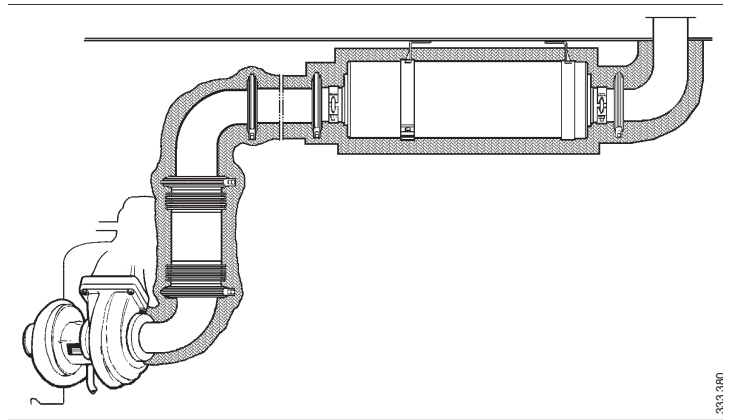




Exhaust system

**Marine engines
DI09, DI13, DI16**



2013 2180



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Sound reduction

Assess the need for sound reduction in new installations from case to case, based on the applicable conditions in relation to noise requirements, length and type of exhaust system, location of the exhaust system outlet etc.

Some form of sound reduction is required in most installations.

The thermal insulation of the exhaust system affects the sound level. A thermally insulated system can result in a higher noise level than an uninsulated system.

Exhaust noise

Undamped exhaust noise, measured 1 metre downstream of the turbocharger at full power output:

Engine	Sound level (dBA)	Most important one-third octave band (Hz)
DI09	115-117	40-160
DI13	115-118	50-200
DI16	116-118	63-250

The most important frequency range for exhaust noise is between 50 and 500 Hz. Exhaust flow in the system can generate hissing sounds, e.g. at sharp pipe bends and edges. This is known as self-generated sound. This phenomenon occurs higher up in the frequency range and is effectively dampened with an absorption silencer (e.g. glass fibre). Vibrations in the silencer casing can also generate noise. For this reason, avoid silencers with flat surfaces.



Exhaust system design

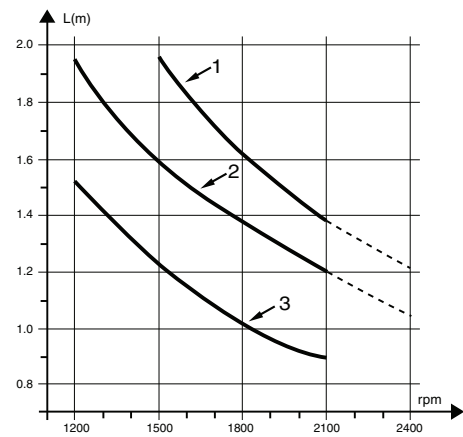
Position the silencer as close to the end of the exhaust system as possible. In order to obtain the best noise reduction, there should only be a short tailpipe after the silencer as shown in the graph.

- For all-speed engines, read the specified maximum speed for the engine.
- For single-speed engines, read the operating speed of the engine.

If the silencer cannot be positioned close to the exhaust system outlet because of a lack of space, it should be placed as close to the engine as possible. This location is, however, unfavourable in silencing terms if the pipes beyond it are long. It may then be a good idea to install another silencer close to the outlet or to end the exhaust system with two 90° pipe bends with a suitable length between them.

Note:

Sharp exhaust pipe bends close to the outlet increase the risk of hissing sounds.



Graph for determining the longest length of tailpipe.

1. D109.
2. D113.
3. D116.



Exhaust outlet

Design the exhaust system so that the exhaust gases are not reflected against vertical walls, since this results in increased noise level.

Position the exhaust outlet so that no exhaust gases can be drawn into the engine intake. If exhaust gases are drawn into the intake, intake air temperature increases rapidly. The exhaust gases contain soot particles so there is also a risk of the air filter becoming blocked.



