ATTENTION

Handle the turbocharger components with great care while cleaning and drying them to avoid any damage.

4. TURBOCHARGER FAILURE ANALYSIS

Due to high pressure and high temperature working conditions, the turbocharger wheels are made very sensitive to abrasive and other specific operating environments.

Some of the most frequent causes of turbocharger failure include:

Presence of foreign material in the intake system, causing damage to the compressor blade profile. Foreign materials can be of such nature as:

- Weld slag that failed to be removed from the pipes.
- Particles that detach from air filters.
- Nuts, bolts, washers, etc.
- Compressor wheel fixing nut loose and moving along the threaded shaft.
- …

Presence of foreign material in the exhaust system, resulting in breakage, deformation or knocking of the turbine impeller blades. Such material can be:

- loose items in the exhaust manifold, namely nuts, bolts, washers and parts that were not removed when the turbo was last overhauled,

- fragments of broken parts of the engine (valves, valve guides, seats, piston rings…).

Inadequate part clearance leading to collision of the compressor wheel or turbine wheel with their respective casing. Incorrect play may result from damaged axial bearings that permit shaft movements beyond normal limits. Damage to the bearings can originate in:

- contaminated lubricant

- a lack of lubrication

- improper balance of a rotating unit

- high negative pressure at compressor inlet due to air filter clogging

- high back-pressure at exhaust gases oultet.

Abrasion or erosion develop under the action of sands that bite and thin the leading edges of the blades. Sands and other particles impacting on the blade surface at high speed also produce severe erosion. The presence of such materials may be due to defective air filtration.

1. INTRODUCTION

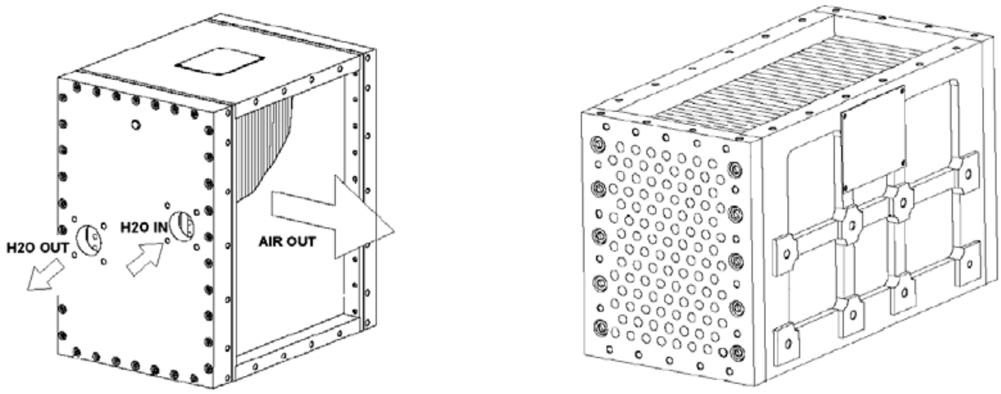
This document describes the correct maintenance procedure for Kohler intercoolers.

2. CLEANING THE INTERCOOLER

Kohler has designed and manufactured its intercoolers with a view to minimising the necessary maintenance operations.

Therefore, no special maintenance process other than cleaning is necessary for operating the intercooler. Cleaning specifically implies:

- cleaning the set of plates
- cleaning the water pipes
- plugging the water pipes



Different intercooler models

2.1. Cleaning the set of plates

Excessive dirt build-up on the plate surface reduces the performance of the intercooler considerably. Dirt on the plates also leads to a pressure drop in the air stream that flows through the cooling core.

To clean the intercooler, it is necessary to remove the cooling core from the air pipework (see section 3). Next, clean the plates with a jet of warm water.

PRECAUCION

When performing this operation, take care not to damage the plates. Direct the water jet parallel to the plates.

Then, dry the plates with compressed air. If any plate gets damaged during this process, you can repair it with long-nose pliers or a special-purpose tool.

If the dirt is not removed by the above procedure, use a solvent, as outlined below, to get a deeper clean.

