



GENERATING SETS INSTALLATION GUIDE



General Installation Summary Industrial Engines

Engine Room Layout

Typical engine room layout

A typical engine room layout is known in the figure below, using a single generating set installation as an example.

It is essential that the hot air from the radiator is ducted outside the engine room and not allowed to recirculate to keep the engine room temperature as low as possible for the engine to give the required performance.

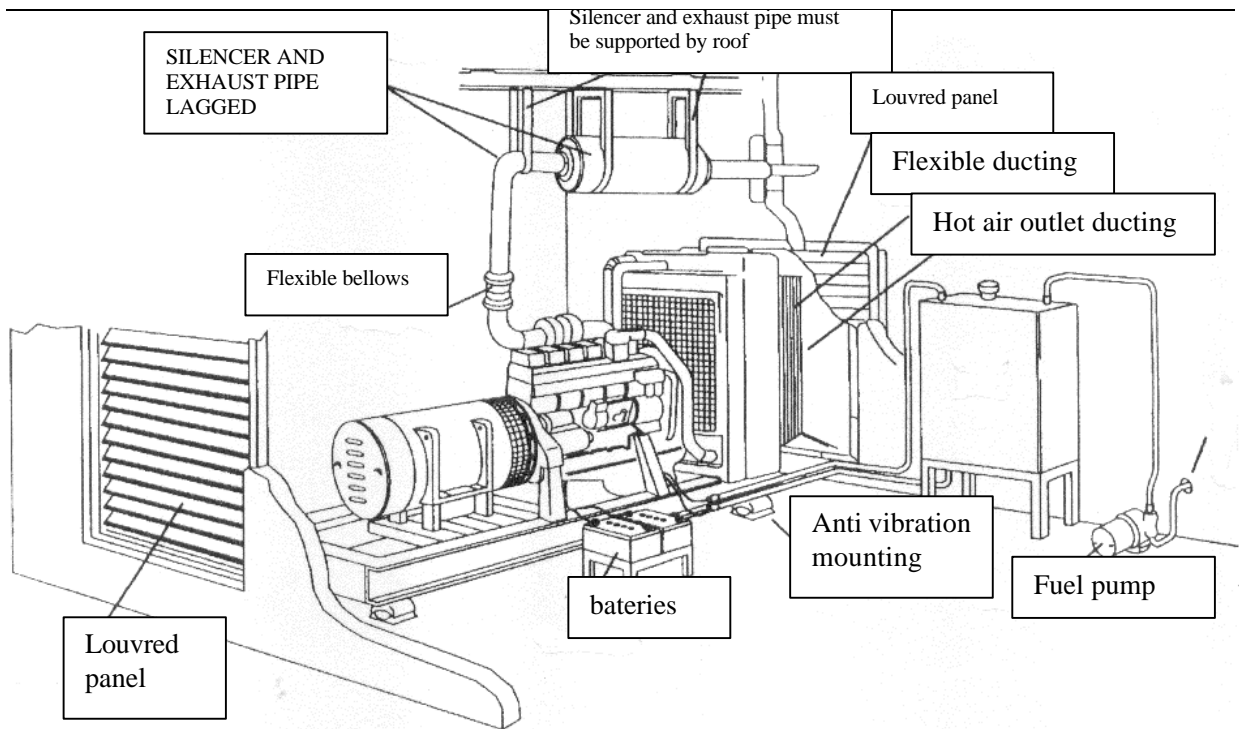
The exhaust silencer must be supported from the roof, and the support brackets should allow for expansion of the piping. A length of flexible pipe or bellow should be fitted between the engine exhaust outlet and the rigid pipe work, especially if the generating set is mounted on anti-vibration mountings. The exhaust system must be as short as possible and the number of bends kept to a minimum, so as not to exceed the appropriate engine back pressure recommendations.

Where conditions would cause the back pressure to be in excess of the recommended, then the size of the exhaust piping should be increased to suit.

The same comments apply for the hot air outlet ducting and any other engine/alternator connections, must be of the flexible type, i.e. fuel pipes and electrical connections.

The daily fuel tank is supplied with fuel from a bulk tank and not the day tank housed remotely from the engine room.

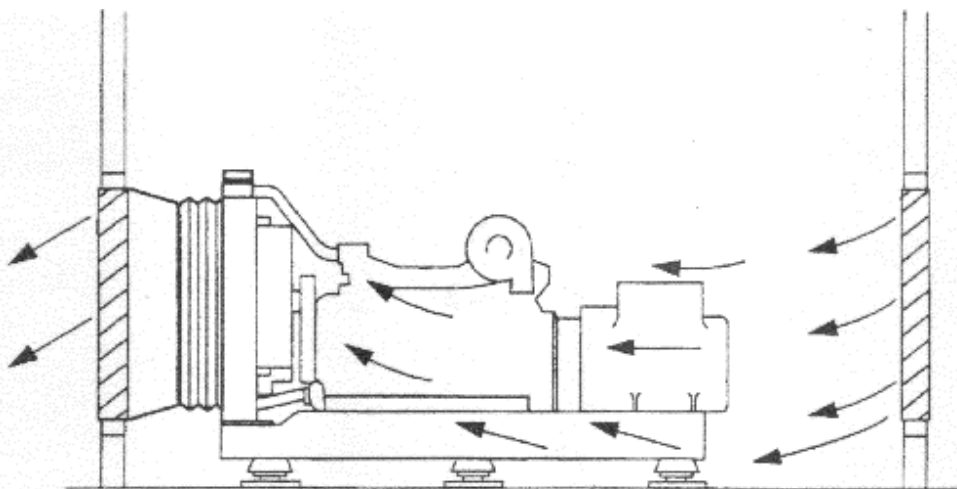
The fuel return from the engine must be piped back to the bulk tank and not the day tank to avoid fuel overheating. The starter batteries are to be kept fully charged during idle periods by a static charger. The static charger may be incorporated in the control panel.



Ventilation – engine room

When a set with an integrally mounted radiator is installed in an engine room, the basic principle is to extract hot air from the room and induce air at the ambient temperature outside the engine room with minimum re-circulation.

The figure below illustrates the most suitable position in relation to the walls of the building. The object is to get cool air in at the lowest possible point, push it through the radiator matrix and then out of the building.





It is unsatisfactory to position the set so that the radiator is adjacent to the opening in the wall. When in operation some hot air will re-circulate back into the radiator fan via the gap between the radiator and the wall.

This will lead to inefficient cooling and could result in overheating problems. The outlet opening in the wall should have free flow area about 25% larger than the frontal area of the radiator matrix and be of the same rectangular shape.

A sheet metal or plastic duct is fixed to the opening frame using a flexible connection to the radiator duct flange. The flexible section is particularly necessary when the set is mounted on a floating concrete block or anti-vibration mountings.