WARNING!

Position the exhaust outlet so that exhaust gases cannot enter areas occupied by people.

Example

If 2 silencers are used in the system, they should be positioned in series at a distance of 2/3 of the length of the tailpipe and with the silencer used to dampen high-frequency noise furthest away from the engine.

Since the pipes which form part of an exhaust system also operate as silencers, it is important that they are dimensioned correctly.

Note:

The exhaust back pressure increases with the number of pipe bends and with increased pipe length. This leads to higher fuel consumption and loss of power.



IMPORTANT!

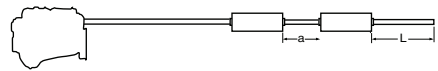
The installer is responsible for ensuring that the exhaust system is well sealed during installation. He is also responsible for ensuring that the pipe and silencer suspension is designed in such a way that system leaks cannot arise during operation.



Examples of long exhaust systems (i.e. longer than 5 metres) with designs which aid sound reduction.

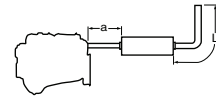


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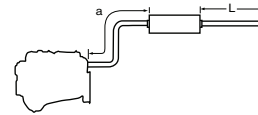


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Examples of short exhaust systems with designs which aid sound reduction.



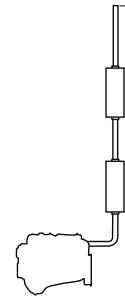
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338 557

L = Length of tailpipe, determined from graph

a = 2/3 of L. Length a is less significant in exhaust systems with only one silencer



338 558



Connection of exhaust system to engine

There should always be a flexible connection between the exhaust system and the engine which absorbs the movement of the engine and changes in length in the exhaust system due to temperature changes. A flexible connection can consist of the Scania exhaust bellows. Position the flexible connection as close to the turbocharger connection as possible.

! IMPORTANT!

The weight of the exhaust system must not load the exhaust bellows or turbocharger. Therefore, place a suspension point immediately after the flexible connection.

The illustration to the right shows the recommended installation of the exhaust system.

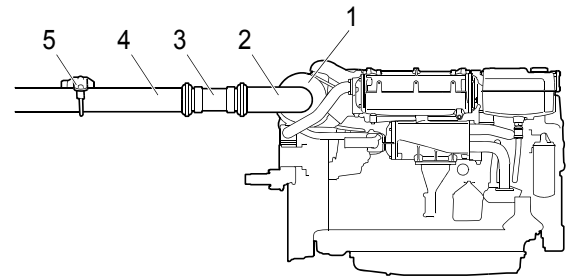
If the exhaust pipes are very long or if the exhaust system has a relatively long horizontal part between 2 vertical parts, several flexible connections may be required in the system. There must then be a fixed anchorage point on one side of the vertical exhaust bellows and a suspension which allows axial movement on the other side.

V-clamp

Scania pipe sections have flanges secured with V-clamps.

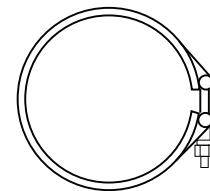
Note:

Do not use the V-clamp to force together joints, but only to fix the flanges.



Recommended installation of exhaust system.

1. Turbocharger.
2. Exhaust pipe bend.
3. Exhaust bellows.
4. Exhaust pipe.
5. Bracket.





Exhaust pipe bends

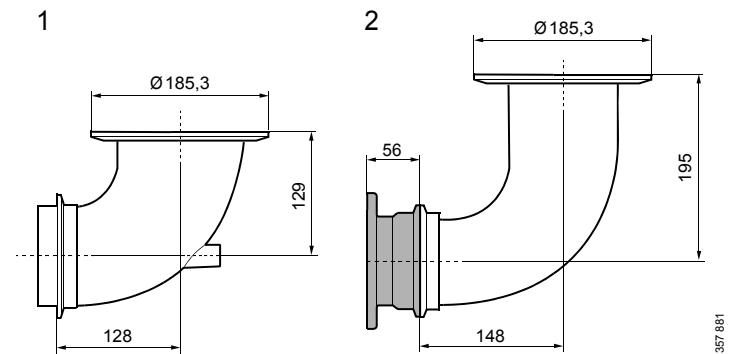
Dry exhaust pipe bends

The engines can be equipped with a 90° exhaust pipe bend on the turbocharger exhaust outlet. The exhaust pipe bend can be fitted at different angles and rotated 360° around the connection with the turbocharger.