- Firstly, insert the bundle of plates into a tank where they are completely covered. Add a benzene (minimum 75%), hydrocarbon (minimum 10%) and alcohol (minimum 2.5%) based solvent, leaving it to stand for 24 hours. After this time, visually inspect the plates for cleanliness obtained.
- If the previous step does not thoroughly clean the plates, a closed cycle recirculating a cleaning solution is applied, wherein the flow of solvent through the bundle of plates is strengthened by means of a transfer pump. The pump should impel 6m3/h at a pressure of 1 bar.
- As a final step, compressed air is used to dry the plates.

Finally, reassemble the cooling core as explained in section 4.

2.2. Cleaning the water pipes

For chemical cleaning of the water pipes inside, it is not necessary to remove the intercooler from the engine or the cover from the water system. If cleaning is by mechanical means, it will be necessary to remove the water system covers in order to reach the pipes.

Chemical cleaning is suitable when the parts are not excessively dirty. To clean the pipes, circulate a mixture of water and special cleaner in the system for at least one hour. Next, check the pipes cleanliness through the water inlet/outlet. Finally, flush the system with clean water.

In the event of a mechanical cleaning process (after removing the covers), clean the inside of the pipes with a special brush and then flush the system with water to remove dirt. Finally, reassemble the cooling core as explained in section 4.

2.3. Plugging the water pipes

If any pipe leaks or is broken, both ends can be plugged with special covers to repair the leak.

NOTA

When the number of plugged pipes exceeds 5% of the total, it is necessary to replace the entire intercooler.

3. REMOVING THE INTERCOOLER

Here is the procedure for removing the intercooler:

- Stop the engine; allow water to circulate for several minutes until it cools down.

- Close the coolant supply (where appropriate) and remove the drain plugs and bleeders to empty the cooling circuit.

- Release the connectors of the inlet and outlet coolant pipes, taking care not to damage the pipes and seals In the contact areas. Unscrew the air circuit adaptors and remove the intercooler.

- After removing the intercooler, remove the side covers from the intercooler, taking care not to damage the surface of the gaskets.

4. FITTING THE INTERCOOLER

Here is the procedure for fitting the intercooler:

- Check and clean the seals contact areas. Change old seals with new ones.

- Set the sealing gaskets in the side covers of the intercooler.

- Fit the side covers and tighten the fixing screws alternately diagonally (top left, bottom right...) to avoid stress in the covers. The following tightening torques apply:

Screw	M6	M8
Tightening torque (Nm)	8,6	21

- Set the intercooler between the two air circuit adaptors and fix it.

- Fit the connectors of the in and out coolant pipes.

- Close the circuit-draining plug and open the coolant supply, with the circuit bleeder still open. After filling the circuit, close the coolant supply and circuit bleeder.

1. INTRODUCTION

This document describes the procedure for correct maintenance of speed pick-ups on Kohler engines.

2. MAINTENANCE OF PICK-UPS

The magnetic pick-ups serve as instant input of the engine speed or cycle (expansion or compression) to the engine control, carburetion, injection and other systems.

Pick-up maintenance is a simple process that shall take place according to the engine maintenance schedule. Concretely, the maintenance operations consist in:

- Removing the pick-up: disconnect the cable from the top and unscrew the pick-up from its housing.

- Cleaning the pick-up: wipe the pick-up head with a damp cloth to remove sticking dirt. Do not use any solvent or other aggressive products that would damage this device.

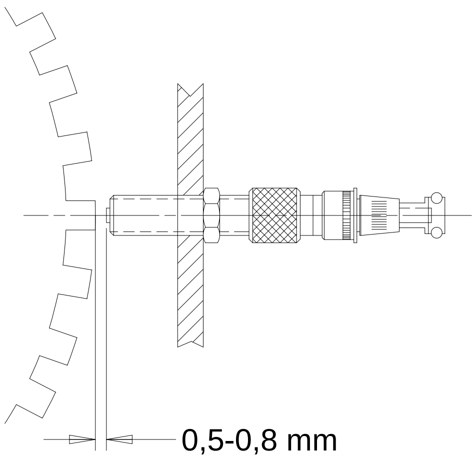
  Also, clean any waste oil, dust, etc. off the two connectors (cable and pick-up) with an electrical circuit cleaner.