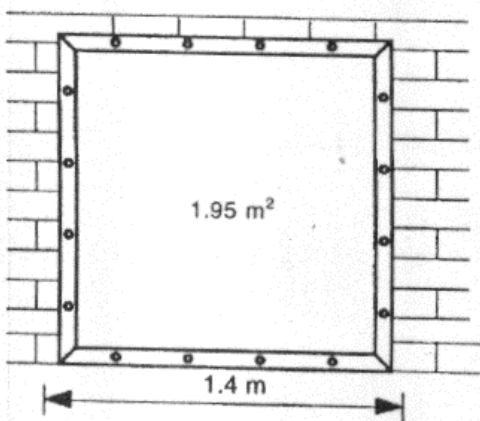
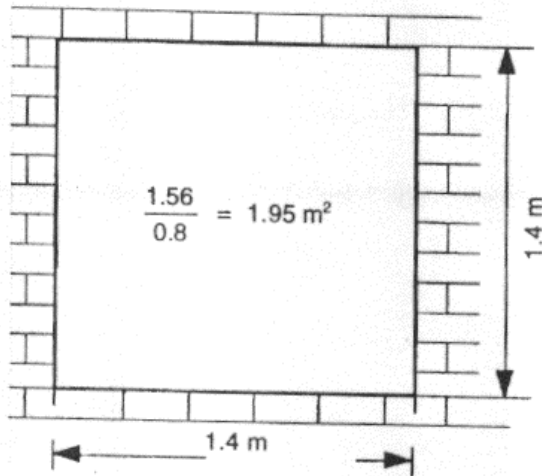
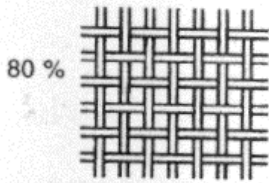
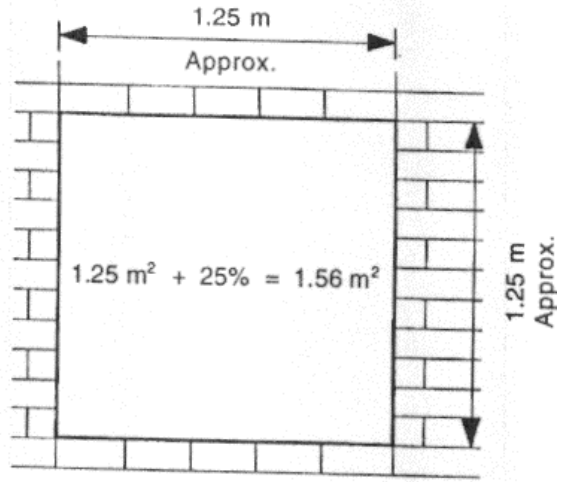
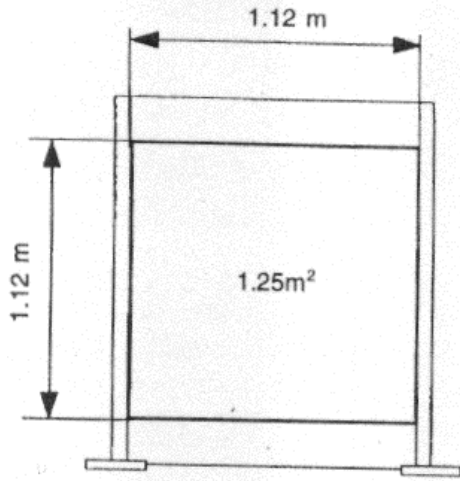
The inlet air opening should also have a **free flow area** at least 25% larger than the radiator matrix.

With the design of inlet and outlet it must be remembered that the radiator has a limited total allowable external resistance -i.e. "inlet to fan plus outlet from radiator"- this must not be exceeded or cooling air flow will be reduced.

The inlet and outlet openings will usually be fitted with a mesh grille, louvers, noise attenuating panels or inside and outside ducting. Whatever is fitted will promote resistance to air flow and it may be necessary to further increase the opening area.

Example:

For a radiator matrix frontal area 1.25 m² the air outlet/inlet opening in the wall should have an area of 1.56 m², if a grille is fitted then the opening should be increased to give 1.95 m². See the figures below.



The large quantity of air moved by the radiator fan is usually sufficient to adequately ventilate the engine room.

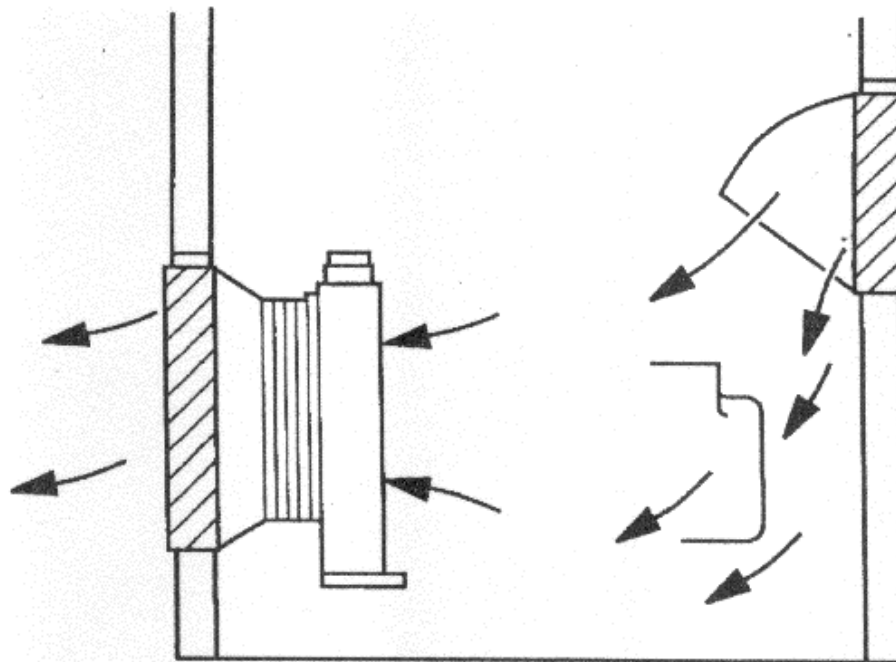
As shown in the figure below the cool incoming air is drawn over the alternator which takes its own cooling air from this flow, across the engine air intake filters and the engine. The radiator fan then pushes air through the radiator matrix to outside. There must be no obstruction to air flow immediately in front of the radiator outlet and to deflectors etc.

Where a high engine room temperature cannot be avoided then the temperature of the induction air into the engine air filters must be checked.

The temperature of the intake air to the engine should be below +40 °C. If intake air temperature is higher than that continuously, the engine output must be derated according to data stated for the specific engine. The derating factor is normally 2% every 5 °C above +40 °C. Therefore, the intake air should be ducted to the engine from a fresh air supply outside the engine compartment (fresh air intake).

The figure shows the air inlet position high in the wall.

This is acceptable if ducting directs the air to the end of the alternator and has the advantage of preventing heated air from collecting near the ceiling.



Intake air taken from outside the engine room

The air intake must be located in such a way that the intake air is as clean as possible and so that neither engine fumes nor heated air from radiators can mingle with the intake air.

The air intake must be designed to keep out water, snow and impurities.

Max permitted pressure drop is 300 mm water column. This value includes the pressure drop with a new clean air filter, connected coarse filter and in fresh air channel.

The air duct must not have sharp bends.

The air duct must have a smooth and even side.