The exhaust pipe bend is connected to the turbocharger with a V-clamp.

The exhaust pipe bend outlet has a flange that is connected with a V-clamp. It is usually connected directly to the Scania exhaust bellows.

On DI16 XPI a flange is connected between the turbocharger and exhaust pipe bend. The flange, which is marked in grey in the illustration, is connected with 4 Ø 11 mm screws.



1. Exhaust pipe bend for the DI13 072/077.

2. Exhaust pipe bend for the DI09, DI13 except for 072/077 and the DI16. The flange marked in grey is only used on DI16 XPI.



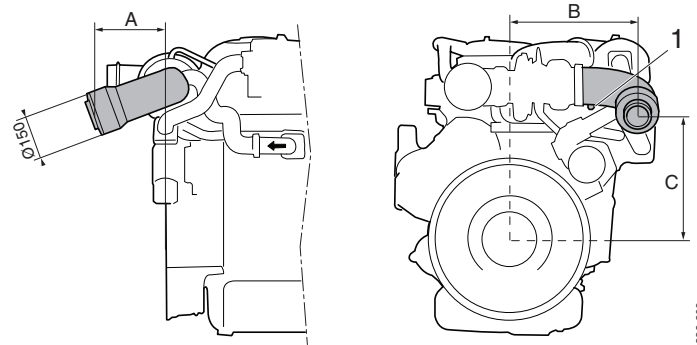
Water-cooled exhaust pipe bends

DI09, DI13

For engines with heat exchangers, there are also water-cooled exhaust pipe bends. They have outlets to fit an exhaust gas temperature sensor (1), thread 1/8-27 NPTF.

The upper illustration shows an example of a water-cooled exhaust pipe bend for DI09 and DI13. The table gives the measurements for all water-cooled exhaust pipe bends for DI09 and DI13.

Engine type	Dimensions (mm)		
	A	B	C
DI09	246	437	423
DI13 072	200	437	434
DI13 077	199	495	433
Other DI13	146	454	400



Example of a water-cooled exhaust pipe bend for DI09 and DI13.

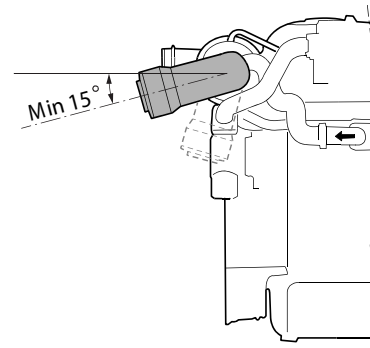
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IMPORTANT!

The exhaust pipe bend and hose or pipe downstream of it must not be angled higher than the bottom edge of the turbocharger, i.e. 15° (see illustration). Otherwise, water can penetrate into the back of the engine and cause liquid slugging. This may lead to bent connecting rods and the total destruction of the engine.

This applies to the entire exhaust installation downstream of the turbocharger.



Minimum installation angle for DI09 and DI13.

