ENDCAPE GENERATORS

MADE IN BRITAIN

EXHAUST SYSTEMS

Factors that govern selection of an exhaust silencer are:-

1. Available space.
2. Cost.
3. Noise reduction required.
4. Allowable back pressure.
5. Availability
6. Appearance.
7. Proximity to other components or personnel.

As a general rule, an increase in silencer size will improve the silencing level. An increase in noise suppression for a given silencer volume will normally increase exhaust restriction and thus increase back pressure.

A round silencer is usually preferable, as it has a greater tendency to contain the sound, rather than allowing it to escape through the flat surface. A double wrap tubing and double wall surface aids in containing the sound as well.

Generally speaking, silencers are available which provide two levels of silencing ie; industrial silencers which provide approximately 15 to 20 decibels of suppression, and residential/critical silencers which provide approximately 20 to 30 decibels of suppression.

The exhaust inlet and outlet are commonly on the ends of the silencer, however the inlet and outlet can be on the sides, which often simplifies the exhaust piping installation. Figure 1 illustrates a dual side inlet silencer with a 12 cylinder diesel generator set.

Provision should be made to prevent rainwater from entering the exhaust outlet opening. Counterbalanced flapper type rain caps have proved successful in many varied applications.

Because of the high pressure drop caused by conical shaped covers and other common ventilating covers, they are seldom practical.

From an aesthetic point of view, care should be given to the location of the exhaust outlet point, considering the tendency over a period of time for exhaust gas carbon deposits to accumulate on any nearby structures.

Because water vapour is formed in the combustion process of diesel fuel, it is necessary to incorporate into the exhaust piping design a condensate trap and drain valve. The condensate trap should be located as close as is practical to the engine.

In multi-engine installations, special consideration must be given when manifolding or joining the exhaust runs from the engines into one common exhaust run. A problem may arise if one or more engines are operating and the exhaust gas finds its way back into a non-operating engine. The use of check valve devices within the exhaust pipe runs should be avoided owing to their strong tendency to freeze and become inoperative.

Provision should be made for relative movement between the exhaust piping and the engine so that no damaging stresses will be imposed on the exhaust system components, because of engine mount flexibility or thermal growth.

Because the exhaust gas temperature leaving the engine is generally in the 500^{o} C range, the piping may be insulated, as steam pipes are, to minimise the heat radiated to the room.

Flexibility

The most common method of obtaining flexibility is through the use of flexible piping (spiral or bellows type). The use of these components is recommended where either relative motion or thermal growth will subject the components to excessive stresses.

A minimum of 200 mm of flexible stainless steel bellows connection must be provided within the first 1 metre of exhaust piping to allow for thermal growth without over stressing engine components.

When the engine package is mounted on spring type vibration isolators, the flexible pipe section may be increased in length.

For proper installation, the flexible pipe should not be used to form pipe bends, or compensate for misalignment.

Material

Black iron Schedule 40 pipe is most commonly used for permanent installation where weight is not a factor.

Support

There are many ways to obtain the desired flexibility while still adequately supporting the piping and other components in the system. To reduce the loading imposed on the exhaust manifold or turbocharger, it is necessary to support long lengths of piping from the surrounding structure. However, flexibility must still be maintained through the design of the support and the use of flexible connections.

The weight of all external engine exhaust piping must be supported in order not to impose any dead weight loads on the engine manifold or turbocharger outlet.

Exhaust System Bending Moment

The exhaust components attached to the engine are designed to support reasonable piping loads, but not to support major systems. The turbocharger operates at relatively high speeds with closely fitted bearings and impeller. The turbo charger is designed and built to pump large quantities of air. It is not designed to support long runs of pipe or silencers. The turbocharger is capable of absorbing a maximum of 20 ft-lbs [27.12 Nm] of bending moment measured at the exhaust flange outlet without sustaining excessive deflection or stress. Good design practice will hold the bending moment value to a minimum (Figure 2).

In like manner, the exhaust outlet on a naturally aspirated engine will sustain up to 35 ft-lbs [47.46 Nm] at the exhaust flange, and the junction of the manifold to the head will sustain 65 ft-lbs [88.14 Nm] bending moment.

With typical pipe diameter and weight used in present engine installations, a support will probably be required within 4' [1.22 m] of the turbocharger and 6 to 7' [1.83 to 2.13 m] of the naturally aspirated engine manifold, unless the length must be shortened due to high shock loads being encountered. Neither the silencer nor exhaust pipe should be directly mounted on the exhaust manifold on any engine without supplementary support. A 200 mm length of flex tubing properly mounted will permit an exhaust system attachment to the engine without over stressing the engine components. A representative example of flex section application is illustrated in Figure 2 (page 8).

Exhaust Back Pressure

The exhaust back pressure on engines, when measured at full load and governed engine speed, should not exceed the values indicated on the engine datasheet.

When the engine must work against excessive back pressure in the exhaust system, the usable output of the engine is lowered. The air:fuel ratio is reduced because of incomplete scavenging of the cylinders, the fuel economy is reduced and the exhaust temperature increases. Although turbocharged engines are affected to a lesser degree than naturally aspirated ones, due to the positive pressure in the intake manifold, it is essential for the exhaust system of all engines to be designed offering the least possible restriction to the exhaust flow.

The exhaust back pressure imposed in a given engine installation will depend on the size of pipe, the number and type of bends and fittings, and the silencer selection and location. Tight bends are usually the highest contributor to back pressure. The pipe size given on the datasheet for an average installation assumes a minimum of short radius bends and reducers. As restriction is proportional to the fifth power of the pipe diameter, a small increase in diameter will dramatically reduce the pressure restriction.