ATTENTION

If you observe any impact, wear or other defect on the pick-up, change it for a new one.

- Adjusting the pick-up: the gap between the pick-up sensor and the moving component must be from 0.5 to 0.8 mm. To adjust the pick-up, screw it in to a stop and then back it half a turn. Next, secure the pick-up with the locknut and plug the signal cable.

  Other pick-ups are available, which permit a greater clearance between pick-up and moving part (0.25 and 1mm). However, we recommend you adjust the gap to the abovementioned values.



PRODUCT INFORMATION	INDEX	DATE	
IO-C-M-15-003e		*June 2007*	*Dep. 2*

KOHLER Powered by DRESSER-RAND

MAINTENANCE OF FLEXIBLE COUPLING

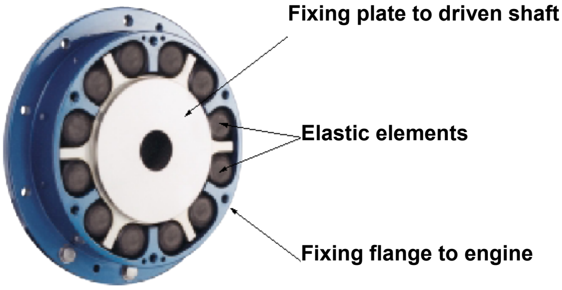
O&M_2.002262.810_10_2016

1. INTRODUCTION

This document provides information for appropriate maintenance of flexible couplings on KOHLER engines.

2. INSPECTING THE FLEXIBLE COUPLING

The flexible coupling on KOHLER engines consists of three major elements: fixing flange to engine, fixing plate to driven shaft and elastic elements.



According to the hours of operation and operating conditions (temperature, dirt, power variations…), it will be necessary to check the elastic elements of the coupling. The maintenance schedule specifies the inspection frequencies for each specific application.

NOTE

Sometimes, a visual inspection of the elastic elements may be difficult due to the peculiarities of the generating set or propulsion system. Under those circumstances, it will be necessary to carry out this visual inspection with an endoscope.

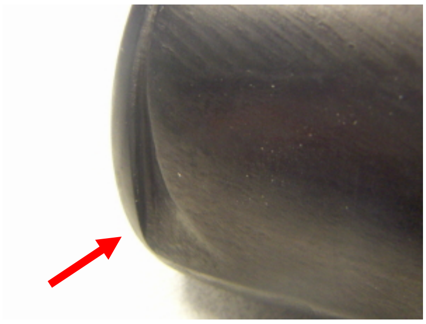
When inspecting a coupling visually, pay special attention to the following points:

- **Excessive deformation of the circular section**: if you notice that one of the elastic elements deviates from its original diameter in more than 10%, change it.

New elastic element

Deformed elastic element

- **Presence of cracks or indents**: change el elastic element if there is any type of crack, indent, and sign of corrosion… on it.



Indent in elastic element

To avoid this type of indents, make sure the elastic elements fits completely into its housing.

- **Wear of the element**: Change the element when the edges of the cylinder are worn, even if the element still has its original shape.

- **Change in the element hardness**: Change the element if its hardness varies from the nominal value in more than 10%.

  A sticker on the elastic element shows its Shore hardness. Example: if the element is SM70, its Shore hardness is 70; therefore, the permissible hardness range is 63 to 77 Shore.

1. INTRODUCTION

This document specifies instructions and recommendations for correct inspection and maintenance of batteries in service on KOHLER machines.

2. MAINTENANCE

2.1. ROUTINE INSPECTION

It is necessary to carry out the inspection and servicing tasks described below within the time intervals specified in the application-specific maintenance programme. Those tasks are:

- Adjusting terminal caps and vents.
- Removing dirt from the top of the battery with hot water and drying thoroughly.
- Checking voltage across the battery terminals with a voltmeter or similar tester. The measured voltage must be equal to or greater than 12.5V (6.25V for 6V batteries). Otherwise, the battery needs recharging (section 2.2).

NEVER PUT A FLAME OR MAKE SPARKS NEAR A BATTERY. FLAMMABLE VAPOURS COULD BE ISSUING.