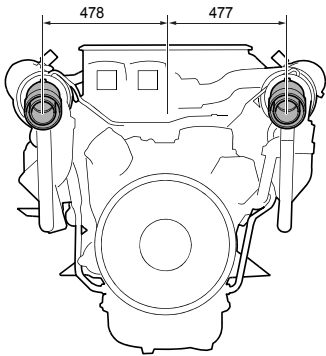
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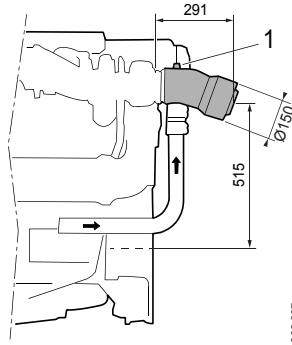
D116

The illustrations below show the dimensions of the water-cooled exhaust pipe bends for D116.

1 = Outlet to fit an exhaust gas temperature sensor, thread 1/8-27 NPTF.

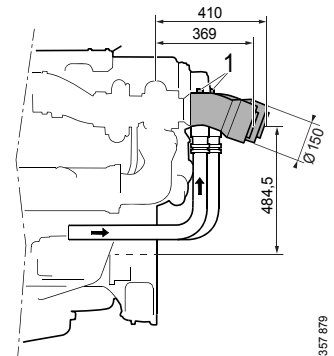
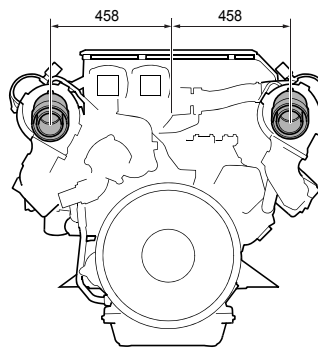


D116 PDE.



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D116 XPI.

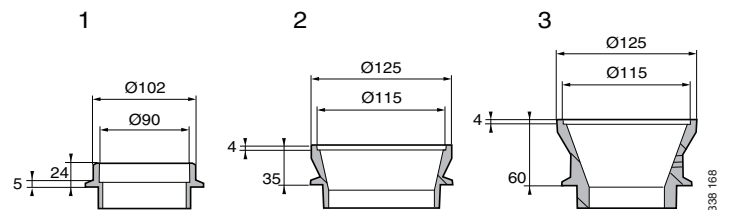


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Weld flanges for connection to turbocharger

The engines can be ordered with a weld flange for connection to the turbocharger.



1. DI09 and DI13 except 072/077.
2. DI13 072/077.
3. DI16. The illustration shows the weld flange for DI16 PDE, but the weld flange for DI16 XPI has the same dimensions downstream of the turbocharger. It is connected with 4 $\text{Ø} 11$ mm screws.



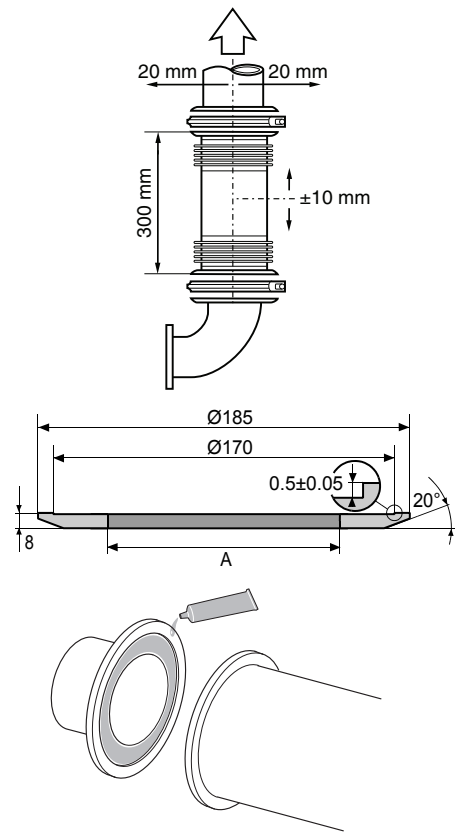
Exhaust bellows

The Scania exhaust bellows consists of 2 flexible sections with several layers of corrugated stainless steel plate that are connected to a short pipe. The exhaust bellows can absorb both longitudinal and lateral movements. It allows a maximum simultaneous lateral movement of ± 20 mm and a longitudinal movement of ± 10 mm.

