

DIESEL ENGINES INDUSTRIAL APPLICATIONS

**INSTALLATION
HANDBOOK**

TECHNOLOGICAL EXCELLENCE

**IVECO
MOTORS**

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PREMISE

Aim of this handbook

This Handbook has been written to give you the basic information and instructions for the correct choice and installation of IVECO Diesel engines for industrial, agricultural and automotive applications. To get the best performance and longest life from your engine you must install it correctly.

The content of this publication does not replace the expertise and work of designers and engineers who have the full responsibility for the choice of the machine engine.

Further and more detailed information about the characteristics of IVECO engines can be found in the specific publications.

Every information included in this Installation Handbook is correct at the time of approval for printing. IVECO reserves the right to make changes without prior notice, at any time, for technical or commercial reasons or possible adaptations to the laws of the different Countries and declines any responsibility for possible errors or omissions.

General installation criteria

As an introduction to this Handbook, reference must be made to the following basic installation criteria:

- choose the engine which is most suitable for the machine according to the power, torque and rpm requirements and considering the type of use and the environmental conditions for the engine operation (temperature, humidity, altitude);
- connect the engine to the driven elements in the correct way, bearing in mind the problems linked to the drive and the resulting vibrations;
- adjust the size of the engine compartment or the engine room to facilitate access to the engine and the connected parts, both for ordinary maintenance operations and possible repairing operations;
- foresee the suitable air intake needed for the engine combustion and fundamental for the engine room ventilation;
- get the fuel system dimensioned and positioned correctly;
- give the priority to those safety problems concerning the personnel in charge of the engine operation, such as:
 - use of the suitable protections and guards for each exposed moving part (pulleys, shafts, belts, etc.)
 - correct insulation of wires and electrical parts
 - suitable protection and insulation of all exhaust pipes.
 - act while respecting prescriptions required for the antifire protection.

Laws and regulations

The IVECO industrial engines are designed and manufactured in compliance with the laws in force and are approved by the main homologation/type approval Board.

As the subject is particularly complex, it is always necessary to make reference to the specific laws of each country which can regulate the different aspects of this subject in different ways, especially:

- the limitations to gas and noise emissions
- the restrictions to the installed power for the operation in dangerous areas
- the engine characteristics to meet the requirements of particular electrical systems and safety devices.

Warranty

The choice of a type of engine which is not suitable for the required application and/or the non observance of the installation instructions and the use and maintenance rules can make the warranty void.

Safety precautions

We remind you that IVECO industrial engines are designed for professional applications, and not for sports or competitive purposes for which the warranty decays and the supplier's responsibility is excluded.

The machine safety always depends on the user's responsibility and common sense. Keep away from the engine moving and hot parts, and take care when coming closer to the engine to prevent possible injuries due to direct contact with the engine or through clothes, jewels, or other objects.

Use the suitable protection devices when carrying out maintenance operations and engine setting.

Before starting the engine, make sure it is fitted with all the elements foreseen by the manufacturer and the installation; do not start the engine with the lubricating, cooling and fuel circuits closed by plugs or obstructed.

Daily check the complete tightness of fluid circuits, especially those of fuel and lubricants, which may cause fires and thus damage people and things.

Make sure that the different pipes are not in contact with hot surfaces or moving elements.

Disconnect the battery in the event of maintenance operations concerning the electrical system.

Drain the cooling, lubrication and fuel circuits only after the fluids cooled down. The pressurised cap of the water circuit can be opened only after the engine cooled down.

The batteries contain a solution of sulphuric acid which is highly corrosive, therefore they must never be turned upside down and must be handled with great care to prevent the fluid transfer. Make sure the battery compartment gets the suitable air intake.

The used engine fluids and air, water and oil filters must be suitably preserved and sent to the appropriate collection centres.

SECTION I

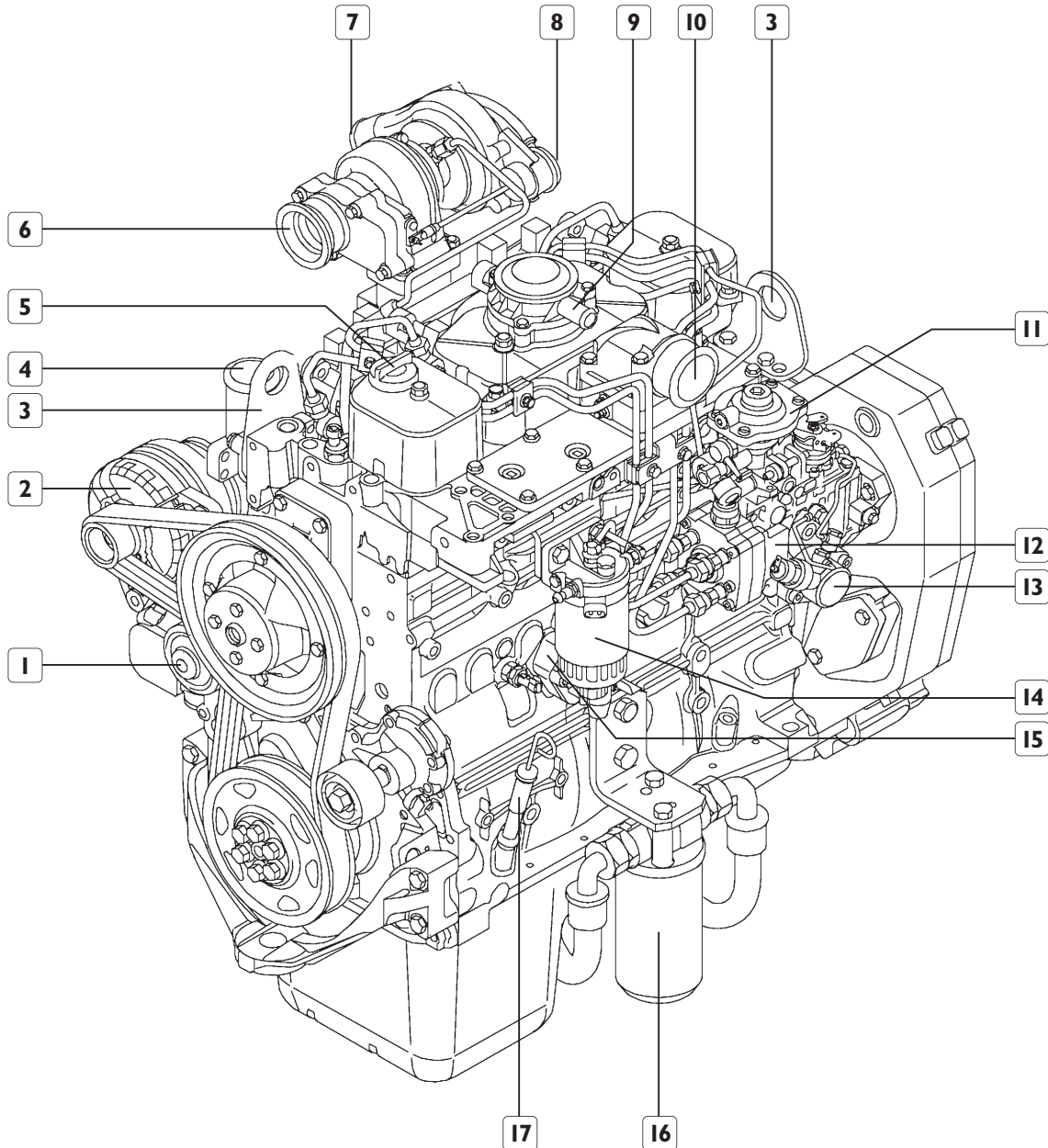
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1.1 ENGINE

Before analysing the main characteristics of the engine relevant for its choice and suitability for the machine and the connection to the engine elements, we believe it is useful to identify the names of the engine components.

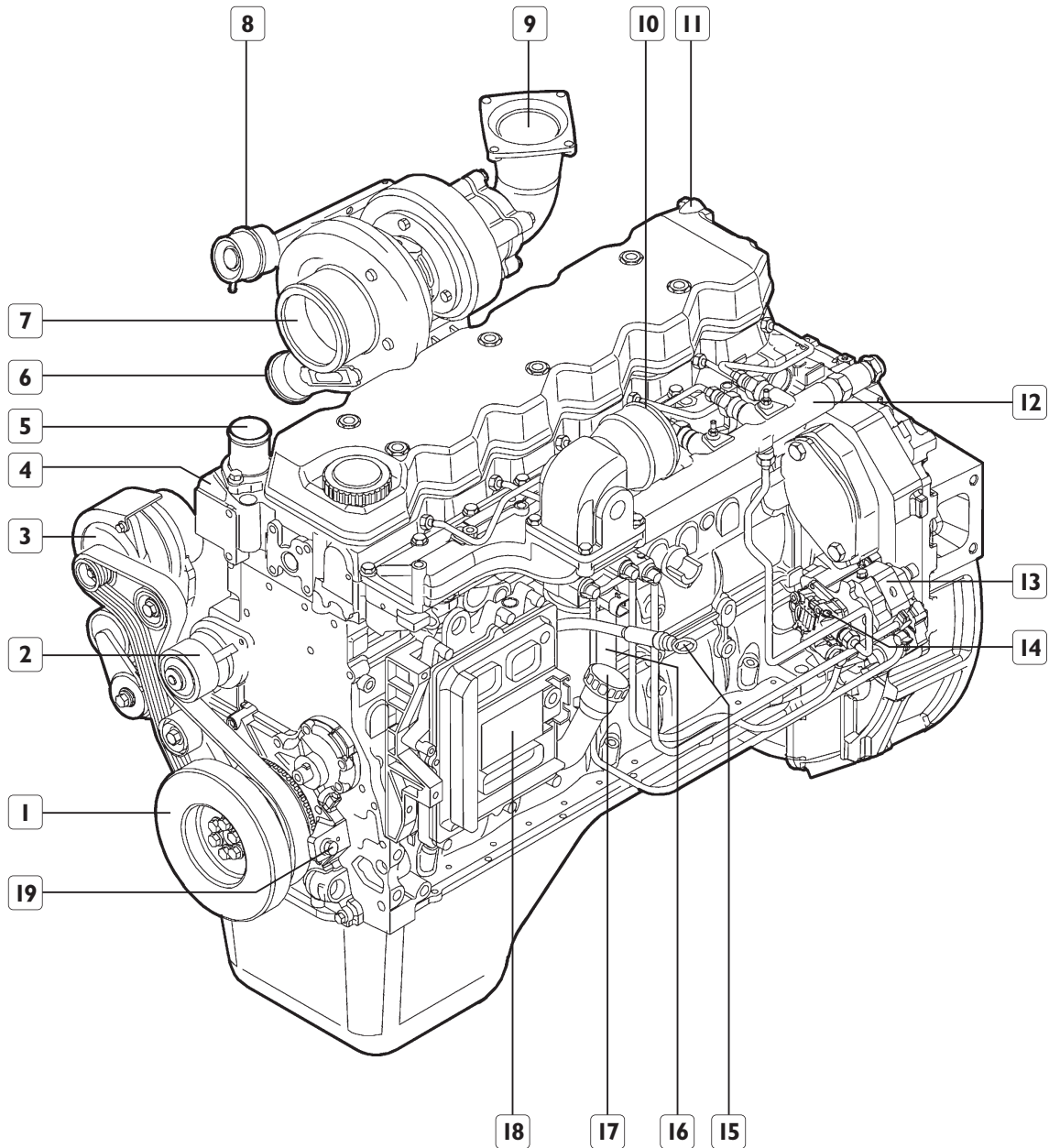
Figure 1 A



ENGINE EQUIPPED WITH MECHANICAL INJECTION PUMP

1. Dragging pump for coolant fluid- 2. Alternator - 3. Eyelet or eyebolt for lifting purpose - 4. Coolant outlet towards heat exchanger (radiator) - 5. Filler cap for lubricating oil - 6. Turbine exhaust gas outlet - 7. Supercharging air outlet towards heat exchanger (intercooler) - 8. Waste gate actuator - 9. Oil vapour breather (blow by) - 10. Suction induction manifold - 11. LDA device (injection adaptation for supercharging operation) - 12. Injection pump - 13. KSB device (injection adaptation for low temperature) - 14. Fuel filter - 15. Fuel transfer pump - 16. Oil filter - 17. Oil level dipstick

Figure I B



ENGINE EQUIPPED WITH ELECTRONIC CONTROL INJECTION SYSTEM

1. Damping flywheel - 2. Dragging pump for coolant fluid - 3. Alternator - 4. Thermostatic valve - 5. Coolant fluid outlet towards heat exchanger (radiator) - 6. Supercharging air outlet towards heat exchanger (intercooler) - 7. Air intake in turbosupercharger - 8. Waste gate actuator - 9. Exhaust gas outlet from turbine - 10. Intake suction manifold - 11. Oil vapour breather (blow by) - 12. Common rail - 13. High pressure pump - 14. Fuel transfer pump - 15. Oil level dipstick - 16. Fuel filter - 17. Filler cap for lubricating oil - 18. Electronic Control Unit - 19. Rotation speed sensor.

Piston displacement

The element which best distinguishes the engine is the “overall piston displacement” which represents the total volume of air moved by the pistons during one complete turn of the drive shaft. It represents also the theoretical quantity of air sucked by the cylinders during 2 revolutions of the drive shaft. It is given by the formula:

$$\frac{\pi d^2 \cdot c \cdot i}{4} \text{ in cm}^3, \text{ where:}$$

- π : 3.1416
- d : cylinder diameter (bore) in cm
- c : piston travel in cm
- i : n° of engine cylinders

Effective average pressure

It is the average value of the pressure inside the cylinders during the different operating phases of the engine. It increases during the combustion phase and decreases during the exhaust and suction phases. It is possible to consider it as an indicator of the engine stress since it represents the work done per displacement unit. The real average pressure generates the driving torque and therefore the engine power:

$$N = p.m.e. \cdot \frac{V \cdot n}{1200} \text{ where:}$$

- N : power [kW]
- $p.m.e.$: real average pressure [bar]
- V : total piston displacement [dm³]
- n : rotation speed [giri/min.]

From it you obtain:

$$p.m.e. = \frac{N \cdot 1200}{V \cdot n}$$

With these formulas you obtain that:

- the power is the linear function of the real average pressure and of the engine rotation speed;
- with the same power and the same number of rpm, the engines with a higher piston displacement are subject to a lower real average pressure

The power needed for a machine/vehicle propulsion requires, if the operating rpm number is the same, the appropriate consideration about the engine to be used: an engine with a higher piston displacement is subject to a lighter mechanical load as shown by a lower value of the real average pressure and therefore it will be possible to use it for heavy duties compared to the engine with a lower piston displacement.

Driving torque

It represents the thrust impressed by a piston through the connecting rod on the crank arm of the drive shaft. It can be defined as the “rotating force” available to the engine flywheel; it depends on the real average pressure and is strongly influenced by the volumetric efficiency of the engine, i.e. from its capacity to suck as much air as possible. Other important factors to obtain a high driving torque and therefore power are the correct fuel intake and the perfect injection system setting.

The driving torque M depends on the power according to:

$$M = 1000 \cdot \frac{N}{n} \quad \text{where:}$$

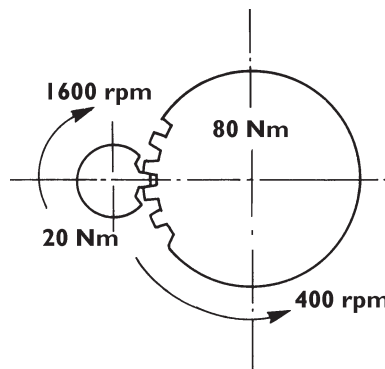
- M : driving torque [Nm]
- n : rotation rpm [rad/sec] (1 rev per min = $\pi/30$ rad/sec)
- N : power [kW]

The formula shows that with equal power it is possible to install engines with high torque and low rotation speeds or vice versa, low torque and high rotation speeds.

High rotation speeds can generate a high torque by means of a speed regulator:

Figure 2 shows how a revolution reduction ratio of 4:1, obtained by coupling the gear wheels with this ratio, makes the output torque increase by the same value 4.

Figure 2



Power

The air and fuel intake inside the cylinders and then burnt during combustion produces the same heat energy which, translated into pressure and force, passes to the crank mechanisms and then to the engine flywheel in the form of mechanical energy, less thermo-dynamic and friction losses. Such energy referred to the time unit is the power that can be generated by the engine and is expressed by the formula:

$$N = \frac{M \cdot n}{1000} \quad \text{where:}$$

- M : driving torque [Nm]
- n : rotation rpm [rad/sec] (1 rev per min = $\pi/30$ rad/sec)
- N : power [kW]

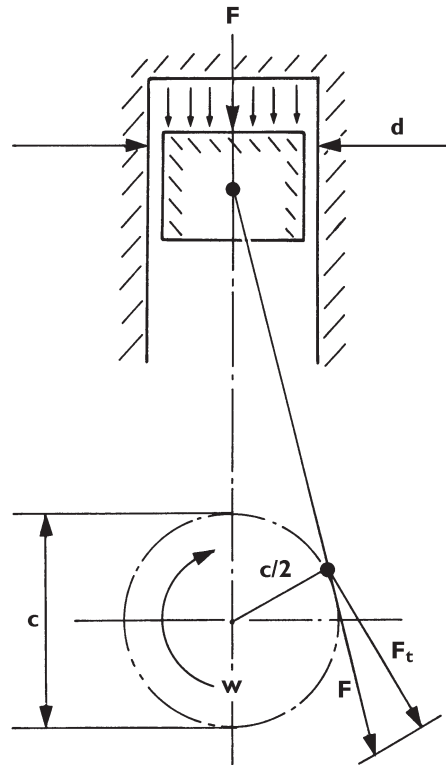
Figure 3 illustrates the process which generates power as the product of the torque by the angle speed, corresponding to the work of the time unit referred to the rotating motion.

In addition, we provide the following equivalences:

■ 1 kW = 1.36 CV = 1.34 HP

■ 1 CV = 0.986 HP (unit of British Std. and S.A.E).

Figure 3



d. bore - c. travel - w. angle speed - F. force generated by the real average pressure. - $c/2$. crank arm.

Brake real power

It is the power measured with the dynamometric brake at the drive shaft (flywheel) during the bench tests.