If a hose is used it has to be reinforced to avoid collapse.



Pressure drop measuring is normally carried out at the pressure drop indicator.

The total pressure drop in the intake system with clogged air filter must not exceed 500 mm water column.

If the pressure drop is excessive fuel consumption and the amount of smoke will increase. There is also a risk that the air quantity to the engine becomes insufficient with subsequent engine disturbances.

When intake air to the engine is taken from outside the engine room it is important to check that the temperature in the engine room does not exceed 60 °C.

If the temperature exceeds this value there is a risk of functional disturbances in the electric components of the engine (alternator, charge regulator, stop solenoid).

It may therefore be necessary to arrange for ventilation of the engine room with a fan if there is risk that the temperature will exceed 60 °C.

When dimensioning engine room ventilation, also other air consumers in the engine room should be considered.

Forced ventilation – engine room

When a remote mounted radiator is fitted, the ventilation of the engine room must be considered.

First – the exhaust system in the engine room must be efficiently lagged so that the radiated heat is minimal.

Note! The exhaust manifold and turbo charger must not be lagged, only the exhaust pipe silencer. For the best forced ventilation system it is usual to use electric motor driven fans. One fan pushing the air into the room and being mounted in the wall opposite the generator end of the set. The other fan is an extractor fan, taking hot air out of the engine room. This fan should be mounted in the wall next to and above, the engine.

On the inlet air side ducting is necessary if the cooling air is not reaching the alternator/ engine. The duct directs the air to the alternator and across the engine to the extractor fan.

If the duct is not fitted when the inlet fan is at the high level the incoming cooling air will bypass the generating set and be extracted by the extractor fan without cooling set.

If a large air intake opening can be accommodated and correctly positioned then a fan pushing air into the room can be deleted.

The extractor fan will require adequate suction to overcome the resistance to air flow through the inlet and outlet louvers and ducts if fitted.

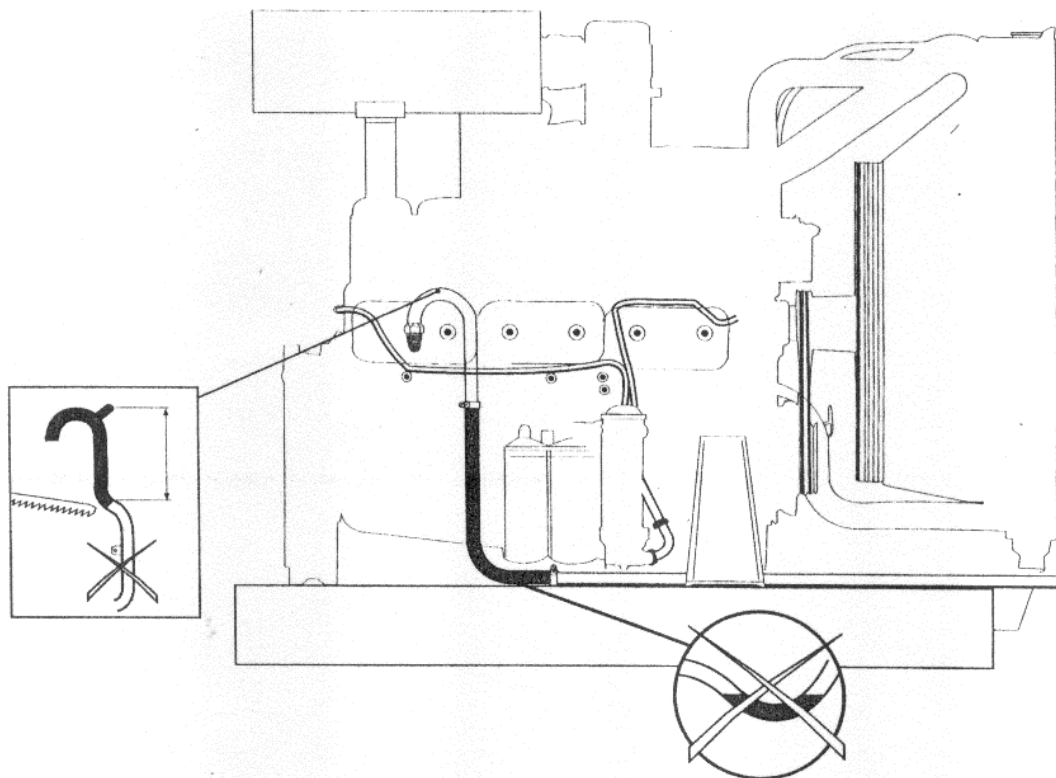
If an extractor fan is used and the combustion air is drawn from the engine room, underpressure can occur. The underpressure in the engine room can be checked with a plastic hose filled with water and formed as a U one end to be connected to the engine room and the other to atmospheric pressure.

Measure the pressure difference that corresponds to the level difference of the water in mm water column, when the engine has been run at full speed for at least 5 minutes. The pressure should not exceed 10 mm WC (0.8 mm Hg or 1 millibar). For engine with remote radiator without fan an underpressure of 20 mm WC is acceptable.

Crankcase ventilation

Warning! The fumes from the engine crankcase must be ducted from the engine room through a separate passage.

The crankcase ventilation pipe, can as a minimum safety precaution be extended forward or, as shown in the figure below, straight downwards through the floor where applicable to allow the crankcase fumes to be ducted outside the engine room. This is of particular importance when the engine has a pushing fan as otherwise the crankcase fumes are deposited on the radiator which subsequently becomes fouled with dirt causing it to clog up, thereby reducing cooling capacity.



Calculation of required engine room ventilation

When calculating the engine room ventilation, the following important parameters must be observed:

- Max. intake air temperature to the engine is 40 °C.
- Max. air temperature in engine room, providing the combustion air is taken from outside engine room, is 60 °C.
- The entire exhaust pipe and silencer in the engine room should preferably be lagged.
- The exhaust manifold and turbocharger **must not** be lagged.
- Max. air on temperature for the radiator cooling system. See **Engine Sales Handbook**.



The large quantity of air moved by the engine mounted cooling fan is usually sufficient to ventilate the engine room. When a remote mounted radiator water cooled heat exchanger is installed, the ventilation of the engine room must be considered.

The quantity of air required to give a pre-determined temperature rise in the engine, can be calculated from the following:

$$\text{Air flow required} = \frac{\text{Total heat rejection to air}}{\text{Air density} \cdot T_{\text{rise}} \cdot \text{Constant}} + \text{Combustion air required}$$

Total heat rejection to air: Heat rejection from engine + alternator and other heat generating equipment in engine room (kW).

Air density: Density of air at various temperatures as per table below, in kg/m³.

Trise: Max. air temperature rise in engine room above ambient temp. in °C.

Constant: = 0.0167

Combustion air required: Engine air consumption in m³/min as stated in the **Engine Sales Handbook**.

Air Density

°C	0	5	10	15	20	25	30	35	40	45	50	55
Kg/m ³	1.30	1.27	1.25	1.22	1.20	1.19	1.17	1.16	1.14	1.12	1.09	1.08

Multiple engine installation

Generally multiple engine installations follow on the same lines as for a single unit installation, each unit having its own independent foundation and exhaust system.