The exhaust bellows has an inside diameter of 127 mm and flanges that are secured with a V-clamp. It is supplied with a loose flange that is welded to the pipe which is to be connected to the exhaust bellows.

The loose flange supplied with the exhaust bellows can be selected with different inner diameters for connection to different pipe diameters. Available inner diameters (A) are 130 or 155 mm for DI09 and DI13, and 114 and 130 mm for DI16.

Use the sealant with part number 1 373 091.





Exhaust back pressure

The back pressure in the exhaust system must not exceed the maximum recommended exhaust back pressure, including silencers. A higher exhaust back pressure leads to increased fuel consumption and a loss of power.

The maximum recommended exhaust back pressure is 100 mbar for all engines.

If the exhaust back pressure is above the maximum recommended value, this has a negative impact on engine performance.

Always check the exhaust back pressure when installation is complete.

Measuring exhaust back pressure

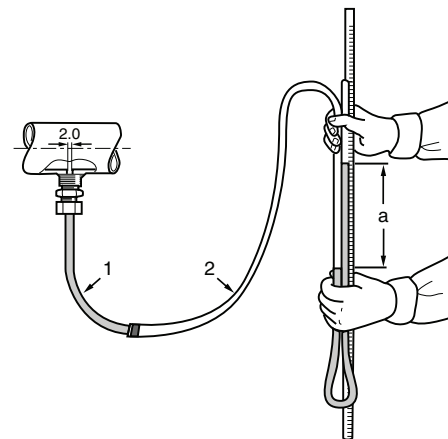
Perform the measurement on a straight section of the system approximately 1 metre downstream of the turbocharger.

A simple device for measuring exhaust back pressure is a transparent plastic hose. Connect the hose to a test connection on the exhaust pipe as illustrated. Bend the hose and fill it part-way with water.

Drill a hole with 2.0 mm diameter in the exhaust pipe. It is important that the hole on the inside of the pipe has a clean, sharp edge. Residual burrs and unevenness can result in significant measurement errors.

First warm up the engine and then run it at maximum load and full load speed. At the same time, measure the level difference (a) of the water in the hose.

This is a direct measurement of exhaust back pressure in mmH₂O. 1,000 mmH₂O is equal to 100 mbar.



Example of exhaust back pressure measurement.

1. Pipe.
2. Plastic hose.



Type of exhaust system

Both dry and wet exhaust systems are found in marine installations.

Dry exhaust systems are preferable in the case of vertical exhaust outlets. Dry exhaust pipes must be insulated to reduce the temperature and the risk of fire.

For installations with exhaust outlets in the stern or at the sides more or less level with the engine exhaust connection, wet exhaust systems are recommended.

In this case, sea water is brought in and mixed with the exhaust fumes, which results in dampening of the noise level and a lower exhaust temperature. After the connection point for the sea water, the exhaust system does not need to be insulated.

A very short exhaust system can be fully encased in water. If so, no silencer is needed.



Wet exhaust system

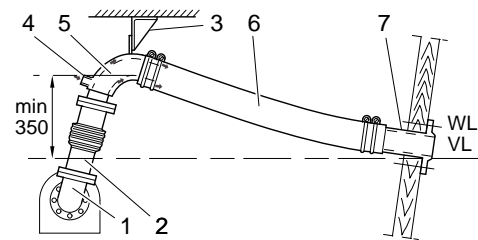
The exhaust system outlet should always be positioned above the water line, even when the vessel is heavily loaded. The system must slope downwards towards the outlet. The outlet must always be lower than the water inlet in the system to prevent water from entering the engine. If the exhaust system outlet is higher than the engine exhaust connection, the exhaust system must be designed with a water lock that prevents water from entering the engine when stationary.

If a mixing vessel is used in the wet exhaust system as a water lock and to suppress noise, the lifting height for the gas and water mixture must not be so great that the total exhaust back pressure is above 100 mbar. The mixing vessel must hold at least the amount of water that is drained from the system when the engine is stopped.