2.2. CHARGING THE BATTERY

- Do not charge a battery if the room temperature is below 3ºC. The electrolyte may have frozen.
- It is best to remove the battery from the engine or set for its charging (see section 2.4).
- Always make sure the charger is off.
- Connect the battery, taking account of the terminals' polarity.
- Switch the charger on.
- Stop charging the battery if a lot of gas comes out or if the battery temperature rises above 50ºC.
- Observe the charging time specified for the type of charger used.
- After charging the battery, switch the charger off and wait for 20 minutes, until flammable gas has dispersed. When disconnecting the terminals, sparks may fly out.
- Check the acid levels (section 2.3) and refill as appropriate.
- Fit the battery on the engine. Connect the terminals and vents.

2.3. ADJUSTING THE ACID LEVELS

- If the battery does not operate once recharged, check and complete the acid level. If the battery remains flat, then you have to change it.
- Never fill electrolyte up to the maximum level of a battery that you are going to charge, since the level will rise during the charging process. However, if the acid level is under the separators, add distilled or deionised water until it covers the separators.
- Set electrolyte to the maximum level, once you have charged the battery.
- Do not overfill a battery: acid would flow through the vents during the charging process.
- Always use distilled or deionised water to refill the batteries. The use of acid liquid is restricted to the initial filling of the battery.
- After putting the battery in service again, recheck the acid level and adjust to the maximum level identified on the battery with a line or mark.

2.4. CHANGING THE BATTERY

- Detach the clips from the terminals, starting with the negative one.
- Do not short-circuit the loose connections.
- Remove the waste battery.
- In the event of 24V battery systems, both 12V batteries need a change. If you change only one of them, the service life of the new battery could be shorter.
- Check that clips and seat are free from corrosion and dirt. If necessary, clean with hot water.
- Remove the caps from the new battery terminals and put them on the old battery to prevent short-circuits.
- Set the new battery and do routine inspection (section 2.1.).
- Adjust and tighten the connection clips, starting with the positive one. DO NOT TIGHTEN TOO MUCH.

NOTE

These recommendations are of a general nature and users must follow the battery manufacturer's instructions. KOHLER shall accept no liability for troubles originating in the batteries.

CHAPTER 6 – TROUBLESHOOTING

1. INTRODUCTION

These instructions are intended as a guide to quick troubleshooting in Kohler gas engines.

The layout SYMPTOM / PROBABLE CAUSE / REMEDY leads to the solution of many minor engine problems.

At all times, an after-sales technical service is at our customers' disposal for any help to diagnose failures.

2. TROUBLESHOOTING GUIDE

SYMPTOM	PROBABLE CAUSE	REMEDY
Crankshaft will not rotate, using manual barring device.	Engine-driven machine in gear	Disengage the driven machine
	Coolant inside cylinder: 1. Damaged head gasket 2. Damaged exhaust manifold gasket 3. Cracked head 4. Cracked liner 5. Cracked crankcase	NOTE: Remove spark plugs to vent cylinders of accumulated coolant. 1. Change head gasket 2. Change manifold gasket 3. Change head 4. Change liner 5. Repair crack or change crankcase
	Seized piston	Change piston, rings and sleeve, as appropriate.
	Bearing stuck to crankshaft	Change bearings, check crankshaft.
Engine does not turn when pressing the start button	1. Worn or faulty starter batteries(1) 2. Air valve closed or low air pressure (2) 3. Defective starter motor 4. Drive pinion blocked 5. Emergency stop on 6. Alarm activated	1. Check batteries and change, if necessary 2. Open air valve or wait until there is enough air pressure 3. Change starter motor 4. Unblock the pinion 5. Release emergency stop (3) 6. Check system alarms and reset after solving the failure

(1) Electric starter
(2) Pneumatic starter
(3) First check that there is no risk for people or equipment and then solve the fault, if any.

CAUTION

Before operating the starter motor or the barring device, make sure the starter air valve is closed or the starter batteries off in order to avoid personal injuries in case of unintentional start.