Warning! The exhaust gases from a multiple engine installation must not be combined into a common exhaust system as this can be very dangerous and could cause engine damage. If the exhaust system in a multiple engine installation must be combined into an existing common exhaust system, each engine must be equipped with a separate shut off exhaust valve, to prevent exhaust gases from entering any possible engine not in operation. See also page 62, **Multiple Exhaust Outlets**

Power correction by height and temperature

For turbine engines the following coefficients are recommended:

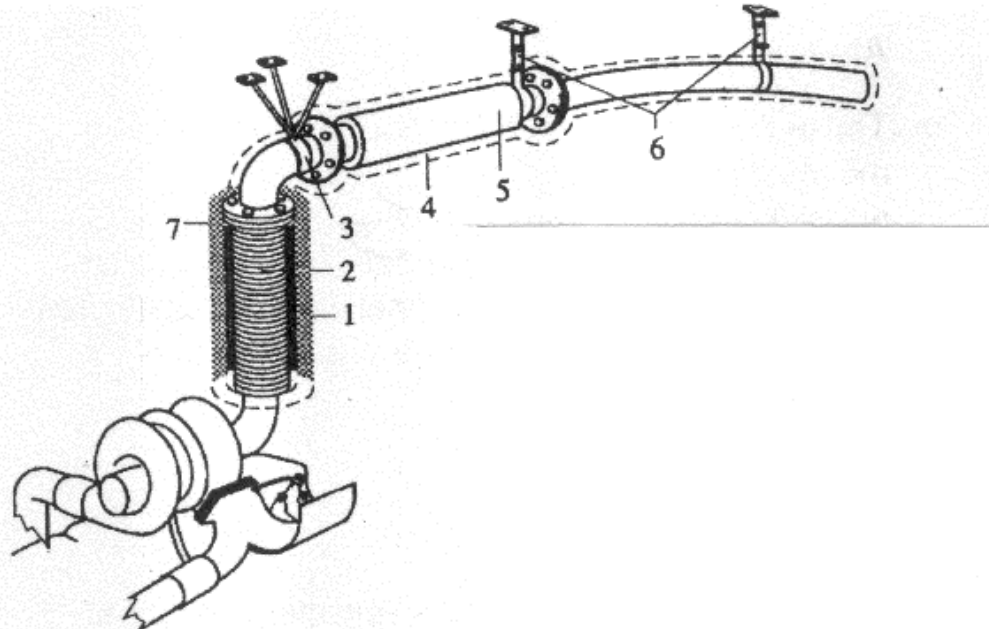
Min. height at 3000 m	4% / 500 m
Max. height at 3000 m	6% / 500 m
By ambient temperature	2 % / 5 °C

Exhaust System

General considerations

The exhaust system should be planned at the outset of the installation.
The main objectives are:

- Ensure that the back pressure of the complete system is below the maximum limit laid down by the engine manufacturer.
- Keep weight off the engine manifold and turbo charger by supporting the system.
- Allow the thermal expansion and contraction.
- Provide flexibility if the engine set is on antivibration mountings.
- Reduce exhaust noise. A typical installation is shown in the figure below.



Exhaust line

- 1- Mesh
- 2- Flexible exhaust hose
- 3- Three point fixture
- 4- Insulation (mineral wool)
- 5- Silencer
- 6- Flexible attachment
- 7- Glass fiber fabric

Back pressure

The exhaust system will produce a certain resistance to flow for the exhaust gases. This resistance or back pressure must be kept within specified limits. Excessive back pressure will lead to:

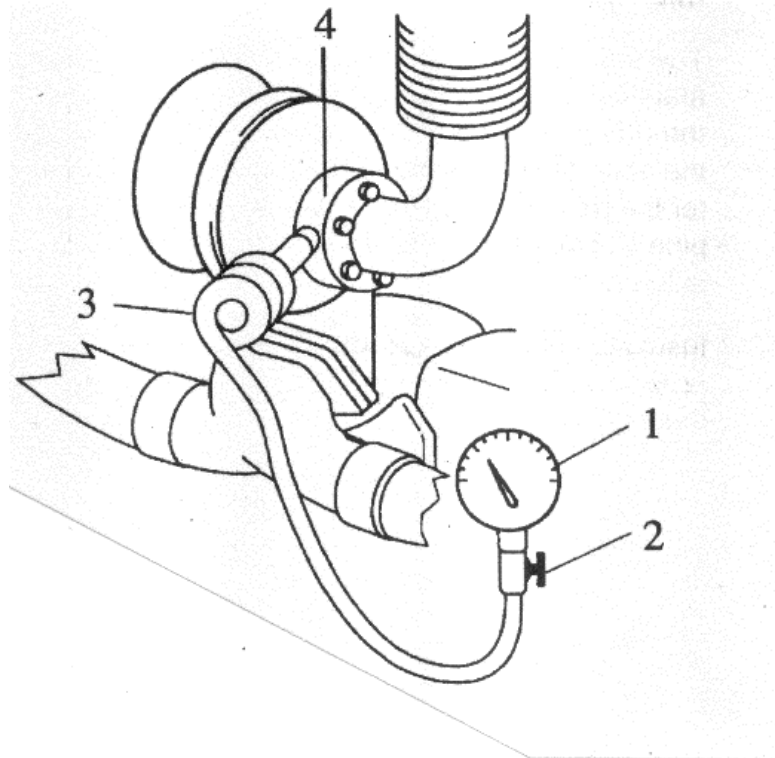
- Loss of power output
- Poor fuel economy
- High exhaust temperature

These conditions produce over-heating and excessive smoke from the installation and reduce the life of the valves and turbocharger. Maximum permissible back pressure for engines can be found in the sales handbooks.

A manometer is used to measure the exhaust back pressure at maximum rated power.

There are special flanges for measuring the back pressure, which are bolted directly onto the turbocharger.

The flanges have a threaded hole for connecting measuring equipment.





- 1- Manometer 2500 mm W.G.
- 2- Cock or damper unit
- 3- Cooling coil
- 4- Flange with threaded hole

Silencer

There are generally two types of silencers described as either absorptive or reactive.

Absorptive type

These work on the principle of absorbing noise by means of an absorbent lining inside the silencer and normally provides attenuation over a broad frequency range. It is generally designed as a straight through and would only create a marginally greater back pressure than a similar length of straight pipe.

Expansion (reactive) silencers

These work on the principle of reflecting and thus containing sound within the silencer.

There are internal baffle plates fitted to divide the silencer into sections, which can be individually tuned to a specific frequency.

A reactive silencer creates a relatively high back pressure due to the tortuous gas flow path, i.e. through the baffle plates, which reverses flow.

Some silencers ideally combine reactive and absorptive type of silencing.

Silencer location

The reactive silencer is fitted as close to the exhaust manifold as is practical (to prevent noise breakout through pipework) or at the end of the system and the absorptive unit is fitted in line, generally, directly after the reactive unit. There should only be a short tail pipe (= 1m) after the silencer if fitted in the end of the exhaust line.

Insulation of long lines will affect the exhaust back pressure and therefore the exhaust pipe diameter must be increased.