The real power values are considered as indicators of the engine capability of generating power in the temperature, pressure and humidity conditions of the test room where the measurements have been carried out. The resulting power can change according to the environmental and load conditions of the accessories connected to the engine (air filters, silencers, fans, pumps, alternators, compressors, etc.).

Correct power

To make it possible to compare the power values measured on the brake in different environmental and testing conditions, some "test standards" have been issued by the different ruling bodies (ISO, BS, DIN, SAE, etc), whose aim is to establish the suitable correcting factors to be adopted to adjust the different power rates. The rules are different, basically for the choice of the number of accessories to be connected to the engine during the test and the different reference environmental conditions. As a result, the measurements carried out on the same engine, on the basis of the different prescriptions given by different rules, lead to different results; therefore, it is possible to compare the engine powers only if measured on the basis of the same rule or by applying the correcting coefficients for the off standard performance.

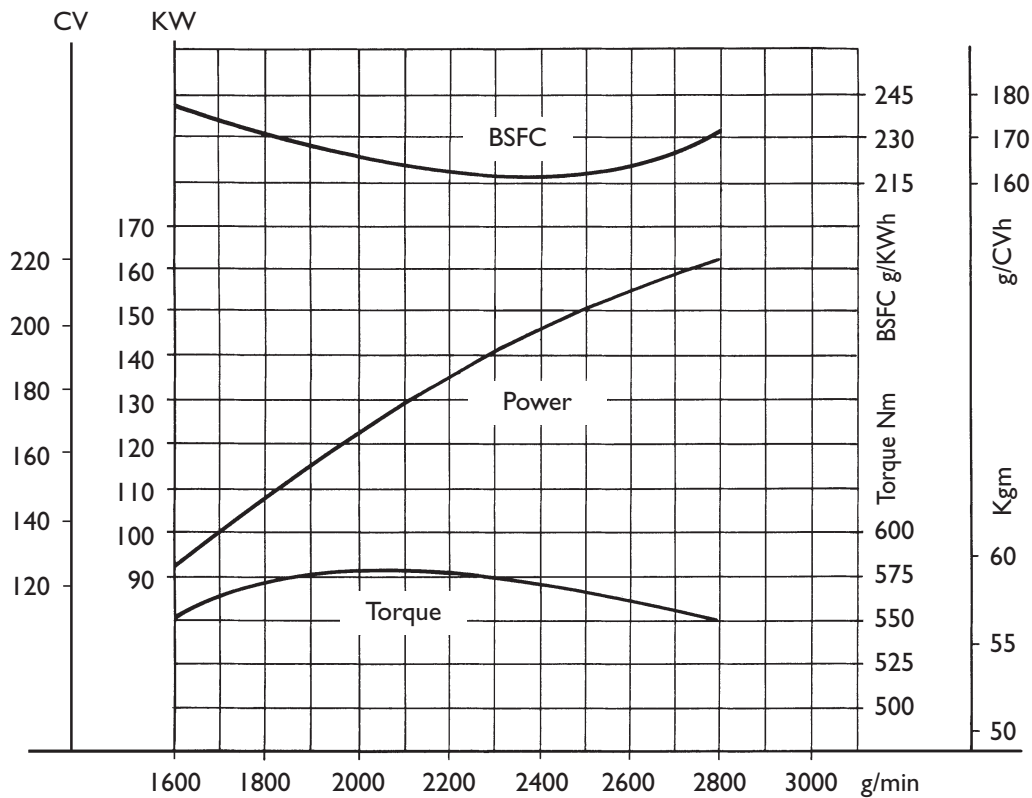
In particular, ISO 3046/1, concerning the definition of powers and the bench testing conditions, establishes and unifies:

- The test method for the brake net power and the engine equipment during the test (presence of power-absorbing accessories)
- The reference environmental conditions: temperature of sucked air 298°K (25°C), ambient pressure 100 kPa (750 mmHg), relative humidity 30% and the correcting formulas
- The fuel characteristics.

In addition, IVECO provides the customers with the technical and commercial documentation concerning IVECO engines including the reference to the rules required for the correct choice of the engine.

Figure 4 illustrates the power curves of an IVECO engine.

Figure 4



Engine total efficiency

The engine total efficiency is defined as the relationship between the flywheel work and that corresponding to the quantity of the fuel heat energy used to obtain that work. All the technical factors contribute to the engine efficiency, from the design to the setting, the maintenance to the fuel quality.

The engine efficiency, index of the efficiency of transformation of the fuel energy into mechanical energy, is inversely proportional to the fuel specific consumption: an higher efficiency means a lower fuel consumption required to obtain the power yield. The overall efficiency of a Diesel engine is around 0.4 with a clear loss of 60%.

Fuel consumption

The mechanical energy supplied by the engine is obtained by means of the fuel introduced in the engine itself. There are two definitions for the consumption:

- specific consumption
- hourly consumption.

The “specific consumption” represents the quantity of fuel used to obtain a unit of mechanical energy; it is expressed in g/kWh and derives from the formula:

$$C_s = 3600 \cdot \frac{L \cdot \gamma}{N \cdot t}$$

Where L is the volume in cm³ of the fuel having specific gravity γ (in g./ cm³), consumed by the engine in time t expressed in seconds, while power N (in kW) is supplied at given rpm.

The “hourly consumption” represents the quantity of total fuel used by the engine when supplying a power with value N at constant rpm for 1 hour; it is expressed in kg/h and is derived as follows:

$$C_h = \frac{C_s \cdot N}{1000} = 3,6 \cdot \frac{L \cdot \gamma}{t}$$

The corresponding value in litres is obtained by dividing the result by the fuel specific gravity; for the diesel fuel it amounts to 0.83 kg/dm³ at ambient temperature.

As the consumption is related to the power supplied by the engine, the evaluations and the comparisons between hourly consumption rates must be made taking into consideration precise and homogeneous engine operating conditions.

Load factor

It represents the average load in time of the power actually required to an engine, expressed as a percentage of the value of its maximum power:

As it represents the engine heavy duty index, it is a relevant indicator for the choice of the correct engine in relation to its application and use. Analysing the engine “load factor” means evaluating which power levels are required during the different work cycles in relation to its possible use at maximum power.

It is expressed by the following formula:

$$F = \frac{\sum_1^N P_i \cdot t_i}{P_{\max} \cdot \sum_1^N t_i} \cdot 100 \quad \text{where :}$$

- P_i : power absorbed for time t_i
- P_{\max} : maximum power
- N : number of phases in which the work cycle can be split.

Example of calculation for an application having:

- Max power 200 kW
- Working cycle of 12 hours, out of which 3 hours at maximum power and 9 hours at half power

The resulting load factor is:

$$F = \frac{(200 \cdot 3) + (100 \cdot 9)}{12 \cdot 200} \cdot 100 = 62,5\%$$

Since there are no established rules for the calculation of the heavy duty rate according to the load factor, it is possible to consider the following elements:

- Light work load factor below 50%
- Medium work load factor from 50 to 70%
- Heavy work load work above 70%

Therefore, the work factor is an index of the work heaviness.

The definition of load factor already includes the time parameter. However, it is important to stress the concept of "continuous" work or "intermittent" work (see figure 5):

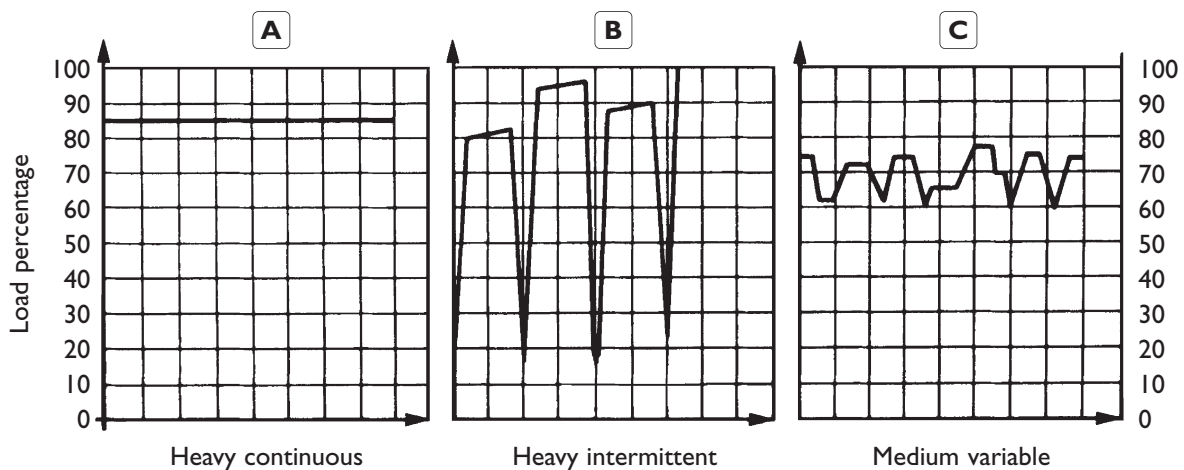
- As continuous work it is usually meant the engine constant operation at maximum load (24 hours a day), with minor load and speed variations, or having no variations at all.
- As intermittent work it is meant the use of the engine with frequent and substantial load and/or speed variations.

In this respect, see the power classification included in the technical-commercial documentation of each engine.

The above mentioned points are fundamental for the choice of the engine in terms of piston displacement, power, overhaul intervals, engine and transmission foreseeable duration.

In particular, it is important to bear in mind that the engine load, i.e. its real average pressure, influences the engine overhaul intervals.

Figure 5



Engine duration

The engine duration is identified by the relevant BEI0 and is related to a given Load Factor (L.F.).

Example: $BEI0 (L.F. - 0.7) = 10.000 \text{ h}$

It shows that 90% of the engines working with a medium load factor of 70% exceed the operation duration of 10,000 h, without actions needed for the removal of their main components.

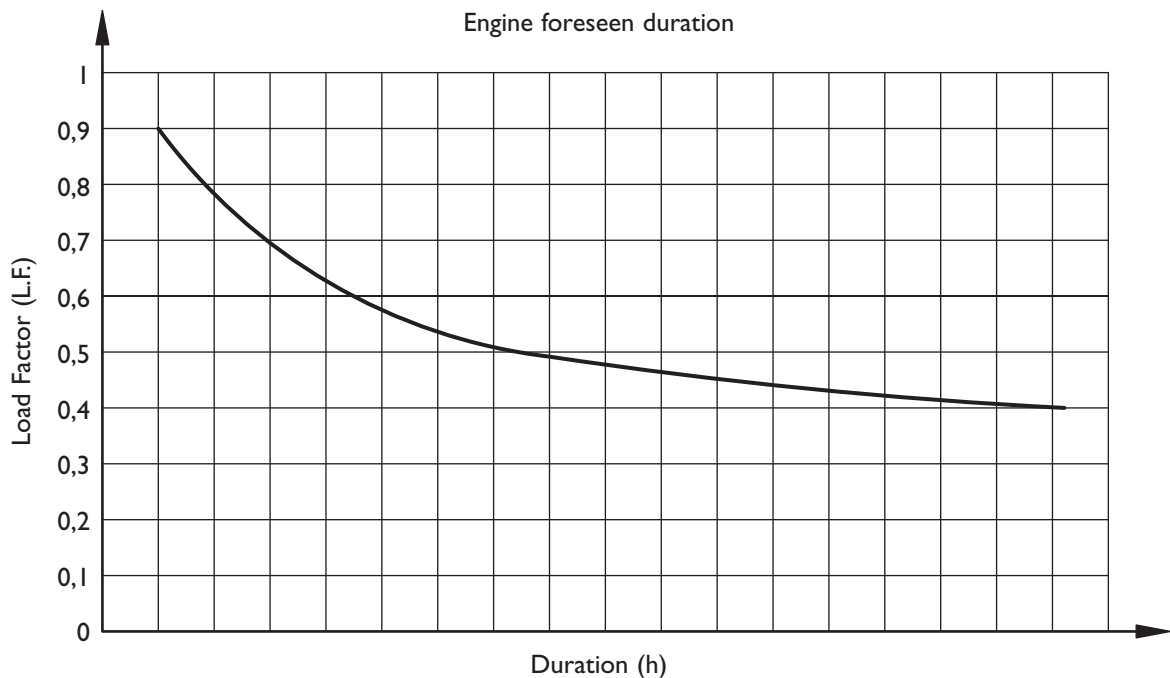
Each engine family and each setting have been associated to a BEI0 and the relevant "load factor". The values result from the use practical tests and the processing of the different data obtained during the bench tests.

It is possible to foresee the engine duration for a specific setting and "load factor" with a good margin of approximation, on the basis of the following correlation:

$$(L.F.)_i = (L.F.)_1 \cdot \left(\frac{h_1}{h_i} \right)^{0,3}$$

Figure 6 illustrates the function linking the Duration with the Load Factor:

Figure 6



CAUTION

The engine duration is closely linked to the correct and precise performance of the maintenance actions foreseen by the manufacturer.

To the definition of "engine duration" it must be associated the concept of "**service continuity**" whose reliability is substantially influenced by the environmental conditions and by the efficiency of components installed in the engine such as the air filters, fuel filters and oil and the other components subject to wear and by the observance of the maintenance terms.

The filtration systems agreed upon with IVECO in terms of contract or installed by the constructor or the machine installer, will have to be dimensioned according to common sense criteria, best if with redundancy criteria, especially when is expected an engine exploitation with load factors exceeding 70 % for long period of time; for instance it could be adopted multistage or parallel filters with the possibility to switch them for possible substitution during engine operation.

Particular attention should be paid to filters dimensioning and choice for those applications which are expected to be used with engines in environment highly polluted because of any kind of dust or the refuelling from tanks for which is not ensured a periodic and frequent cleaning operations; in such cases the filter cleaning and substitution must occur at time intervals reduced with respect to what normally expected for different uses.

SECTION 2

ENGINE CHOICE FACTORS

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2.1 OVERVIEW

The type of machine/vehicle and its purpose, represented by the load factor and the foreseeable operating time, together with the choice of the transmission, make it possible to identify the performance required to the engine.

As the power data which can be derived from the typical curves are the net ones resulting from the flywheel and referred to particular environmental conditions, in the choice of the engine it is necessary to foresee a sufficient power reserve to compensate for factors such as:

- The environmental conditions (temperature, height, humidity)
- The power absorbed by accessories such as pumps, compressors, winches, alternators actuated by the engine, silencers, additional air filters and mechanical organs between engine and transmission
- Fuel temperature
- Insufficient maintenance and lack of regular setting-up
- Preservation conditions and efficiency of the entire machine

2.2 ENGINE PERFORMANCE

The diagram of the typical curves of an engine illustrates the maximum engine power and torque according to the rotation speed and provides the engine specific consumption. The engine power and torque values will be different according to the position of the accelerator lever (see figure 1).

On the basis of the power and torque curves, which bound the engine operating range when the accelerator is in limit switch position, it is possible to derive other important parameters for the choice of the engine:

- **Maximum idling speed (n_v):** it is the maximum rotation reached by the engine without load, with the accelerator in limit switch position. This limit is set by the speed regulator of the injection pump, or by the engine electronic control system EDC, which limits the fuel inlet to the quantity needed to keep the engine running, thus preventing overspeed. This parameter must be taken into consideration for the choice of the engine when there are limitations to the maximum rotation speed bearable by the drive system, as in the case of the hydrostatic pumps, or at the speed of the vehicle/machine.
- **Maximum power speed (n_p):** it is the speed where the maximum power is supplied, called also rated speed. It corresponds to the rotation speed at which the regulator - mechanical or electronic - with the accelerator in limit switch position, starts to reduce the fuel inlet to control the speed as the torque required by the engine drops. During the bench tests it is possible to detect the maximum power speed by loading the dynamometric brake, starting from the idling maximum speed with the accelerator at limit switch, until the maximum power is detected.

This ratio $\frac{n_v - n_p}{n_p} \cdot 100$ represents the **regulator percentage difference** at the rated speed.

The curve linking the maximum power value to the null power at the maximum speed is called **gap curve**. Depending on the use, it may be noticed reduced errors (equal to 5-7 %), normal or typical of the industrial use (equal to 8-10 %) and for vehicular use (>10 %). The error value may be considerably reduced in presence of the EDC system.

- **Maximum torque speed (n_c):** it is the speed, or speed interval, at which the engine reaches the maximum torque. It is measured during the above mentioned tests, starting from the maximum power with the accelerator in limit switch position and increasing the load of the dynamometric brake. The higher need for energy makes the engine reduce its running speed in order to obtain the maximum torque.

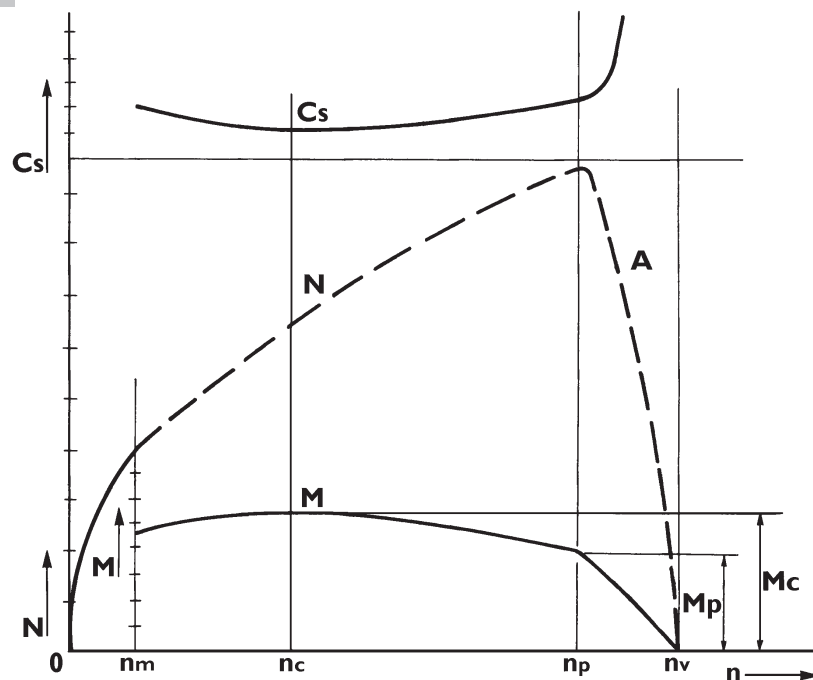
The relationship between the torque speed rate and maximum power, and the corresponding torque increment, allow the engine elasticity parameter identification:

$$\text{Elasticity: } \frac{M_c}{M_p} \times \frac{n_c}{n_p} \quad \text{where:}$$

- M_c : Maximum torque value
- M_p : Torque value at the maximum power r.p.m.