GAS ENGINES TROUBLESHOOTING

SYMPTOM	PROBABLE CAUSE	REMEDY
The engine rotates, but does not start	Ignition fails 1. Pickup broken, faulty, dirty or in wrong position 2. Incorrect pick-up wiring, loose or broken wire 3. Reset pickup and hall-effect pickup are not synchronised (1). 4. Pick-up wrong positioned 5. Defective ignition module 6. Faulty spark plugs 7. Failure of high-voltage wires or coil 8. Incorrect programmed angle of reset pin (1)	1. Check, clean or change pickup as appropriate 2. Check and change wiring as appropriate 3. Synchronise with an oscilloscope 4. Change ignition module 5. Adjust the position of pick-up 6. Change or regap spark plugs 7. Check coils and high-voltage wires (IO-G-M-33-003e) 8. Measure and correct angle
	Fuel system fails 1. Manual gas valve closed 2. Insufficient gas supply pressure 3. Emergency solenoid valve closed 4. Pressure controller off, incorrectly set or defective 5. Carburetion failure 6. Fouled gas filter 7. Mechanical carburetion screw closed (2) 8. Zero pressure regulator broken or set incorrectly (2) (4) 9. Electronic gas valve closed (3) (4)	1. Open gas valve 2. Check line or contact supplier 3. Check power supply and opening 4. Reset, adjust or change controller 5. Readjust carburettor mixture valve. 6. Clean or change filter 7. Open screw and carburet again 8. Change or set regulator correctly 9. Check shaft movement and supply
	Insufficient compression 1. Broken or worn piston rings 2. Scratched sleeves 3. Overhead valves do not close correctly 4. Defective cylinder head gasket	1. Change piston rings 2. Change sleeves 3. Repair or change cylinder head 4. Change cylinder head gasket
	Dirty air filters	Change air filters
	Throttle valve does not open 1. Power supply failure 2. Mechanical failure 3. Problems with the control system 4. Programming error (3)	1. Check power supply, batteries and battery-charger 2. Check bearings and shaft bend 3. Check control system and change parts where appropriate 4. Check program.
	Alarm on	Reset alarms

(1) Engines with CPU95, GIS and GCS-e ignition system
(2) Engines with mechanical carburetion
(3) Engines with electronic carburetion
(4) Engines with NOx sensor or lambda sensor carburetion

SYMPTOM	PROBABLE CAUSE	REMEDY
Emergency stop	Engine alarm: 1. Oil pressure 2. Water temperature 3. Control program alarm 4. Overspeed 5. Knock detection system 6. Mixture temp. in intake manifold 7. Running instability 8. Exhaust temperature (1) 9. Emergency stop button depressed	Note: Check sensors to see if problem is due to measurement failure 1. Check lubricating system and reset 2. Check coolant system and reset 3. Check control system and reset 4. Check equipment and reset 5. Check cylinders 6. Check coolant system and reset 7. Check carburetion, spark plugs, high-voltage wires, coils, control system, fuel system, piston compression, valves adjusting 8. Check control system, lambda sensor and carburetion 9. Check equipment and release
	Faulty ignition system 1. Spark plug failure 2. Ignition module failure 3. High-voltage wires or coils failure 4. Power supply failure 5. Pickup fault	1. Change or regap spark plugs 2. Change ignition module 3. Check wires and coils 4. Check wiring, batteries or charger 5. Change faulty pickups
	Excessive load swing (2)	Reset and restart.
	Seized piston	Change piston, rings and liner, as appropriate
	Bearing rotation	Change bearings and check crankshaft