Multiple exhaust outlets

If more than one engine is being installed the exhaust from the engines must not be taken into the same flue.

Warning! The exhaust gases from a multiple engine installation must not be combined into a common exhaust system as this can be very dangerous and could cause engine damage.

The reason is that if one engine is stopped when others are running, exhaust gases will condensate and carbon will be forced into the exhaust system of the stopped engine and then into the engine cylinders which can cause corrosion.

If a flap valve of good quality is fitted in each exhaust line near the flue, multi-engine installations on one exhaust line can sometimes be accepted.

To calculate the total diameter of a common exhaust pipe use the following formula:



$$D_{\text{Total}} = D \times K$$

Where:

D = is exhaust pipe diameter for one engine

K = is a factor

Number of engines	Factor K
2	1.32
3	1.55
4	1.74
5	1.90
6	2.05

Calculation of back pressure

Calculation of HD silencer back pressure

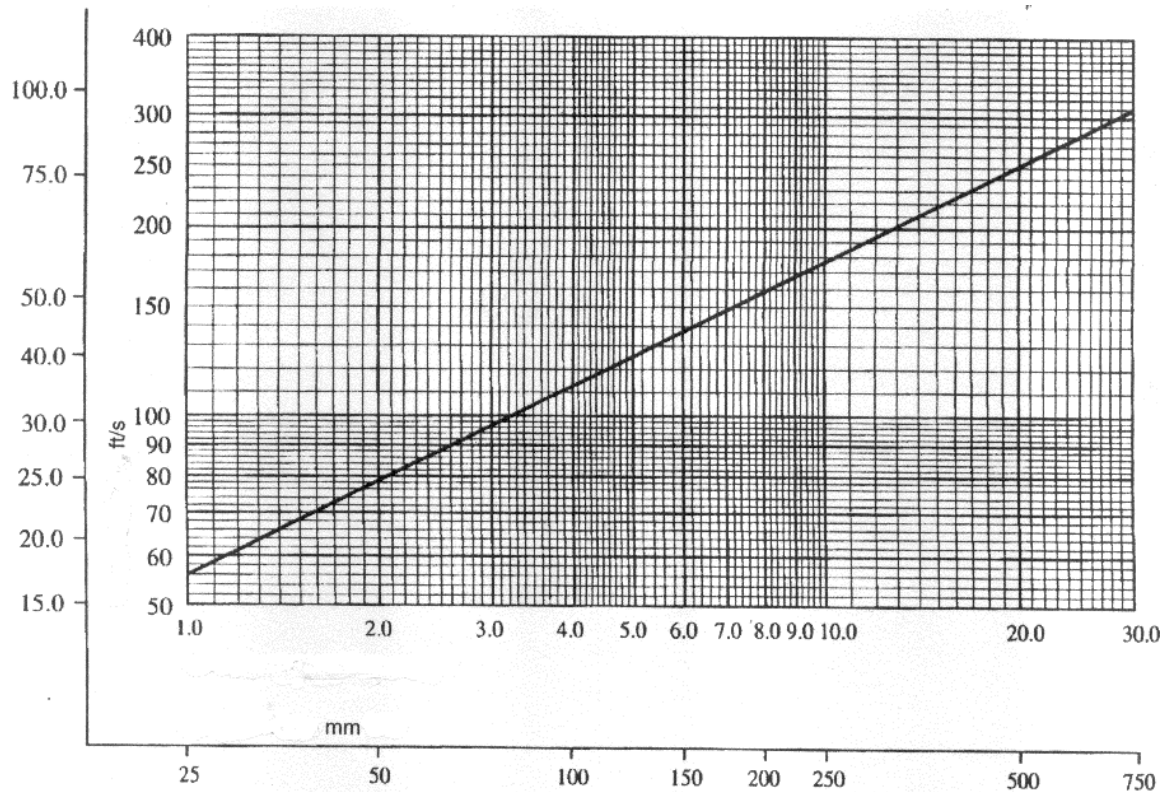
To calculate the back pressure HD silencers use the following graph: exhaust gas flow and temperature can be found in the **Industrial Sales Handbook**.

$$\text{Bore velocity} = \frac{\text{Exhaust gas flow (m}^3 / \text{min)}}{\text{Area of pipe (m}^2) \times 60} \quad (\text{m/sec})$$

$$\text{Back pressure} = \frac{\text{Resistance from graph (mm Wc)} \times 673}{(T + 273)} \quad (\text{mm Wc})$$

T = engine exhaust temperature (°C) 1mm Wc = 0,0098 kPa

* See graph for Velocity / Resistance curve at 400 °C (Side entry version gives approximately 10 % greater resistance than shown on graph)



Back pressure – exhaust pipe – calculation

Using the value of the exhaust gas flow from the **Industrial Sales Handbook** and having calculated the back pressure for a certain silencer (HD) you will be able to determine the resistance to flow in a straight exhaust pipe.

The following formula is recommended:

$$P = 6.32 \frac{L \times Q^2}{D^5} \times \frac{1}{(T + 273)}$$

Where:

- P = is back pressure through the exhaust pipe in Pa
- L = is total equivalent length of straight pipe meters
- Q = is exhaust gas flow in m³/s
- D = is pipe diameter in meters
- T = is exhaust gas temperature °C

Note! When the bends are used in the exhaust system then the pressure loss is expressed in equivalent length of pipe.

Adding the pressure losses through the silencer to the loss through the pipe work will give the total back pressure incurred by the exhaust system. This must not exceed the figure quoted in the **Industrial Sales Handbook** against the appropriate engine and rating.



Example

Engine

Standby power 294 kW/ 1500 rpm

Silencer 6 inches HD

Calculation of pressure loss through the silencer.

$$\text{Bore velocity (m/s)} = \frac{Q \text{ (m}^3\text{/s)}}{\text{Pipe area (m}^2\text{)}}$$

$$Q = 6205 \text{ m}^3 / \text{min} = 1.04 \text{ m}^3 / \text{sec}$$

This value is taken from **Industrial Sales Handbook**

$$\text{Pipe area} = \frac{3.1416 \times D^2}{4}$$

$$D = 6 \text{ inch} = 152 \text{ mm} = 0.152 \text{ m.}$$

Pipe area will be

$$A = 0.01823 \text{ (m}^2\text{)}$$

$$\text{Bore velocity} = 57 \text{ (m/s)}$$

From the diagram on previous page you will find the resistance in mm Wc.