The maximum torque speed is usually identified as the condition with the lowest specific consumption. With a speed ranging between the maximum power value and the maximum torque value the engine has a "stable" behaviour; i.e. it regulates itself to adapt its speed spontaneously to the load changes.

Figure 1



ENGINES PERFORMANCES

Cs. Specific consumption - N. Power - n. Engine speed - M. Torque - A. Gap curve.

To the regulator of maximum speed, is associated, normally, a idling speed regulator which manages the engine rotation speed when the accelerator is in the idling position.

The **regulators** controlling the minimum and maximum speeds are called "**minimum - maximum**"; they are typical of engines for vehicular/road applications; to optimize the driveability the regulator error is normally > 10 %. At intermediate speeds the engine operating point is determined instant by instant by the accelerator pedal position and by the balance between delivered torque and the resisting torque. The driver compensates the engine performance exigency by acting on the accelerator.

In the cases in which the engine is used at constant speed, as is typical the use with oleodynamic transmissions, where the work control given by the machine is frequently obtained by changing the hydraulic pump piston displacement, it is necessary to have an engine with a so called "**all speeds**" regulation. In this case, for each accelerator position, the mechanical or electronic regulator controls engine speed and power in accordance with a logic similar to the one described for the maximum speed regulator.

2.4 ENVIRONMENTAL CONDITIONS AND “DERATING”

Pressure, temperature and humidity of the air sucked by the engine, different from the reference values, play an important role in the supply of power when they vary substantially and persist in time. They affect the density and therefore the weight of the air getting inside the engine and also the fuel quantity regulated by the injection pump, in relation to the quantity of air inlet.

“Derating” consists in the adjustment of the injected fuel quantity according to the weight variation of the air sucked by the engine, without affecting the optimum ratio, in the event of excessive air, that the diesel engine needs and to prevent the growth of the combustion temperature and the exhaust smoke. The regulation of the injection proportion is obtained, for engines powered with traditional pumps, by acting in the injection pump, whilst, with the engine electronic control (EDC), the adjustment of the introduction is a function implemented by the managing software.

For the choice of an engine, it is necessary to consider the environmental factors to ensure that it has a power suitable for the load in real operating conditions.

The engine behaviour in particular environmental conditions can be very different according to its characteristics and fittings:

- Aspirated, supercharged, supercharged with aftercooler
- Boosting with and without waste gate or controlled by VGT
- Injection with mechanical pump or electronic control

The following section includes some considerations on the engine performance variations according to the environmental conditions. However, IVECO reserves the right, when negotiating the contract, to assess every single application to choose the most suitable engine setting and define the possible “derating”.

Ambient temperature

A high temperature can lead to the engine power reduction, as a result of the air rarefaction, and therefore generate cooling, lubrication and oleopneumatic system operating problems. It can be due to the climate conditions or an insufficient ventilation of the engine room.

The power reduction in aspirated engines amounts to 2% every 5.5 °C increase above the reference temperature of the test rule.

The reduction of power in supercharged engines depends on the work margin of the compressor and the available supercharging pressure and, if present, on the efficiency of the air-water exchanger. It can be null when there is more supercharging pressure and with an air-water exchanger having the right size, or it can be equal to the percentage values mentioned for the aspirated engines.

When the temperature is below the reference value, there is no power reduction. Below certain values, it could be difficult to start the engine and could be critical for some components.

Height

The lower atmospheric pressure found with increasing altitude and the consequent reduction of the air density, requires an injected fuel quantity reduction, as a function of the less quantity of oxygen available in the air sucked by the engine, with the consequence of a lower torque and power, with respect to what indicated by the characteristic curves.

The lower performances depend on the characteristics of the turbocharger, where present, and of the engine setting, i.e. of the air system capacity to compensate for the air rarefaction with a higher volume of air inlet.

On aspirated engines there might be, up to 2500 m in height, a power loss of 3.5 % every 300 m of difference in height, while on supercharged engines with turbine fitted with waste gate the power reduction can be between zero and approx. 2.5% every 300 m of difference in height, according to the size, type and matching of the turbocharger.

For a different adjustment of the quantity of injected fuel, the “derating” becomes necessary for those applications where the critical height is exceeded for a long time and also for other reasons linked to the air rarefaction:

- The lower counter-pressure at the gas exhauster helps the runaway speed rate conditions of the fixed -geometry- turbosuperchargers in the equipment lacking controls or r.p.m. limitations.
- The atmospheric pressure in altitude, reduces the water boiling point temperature.
- The air rarefaction induces the exhaust gas temperature increase.

The “derating”, agreed upon in the contractual phase, is generated by IVECO on the basis of the indication on the machine operative conditions, supplied by the Client.

Humidity

The engine setting for its use in conditions of high air humidity does not happen frequently, save for the operation in environments constantly above 60% of the relative humidity, as in Tropical forests. In these cases it can be foreseen that every 10% increase of the relative humidity above 60% there can be a derating of:

- 0,5% for ambient temperature of 30 °C
- 1% for ambient temperature of 40 °C
- 1.5% for ambient temperature of 50 °C

2.4 MECHANICAL AND AUXILIARY COMPONENTS

Depending on choice factors and performances required to the engine it must be considered the presence of all the components causing power absorption; it is necessary to know exactly the absorbed power since it is picked up at the detriment of that available at the flywheel. It is here reminded that the powers absorbed by the auxiliary components through the power takeoffs must be compatible with the pickup limits.

SECTION 3

DRIVE

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3.1 OVERVIEW

In any machine is present a kinematic chain aiming at making possible the transmission and management of motion and forces; the kinematic chain may be composed of rigid elements (simple as toothed wheels, shafts or assembly as transmissions/gearcases), flexible (belts) or fluid-driven. Generally the elements composing the kinematic chain transmit the revolving motion from an engine to user component, changing the torque characteristics, power and rotational speed.

The motion transmission requires the possibility of being interrupted or enabled through rigid couplings or clutch-driven managing in the meantime suitable systems for a quick stop, the brakes.

In order to operate a correct choice of the engine great attention must be paid in the realization of the transmission elements and overall relevant efficiency expressed by the ratio between the power delivered by the engine and that provided by the kinematic chain. Similar attention will have to be placed in the calculation of the stress, vibrations, generated by the transmission of mechanical energy.

The power takeoff, whatever type of transmission has been adopted, rigid, flexible or fluid-operated, can be obtained:

- From the engine flywheel
- From the front pulley
- From engine arrangement and flywheel-cover carter

It is recommended to pay a particular care to the setting up of guards and protections on the moving components to avoid damage to persons and equipment.

3.2 POWER TAKEOFF FROM FLYWHEEL

In driving axle

The connection with the dragged machine must be carried out through a proper elastic coupling, capable of transmitting the required torque and having such characteristics to avoid critical torsional speeds. It is here recalled that in presence of shafts with Cardan coupling is prescribed to adopt specific elastic couplings interposing between coupling and shaft an intermediate support. (see relevant paragraph) Prescriptions:

- It is manufacturer/installer's responsibility to ensure the parts alignment in accordance with the prescriptions supplied by the manufacturers of the different components, in order to avoid vibrations, noise, early wear and breakdowns.
- The dragging system must consider the relevant movements between engine and dragged components due to the suspension of the elastic type.
- Verify that the weight of the components added to the flywheel, such as couplings, adaptation rings and similar, do not exceed the admissible limit for the engine and the limit of inertia mass value is not exceeded.
- Carry out the dynamic and static balancing on the two planes, when mentioned components are arranged longitudinally along the engine axis.

Lateral on parallel planes

The motion transmission on an axis arranged on a parallel plane with respect to the engine may occur through flexible elements, such as trapezoidal or toothed belts, chains, or rigid as toothed wheels.

Prescriptions:

- It is manufacturer/installer's responsibility to select the transmission correct dimensions and to communicate the resultant lateral force value and relevant arm to IVECO for approval.
- In the case of two distinct transmissions it is recommended to carry out the preparation in such a way as to balance the lateral loads, arranging them for instance in opposite direction.
- Support the drive pulley with appropriate bearings independent from the engine and do not constrain pulley tightly to the engine flywheel.

It is important to avoid that the primary or driving wheel be tightly fixed to the engine for the following reasons:

- The lateral force necessary for setting into tension the flexible elements causes a limitation of the transmissible power; this is discharged directly onto the engine shaft bearings which are not able to support large additional external loads.
- The flywheel inertia increases and could reach such values as to introduce torsional criticality in the engine operating field.

Should it be inevitable to fix the driving pulley to the flywheel, attention should be paid to the following conditions:

- Pulley diameter not exceeding the half flywheel diameter.
- Races for 10 mm belts in number maximum of 3; 2 for 13 mm belt.
- Belt axis distance from the engine reduced to a minimum.
- Adapt the power absorption to the admissible lateral force for the engine and resulting from the belts stretching and to the maximum tension admissible by the belt manufacturer.

The systems available for sale to respond to this exigency, are characterized by the following features:

- The countershaft whose output shaft is supported by a bearing that, having seat in the flanged bell at flywheel cover, holds the power takeoff load so saving the flywheel from holding relevant load.
- The mechanical clutch, coupled in a similar way to the preceding but comparing to that has the advantage to be able of interrupting the motion transmission.

3.3 POWER TAKEOFF FROM FRONT PULLEY

In engine axle

The choice of this solution requires that the engine be prearranged with a pulley capable of realizing the dragging with a perfect centering and alignment with the interposition of adequate elastic coupling. Information relating to power limit values and transmissible torque are reported in the installation directives of the individual engines.

Prescriptions:

- The dragging system must take into account the relative motions between engine and dragged components because of the suspension of the elastic type.
- The maximum values of power and torque obtainable are normally less than those available at the flywheel.
- The simultaneous use of a transmission at the flywheel, reduces proportionately the power obtainable from the front pulley.

- It is manufacturer/installer's care to adopt an elastic coupling having adequate characteristics in terms of transmissible torque, flexibility, rotational speed, admissible motions, reliability.
- Should transmission systems be adopted not supplied by IVECO the use is required of couplings having characteristic values of transmissible torque and power values greater than those required.
- The connection element or coupling must have a torsional flexibility capable of uncoupling the torsional vibrations of the masses dragged by the engine.
- It is reminded that in presence of Cardan shafts is prescribed to adopt specific elastic couplings by interposing between coupling and shaft an intermediate support. (see relevant paragraph)

Lateral with belt transmission

IVECO engines for professional use may be equipped with front pulleys having races suitable for belt transmission.

The use of supplementary pulleys is admitted with the condition that be ensured a balancing and a correct centering and alignment and the respect of the maximum limits of inertia. It is up to the manufacturer /installer's responsibility an adequate accomplishment of the application.

Prescriptions:

- Pay the maximum attention to the performance required by user components: incompatible powers with the engine performance generate a very high torsional moment and an excessive belt stress with severe repercussion on the engine shaft.
- The power and torque obtainable are less than those admitted for the power takeoff in engine axis, because of increased stress to which the engine shaft and relevant bearings are submitted, due to the lateral force caused by belts tension.
- The belt transmission will have to be sized in such a way as to avoid that the tension does not generate such a lateral force as to cause a bending moment exceeding the admissible limits, reason why the frequent limitation of transmissible power. The limit values are reported in the technical documentation of each individual engine.
- In presence of two distinct transmissions, these last must be so positioned as to be able to balance the lateral forces and anyhow reducing to a minimum the resultant.
- The installations with engines supported by elastic elements require that the dragged device through belts be integral with the engine itself or to adopt a screw coupling permitting the recovery of the belt tension variations.

3.4 BUILT-IN POWER TAKE-OFF ON TIMING OR FLYWHEEL HOUSING

On many versions concerning engine it is possible to request the prearrangement for power takeoff which take the motion from the distribution kinematic motion or from the engine shaft.

The connection is carried out with rigid toothed coupling or with a grooved coupling; the rotation speed can be higher or lower with respect to the engine rotation speed.

1. The maximum drive torque obtainable and relevant transmission ratio are reported in the technical documentation of each individual engine.
2. Using hydraulic pumps it is necessary to adjust the plant operating pressure as a function of the powers obtainable. It should be remembered that hydraulic pumps have frequently a maximum power performance higher than admissible, in such cases it must be installed a valve limiting the fluid pressure/flow rate.
3. It is manufacturer /installer's care to verify that the powers drawn be less than the maximum admissible values.

3.5 ELASTIC COUPLING

The interposition of a “damper” elastic joint for coupling the engine flywheel and transmission shaft has the aim of limiting the torsional vibrations transmission and of avoiding overloading the end of the engine shaft. The couplings, together with adequate characteristics of flexibility and torsional damping must exhibit characteristics of axial and radial adaptability and the choice must pay attention to the performance required to the transmission.

When there are not interposed “spring drive” or “flex-plate”, the elastic coupling must be accurately selected for ensuring the transmissivity of the torque and of the possible axial drive that the transmission is able to transmit.

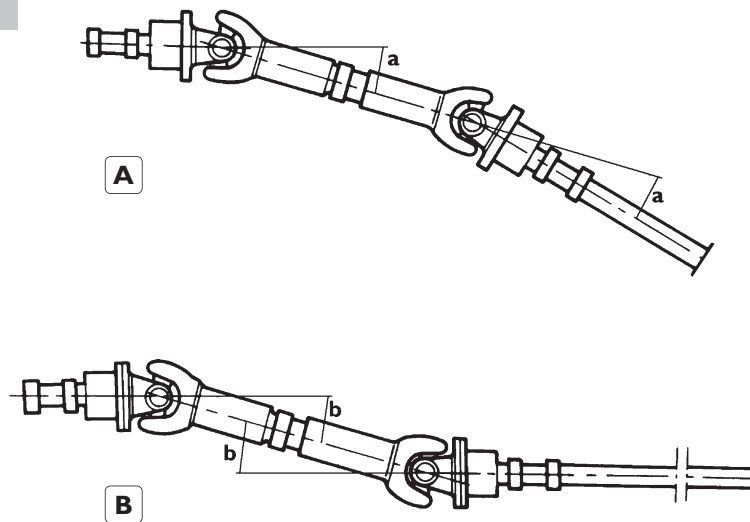
The information relating to the use of couplings and to which we send for reference for a more complete information, are supplied by relevant manufacturers.

3.6 CARDAN COUPLING

The Cardan coupling offers an economic solution for the transmission of the rotating motion between two shafts forming between them an angle \neq from 0.

The motion transmission with axes having a certain angle, through an individual uniform coupling, with a sinusoidal run, with angular accelerations and decelerations every half revolution; in order to obtain motion uniformity or homokinetic transmission, the combination is needed of two couplings and of input and output parallel shafts.

Figure 1



AXES WITH CARDAN JOINT

A. W-arrangement - B. Z-arrangement (homokinetics).

The admissible maximum values for the couplings angles vary with the coupling type and with rotation speed.

The adoption of shafts with Cardan joints requires a perfect alignment and adequate balancing of rotation masses; the respect of this prescription prevents the coupling of these shafts to the engine by means of couplings of the “Giubo” type, since they offer the possibility of misalignment between engine shaft and transmission.

The respect of the admissible inertia limits, prescribes of supporting the cantilevered masses according to the bending moment calculated on the basis of the entity of the maximum dynamic stress and not only on the static mass; it is typical the reference to accelerations equal to 5 - 12 g.

3.7 COUPLING OF THE “GIUBO” TYPE

Provided by IVECO in some applications, it is the most common elastic coupling of the rubber toroidal type. For a correct use, it is recommended to remove metal band enveloping it only after having secured the bolts anchoring it to the flanges, allowing so to operate pre-compressed preventing so a tearing process.

3.8 CLUTCHES

Subject to the prescriptions reported until now for coupling components and moving masse to the engine, employing clutch joints, pay attention to assess correctly the axial thrust required for the engagement of the same and that might load the engine shaft.

3.9 TRANSMISSIONS

The transmission ratio variation becomes necessary to adapt the torque speed and the engine maximum power to the speed rotation required by the user.

The performance required to the transmission gear ratio must be obviously equal to those of the engine in terms of transmitted torque and rotation speed.

It assumes particular importance, among the choice factors, the peak r.p.m. stood by the transmission with relation to that the engine can reach in the accelerations in absence of load, depending on the injection pump regulator “error”; being then the reduction ratios available, not in continuous sequence but discrete, it is necessary to correctly evaluate the sizing in order to render perfectly compatible the engine-transmission-user set.

In order not to have the transmission weight loading the engine flywheel, it is suggested to couple the gearbox to the engine in a rigid way, making that supported by the flywheel housing.

Efficiency

The transmission mechanical efficiency index permits to know the power absorbed during the operation and consequently the overall power requested to the engine.

The efficiency varies with the type and construction: it is high for the mechanical solutions or rather over 0,90 for those realized with ordinary straight tooth gearing or helical accurately finished; it reduces to values equal to 0,80 - 0,85 for epicycloid gearing systems or hydraulic transmissions.

The motion transmission towards auxiliary power takeoffs reduces the power obtainable from the output shaft as a function of what must be given to the power takeoffs.

Lubrication or hydraulic oil cooling

Some solutions of transmission converters require that the lubrication oil or hydraulic oil be cooled by means of adequate heat exchangers with water or air.

In particular way, the use of converters and hydraulic brakes require that the heat dissipation occur with high efficiency and therefore with oil/water exchangers; in such case if the engine cooling fluid is used, this will have to be picked up at the engine output.