The most common type of water lock (when the exhaust connection on the engine is lower than the water line) is an upward-facing, jacketed exhaust bend at a height of at least 350 mm above the exhaust system outlet. See illustration.

If the engine is installed in such a way that the exhaust connection is located at least 350 mm above the water line, it is possible to connect a jacketed exhaust pipe with water inlet after the flexible pipe on the exhaust outlet from the engine. See illustration on next page.

The jacketed exhaust pipe is then connected to the board lead through with a rubber exhaust hose. Only corrosion-resistant hose clamps may be used for the rubber hoses.



Wet exhaust system with engine exhaust connection below the water line.

1. Exhaust connection to turbocharger.
2. Flexible pipe.
3. Mounting bracket.
4. Sea water inlet to jacketed exhaust pipe bend, diameter 50 mm.
5. Jacketed exhaust pipe bend.
6. Rubber exhaust hose.
7. Board lead through.

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The jacketed exhaust system can be connected directly to the sea water line outlet. The connection diameter must be at least 50 mm.

The material in the jacketed exhaust pipe must be corrosion resistant. It must not be copper or copper alloy.

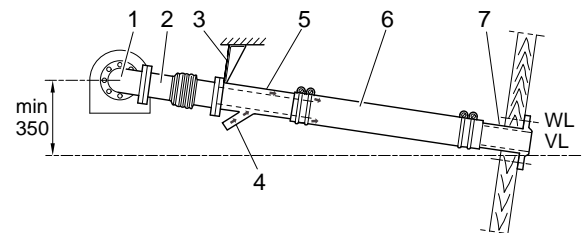
! IMPORTANT!

The weight of the exhaust system must not load the exhaust bellows or turbocharger. Therefore, equip the exhaust system with suspension or supports.

! IMPORTANT!

Equip engines that have a sea water-cooled exhaust system comprising rubber hoses with a warning system that triggers an alarm in the event of high temperature. Otherwise, there is a risk of the hoses overheating if the sea water pump malfunctions or the sea water intake becomes blocked.

Design the water intake to the rubber hose so that the spread of water over the surface of the hose is assured even at low engine speeds when the sea water flow is also low.



Wet exhaust system with engine exhaust connection above the water line.

1. Exhaust connection to turbocharger.
2. Flexible pipe.
3. Mounting bracket.
4. Sea water inlet to jacketed exhaust pipe bend, diameter 50 mm.
5. Jacketed exhaust pipe.
6. Rubber exhaust hose.
7. Board lead through.



Insulating the exhaust system

Assess on a case-by-case basis whether the exhaust system requires thermal insulation.

If the engine intake air is taken from the engine compartment, exhaust pipes should be insulated especially well to keep down the temperature in the engine compartment.

Other reasons for insulating the exhaust system are to prevent burn injuries to personnel, reduce ventilation costs or reduce the risk of fire from the discharge of fluids, such as hydraulic oil. The exhaust system may also require insulation if there are lead throughs made of or near flammable material.

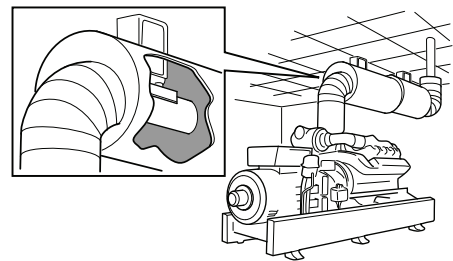
Insulation must withstand a temperature of at least 700°C and must always be protected from splashes closest to the engine.

Note:

The part of the exhaust system that connects to the outlet flange from the turbocharger must always be insulated.

The outer shell of the insulation must be so well sealed that fibres from the insulation cannot come loose during vibration and block the air filter. The insulation of long pipes affects the exhaust back pressure. The diameter of the exhaust system should therefore be increased if it is insulated. An insulated system can increase the noise level at the outlet. This should also be considered when determining the measurements.