The resistance is 280mm Wc

The pressure loss will be calculated according to the formula:

$$\text{Pressure loss (mm WC)} = \frac{\text{Resistance from graph (mm Wc)} \times 673}{(T \text{ } ^\circ\text{C} + 273)}$$

T = exhaust gas Temperature

T = 545 °C (from Industrial Sales Handbook)

Pressure loss will be:

$$\text{Ploss } 230 \text{ mm Wc} = 2.254 \text{ kPa}$$

Calculation of the pressure loss through the exhaust pipe.

$$P_{\text{pipe}} = 6.32 \times \frac{L \times Q^2}{D^5} \times \frac{1}{(T + 273)}$$

Suppose that the pipe is 15 m and there are 5 bends of 90 deg. The equivalent straight length will be:

$$L = 15 + (5 \times 2.28) = 26.5 \text{ m}$$

The pressure loss through the exhaust pipe will be:

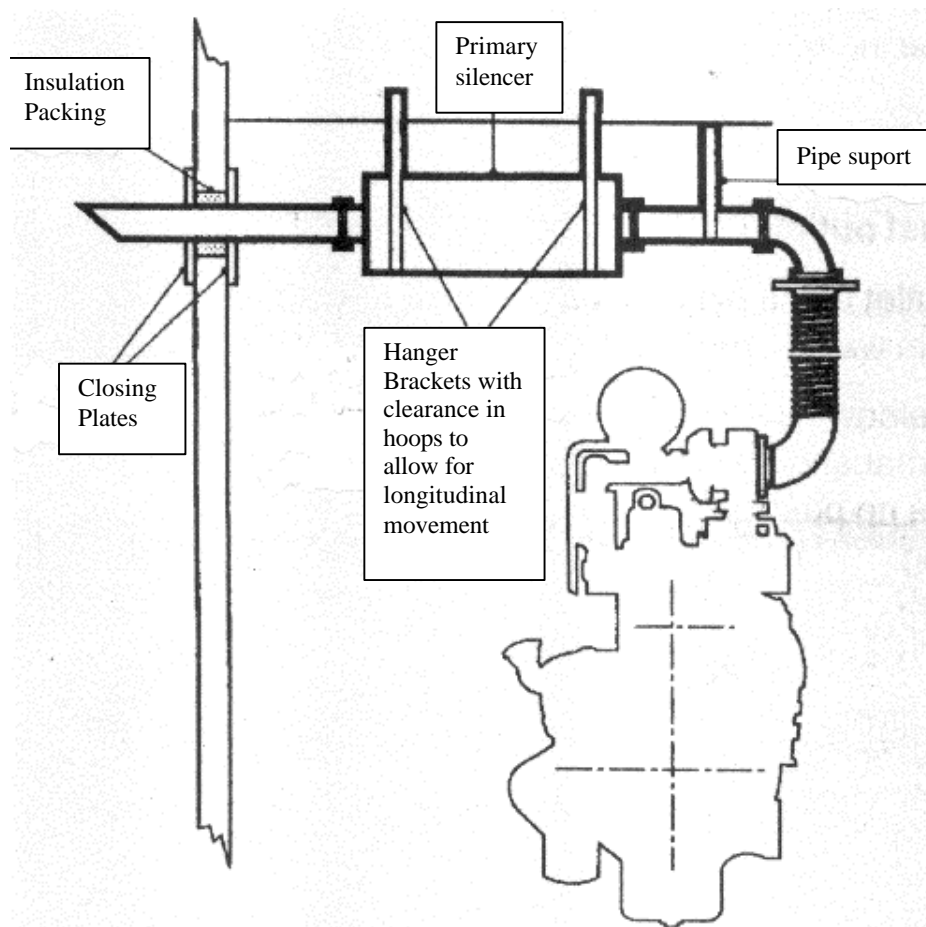
$$P_{\text{pipe}} = 2729 \text{ Pa} = 2.7 \text{ kPa}$$

Adding the pressure loss through the silencer then the total back pressure in the exhaust system will be:

$$P_{\text{tot}} = P_{\text{silencer}} + P_{\text{pipe}} = 2.25 + 2.7$$

$$P_{\text{tot}} = 4.95 \text{ kPa}$$

The max. allowable back pressure in exhaust line stated in the Industrial Sales Handbook is 5kPa 1,500 rpm.



INSTALLATION

Flexible connections

Exhaust pipes are isolated from the engine with flexible connections. Installed close to the engine's exhaust outlet, flexible exhaust connections have three functions:

- 1- Isolate vibrations and weight of exhaust piping from the engine.
- 2- Compensate the thermal expansion of the exhaust piping.
- 3- Compensate for lateral movement when the engine starts and stops, if the engine is on antivibration mountings.

The flexible pipe is able to take up small radial movements, but not twisting or axial movement. It must not be bent. The flexible element can be fitted in different positions, but should preferably be fitted vertically.

Thermal growth of exhaust piping must be planned to avoid excessive load on supporting structures.

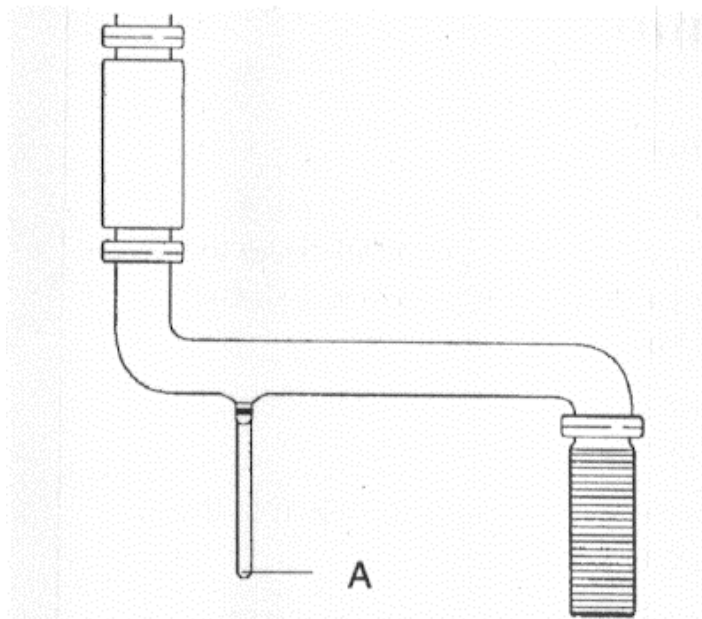
The expansion of one meter of steel pipe per rise in temperature of 100 °C is app. 1.2 mm.

It is therefore important to locate supports to allow expansion away from engine, avoid strains and distortions to connected equipment and to allow equipment removal without additional support.

Long pipe runs are sectioned with expansion joints. Each section is fixed at one end and allowed to expand at the other.

Condensate drain

Rain or condensed water that enters into the engine can cause severe damage. Long exhaust lines should be located as close to the engine as possible.



Insulated exhaust systems



Warning! When engines are delivered without protection all hot surfaces must be protected if after being built into the respective application this is necessary for personal safety.

Due to high temperatures that arise in dry exhaust pipe (400-500 °C) it is sometimes necessary to insulate it. Thereby the temperature in the engine room can be kept low and burns from touching can be avoided. The insulation also helps to keep the noise level low.

Insulation of long lines will affect the exhaust backpressure and therefore the exhaust pipe diameter must be increased.

Exhaust outlet position

The outlet of the exhaust pipe must be designed so that the rain water cannot enter the exhaust system.

Fit an elbow, hood or self-closing cover to the end.

The exhaust outlet must be in such position that there is no possibility of hot gas entering the air inlet opening.

Cooling System

Cooling performance

Air on temperature

The cooling performance for an installation depends on the engine heat rejection and all the components in the cooling system:

- Radiator
- Fan type and diameter
- Fan speed ratio
- Fan ring type and fan position
- Extra components in the cooling system
- Engine room and air ducts

Extra components in the cooling water system.