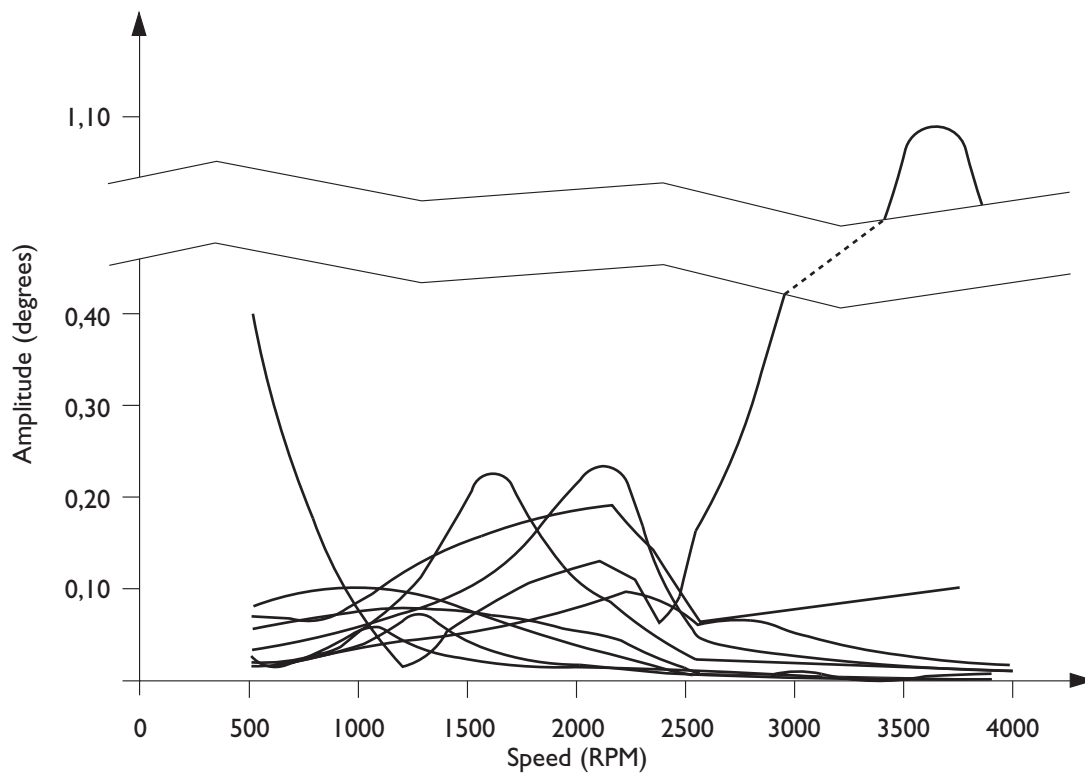
The prescription of the type, quantity and exigency of cooling down the lubricant or the oil for hydraulic transmissions, are contained in the use and maintenance manuals of the relevant products.

3.10 TORSIONAL VIBRATIONS

In the Diesel cycle engines, given the origin of the motion alternative type, the drive torque given by the transmission shaft is an expression of the summation of a series of "harmonic oscillations" originated by the different masses in motion. The shafts are normally so designed as to have the own frequencies higher than the harmonics of the engine lower order (2nd or 3rd order as function of the number of cylinders). The addition of inertia force to the shafts, determines a variation of the own frequencies of the resultant system and a different frequency positioning with respect to the engine main harmonics; to avoid such circumstance might be necessary the coupling of such additional inertial forces by means of an elastic coupling.

The torsional vibration analysis is the machines manufactures' responsibility; in case of necessity they will be able to contact the IVECO Technical Boards entitled to supply suggestions on the topic and data referred to the engine necessary for the calculation.

Figure 2



SECTION 4

ENGINE INSTALLATION

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4.1 TRANSPORTATION

The transportation of the engine or the propulsion unit shall be carried out with the suitable lifting systems by means of grommets (eyebolts) made for this purpose, and in a safe way to prevent any injuries to the operator and irregular stresses on the unit components.

In order not to alter the eyebolts safety coefficient, no modification is permitted.

The engine room must be prearranged taking into consideration the operating needs and to facilitate maintenance and checks.

In addition, it is necessary to ensure the removal of the engine, of the drive and their parts.

4.2 INSTALLATION

The installation of the propulsion unit on the machine must be carried out with safety precaution and respond to the most elementary safety and structural strength standards.

The support must be such as to consent the correct suspension of the group avoiding that this one has structural function, with exception of engines expected for this solution.

4.3 SUSPENSION

The engine anchorage solutions are generally two: rigid and elastic.

The quantity of engine or group suspension points may be:

- On three points. For small size engines, with two suspensions in transversal line with the engine center of gravity and one sustaining the transmission.
- On four points. Recurrent solution for medium dimension engines; with transmission components flanged to the engine, two supports will be dedicated to the engine and two to the transmission.
- On six points, two of them used for the transmission. Adopted for heavier and bigger engine and transmission assembly and always when the drive element weight does not enable the overhanging assembly. Max support coplanarity is required in case of rigid assembly.

Rigid suspension

It is not admitted for 3-cylinder engines and 4-cylinder engines without balancing masses.

It is often used on work machines where a lower dampening level of the vibrations and noise coming from the engine and the transmission is usually accepted.

The engine is anchored with its own support brackets directly to the machine chassis while taking care of the maximum coplanarity of the supporting points, interposing, if needed, suitable steel shims. For this type of suspension is required that all the machine structure be characterized by a high stiffness, bending-free, to avoid loss of load to the supports.

Flexible suspension

It is used when a higher soundproofing and vibration reduction are required; it is imposed for 3-cylinder engines and 4-cylinder engines without balancing masses.

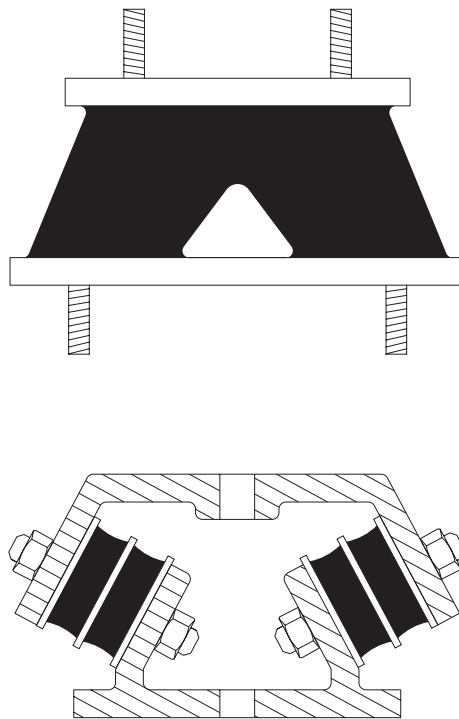
It is installed by placing flexible elements between the engine brackets and the chassis or machine support. The flexible elements are chosen according to the weight resting on them and the level of required isolation.

The height adjustment, for which exist specific instructions released by each support supplier, is the end operation with which the perfect engine-transmission alignment is obtained and the correct load distribution on the supports.

It is recalled that in order to avoid dangerous bending caused by horizontal oscillations, the engine brackets must be placed the closest possible to the elastic element and never at the top of the threaded terminal.

We think to recall the attention on the fact that the concurrence of engine and structure oscillations may generate resonance phenomena, with dangerous effects for the integrity of the realization.

Figure 1



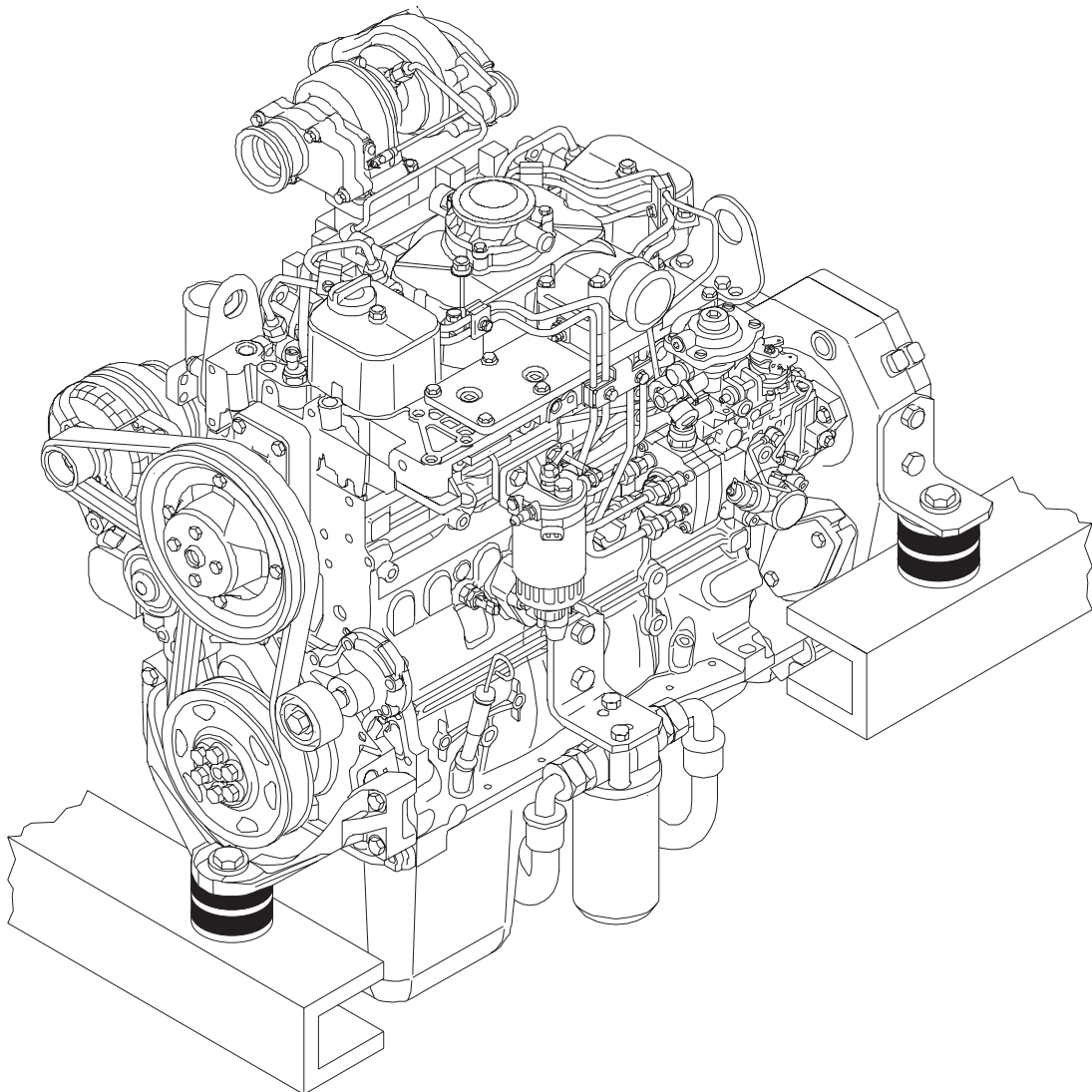
ELEMENTS OF SUSPENSION FOR INDUSTRIAL ENGINES

CAUTION

The use of the elastic suspensions requires that the connection of the supplies and of the exhaust be effected with flexible unions. As for the coupling with the transmission system we send back to what explained on the matter in section 3.

In the cases in which the elastic suspension is not a part of the engine supply, reference must be made to the prescriptions and to the choice criteria of the same supplier.

Figure 2



EXAMPLE OF ENGINE ON ELASTIC SUPPORTS

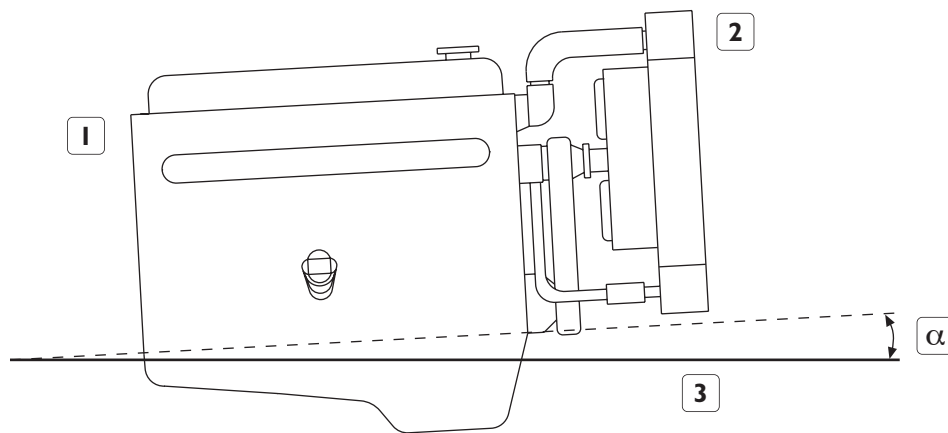
4.4 TILTING

The maximum tilting angles are a typical characteristic of each engine family and basically depend on the type of oil sump, the characteristics of the lubrication circuits and the technology of some systems.

Whenever for different reasons the engine has to be placed into operation with inclination angles different from the one admissible, reference must be made to the oil sumps that IVECO set at disposal to employ the engines at different slant angles.

The choice of the oil sumps considers that in the contractual phase IVECO is expected to indicate, for the engine as configured for the purpose, the maximum admissible inclinations, whose values in any case shall not be exceeded excepted for short transients.

Figure 3



α . Inclination angle - 1. Rear side - 2. Front side - 3. Horizontal plane.

Engine inclinations involving the lifting of the rear part are not normally admissible for the necessity of allowing the cooling system an adequate degassing process.

Should degassing be needed, consult the IVECO technical Boards.

SECTION 5**AIR SUPPLY**

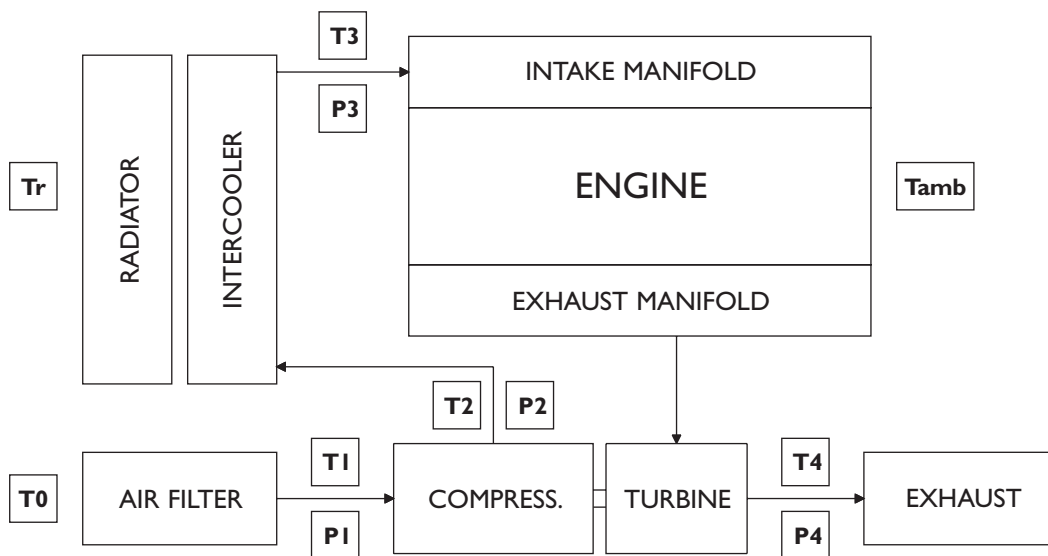
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5.1 OVERVIEW

The circuit designed for supplying engine with air must ensure:

- an air flow in the quantity necessary to allow the complete combustion in the engines;
- the adequate ventilation of the engine room to dissipate the heat produced while ensuring that the operation temperatures would not reach critical values for the electrical/electronic equipment and for the parts associated to the engine such for instance the belts.

Figure 1



T. temperature / P. pressure

0. Air sucked, upstream the filter - 1. Air sucked, downstream the filter - 2. Air of supercharging, downstream compressor - 3. Air of supercharging, downstream heat exchanger - 4. Exhaust gas discharge - r. Referred to the air/water exchanger - amb. Referred to the ambient or to the atmosphere.

5.2 PREARRANGEMENT OF THE ENGINE ROOM

With reference to the diagram of figure 1, the machine constructor must prepare the engine room so that:

- The air intake is located in such position as to prevent the suction of the exhaust gas or of the ventilation air outgoing; this ensures that in the air to be combusted is present an adequate quantity of oxygen for the combustion that the air is at ambient temperature, not overheated.
- The difference between the ambient temperature T_{AMB} and the temperature T_1 at the compressor input or at the intake manifold in the case of aspirated engine, shall not exceed the maximum value indicated for the engine and reported in the relevant technical documentation.
- The pressure variation through the "intercooler" exchanger P_2-P_3 shall not exceed 7.5% of the pressure detected in intake manifold P_3 .
- The temperature detected in the intake manifold shall not exceed the value T_3-T_{AMB} , indicated for the engine and reported in the relevant technical documentation.
- High values of the temperatures T_r and T_0 are an index of the engine room poor ventilation.

- The air/air “intercooler” exchanger, must be lapped by the ventilation air prior that this comes in contact with the water/air” exchanger; pay attention to the direction of the ventilation flow.

Testing operations must be conducted at the maximum power or torque, or in the most recurrent work conditions of the machine or vehicle, for a sufficient time so to allow the stabilization of the values.

5.3 FILTERS AND AIR PIPES

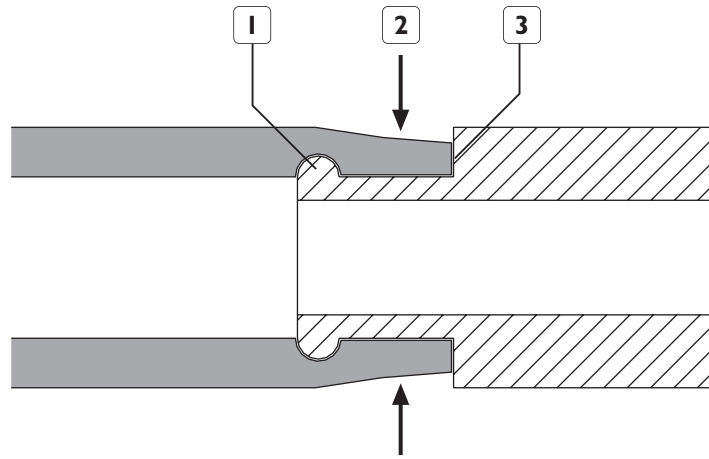
The air filters characteristics depend on the machine performance and will have to exhibit a filtrating power as a function of the work conditions; they must be realized in accordance with the state of art or, preferably, supplied by Firms offering good warranty of reliability.