Values for insulated exhaust systems can be found in 02:06 Technical data.



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IMPORTANT!

Design the insulation so that the flexible part of the exhaust system is not restricted in its movement. It must also be possible to inspect the exhaust system without damaging the insulation during dismantling.

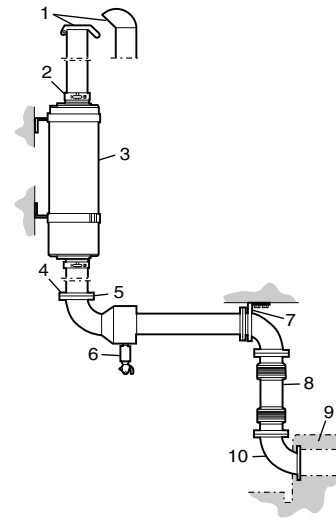


Protection against water ingress

If rain or condensation enters the engine, it will cause corrosion damage and, in the worst cases, liquid slugging. This could result in bent connecting rods and the total destruction of the engine. Therefore, design the exhaust system so that water ingress is prevented. Equip long exhaust systems with a condensation separator. Position this as close to the engine as possible, but after the flexible connection.

The occurrence of condensation is greater with a vertical exhaust system since the exhaust gases in a horizontal system carry away much of the condensation. Even with short exhaust pipes, it may be a good idea to fit a condensation separator if there is any risk of rain water entering.

Equip vertical exhaust outlets with a device that prevents water ingress. The illustration shows the design of a short vertical exhaust system with a condensation separator. Also connect a drainable water trap to the condensation separator.



1. Device for protecting against water ingress.
2. V-clamp.
3. Silencer.
4. Connecting flange.
5. Gasket.
6. Condensation separator.
7. Bracket.
8. Flexible connection (exhaust bellows).
9. Engine.
10. Exhaust pipe bend.



Multi-engine installation

Multi-engine installations should have separate exhaust systems for each engine, if possible.

If the exhaust pipes for several engines are linked to a common exhaust system, the exhaust systems for each engine should first be calculated individually using the description below.

Then calculate the necessary area (A_{tot}) for the common exhaust system by adding together the areas of the exhaust systems for the individual engines.

If the engines are of the same type, read off the diameter for the common system in the table.

Number of engines	Diameter
1	d
2	1.41 x d
3	1.73 x d
4	2.00 x d
5	2.22 x d
6	2.45 x d

If the engines are of different types, calculate the diameter of the common pipe (d_{gem}) using the formula on the right.

$$d_{gem} = \sqrt{\frac{4 \times A_{tot}}{3,14}}$$

Formula for calculating the diameter with different engine types.



When several engines are connected to a common exhaust system, there must be an easily operated and effective shut-off device in each branch system.



IMPORTANT!

The shut-off device must also be closed for a stationary engine! Exhaust gases from an engine in operation could otherwise penetrate into the engine which is not in operation and cause corrosion damage. There is also a risk that the exhaust gases could enter the engine compartment.



Dimensioning the exhaust system

Dimensioning is based on the back pressure in the exhaust system.

The diameter of the exhaust pipes is calculated as follows:

- Calculate the length of the planned exhaust system (L_u).
- Read off the preliminary inside diameter of the exhaust pipes (D_p) in the relevant table in 02:06 Technical data.
- Decide on the total number of 90° pipe bends which will be included in the exhaust system. Two 45° pipe bends equal one 90° pipe bend.
- Read the additional length (L_t) in the graph for calculating the additional length. In this graph, the back pressure is converted from the number of pipe bends used and the discharge resistance to a straight pipe with the length (L_t).
- The additional length (L_t) is only used to calculate the new diameter required. Note that the additional length must also be read for a system without pipe bends because of the discharge resistance. Refer to line 0 in [Graph for calculating additional length in exhaust system](#).
- Add the additional length obtained (L_t) to the planned length (L_u). Then use the calculated total length (L_{tot}) to read the final diameter in the tables in 02:06 Technical data. Select the next higher standard diameter.
- If corrugated hose is used for a large part of the system, the dimension must be increased by at least 10 %.