The Air To Boil temperature (ATB) is often used as a measure of the cooling performance for a cooling system installation.

The ATB temperature is defined as the ambient air temp. that gives a coolant outlet temperature of 100°C. ATB is calculated according to the formula:

$$ATB = 100 T_w + TAA \text{ (}^\circ\text{C)}$$

T_w = Coolant temperature at the outlet of the engine

TAA = ambient air temperature

The Air On Temperature is another measure of the cooling performance. The Air On Temperature also refers to a coolant temperature of 100 °C after the engine but it is defined as the cooling air temp. entering the radiator or charge air cooler. The difference between the Air On



Temp. and the ATB temp. is that the entering cooling air temp. should be used instead of the ambient air temp.

$$\text{Air On Temperature} = 100 - T_w + \text{TEA } (^{\circ}\text{C})$$

TEA = Cooling air temperature entering the radiator or charge air cooler.

For an engine with a puller fan the Air on Temperature is equal to the ATB temperature. If a pusher fan is used the cooling air is heated by the engine before it enters the radiator (or charge air cooler for TAD engines). For a Gen Set the air is also heated by the generator and the ATB is equal to the Air On Temp. minus the temperature increase over the generator and the engine.

Example

For an engine of 262 Kw at 1,500 rpm net prime power.

From the **Industrial Sales Handbook** the following figures are taken:

Air on temp.: 50°C

Air flow: 4.45 m³/s

Max additional restriction: 160 Pa

$$\Delta T = \frac{Q_{\text{heat}}}{\rho \times q_A \times C_p}$$

ΔT : temp. increase (°C)

Q_{heat}: Heat power from the generator and radiation from engine (kW)

ρ : Air density (kg/m³)

q_A: Cooling air flow (m³/s)

C_p: Specific heat for air (kJ/kg °C)

Assumed efficiency for the generator: 0.92

92% of the engine power is transformed to electric power –8% is heat loss.

Heat loss from generator: 0.08 x 262 = 21 kW

The heat radiation from the engine is 19 kW at 1500rpm.

$$Q_{\text{heat}} = 19 + 21 = 40 \text{ kW}$$

Air density and specific heat is obtained from a table :

At 50 °C:

$$\rho = 1.09 \text{ kg/m}^3$$

$$C_p = 1.009 \text{ kJ/kg } ^{\circ}\text{C}$$



The cooling air temp. increase can now be calculated according to the formula:

$$\Delta T = \frac{Q_{\text{heat}}}{\rho \times q_A \times C_p} = \frac{40}{1.09 \times 4.45 \times 1.009} = 8 \text{ }^\circ\text{C}$$

The ATB is now obtained as the Air on temp. minus the temp. increase: $\text{ATB} = 50 - 8 = 42 \text{ }^\circ\text{C}$
The max ambient air temp. in which the engine can run is about $42 \text{ }^\circ\text{C}$.

Summary of system design

Careful consideration must be given to the following points when designing a cooling system:

- 1-The maximum ambient air temp. in which the engine must be able to operate.
- 2-The direction of the cooling air flow, i.e. if a puller fan or a pusher fan should be used.
For Gen Sets a pusher is recommended to avoid overheating of the generator. For mobile Applications a possible ram air flow must be considered.
- 3-For a pusher fan system the radiated heat from the engine causes a temp. increase of the cooling air.
- 4-For a Gen Set with a pusher fan the heat from the generator causes a temperature increase of the cooling air. The heat loss from the generator is 7-10% of the net. engine output.
- 5-Further coolers in front of the radiator (for puller fan) or behind the radiator (for pusher fan) causes a temp. increase of the cooling air and reduces air flow.
- 6-A dusty environment will cause fouling of the radiator which reduces the cooling performance. The radiator should be installed in such a way that it can be easily cleaned.
- 7-There should be as few restrictions as possible in the cooling air flow. The design of the air ducts, the grille and the engine room is important.
- 8-Recirculation of hot air can reduce cooling performance greatly and must be prevented by sealing.
- 9-The heat rejection from the engine to the coolant must be known to calculate the cooling performance. This value is stated in the Industrial Sales Handbook.
- 10-If extra components are connected to the water cooling system, for example a converter oil cooler, the heat rejection from these components must be known. These components also cause a



pressure drop that reduces the coolant flow.

11-With a 50% mixture of ethylene glycol in the coolant the ATB will be approximately 3 °C lower

than with pure water.

12-The altitude of the location where the engine is going to operate must be known as the ATB will

be reduced, e.g. approx. 1.4 °C at 300 m of elevation over the sea level.

13-If the cooling performance needs to be increased, this should first of all be done by increasing the size of the radiator and improving the flow path of the cooling air. If the fan is altered or the

fan speed increased this leads to increased fan power consumption and often increased noise level.

Coolant water system

The function of the cooling water system is to transport the heat energy from the engine and extra components to the radiator.

Coolant

The coolant has three different functions:

1-Provide adequate heat function.

2-Protect all metals in the cooling system from corrosion.

3-Provide adequate anti-freeze protection.

The coolant shall contain mixture of water and either ethylene glycol or anticorrosion additive. In areas where the water has a high lime content treated water or rain water should be used to avoid clogging.

The cooling raw water shall comply with the following requirements (ASTM, D 4985 x 1.1)

Solid particles max. 340 ppm

Total hardness max. 9.5 °dH

Chloride content max. 40 ppm

Sulphate content max. 100 ppm

PH 5.5 – 9.0

When there is any risk of freezing, min. 40% ethylene glycol should be used. At about 40% glycol the freezing point of the coolant is about -25 °C.



At 60% glycol the freezing point is lowered to -56°C .

Increasing the glycol content to more than 60% does not give a better freezing protection.

In areas with no freezing risk an anticorrosion additive can be used instead of ethylene glycol, although glycol gives a much better protection against corrosion and cavitation. After filling the additive the engine should be run warm to get the best corrosion protection.

Note! If anticorrosion additive is used, the cooling system must be topped up with 0.5 L of concentrated additive every 400 hours of operation.

Note! Glycol or any other type of anti-freeze must never be used in combination with anticorrosion additive. Heavy foaming can occur which can reduce the cooling performance.

A cooling water filter is available as option for all the engines (standard on 16 litre engines). The filter stops any foreign objects in the coolant and keeps the cooling water system free from deposits. The filter also contains an inhibiting concentrate that increases the corrosion protective properties of the coolant.

With 50% glycol in the coolant the ATB temp. is reduced approximately 3°C compared to pure water. The Air on temp. stated in the Industrial Sales Handbook are valid for 50% glycol.