IVECO equipment and engine components satisfy the standard IVECO STANDARD I8-7032.

General prescriptions, with reference to figure 1:

- The air pipes, between filter and compressor's intake, or air intake manifold in the case of suction engines, shall not present sudden variation of section or curves particularly prominent, to avoid dangerous pressure falls.
- The depression value at intake P_1 is characteristics of each engine and of the filter use condition. The measurement must be effected on a section of straight pipe and in proximity of the compressor, or intake manifold for the aspirated engines, with engine delivering maximum power or in the machine typical working condition. From the measured value the kinetic component must be subtracted.
IVECO engines respond to what explained, in accordance with standard IVECO STANDARD I6-1012.
- The part of pipe submitted to the depression of the intake P_1 , must be of good manufacture and so realized as to prevent any shrinkage (e.g., with internal metal spiral) and with the end part adapted to the fastening with screw clamp (see fig. 2).
- The section of pipe in “high pressure” P_2 , will be able to be realized in silicone rubber resisting to temperatures ≥ 200 °C and pressure ≥ 3 bar, provided with a “bellows” to restrain the axial thrust and to avoid that thrust exerts a load on the turbo-compressor.
- The section of pipe in “high pressure” P_2 , realized with metal materials must be provided with precautions capable of absorbing the thermal expansion produced by the high temperature relating to the supercharging air T_2 , to prevent formation of axial thrusts on the turbo-compressor.
- The pipes prior to be installed, must be accurately cleaned removing the residual scrap due to the manufacturing process which could be inspired by the engine; the junctions must be dust-free.
- Pay attention so that the tubes do not come into contact with moving components or with high temperature.
- The oil vapours feed “blow-by” at the intake, must be jointed to the suction intake pipe downstream of all components here connected, including the air service compressor suction joint. The pipe shall be of suitable material and having structure such as to prevent restraint and occlusions.
- It is recommended to install downstream from the filter a sensor which will allow a useful programming of preventive maintenance operations. During the contractual phase IVECO will be able to suggest the most appropriate sensor for each application.

Figure 2



1. Beading - 2. Fastening point with clamp - 3. Stop bead.

SECTION 6**FUEL SUPPLY**

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6.1 FUEL CHARACTERISTICS

The fuel inside the engine fulfils two basic functions:

- it is used for the thermodynamic transformation of the energy
- it cools down and lubricates the elements and components of the injection system (pump, injectors, etc.)

The characteristics of the fuel prescribed for IVECO engines comply with UNI EN 590 specifications; they correspond to those of the diesel fuel produced by the most qualified Oil Companies and distributed at filling stations.

6.2 HYDRAULIC CIRCUIT

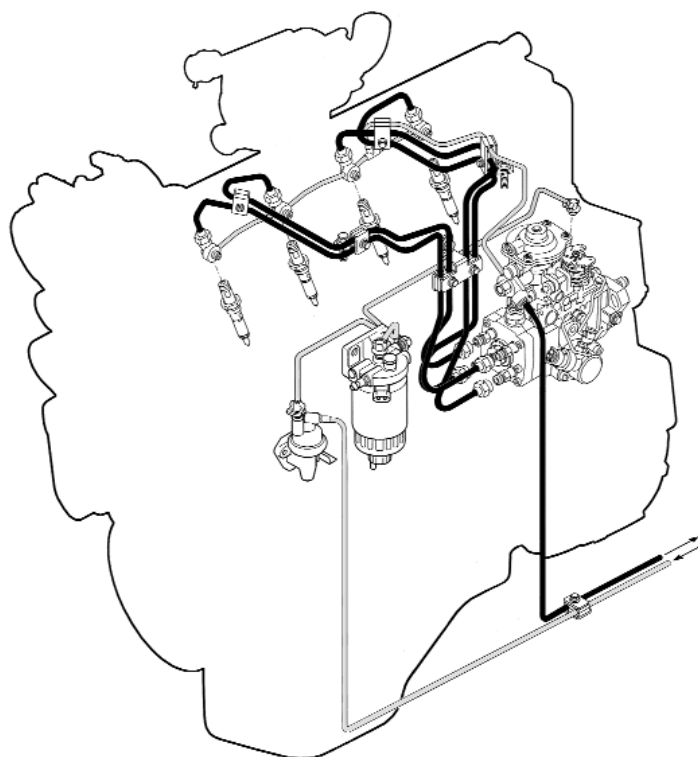
The fuel circuit function is to supply the right quantity of fuel to the engine injection system. The fuel has to be clean and not polluted with remains and water and it is necessary to drain off the fuel surplus from the reservoir.

A fuel circuit accurately designed and correctly implemented is fundamental for the regular engine operation, in particular at start up.

The design and implementation of the whole system are part of the expertise and responsibility of the Machine manufacturer/installer.

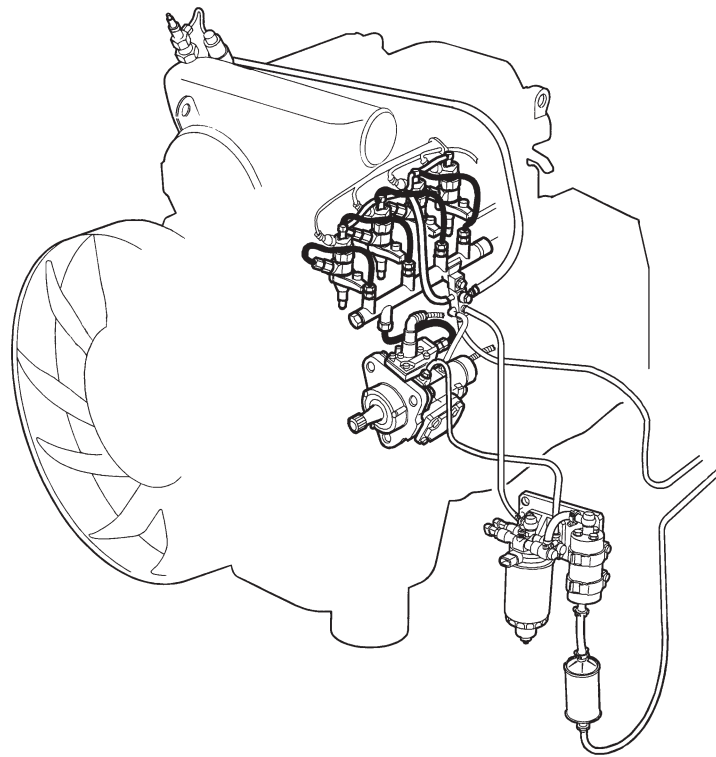
The fuel circuits required for IVECO engines are related to different injection systems, as illustrated in the following figures:

Figure 1



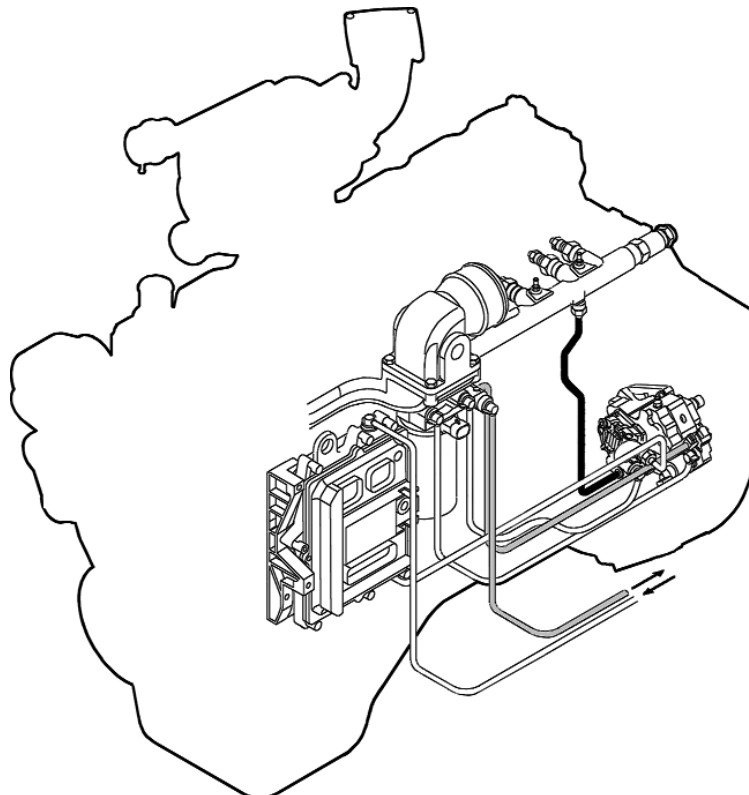
CIRCUIT FOR TRADITIONAL MECHANICAL PUMP

Figure 2



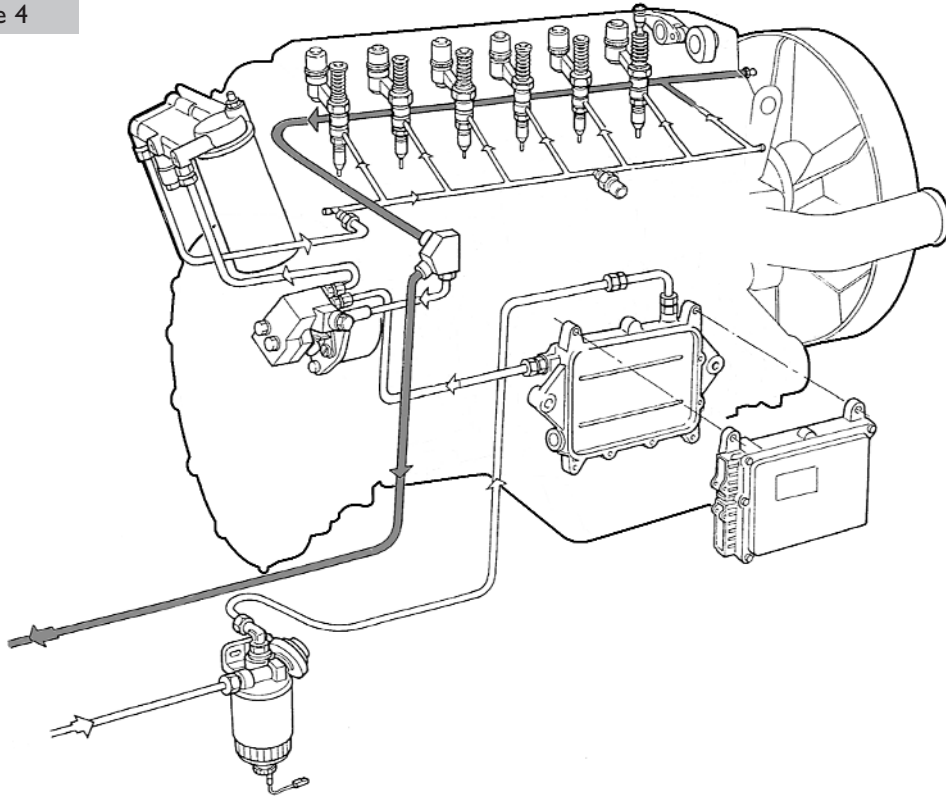
CIRCUIT FOR COMMON RAIL SYSTEM (CP1)

Figure 3



CIRCUIT FOR COMMON RAIL SYSTEM (CP3)

Figure 4



CIRCUIT FOR PUMP INJECTOR SYSTEM (EUI)

Because of the different performances of the injections system, the fuel pressures, temperatures and capacities have specific values; therefore, you are suggested to see the installation diagrams of each engine for the analysis of the prescriptions concerning each different system.

For the correct and regular fuel supply, it is absolutely necessary that all the circuit components, especially those depending on the fitter-out such reservoir, cocks, pipes, additional filters and other, are installed accurately and the whole circuit is perfectly waterproof.

The presence of air in the circuit reduces its quickness at start up and generates engine irregularities. The fuel leaks are a potential fire danger, for this reason it is particularly important to observe fire prevention rules.

6.3 TANK

The fuel tank is normally up to the machine installer's responsibility and will have to be realized in accordance with the following:

- It must be placed far from heat source, at the same engine level and at limited distance from the same.
- It shall be made with materials able to resist chemical agents and hot fuel for the whole machine life. Metal reservoirs protected through zinc-coating or copper-coating galvanic treatments are not suitable to contain "diesel fuel" as the sulphur in the fuel can generate chemical reactions, thus producing sulphate dangerous for the injection system. The tanks must be, furthermore, resistant to the chemical attack of the brake fluid and of the battery acid solution (for the applications for which such use is considered). When adopting welded tanks verify that they do not release dust or sludge from welding process.

- It shall be fitted with a breather to prevent pressurisation and depression. Foresee also a breather valve to stop the fuel leak in the event of capsizing, preventing at the same time dust and water from getting inside.
- It shall ensure a fuel reserve in any condition. For this purpose, the instrument panel shall be fitted with a fuel level gauge or an alarm for the fuel low level. Verify that the engine delivers the maximum power even when only the reserve quantity is present.
- The tank fuel suction device must be located at not least of 20 mm above the tank bottom. (See note)
- The suction and re-entering pipes must be placed at about 30 cm to avoid that the fuel return out-flow would disturb directly the suction intake process. (See note)
- The intake pipe must be provided with pre-filter capable of filtrating sediments having the dimension exceeding 0.5 mm and such a to avoid air to enter the circuit. (See note)
- In the case that fuel temperatures are observed close to limit and causing misalignments, it is recommended to install a heat exchanger on the return circuit.

Further prescriptions are reported in the technical documentation of each engine.

NOTE

IVECO makes available to machines and vehicles Manufactures/Installers some different solutions of fuel suction device/level indicator assembly that, while respecting the quoted prescriptions, will integrate the intake fuel suction device and return and simplify the tank realization.

CAUTION

The fuel tank realization, piping and relevant unions must meet the requirements enforced by the standards of the country where the machine is bound to operate.

6.4 ENGINE-RESERVOIR PIPES

The engine and the reservoir are mutually connected by fuel supply and return pipes.

The two pipes can have different diameter; i.e. the supply pipe diameter is higher because of the higher fuel capacity, at least double. However, they must have the same diameter for those engines where the injector draining is combined with the injection pump return.

The pipe size depends on the installation structure and on the pipe unions set on the engines; to identify their diameters and length, refer to the relevant installation diagrams provided with each engine.

Prescriptions:

- The preferable materials for realization of the fuel circuits are the fabric-reinforced flexible rubber (if a flexibility is required), or rather ferrous alloy or stainless steel for pipes "without welding".
- The pipes must be suitable in temperature and pressure conditions typical of the engine application; they must also resist to the chemical attack of the brake fluid and of battery acid solution (for the applications for which such use is considered).
- The pipe diameter shall not be lower than the diameter of the pipe unions on the engine and grow as the engine - reservoir distance increases.
- The engine-pipe union connections shall be designed for all types of engine suspensions, rigid or flexible. They shall be realised by inserting a flexible element between the engine and the pipe. If present, the rubber holder eyelet shall consist of a rubber sleeve reinforced with textile inserts, suitable for diesel fuel and resisting the fire according to the rules in force in each single country and with the right length, to be tightened on pipes and unions by means of screw clamps. If there is a threaded pipe union, a low pressure hose shall be inserted in between, suitable for diesel oil and resisting fire, provided, at the two ends, with suitable threaded couplings. Some engines are pre-arranged with quick connect unions (fig. 6).

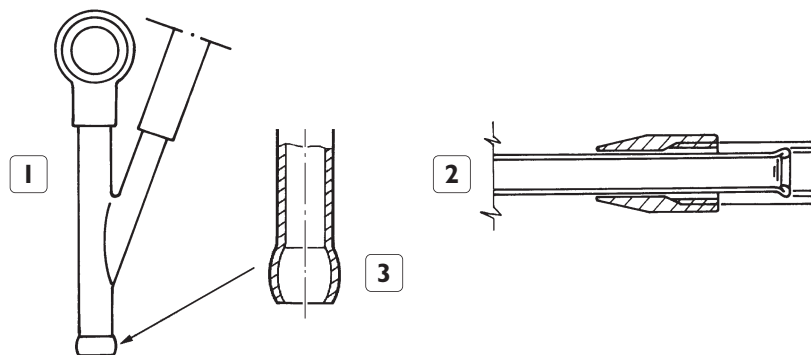
- The pipes connected with rubber sleeve, must be beaded (see Fig. 5) in order to permit a safe hold of the screw-driven clamps.
- Take great care when joining the pipes and regularly check their tightness.
- The pipe anchoring on the machine structure shall be carried out safely and by means of brackets suitably spaced to prevent the vibration and bending resonance due to the pipe weight; it is suggested to use brackets with flexible coating.
- The pipe routing shall foresee the minimum number of curves which, if present, shall be wide enough to prevent the formation of intermediate pockets. Foresee also the suitable guards in the areas exposed to bumps or heat.

CAUTION

Clean accurately the pipes and the reservoirs before using them through washing and blowing to remove the impurities and remains inside them.

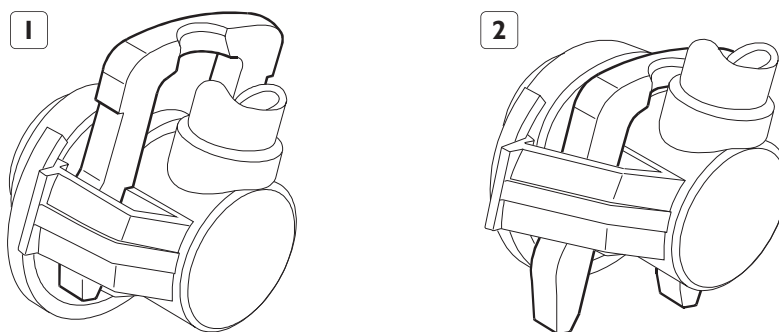
The unions can be of the eyelet type with rubber holder or with threaded terminal.

Figure 5



1. Attachments for fuel piping with rubber holder - 2. Attachments for fuel piping with threaded union - 3. Pipe end beaded.

Figure 6



Quick connect in the conditions of: 1. Extraction or insertion - 2. Locked.

6.5 FUEL FILTERING

IVECO engines are fitted with replaceable single or double-filters with paper filtering element which meet the requirements of the injection system in terms of filtering level. They are inserted in the feed pump supply circuit, before the high-pressure injection pump. The possibility is not excluded of inserting as necessary, further filtrating elements.