Calculation example

Engine type	Operating speed	Power
DI13 70M	1,800 rpm	331 kW

1. Planned length (Lu): 13 m.
2. Preliminary inside diameter (Dp): 125 mm.
3. Calculated number of 90° pipe bends for the entire system:

90° pipe bends	4
Four 45° pipe bends	2
Total number of 90 ° pipe bends	6

4. Additional length (Lt): 12 m, see [Graph for calculating additional length in exhaust system](#).
5. Ltot (for calculating final diameter): Lu + Lt = 25 m, rounded to 30 m.
6. Read the final inside diameter for DI13 70M = 150 mm. Refer to the table example from 02:06 Technical data below.

Engine type	Engine power	Engine speed (rpm)	Exhaust flow (kg/min**)	Exhaust gas temp. (°C*)	Length of the exhaust pipe (metres), inside diameter of the exhaust pipe (mm)					
					5	10	20	30	40	50
DI13 070M	331 kW/450 hp	1,200	19	482	95	105	115	125	130	135
		1,500	26	430	105	115	130	140	145	150
		1,800	32	400	115	125	140	150	155	160



In the case of short exhaust systems for certain engine types, the calculation may suggest a relatively small pipe diameter of 90-100 mm.

It would then be a good idea to choose the smallest diameter which can be connected directly to standard components, i.e. 115 mm.

Pipe bends in the exhaust system must have a large bending radius (1.5-2.0 x the diameter).

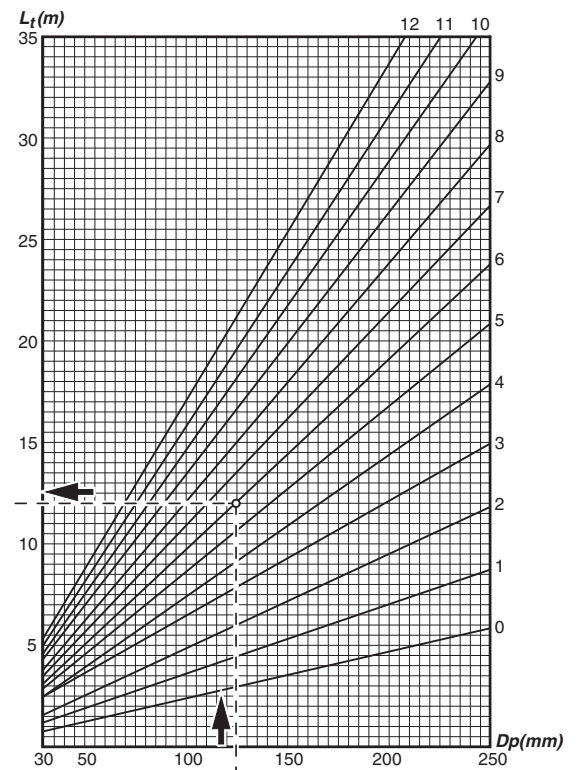
The calculated inside diameter applies to an insulated system, which means that it is not necessary to increase the diameter for insulating.

A wet exhaust system must have a larger inside diameter (approximately 10%) than a dry system due to the increased gas flow generated by the evaporated cooling water. A water-jacketed exhaust system can normally be set up with a slightly smaller inside diameter.

Graph for calculating additional length in exhaust system

From the calculation example:

- Preliminary inside diameter (D_p) = 125 mm
- Number of pipe bends = 6
- Additional length (L_t) = 12 m





Important data

Maximum recommended exhaust back pressure with high power silencer	100 mbar
Minimum temperature resistance for insulation	700°C
Inside diameter for exhaust system at different lengths	Refer to 02:06 Technical data