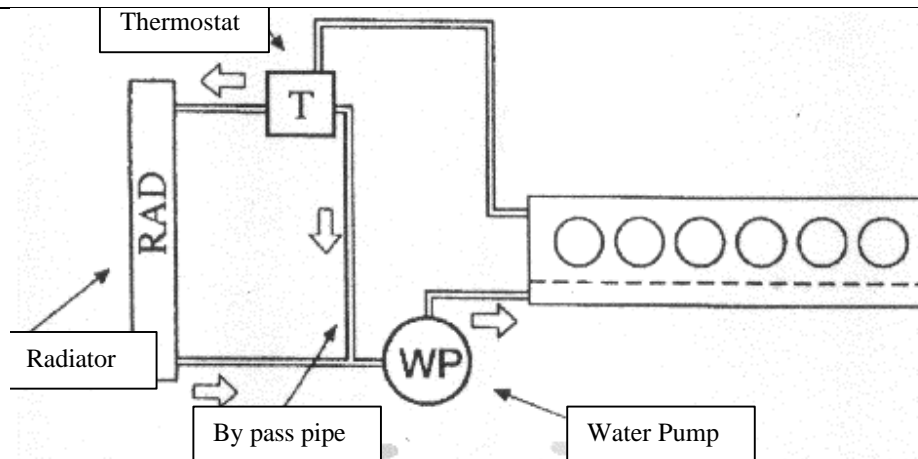
Engine and radiator circuit

This circuit consists of the following main components:

- Water pump
- Water channels in the engine block and cylinder heads
- Thermostat
- By pass pipe between the thermostat housing and water pump
- Radiator
- Pipes and hoses

The radiator can in some cases be replaced with:

- Water to water heat exchanger



Thermostat

Note! If the thermostat is removed, the following will happen:

- The warming up time of the engine to normal working temperature will be a lot longer and the engine will not be able to normal working temperature under idle, light to medium engine load and at moderate ambient air temperatures.
- The engines' lube oil temperature will not reach the correct level, which will increase the fuel consumption. The exhaust emissions will increase (more white smoke) and slightly reduce the engine output. Furthermore this will increase the engine wear and reduce the engine life span.
- The cooling capacity of the system will also be reduced, as not all cooling water is going through the radiator (uncontrolled water flow).

Even though the temperature gauge is showing correct water temperature, local boiling can occur in the engine water jacket.

- **Engines running without thermostat are not covered by warranty.**

Expansion tank

The expansion tank can be fitted separately or built in into the radiator top tank.

The expansion tank has four different functions:

- Give space for the thermal expansion of the coolant in the water-cooling system.
- Separate air from the coolant.
- Keep a static pressure on the suction side of the water pump to prevent cavitation.
- Give certain system pressure by building up a pressure in the air volume above the coolant level.

Expansion tank volume

The total expansion tank volume should be minimum 18% of the total coolant volume in the water cooling system. The air volume above the max level should be min 6% of the total coolant volume. The coolant volume below the min level should be about 3 litres.

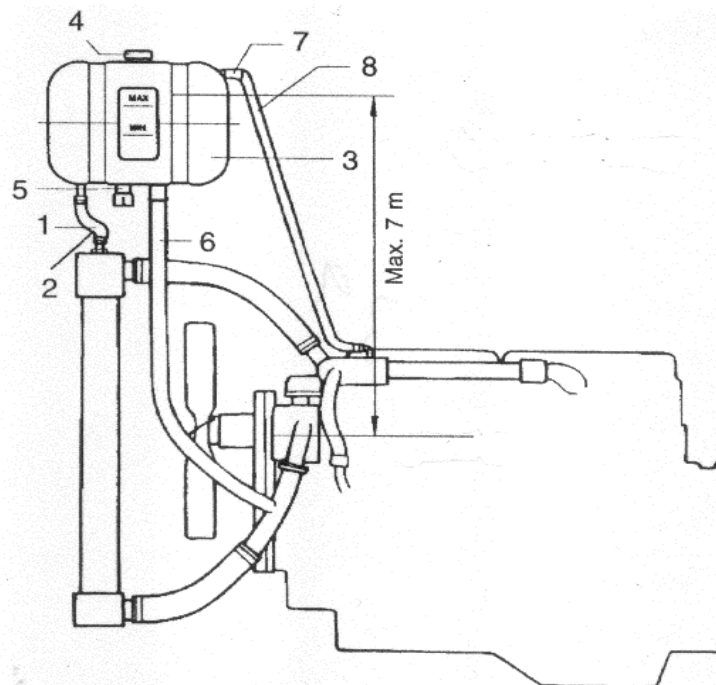
Recommended expansion tank:

6 and 7 litre engine: 8 l tank

10, 12 and 16 litre engine: 12 l tank

Installation of separate expansion tank

1. Deaeration hose from the radiator to the expansion tank. The hose should incline upwards all the way. If it is not inclining a deaeration cock must be used.
2. Deaeration cock.
3. Expansion tank.
4. Pressure cup.
5. Connection for coolant level indicator (optional).
6. Hose from the expansion tank to the water pump inlet.
7. Nipple with a restriction of 2,5mm.
8. Deaeration hose from the thermostat housing to the expansion tank. The hose must incline upwards.





The hose from the expansion tank to the water pump inlet (# 6) had the function to keep a static pressure on the suction side of the water pump. In order to avoid major engine damages it is important that the min level of the expansion tank is placed higher than on all other parts of the water-cooling system. Otherwise air pockets may occur in the system. The maximum height from the water pump center line to the expansion tank is 7 m.

Pressure cap

The purpose of a pressurized system is to increase the boiling point of the coolant and to prevent cavitation in the water pump. This is specially important at high ambient air temperatures and at high altitudes.

The pressure cap also prevents after-boiling and coolant loss when a hot engine is shut down. Normally two different types of pressure caps are used:

- A metal pressure cap with an opening pressure of 70 kPa for the radiators built in expansion tank and for the sheet metal expansion tanks.
- A plastic pressure cap with an opening pressure of 50 kPa for the separate expansion tanks of plastic.

The old, small type of plastic expansion tank has a 30 kPa plastic pressure cap.

When the coolant temp decreases there will be a negative pressure in the system. To avoid a too low negative pressure there is a vacuum valve in the cap. Max permitted negative pressure is 10 Kpa.

Altitude above sea level (m)	Atmospheric pressure (kPa)	Boiling point at atm. Pressure (°C)	Boiling point with 50 kPa cap (°C)	Boiling point with 70 kPa cap (°C)
0	101	100	112	115
500	95	98	110	114
1000	89	96	109	113
1500	84	95	108	112
2000	79	93	107	111
2500	74	92	106	110
3000	69	90	105	109
3500	65	88	104	108
4000	61	86	103	107



De-aeration nipples and hoses

To achieve a correct function of the cooling system it is essential that the coolant is free from air and that it is possible to fill the system completely.

The de-aeration nipples should be placed to avoid air being rapped at any point of the water cooling system. Air mixing of the coolant and trapped air can have the following consequences:

- Reduced cooling performance of the cooling system.
- Low heat absorption and heat rejection properties.
- Possibility of local boiling, which causes high metal temperatures.
- Excessive coolant loss due to the air expansion.
- Cavitation in the water pump and lines.
- Piston seizure.

All engines have a deaeration nipple in the connection to the thermostat housing.

The nipple should have a restriction of 3 to 4 mm to reduce the water flow. Radiators without a built in expansion tank should have a deaeration nipple in the top tank.

These nipples should be connected to the expansion tank and the function is to deaerate the coolant continuously.