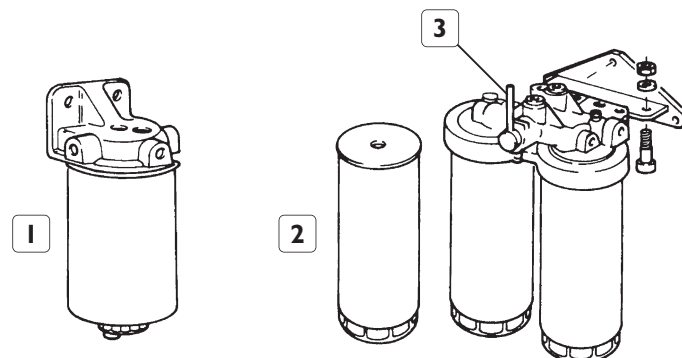
Other data and information about the maintenance intervals are included in the use and maintenance handbooks of each engine.

IVECO comprises in the engine supply, a pre-filter settler which, installed by the machine manufacturer or installer, carries out the double function of protecting the feed pump from possible foreign matter and from the water present in the fuel.

Prescriptions:

- The pre-filter shall be installed on the feeding pipe next to the reservoir, in a point relatively low of the circuit and in a position easily accessible for maintenance, water and deposit bleeding, and priming. The position close to the reservoir ensures that the pipe is free of water and deposits which might damage it.
- Do not use additional filters, mesh or paper filters, along the feeding pipes between the decanting pre-filter and the pump. The filters mounted on the engine perform correctly their function; the placing on the engine in a "hot" place, limits the risk of clogging for ice or paraffin oils.
- For applications assigned to operate in countries where the fuel is frequently contaminated by dust and water, like South Africa, Middle and Far East, East Europe, South America, we suggest to equip the feed circuit with an additional pre-filter.
- Verify at the end of each installation and periodically during maintenance operations that the depression values during the intake phase and counter-pressures at the fuel discharge are respected.
- For applications assigned to operate into environments heavily polluted by dusts of any kind or submitted to refuelling from tanks for which is not ensured a periodic and frequent cleaning, the drainage of water and sediments and the filter substitution shall occur at reduced intervals with respect to what prescribed for applications in different conditions.
- When choosing the engine installation, provide an easy access for the correct drainage and filters substitution.

Figure 7



1. Individual cartridge fuel filter - 2. Dual cartridge fuel filter with possibility of substitution with running engine - 3. Exclusion lever.

SECTION 7

LUBRICATION

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7.1 LUBRICANT CHARACTERISTICS

The minimum acceptable characteristics for lubricants employed in IVECO engines are equivalent to the prescriptions ACEA E3 - E5.

As for the grade, working temperature, quantity needed for the engine and substitution intervals reference is made to the information reported in the Handbooks and in Use and maintenance booklets for each engine. The use of oils different from what above-mentioned prescribes that the substitution intervals be reduced to 1/2 of what reported in handbooks and use logbooks.

7.2 OIL FILTRATION

IVECO engines take full flow; easy-change filters, or filter cartridges that filter the total quantity of oil forwarded from the pump to the engine.

The filtrating element constituting the cartridge is made of special paper whose conventional filtration grade, i.e. referred to the granulometry of 90% of the retained particles is from 15 to 20 μm .

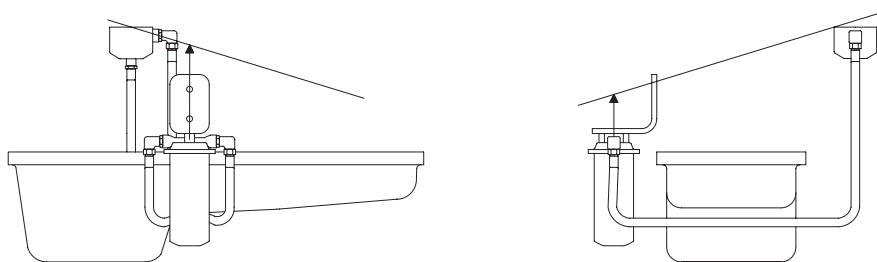
For some types of engines it has been adopted the solution "at dual filtration" where the filtrating element, with replaceable cartridge, is composed of two sections: one in total flow rate with conventional filtration grade equal to from 15 to 20 μm (normal), the other in by-pass with conventional filtration grade equal to 3 - 6 μm (fine).

The number of filters varies ranging from one to more than one, depending on their size and on the flow of lubricant oil in the engine.

To ensure keeping the correct pressure value in the circuit, in the case of remote filters installation, the following prescriptions shall be respected:

- The filter must be installed in a vertical position.
- The point of screwing to the support must be always found below the union point of the adapter to the engine. The verification of this may be done by tracing a line starting from the adapter union point, that forms with the horizontal plane an angle equal to the maximum inclination of the machine/engine in both directions, longitudinal and transversal; the filter screwing point must result below the line (see figure 1).

Figure 1



- The pipes must be suitable for the temperature conditions and pressure typical of the engine application; they must also resist to the chemical attack of the brake oil and battery acid solution (for the applications for which such use is considered).
- The pressure fall on each pipe including attachment must be less than 0,05 bar at 20°C in the conditions of maximum flow rate.
- The pipes shall never come into contact with engine parts and must be fixed in not least of two intermediate points comprised between extremities. The length of each pipe shall not exceed 1200 mm.
- The pipes must be of the flexible type.

7.3 OIL QUANTITY AND LEVEL DIPSTICK

The oil quantities suggested in the repair and use and maintenance manuals refer to the engine that is set up in horizontal position or slightly tilted.

The use of engines that are set up with inclination angles different from what indicated in the technical documentation, require accurate testing of the exact quantity of oil needed.

The quantity of oil in the engine oil sump is checked with the level dipstick. Due to the importance of the presence and level of oil in the oil sump, a frequent and careful control is required.

Engines installed with inclination angles not compliant require specific different level dipsticks. For some equipment the possibility is offered to mount the level dipstick on the engine left or right side.

General prescriptions:

- When choosing how to install an engine, make sure that the dipstick can be easily reached to check the level of oil daily.
- An excessive quantity of oil may cause the formation of foam, a temperature increase and extra oil consumption.
- An insufficient quantity of oil may lead to a partial or a total oil pressure drop and, consequently, to the engine wear and tear or jamming.

7.4 LOW PRESSURE SIGNALLING

Engine lubrication is so important to require the setting up of an oil low-pressure sensor located on the engine block and connected to the main lubrication conduit, that activates a visual and/or an acoustic signal.

The signal must be activated with a suitable delay to avoid alarms during transient periods; an electronic timer may be used, for example.

The timely intervention, after the low pressure signalling, avoids engine damage.

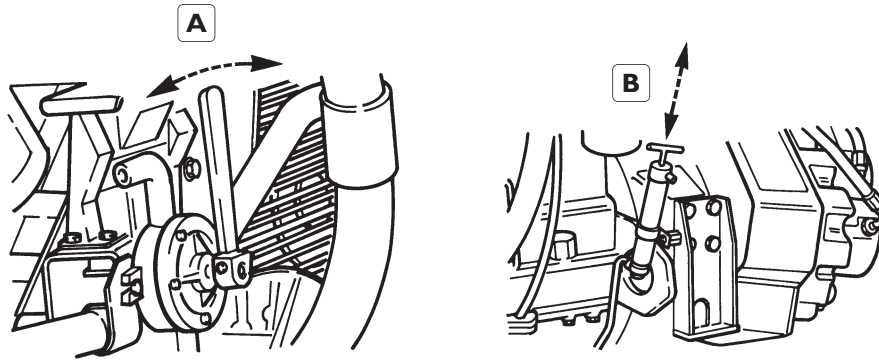
7.5 PERIODIC CHANGE

The machine /engine behaviour modality are the most important factor in determining the degree of oil downgrading in time; this process is influenced by the following concurrent factors:

- The overheated functioning during long periods reduces the oil resistance to oxidation and increases the quantity of insoluble pollutants that constitute a residual oil, which causes the filter wear and tear and obstruction.
- Lubricant dilution because of contamination from fuels: It reduces the oil viscosity and worsens the lubricating characteristics. This is generally attributed to poor maintenance of the injection device.
- Water pollution causes an extreme reduction of the oil lubricant property and the possibility that the high content of hydrogen might cause the acid substance formation. The risk is very high of oxidation of the components lapped by the emulsion.

The lubricant removal may occur by discharge from the prearranged caps or by suction with pumps, which is possible to prearrange on the engines (see fig. 2)

Figure 2



A., B. Manual pump activation to drain the oil.

The oil drain plug must easily accessible as already referred for filters and dipsticks.

In countries where the gasoil presents a sulphur percentage $\geq 0.5\%$, the replacement intervals must be cut into half with respect to the prescriptions of each engine.

7.6 ENGINE VENT

Inside the engine, part of the combustion gas leaks out of the cylinders and flows into the lubrication circuits due to the high pressure; at the same time, the oil produces vapour due to the high temperature. This gas mixture, generally called blow-by, is exhausted out of the engine because of the engine overpressure.

On all the engines is present a device capable of regulating the blow-by flow rate and of separating through suitable filters, the liquid component for canalizing it back into the sump.

The presence of this device requires that is ensured the accessibility for the necessary and periodic maintenance operations.

All the IVECO engines of the new generation are prearranged for the "recirculation" of the blow-by fumes, or rather allow that these are sucked by the engine and brought into combustion; the piping external to the engine, necessary for obtaining this function in the supercharged engines, must be prearranged by the manufacturer/installer's care in accordance with the indications issued by IVECO; the choice of prearranging the fumes recirculation is the machine manufacturer/installer's discretion.

SECTION 8**COOLING**

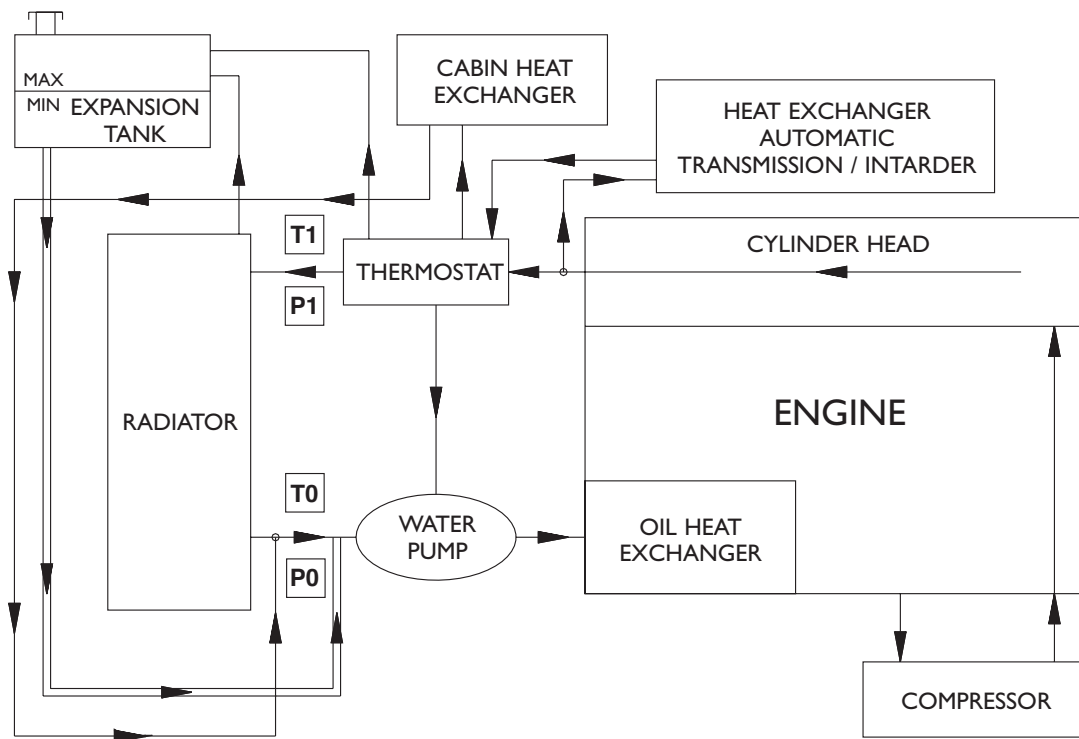
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8.1 PURPOSE OF THE SYSTEM

The Cooling system has the purpose of keeping the engine temperatures inside the prescribed limits for the engine, in the most severe operative and environmental conditions in the course of the machine operation; it will be sized and realized as a function of the type of application.

In figure 1 is schematically represented the cooling system assembly to which reference is made in the description of the different components.

Figure 1



T. temperature / P. pressure

0. In output from the water/air exchanger - I. In output from the thermostatic valve and from the engine.

Prescriptions:

- Design the pipes location so as to avoid the creation of siphons.
- Realize the circuit so as to ensure the total system filling, and avoiding the forming of air pockets, which cause phenomena of local "boiling" and cavitation.
- Use a pipe having a bore of about 30 mm for the filling up and transfer from the suction pump to the expansion tank.
- Provide in the engine circuit high zones and water/air exchanger, the presence of air/fumes bleeds having an internal bore ≥ 3 mm.
- Use preferably rubber pipe EPDM suitable for temperatures of at least 130 °C and pressures up to 3 bar.
- Verify that the relative pressure in P_1 assumes values equal to about 0.5 - 1 bar.
- To avoid cavitation phenomena verify the relative pressure in $P_0 > 0$, in all the engine operating conditions.

- Prefigure in the circuit the presence of a high temperature sensor and on the instrument panel the relevant warning light indication.
- Verify the absence of losses in the circuit submitting this latter to a filling with an antifreeze solution in accordance with what quoted in the subsequent paragraph and reported by the standard IVECO 16-1920.

8.2 COOLING FLUID

IVECO provide to use for its own engines cooling fluids compliant with standard SAE J1034.

The percentage of dilution with water, recommended for the first refilling, is equal to 50%, complying to the prescription requiring a freezing temperature equal to $-35\text{ }^{\circ}\text{C}$; the optimal one for the prosecution of the service depends upon the machine/engine use and on the antifreeze characteristics.

In order to ensure an adequate protection against cavitation and corrosion, it is recommended not to reduce the quantity of the antifreeze below 30%, also in the environmental conditions with high temperature.

The circuit filling up must occur verifying with a suitable meter that the flow rate be comprised between 8 and 10 liters/minute, having opened all the valves of the cooling and heating systems; run up a few minutes of engine operation at idling speed, a verification must be carried out and the possible level restoration.

8.3 EXPANSION TANK

The expansion tank has the function to collect the cooling fluid during its increase of volume, due to the temperature rise, and give it back during cooling down phase.

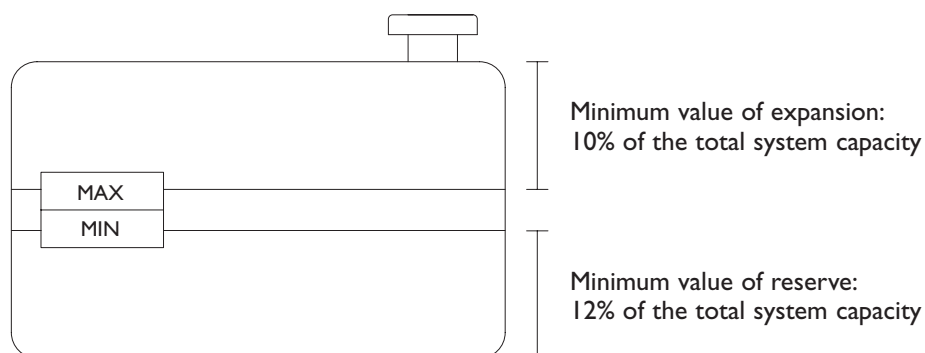
The tank shall be capable of standing the circuit pressurization up to 0.5 - 1 bar of relative pressure and must exhibit a bleed plug adjusted to that pressure.

It must be located in an accessible position for the filling up and placed in a higher position with respect to the engine.

The dimensions must be such to allow the level identification by transparency and with sufficient difference between minimum and maximum; it will be preferable for the purpose, base/height ratio close to 1. In the cases in which the basins are realized with metal materials not transparent they shall be equipped with adequate level sensors.

The expansion tank technical characteristics are resumed in figure 2.

Figure 2



The expansion tank may in some cases be integrated in the water/air exchanger, paying attention to satisfy the prescriptions relating to the filling and bleed pipes previously mentioned and represented in figure 1.

In the realization of these solutions pay attention to arrange the charging and transfer pipe in the lower part of the water/air exchanger and that is possible the bleeding of the fumes.

The integration of the tank integrated in the water/air exchanger is not recommended for those applications in which the engine is submitted to frequent and rapid load and speed variations.

8.4 AIR FOR COOLING

The flow rate, the direction and path of the ventilation air are characteristics of the application and submitted to the machine manufacture/installer choice.

Hereinafter are listed some elementary project guidelines.

- Consider that the airflow necessary for cooling operations totally strikes the exchanger.
- Consider that the airflow striking the exchanger has a temperature close to the environment's. This requirement is generally satisfied by employing suction ventilators; in some applications, typical of the machines moving earth, the use of suction ventilator is not recommended, given the dusty environment these machines work in.
- Consider, in presence of air-air exchanger, "intercooler", that the air flow strikes it prior to lapping other exchangers.