(1) Rich burn engines
(2) Island-mode generation or compressor applications

GAS ENGINES TROUBLESHOOTING

SYMPTOM	PROBABLE CAUSE	REMEDY
Engine does not reach rated speed	Overload due to wrong reading of power signal	Calibrate power signal
	Fuel system fails 1. Low gas pressure 2. Misadjusted pressure regulator 3. Poor carburetion 4. Clogged gas filter	1. Check supply line or contact supplier 2. Readjust or change spring 3. Readjust carburettor mixture valve Check MAP and MAT signals (1) Check NOx sensor or lambda sensor(2) 4. Clean or change filter
	Fuel leaks	Repair leaks
	Inadequate speed setting	Adjust rated speed setting
	Clogged air filter	Change air filter
Engine stops	Fuel system fails: 1. Low gas pressure 2. Misadjusted pressure regulator 3. Poor carburetion 4. Clogged gas filter 5. Regulator off 6. Shut-off electric valve closed 7. Fuel leaks	1. Check supply line or contact supplier 2. Readjust or change spring 3. Readjust carburettor mixture valve Check MAP and MAT signals (1) Check NOx sensor or lambda sensor(2) 4. Clean or change filter 5. Reset regulator 6. Check valve power supply 7. Repair leaks
	No spark produced 1. Ignition module failure 2. Lead or connector loose 3. Pickup damaged or dirty, inadequate spacing, wire detached or hall effect pickup not synchronised 4. Power supply failure	1. Change module 2. Check connectors and wires 3. Check and replace pickups if necessary. Check synchronisation of reset and hall effect pickups with an oscilloscope 4. Check voltage, batteries and chargers.
	Stop caused by GKCS (knocking)	Boroscope engine See knocking paragraph in next sheet
	PLC alarm	Identify alarm and assess its importance before resetting
	Control system alarm	Check equipment and reset alarm
	Overspeed	Check equipment and reset alarm
	Running instability	Carry out a general check of engine to determine the cause of instability.
	Line dropping or micro-cut	Reset power supply

SYMPTOM	PROBABLE CAUSE	REMEDY
Output power decreases or cannot reach preset value	Fuel system fails 1. Low gas pressure 2. Misadjusted pressure regulator 3. Clogged gas filter	1. Check supply line or contact supplier 2. Readjust or change spring 3. Clean or change filter
	Clogged air filter	Replace filters
	Dirty air cooler	Clean air cooler
	Leaks in intake or exhaust system	Check and repair leaks
	Turbocharger malfunction 1. Low oil pressure 2. Dirty blades 3. Excessive backpressure 4. Turbo seized up 5. Damaged blades	1. Check pipes 2. Clean or replace turbocharger 3. Check exhaust 4. Change turbocharger 5. Change turbocharger
	Ignition failure	Check spark plugs, high-voltage wire and coils
	Insufficient compression 1. Piston rings broken or worn 2. Scratched liners 3. Overhead valves do not close 4. Defective cylinder head gasket	1. Change piston rings 2. Change liners 3. Rework cylinder head or change 4. Change cylinder head gasket
	Problem with throttle 1. Speed PID misadjusted 2. Low voltage 3. Problem in program	Check throttle with engine stop 1. Adjust speed PID 2. Check batteries or chargers 3. Check program
	Carburetion problem 1. Carburetion dailure 2. Failure in MAP sensor(1) 3. Failure in MAT sensor(1) 4. Failure in NOx sensor or lambda sensor(2)	1. Readjust carburettor 2. Change sensor/check wiring. Check gas leaks in conections 3. Change sensor/check wiring. 4. Change sensor/check wiring
Engine does not accept sudden changes in power	Too lean air-fuel mixture	Readjust carburettor mixture valve.
	With hydraulic controller, speed PID misadjusted	Adjust PID potentiometers correctly on controller board.
	With electronic controller, speed PID misadjusted	Adjust speed PID. You need to have advanced knowledge of programme
	Ignition system failure	Check wires, coils, spark plugs and connectors

(1) Engines with electronic carburetion
(2) Engines with NOx sensor or lambda sensor carburetion