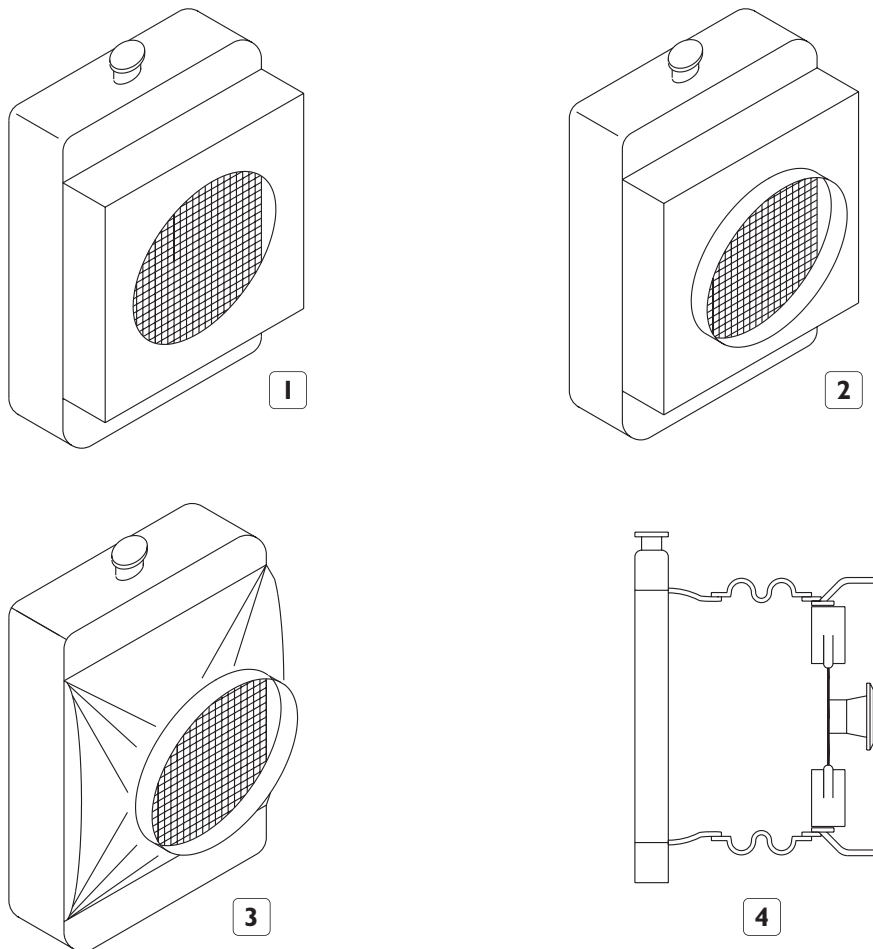
8.5 AIR CONVEYORS

The use of an air conveyor is essential for improving the exchanger efficiency and for avoiding the cooling air recirculation; the adoption of an adequate conveyor offers a valid solution in the cases in which is not possible or convenient to adopt heavy power ventilators; with the use of ventilators of reduced dimensions less noise is produced and a lower power absorption is required.

The use of a conveyor allows the exchanger to operate with a reduction in temperature equal to 6 - 8 °C and ensures the respect of the thermal balance of exchangers of reduced dimensions or with ventilator at reduced speed.

In figure 3 are reported the characteristics of some types of conveyors.

Figure 3



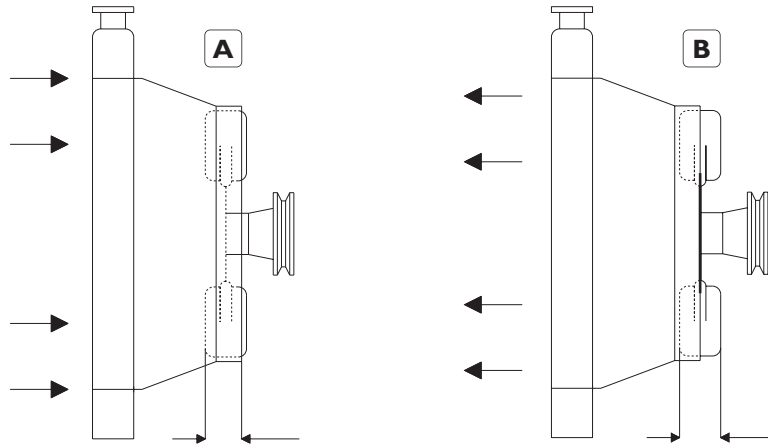
The conveyor of fig. 3.1 is the simplest and cheapest one and is used in the applications where there are not cooling prescriptions very restrictive.

The conveyors of fig. 3.2 and 3.3 are addressed to applications requiring a higher cooling efficiency with a greater ventilating pressure; the model represented in fig. 3.3 is in absolute the one that ensures the less load loss, thanks to the shaping which limits the air turbulence, and is therefore preferable to other solutions.

In the applications where is expected a relative movement between exchanger and engine or in the cases in which a space, between fan and exchanger must be left, the adoption of a bellow as in fig. 3.4 permits to canalize the air flow while ensuring a real thermal exchange.

Figures 4.A and 4.B illustrate the ventilator coupling modality to the conveyor with collar in the sucking and blowing solutions.

Figure 4

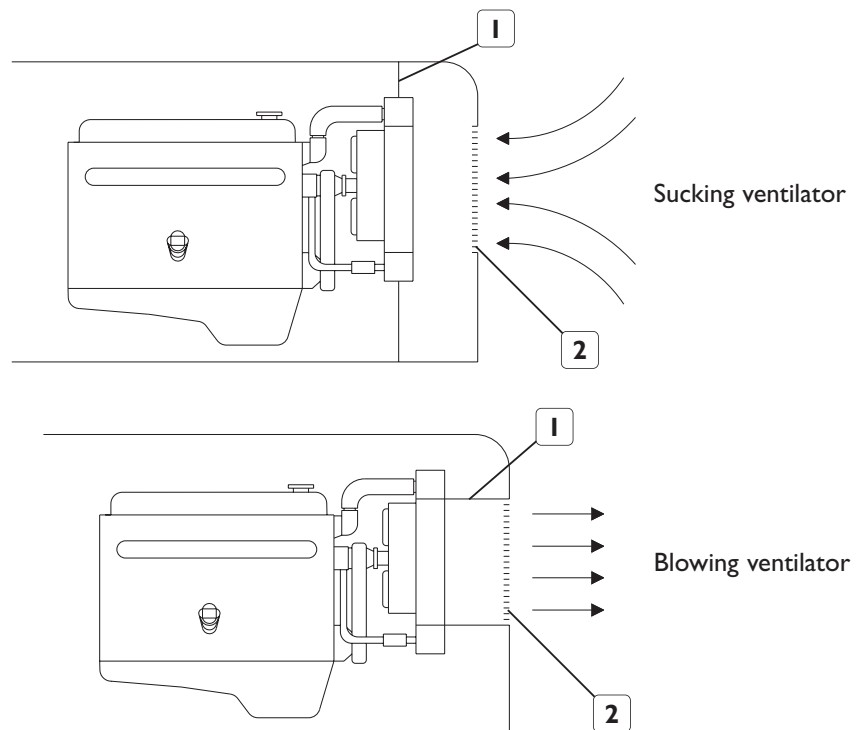


I. Relative position of the ventilator:

8.6 FLOWS RECIRCULATION

The installation of engine and exchanger in the same closet requires the verification of the absence of warm air recirculation to avoid efficiency losses in the thermal exchange; the drawings of figure 5 illustrate solutions that consider the use of barriers, adequate in the case of sucking or blowing ventilator:

Figura 5



I. Barrier - 2. Frontal grid.

In some cases of blowing ventilator, to avoid turbulence it is necessary to extend the engine room aeration grid to the whole frontal area.

In the applications on machines operating in environment with large dimension dust it is recommended to provide the insertion of a protective grid of easy cleaning or movable to provide removal of retained parts.

8.7 VERIFICATION - METHOD ATB

The cooling system efficiency verification is effected with the test of the **AIR TO BOIL**; it deals with the verification of the maximum environment temperature to which the engine, operating at full load, is capable of dispose of a quantity of heat sufficient for avoiding the boiling in the circuit.

The conditions of test and measurement are the following:

- Thermostat fixed with main valve fully open and by-pass valve closed.
- Engine at full load or in the conditions most engaging for the application: maximum power and/or maximum torque or others concerning the machine mission.
- Temperature of the cooling fluid (coolant) stable at the engine output. For vehicles with automatic transmission is used the maximum value of temperature reached in the testing cycle, also in the case of uncomplete stabilization.
- Coolant composed of water and antifreeze in the proportions of 50% - 50%.
- Ventilator blocked at the maximum rotation speed; in the case of dragging with viscostatic joint, condition the temperature to the value imposed by the highest ventilator speed.
- Environment temperature not less than 5 °C and preferably >15 °C.

The calculation of the ATB depends on the temperatures T_{amb} and T_I measured and on the pressure at which is submitted the coolant, with the consent of the over-pressure valve used:

$$ATB = [T_{bw}] - [T_I] + [T_{amb}]$$

Where $[T_{bw}]$ is the boiling water temperature as a function of the overpressure valve calibration; the reference value considered by IVECO is that relating to the pressurization condition i.e. 0,5 bar; minimum acceptable for the circuit, or 106 °C.

The ATB value equal to 42 °C, relating to the temperate is to be considered the absolute minimum.

Climatic zone	TEMPERATE (max temp. < 40°C)	TROPICAL (max temp. < 50°C)	DESERT (max temp. < 60°C)
ATB	≥ 42 °C	≥ 50 °C	≥ 60 °C

SECTION 9**DISCHARGE**

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9.1 OVERVIEW

The exhaust system causes slowing down to the gas flow in output: the phenomenon index parameter is the back pressure which must be limited within characteristic values typical of each engine, on the contrary case there will have worsening in the engine performance.

General prescriptions:

- The machine/vehicle constructor must consider for the exhaust system an adequate space and such as to avoid the interference with the other machine components.
- The exhaust system must be connected to the exhaust gas terminal output from the engine in elastic manner; to avoid that its own weight could charge the exhaust manifold or on the turbo-compressor.
- The elements composing the exhaust system must be provided with expansion couplings which must be capable of avoiding the generation of axial thrusts onto the compressor or on other engine components.
- The exhaust system elements must be placed at an adequate distance from the fuel feed circuit components, filters, pumps, others...
- The exhaust gas ejection must take place in a remote position with respect to suction intakes for the air to be entered the combustion process.
- The maximum admissible volume for the whole exhaust system is indicated by IVECO for each individual engine and it is in relationship with the application to which the engine is assigned (see Note).

9.2 EXHAUST BACK-PRESSURE

The exhaust system must be so designed that the back pressure value does not exceed the limits prescribed for each engine (see Note) and for achieving a level of acoustical emissions within the limits prescribed by the law.

Back pressure values higher than expected might be caused by the following:

- Exhaust ducts diameters too small.
- Exhaust ducts paths warped and/or with limited curving radius.
- Ducts exceeding in length.
- Ducts with sections unexpected variations.
- Silencers with high resistance to flows.

The effects of an excessive back-pressure are the following:

- Power losses equal to about 1% for engines supercharged and 2% for aspirate engines, every 65 mbar above the maximum level of admissible back-pressure.
- Increase of engine temperature and exhaust gas.
- Increase of fuel consumption.

The high sensitivity to the back-pressure of the aspirate engines induces to respect for their applications a maximum limit equal to 65 mbar.

NOTE

The system volume and the back-pressure value at the exhaust pipe are mutually correlated and a significant deviation from the prescribed values may cause an increment of ruled gaseous emissions.

The compliance with the respective prescriptions ensures the validity of the engine certifications.

9.3 BACK-PRESSURE MEASUREMENT

The back pressure value must be measured immediately downstream of the engine exhaust terminal, in a section of rectilinear duct; should a catalytic converter be present in the application the measurement will be carried out upstream of this last one.

The instrument used must have an appropriate full scale for the measurement of the characteristic values of the application and fit to stand the exhaust terminal high temperatures.

SECTION 10

CONTROLS

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10.1 OVERVIEW

The choice of the fittest engine manoeuvre and control systems is very important for the safe use of the machine and for the reliability and warranty of the engine performance.

10.2 FUNCTIONS

The command functions normally required are the following:

- Engine startup
- Variations of the engine rotation speed
- Variation of the transmission gear ratio
- Engine stop

Engine startup

Except for the compressed air system, the engine is set to rotate with an electric motor powered by a storage battery. The engine is powered by a key or push-button, located on the control panel. IVECO plans for its own engines fitted with an electronic injection system, the possibility of a remote control from the engine room, to be used during testing and maintenance procedures.

Further information is reported in Section 11 - Electrical installation.

Engine r.p.m. variation

It is obtained by varying the position of the lever located on the injection pump or of the accelerator potentiometer rod, in the case of EDC system. In some applications with engines equipped electronic control, previous authorization by IVECO, it will be possible to use software commands with protocol CAN on dedicated network.

Most of them are remote controls since the manoeuvre room is far from the engine room. It is possible to prearrange more manoeuvre stations, selectable as function of the machine use exigency.

In the most frequent cases the command occurs by means of a metal flexible cable running into a suitable flexible sheath, so as to be able to act both in traction and thrust.

When installing the remote controls it is necessary to consider:

- The remote control stroke has to be adjusted so that the accelerator can fully complete its rotation arch; so that when the accelerator at the drive place is at high speed position, the accelerator lever must reach the high speed reference, and vice versa for low speed position. Otherwise, the engine performance would decrease, or the low speed would be accelerated, with adverse consequences in the use of the machine.
- The wire rope slide within the sheath must be precise and must ensure that once released, the accelerator lever return is complete.
- The sheath must be installed to avoid accidental contact with rotating parts or high temperatures.
- All connexions and regulating screw elements must be fastened with locking devices so that the remote control does not decrease its performance through time.

As an alternative to wire rope remote controls, compressed air or electronic systems with proper actuators can be used.

It is also worth mentioning for these cases the instructions concerning accelerator complete stroke and drive reliability of the remote control set through time.

Transmission gear ratio variation

The drive systems are similar to those discussed above. Also for the gearshift remote control, is important to control that the cable stroke allows the selector complete displacement to guarantee a complete gear selection.

It is here recalled that a faulty closure implies skidding, overheating and early wearing with consequent failures of the entire system.

The drive system must be reliable and safe to avoid malfunctions that would cause a dangerous situation during use and manoeuvre the machine.

Engine stop

It is well known among the engines equipped with a conventional mechanical pump, the electric stop system made out of a fuel interceptor electrically-operated valve directly fixed to the injection pump as for rotary pumps, or stop carried out by an electromagnetic actuator which can work on the stop lever as for the in-line injection pump.

In the case of engines equipped with EDC electronic control system, the engine stop is caused by the fuel injection rejection generated by the electronic control unit, when the enabling signal is disengaged. The engine cannot be stopped with a battery circuit breaker to guarantee the engine control method operating conditions.

IVECO engines, fitted with an electronic injection system, have been designed with the possibility of using a remote control from the engine room to carry out tests and maintenance operations.

Further information are reported in Section 11 - Electrical installation.

The shutdown action may be caused by excitation or de-excitation, which depends on the electric equipment and on the safety regulations required for the machine use.

If an alternative system is used, make sure that the control allows the selector complete displacement and that the engine stops.

SECTION 11

ELECTRICAL INSTALLATION

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11.1 OVERVIEW

The electrical equipment, together with everything installed on the engine, is completed with a series of components supplied separately which allow the installer an easier and diversified execution of the work, with a higher possibility of adaptation to the project choices.

According to the engine type and version, the electrical installation may be powered by 12V or 24V. The installation powered by 24V may facilitate the engines startup in cold climates and on a discontinued engine startup basis.

General warnings for on board electrical installation:

- **DO NOT USE** the engine equipment wiring to power other electrical equipments on the machine.
- **SET** the electrical wiring separated from other circuits existing on the machine.
- **DO NOT USE** battery circuit breakers to stop the engine.
- **PAY PROPER ATTENTION** to the wiring polarisation and to the correct attachment of its fastening parts.
- **FOLLOW** instructions to carry out the wiring and the electrical connexion.

11.2 POWER CIRCUIT

Connect with two independent lines the storage battery to the electrical start-up motor, and to the connexion electronic preheating system as well as to the EDC installation, if present.

The +B alternator terminal connexion to the +30 positive terminal of the start-up electrical motor is to be carried out with a 16 mm² conductor or a larger one.

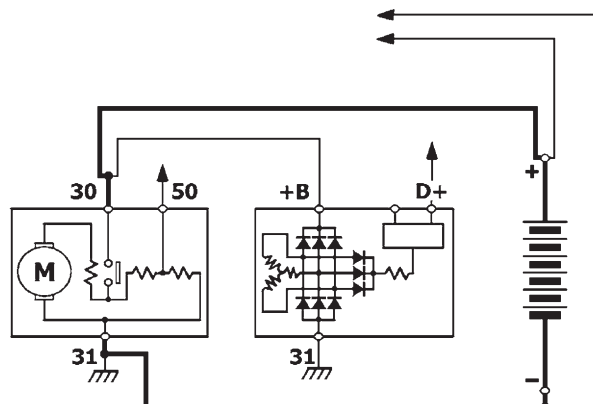
The +30 positive terminal connexion from the startup electrical motor to the storage battery positive pole is to be carried out with a conductor ≥ 50 mm², for a 24 V voltage supply, and with a connector ≥ 70 mm² for a 12V voltage supply.

Similar conductors shall be used for the connexion of negative terminals and/or engine ground connexion. In case the installation requires the batteries to be fitted far from the engine, it is advisable to use larger conductors and to control that the accumulator poles have the proper voltage value (from 12.8 to 14.5 V) (see figure 1).

The protection parts with thermomagnetic switches or battery circuit breaker cannot be used to stop the engine; if necessary, its connexions could be opened only some seconds after the engine has been stopped.

IVECO provides, together with the engines technical data, the basic instructions only for the engine power circuit; the manufacturer/installer personnel are responsible for the batteries electrical dimensioning and for the entire machine electrical circuit.

Figure 1



Reference chart for the conductor's choice according to their current intensity.

Section (mm ²)	I max. (A)	R at 20 °C (Ohm/km)	Section (mm ²)	I max. (A)	R at 20 °C (Ohm/km)
0,5	6	37,5	16	75	1,11
1	11	18,3	25	100	0,75
1,5	14	12,4	35	125	0,53
2,5	20	7,53	50	160	0,37
4	28	4,57	70	200	0,26
6	37	3,15	95	240	0,19
10	53	1,76	120	280	0,15

11.3 WIRING

Ground connexion

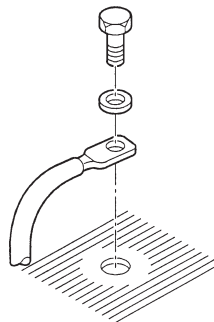
The electrical connection of the engine electrical ground is realized with a cable having the prescribed section, fitted between the battery negative pole and one of the startup electrical motor fixing points in the engine block, as indicated in figure 3. In presence of an engine carrying structure having good electrical conductivity, it will be possible to use it as ground general reference by connecting to it both the accumulator negative pole and the engine basement as previously described.

The wire tip must have an inserted tinned sulphurous copper terminal (see figures 2 and 5).

Indications to carry out ground connection electrical contact:

- Remove protective coating completely from the connecting parts by mechanical means or with an appropriate chemical product.
- In case any element should be fastened onto treated surfaces, remove anaphoresis coating to get a smooth supporting base.
- Apply a uniform paint coat BH44D (IVECO Standard I8-I705) with a brush or an aerosol can.
- Join the ground connexion knot within 5 minutes following painting.

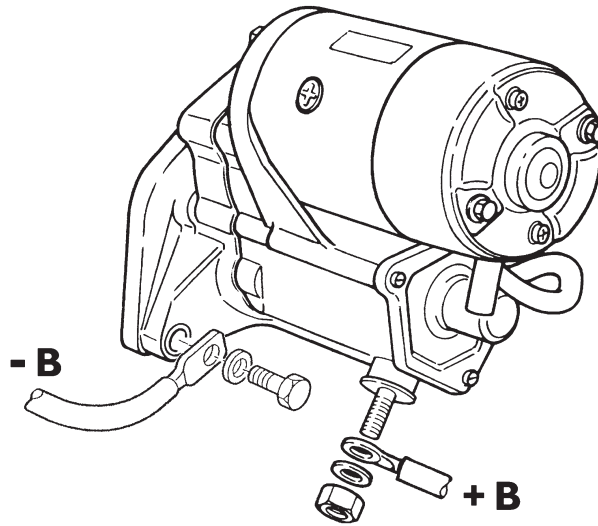
Figure 2



Positive

For the ground connexion wiring, use a wire similar to the one used for the ground connexion line, fitted between the storage battery positive pole and the +30 terminal of the startup electrical motor. The indications to carry out the wiring are similar to those of the ground connexion.

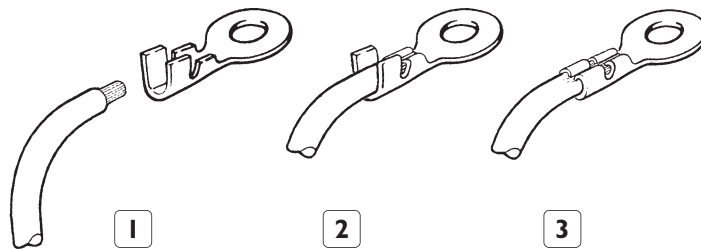
Figure 3



Other connexions

All electrical cables and cords must have appropriate tinned sulphurous copper terminals; wires without terminals must not be connected by means of screwed terminals. To prepare the terminal, remove a portion of plastic sheath without cutting copper threads; then, press carefully the copper conductor. Finally, press the copper again to ensure mechanical retention of the protective sheath. (See figure 4). The effectiveness of the electric installation is only guaranteed by the use of specific tools and by following the instructions corresponding to the different terminals.

Figure 4



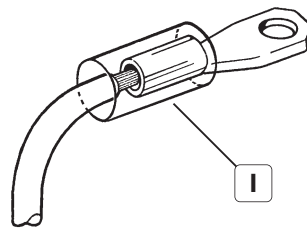
TERMINAL PREPARATION PHASES

1. Sheath removal - 2. Copper pressing - 3. Sheath pressing.

It is important to carry out high quality installations especially in the presence of electronic systems because of the reduced intensity of required currents. The absence of terminals contributes to the progressive reduction of the installation quality, and to the possible wire cut caused by the vibrations or by cuts on the lining.

The choice of conductor's sections and type of terminal must be based on the current maximum conduction intensity, eventually calculated on the different resistance values of the different components. Pay much attention when installing the preheating circuit with electrical resistor (grid-heater) and use appropriate cables, fitted with proper terminals, as previously indicated (see figure 5).

Figure 5



CABLE TERMINALS FOR HIGH CURRENT INTENSITY

I. Heat-contracting sheath.

11.4 STORAGE BATTERIES

The storage batteries must be properly sized to provide the appropriate current intensity to the electric engine startup and to the other engine electric uses.

Should the machine have electrical equipment used also with non-rotating motor, two different storage batteries assemblies should be installed, each one for the engine and the auxiliary services.

Guarantee good ventilation of the storage battery compartment to avoid temperature rise and formation and accumulation of dangerous burning gases.

Storage batteries contain a highly caustic and corroding water and sulphuric acid solution; therefore, they must be handled very carefully to avoid accidental spillage. Once replaced, they must be sent to an appropriate waste-recycling centre.

The alternator characteristics and the indications on discharge capacity of storage batteries are detailed in the technical instruction chart of each engine.

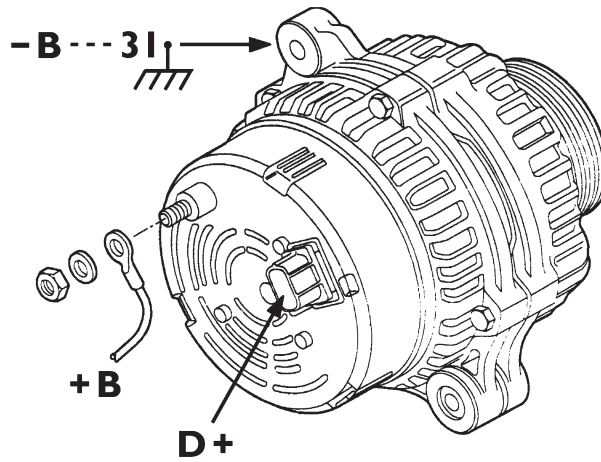
Storage batteries recharge

The storage batteries recharge is accomplished by the alternator through the power circuit; the equipment electronic regulator ensures an effective control of the recharge parameters.

The led indicator powered by the regulator and generally fitted on the on-board panel **does not show** the storage battery recharge real status, which depends completely on the maintenance condition and age.

The storage battery recharge for the auxiliary services, not electrically connected to the engine storage battery, may be managed by a relay. The relay excitation is produced by the recharge signal of the (D+) alternator electronic regulator, in the single engine installations (see figure 7), or by the second engine alternator.

Figure 6



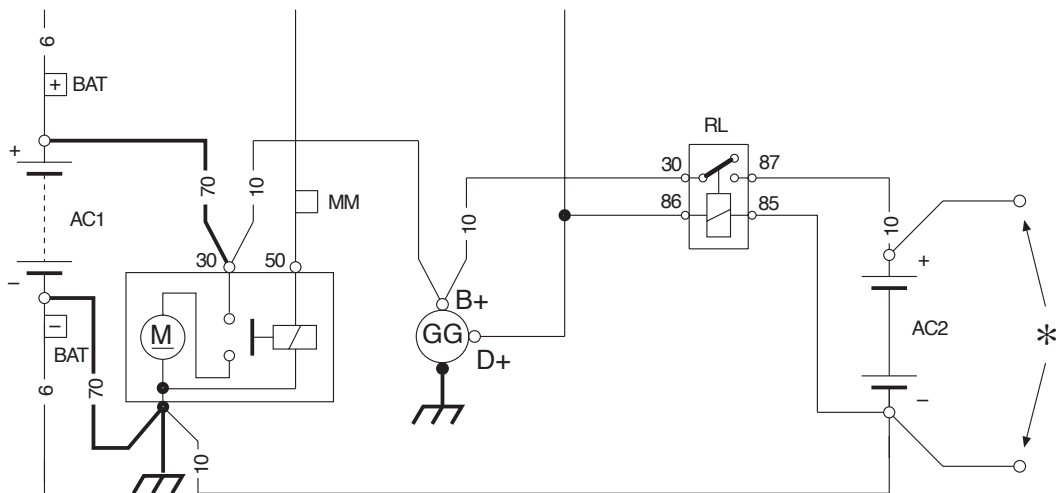
If more electrical power should be needed to attain appropriate machine equipment running conditions, supplementary alternators can be used.

Installation and testing instructions:

- Respect the connexions polarity, especially the ones in the batteries.
- Avoid short circuit on the alternator or regulator terminals.
- Do not disconnect the battery while alternator is rotating.

Alternator can cause disturbances to machine equipment and instruments due to electromagnetic interferences. Therefore, carry out timely compatibility controls.

Figure 7



Key:

- AC1: Main storage battery
- AC2: Auxiliary services storage battery
- RL: Relay 50A max
- *: Services electric power

11.5 ENGINE ELECTRICAL CIRCUIT

The electrical equipment comprises the components installed upon delivery as well as those supplied separately. The availability of optional components facilitates installation completion, according to different layout chosen. Easy access to electrical and electronic components to carry out testing should be guaranteed, even when the engine/machine is active.

The manufacturer will void the Warranty should modifications of the engine equipments be carried out that would cause its operation to be in conflict with specific homologation standards.

Wiring

IVECO units are normally fitted with complete wiring for electrical and electronic connexions and the engine wiring is supplied with standard connexions, and prepared to admit optional connecting components.

Sensors

IVECO engines are equipped with the necessary sensors to monitor the main functions. They are also equipped with optional sensors detailed on each engine instructions.

To access IVECO warranty, components are to be certified: accelerator potentiometer sensor, diagnosis connexions, etc.

Relays and short-circuits protection

Engine equipment with EDC system are made up of switches generally set in an appropriate compartment called Relay Box. Inside the box, anchored to a printed circuit board, are present the power management relays of some components and the elements that protect the electrical lines against short circuits or excessive current absorption: thermal fuses or thermal switches.

Only fuses with nominal shutting-off currents similar to the indicated on the technical documentation must be used. Any difference would not be supported by the other parts of the circuits because of they may be damaged due to an excessive current.

ECU Electronic central unit

It carries out the management and operating controls in engines equipped with EDC electronic injection system. Normally this is provided to be housed on the engine, on the contrary the ECU must be set on vertical position at a maximum distance allowed by the length of the wires and the orientation of connectors. The support should reduce the vibrations and the stress exerted upon the machine either by the engine or any other agent. The maximum exposure temperature must be 80 °C.

The connectors, with an electrical layout indicated in the specific instructions, are not to be exposed to water or liquid drip, nor should they be installed in an exposed position.

11.6 CAN LINE

The data for some functions and the transmission of information delivered to the digital instrument panels, in the engine versions fitted with engine electronic engine control, are exchanged on the line and managed according to the CAN protocol mode, Control Area Network. This system allows the high-speed, bi-directional exchange of large amounts of information, ensuring high reliability among the different on-board electronic systems.

Any use of the CAN line must be agreed with IVECO engineering departments.

11.7 INSTRUMENT PANEL

IVECO manufactures, for its own engines, some types of signal and commands panel to be installed onto the machine. Their connexion to the electrical equipment is done through the engine wiring.

The technical data and instructions for the panel installations are available in the technical information manuals together with instructions and information to manufacture panels for the manufacturer or installer personnel.

The essential board signals are:

- Engine coolant high temperature
- Lubricating oil low pressure
- Water in fuel
- EDC system damage / malfunction (if present).

The level of gathered data will depend on the versions and use requirements. It is important the prior availability of the diagnosis connector fitted in the engine equipment provided by IVECO, in the presence of EDC system.

In the case of engines equipped with electronically controlled injection system, IVECO provides for an optional remote control in the engine room to be used during testing and maintenance procedures. When using it, the main station controls cannot be activated simultaneously, which avoids an unexpected engine startup.

Follow carefully the instructions and information details attached to the electrical equipment layout to operate and use the installation properly.

11.8 WARNINGS AND PRECAUTIONS

Electromagnetic compatibility (EMC)

Electrical and electronic systems on the machine, as well as other external ones, may transmit or be sensitive to parasitic radio signals capable of causing malfunction.

IVECO provides for compatibility tests carried out under specific regulations.

To minimise signal sensitivity in equipment installed by the manufacturer or installer personnel, the engine wiring harnesses must follow different paths from other wiring on the machine. The ground connexion installation should be properly checked to ensure optimal performance at ground connexion points and of the on board equipment to preserve proper conductivity characteristics through timely periodical maintenance.

Electrical and electronic devices, such as radio receivers, generators and others comply with the regulations in force regarding electromagnetic compatibility.

To guarantee total compatibility of the manufactured components a test must be carried out after complete assembly.

Welding

When welding near the engine or its systems, disconnect the on board electronic units and place them considerably far from the engine. Disconnect the alternator and electrical components connectors from the engine. The electromagnetic field generated by the electrical welding equipment could cause serious damage.

NOTE

During welding operations, it is not safe enough to disconnect only the storage batteries, since the electromagnetic field interferes directly with the components electrical lines and generates at the ends potential differences that might cause damage.

SECTION 12

CONTROL TEST PROCEDURES

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12.1 OVERVIEW

Once the machine assembly has finished, the installation must be checked to guarantee proper operation, according to the information herein. Control procedures must be carried out in every new installation and before starting mass production. Thus, eventual modifications may be timely introduced. Some control operations and the measurement of operating parameters can only be carried out on the operating machine.

Control procedures are generally carried out by IVECO technicians or IVECO Authorised Agents' technical personnel. Together with the manufacturer staff who may be in charge of driving the machine and, if necessary, adjusting test procedures to ensure adequate installation conditions according to the manufacturer's indications.

The control operation comprises two main phases: the first one corresponds to examining the engine and onboard installations; the second phase, carried out at work, implies checking the engine and installation performances and assessing some important parameters that are essential to ensure proper engine running conditions.

Upon writing the report, the following conclusions must be added:

«The information herein applies to the fully equipped machine, with the examined configuration and according to the test conditions under which the index parameters required to assess the operative functions in the engine were measured.

It is clearly stated that the installation control operations cannot provide for behaviour or performance assessments in the course of time, which are typically yield by test runs carried out by the machine manufacturer.

IVECO shall not be liable for failures in manufacturing. The machine manufacturer shall be responsible for observing all aspects to prevent personal injury and property damage.»

Instructions to carry out both phases are briefly described below.

12.2 STATIC TEST

According to the appropriate checklist, the following shall be carefully registered:

- Name and characteristics of the machine and its destination
- Engine model and registration number
- Installation system and proper tilting
- Type of transmission
- Auxiliary power take-off
- Easy access to carry out maintenance procedures
- Intake and discharge systems and ventilation of the engine room
- Cooling system installation
- Fuel supply installation
- Electrical installation, controls

The checklist writing, with subsequent added notes, aims to register the outstanding installation characteristics in order to make a comparison with the instructions provided in this Manual.

It is here remarked that the static examination of the installation cannot be exhaustive of the possible problems, but it has simply the purpose of providing suggestions for possible improvements of the installation, in "bona fide" and as far as it is possible to observe.

It remains on constructor/installer's care the responsibility of a correct execution of the installation in all its aspects.

The verifications expected in the operative test must be preceded by some preliminary controls by the machine constructor:

- Verify that the accelerator lever run completes the excursion. It is here recalled that an incomplete run implies the reduction of the engine performance.
- Verify that there are not objects contacting rotating components and check for no fluid leakage.
- Check that the fluid levels are those prescribed for the engine operation.
- Adjust the rev counter by comparison with a manual or digital rev counter.

12.3 OPERATIVE TESTS

The tests and measurements to be carried out may vary according to the use given to the machine and the installation particularities, which may require specific inspections.

Some tests described below are essential and recurrent in certain types of installations, and they are useful to assess important parameters to guarantee the engine proper operating conditions and reliability.

In order to make testing significant the machine must be installed in conditions equivalent to those of the normal use.

Hereinafter are exposed some considerations relating to the tests necessary for drawing engine data and operational information; modalities and procedures are reported in the documents and in the verification check list.

Engine performance

The estimate of the power delivered by the engine is derived, with the help of suitable diagram, from the exhaust gas temperature measurement, effected upstream of the turbine in case of supercharged engine and engine rotation speed.

The test is performed by bringing the engine to operate in the conditions of maximum torque and maximum power.

The supercharging pressure value is optional.

In the case of engines supplied with electronic control injection system, it is possible to assess the main burning air pressure and temperature, the coolant temperature and the amount of injected fuel using the diagnosis instrument that can be found on the technical / commercial IVECO network.

From the measurements described it will be possible to derive fuel consumption and the estimate of endurance.

The testing results allow also the evaluation of the transmission adequacy.

Cooling and ventilation system test

In the case of engines with standard cooling system is not necessary a specific test evaluation, except the measurement of the engine coolant temperature at the cylinders head output, during the full power test. If the cooling system is not a standard one, or rather realized with exchangers not supplied by IVECO, a specific test must be effected for assessing the efficacy of it; operating with engine at peak power or maximum torque, detecting the required parameters only when a stable value is reached proceeding as follows:

- After having blocked the thermostatic valve in the full open position.
- Carry out the reading of the coolant temperature at the engine input and output.

The maximum values admitted are a characteristics of the individual engine and typical of the different applications.

Verify the adequacy of the system to the degassing and filling prescriptions and the fitness of the charge tank to allow the pressurization and the expansion of the water on the spot.

Suction vacuum and exhaust back-pressure tests

If a different filter has been installed or if the air is suctioned through an outside intake, it is necessary to check the suction vacuum when the engine is running at maximum power. In the case of aspirated engines, it should be enough to run the engine at a no-load calibration rate.

The back-pressure must be measured according to the instructions in Section 9.

Instrument panel

It is recalled to evaluate the coherence of the on board instruments indications by comparing them to the results of the measurements carried out during the verifications. Verify the functionality of all the warning lamps by simulating the sensors behavior connected to them.

In the equipment provided with electronic control injection the EDC system indication lamp is present; the functionality of the lamp and the EDC system must be verified following the indications reported in the relevant installation prescriptions; at the end of engine testing it is necessary to verify the absence of errors in the memory of the EDC central unit.

Fuel feed system

The different solutions of injection system, mechanical pumps, common-rail or pump injectors require verifications for each system; proceed, therefore, following the indications reported in the relevant prescriptions for the installation.

Electromagnetic compatibility

The verifications required by the standards on the electromagnetic compatibility relating to the engine electrical equipment are at discretion and charged to machine constructor/installer.

12.4 TEST INSTRUMENTS

The verification activity will occur using appropriate instruments capable as to range, class and conditions in which the test will be performed. For the verifications of engines applications equipped with EDC system is recommended the use of the diagnosis instruments proposed by IVECO; they are adequate for detecting temperature data, rotation speed, fuel injection and many other data, through the information delivered by the system Electronic Unit and derived by means of sensors and transducers composing the system.



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