SYMPTOM	PROBABLE CAUSE	REMEDY
Engine shows signs of ignition failures	Too lean air-fuel mixture	Readjust carburettor mixture valve.Check NOx sensor or lambda sensor signal(1)
	Spark plug failure	Check, regap or change spark plus as appropriate
	Coil or high-voltage wire failure	Change wires or coils that are out of specifications
	Ignition module failure	Change module
Knocking Whenever knocking occurs, endoscopic examination is necessary to determine the extent of the fault and to be able to change any affected parts. If the engine incorporates a Detonation Detection System, check the sensors to see if they fail to detect knocking on time.	High temperature of intake air	Clean air cooler, check thermostats and auxiliary circuit pump
	Oil jet broken or bent	Change jet. Inspect piston dome for signs of overheating and, if any, change piston
	Intake or exhaust valve drop	Change cylinder head and, where appropriate, sleeve, piston...
	Excessively advanced ignition	Check ignition timing
	High water temperature in main circuit 1. Not enough coolant 2. Air in the main circuit 3. Water leak 4. Dirty radiator or heat exchanger 5. Fan failed 6. Damaged pump 7. Damaged cylinder head gaskets	1. Add coolant into the circuit 2. Vent the circuit 3. Repair leak 4. Clean radiator or heat exchanger 5. Change fan 6. Repair or change pump 7. Change cylinder head gasket
	Overload due to wrong reading of power signal	Calibrate power signal
	Too rich air-fuel mixture	Readjust carburettor mixture valve. Check MAP and MAT sensors signal(2) Check NOx sensor or lambda sensor signal(1)
	Broken or damaged spark plug	Change spark plug
	Overhead valves do not close correctly	Change or rework cylinder head
	Foreign bodies in the combustion chamber	Remove foreign bodies
	Carburetion control failure	Check control program
	Failure of gas flow regulating valve	Change gas flow regulating valve
	Sudden change in gas quality	Check against chromatogram if available. Readjust carburettor mixture valve(3) Check programming if electronic system installed (2)
	Seizure	Change any parts concerned.

(1) Engines with NOx sensor or lambda sensor carburetion
(2) Engines with electronic carburetion
(3) Engines with Mechanical carburetion

SYMPTOM	PROBABLE CAUSE	REMEDY
Low oil pressure	Low oil level	Fill oil sump up to the specified level
	Inaccurate pressure gauge	Recalibrate or change, as appropriate, the pressure gauge
	Clogged oil filters	Change filters
	Oil pressure regulating valve damaged	Change spring or piston, as the case may be
	Overpressure valve open	Change overpressure valve
	Damaged or faulty oil pump	Change oil pump
	Oil leak	Locate and repair leak
High oil pressure	Regulating valve in bad condition	Change regulating valve
	Low oil temperature	Check thermostat
	Inadequate oil viscosity	Use oil to specification
	Inaccurate pressure gauge	Recalibrate or change the pressure gauge
	Safety valve stuck	Change safety valve
High oil temperature	Damaged thermostat	Change thermostat
	Overload	Check power signal
	Insufficient cooling	Clean cooler
	Low oil pressure	Check regulating valve
	Low oil level	Refill oil sump
	Rotation of crankshaft bearings	Change crankshaft bearings
Low oil temperature	Thermostat stuck open	Change thermostat
	Low temperature of oil cooler coolant	Check thermostats on water circuit
Excessive oil consumption	Oil leaks 1. Cylinder head gasket 2. Oil cooler 3. Any point of the oil system outside the engine 4. Crankshaft seal	1. Change cylinder head gasket 2. Change oil cooler seals and check tube 3. Repair external leaks 4. Change crankshaft seal
	Inadequate oil viscosity	Use oil of adequate viscosity
	Damaged piston rings or scratched liner	Change piston rings. Grind or change the liner according to depth of scratches
Oil contaminated with coolant. If oil is contaminated, you must solve the problem and then change oil.	Scratched liner	Change liner
	Cracked crankcase	Change crankcase
	Cracked cylinder head	Change cylinder head
	Broken cooler	Repair or change cooler
	Damaged cylinder head gasket	Change cylinder head gasket

SYMPTOM	PROBABLE CAUSE	REMEDY
Low gas pressure	Broken or misadjusted regulator	Readjust or change regulator
	Insufficient gas supply pressure	Contact gas supplier
	Fuel leaks	Inspect fuel system and repair
	Undersized pipelines	Check circuit and make sure pipe diameter is adequate for the gas quality
	Clogged gas filter	Clean or change filtering element
High gas pressure	Broken or misadjusted regulator	Readjust or change regulator
Low water pressure	Damaged or inaccurate pressure gauge	Change or recalibrate
	Low coolant level	Refill with coolant
	Blocked radiator or heat exchanger	Clean radiator or heat exchanger
	Coolant leak	Locate and repair leaking item
	Damaged cylinder head gasket	Change gasket
	Damaged or defective pump	Repair or change pump
	Cavitation	Drain the circuit
High water pressure	Damaged cylinder head gasket	Change gasket
	Flow restriction in water system	Check system and change items restricting flow
	High water temperature	Clean heat exchanger or radiator; check fan, thermostats...
Low water temperature	Thermostats stuck open	Change thermostats
	Broken or inaccurate thermometer	Recalibrate or change thermometer
High water temperature	Broken or inaccurate thermometer	Recalibrate or change thermometer
	Low coolant level	Refill with coolant
	Thermostats stuck closed	Change thermostats
	Air bubbles in circuit	Vent the circuit
	Overload	Check power signal
	Damaged or defective water pump	Repair or change water pump
	Water frozen in radiator	Defrost radiator
	Damaged cylinder head gasket	Change cylinder head gasket
	Late ignition	Re-time
	Cracked cylinder head	Change cylinder head
	Cracked liner	Change liner
	Low water flow	Check system and change items restricting flow

SYMPTOM	PROBABLE CAUSE	REMEDY
High exhaust gas emissions	Excessively advanced ignition	Check with a stroboscopic lamp and re-time as necessary
	Carburetion maladjustment	Readjust carburettor mixture valve.(1) Check MAP and MAT sensors signal(2) Check NOx sensor or lambda sensor signal(3)
	Ignition failures	Check spark plugs, high-voltage wires and ignition coils
	Change in gas quality	Readjust carburettor mixture valve.(1)
	Dirty air filters	Change air filters
Excessive vibrations	Incorrect alignment of engine	Re-align
	Fasteners loose	Retighten fasteners
	Defective damper	Change damper
	Wrong crankshaft counterbalance	Re-balance
	Loose flywheel	Retighten flywheel fasteners
Unusual noise	Knocking	Stop engine and check cylinders
	Overload	Check power signal
	Excessive valve clearance	Re-adjust valve clearance
	Sticking valves	Repair valves
	Piston hits jet	Change jet
	Pin failure	Change pin
	Excessive crankshaft end play	Replace main bearing thrust rings.
	Gears in bad condition	Change defective gears
	Leak in intake or exhaust	Locate and repair leaks
Excessive fuel consumption	Leak in gas system	Locate and repair leaks
	Incorrect ignition advance	Adjust timing with a stroboscopic lamp
	Combustion failure in a cylinder	Check coils, wires and ignition spark plugs
	Incorrect air-fuel mixture	Readjust carburettor mixture valve(1) Check MAP and MAT sensors signal(2) Check NOx sensor or lambda sensor signal(1)
	Overload	Recalibrate power signal

(1) Engines with mechanical carburetion

(2) Engines with electronic carburetion

(3) Engines with NOx sensor or lambda sensor carburetion

SYMPTOM	**PROBABLE CAUSE**	**REMEDY**
Engine oscillates	Engines with electronic carburetion and electrical throttle: 1. Spees PID Misadjusted 2. Low voltage in throttle actuator 3. Tool lean mixture 4. Program prolem 5. NOx sensor or lambda sensor failure	1. Adjust speed PID 2. Change batteries or charger 3. Adjust A/F ratio, opening the screw 4. Check program 5. Check sensor and wire
	Engines with electronic carburetion and electric throttle: Speed PID misadjusted 1. Low voltage at throttle 2. Too lean mixture 3. Problem with program	You need to have good knowledge of the control system in order to solve program-related issues 1. Adjust speed PID 2. Change batteries or charger 3. Readjust carburettor mixture valve 4. Check program
	Clogged air filters	Change filters
	Ignition fails 1. High voltage wires 2. Coils 3. Damaged spark plugs or inadequate gap 4. Defective ignition module	1. Change faulty wires 2. Change defective coils 3. Regap or change spark plugs Change ignition module
	Low or fluctuating gas pressure	Change regulator and, if problem is due to gas supply, contact your supplier
	Dirty air cooler	Clean cooler
	Turbochargers in bad condition	Change turbochargers

TP-7019   8/18b (2.002262.810)

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