An approximation of back pressure can be obtained as follows:-

1. The back pressure across the silencer can be obtained from the silencer manufacturer.

2. Use Figure 3 (Chart) for determining exhaust pipe and elbow contribution to back pressure levels.

Example:-

For an engine with exhaust gas flow of 2000 CFM, a typical system might calculate as follows:-

Item	**Back Pressure**
Silencer	. 750” Hg
12’ of 6” tubing = 12 x .0067 =	.0804” Hg
1.5’ of 6” flex tubing = 1.5 x .0067 x 2 =	.0201” Hg
(4)-6” 90^{o} elbows = $\frac{(16x6x4)}{(12)}$ x .0067 =	.2144” Hg
9’ of 6” tubing = 9 x .0067 =	.0603” Hg
	1.125” Hg

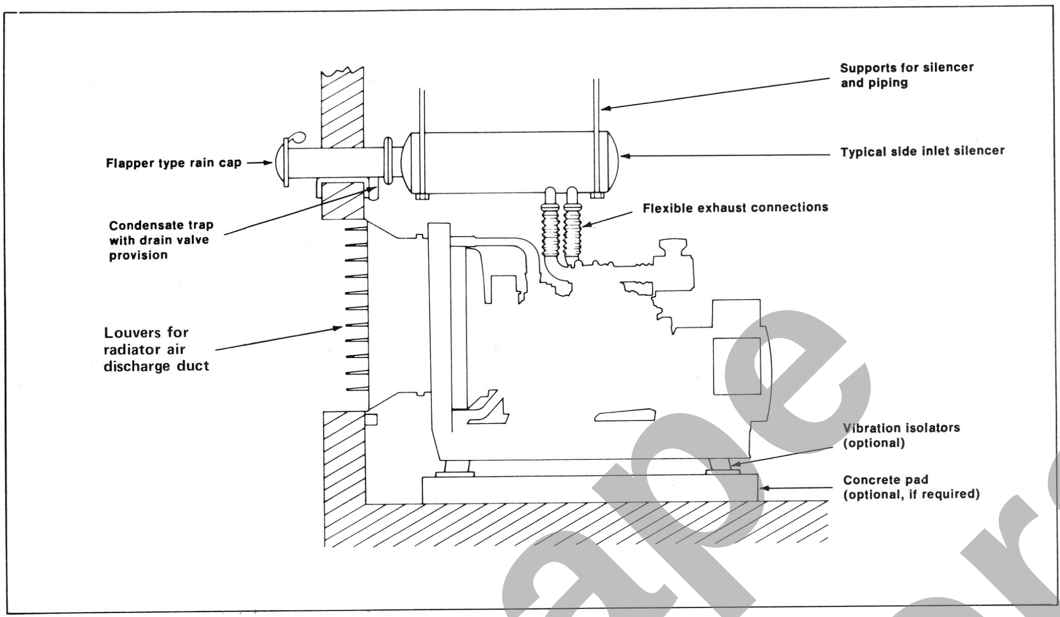
Calculated pressure is an approximation of average pipe friction and must be verified by actual test measurement.

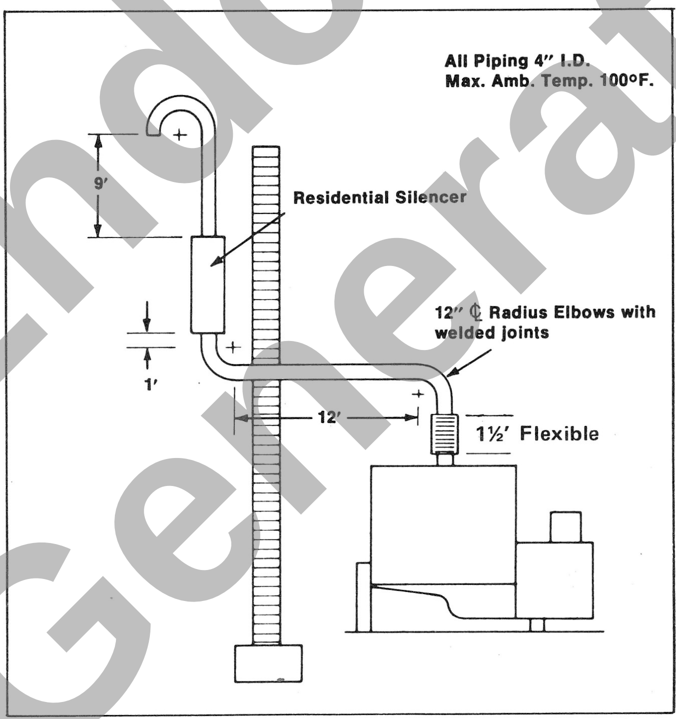
Checking Exhaust System Restriction

A. Connect a manometer scaled to read in excess of 40” [1016 mm] of water (NB: 41” [1041 mm] of water equals 3” [76.2 mm] of mercury) to the exhaust system near the exhaust manifold outlet in a straight section of pipe. Direction of area change near the manometer connection can cause erroneous readings. Weld a pipe-coupling-half to the straight section of pipe and drill a 1/8” [3.175 mm] hole through the centre of the coupling and into the pipe in order to obtain a manometer connection point.

B. Operate the engine at full speed and full load, and record the manometer reading. Check the reading against the allowable exhaust back pressure on the datasheet.

Operating at no load will not be equivalent due to the greater volume at normal exhaust temperature underload.





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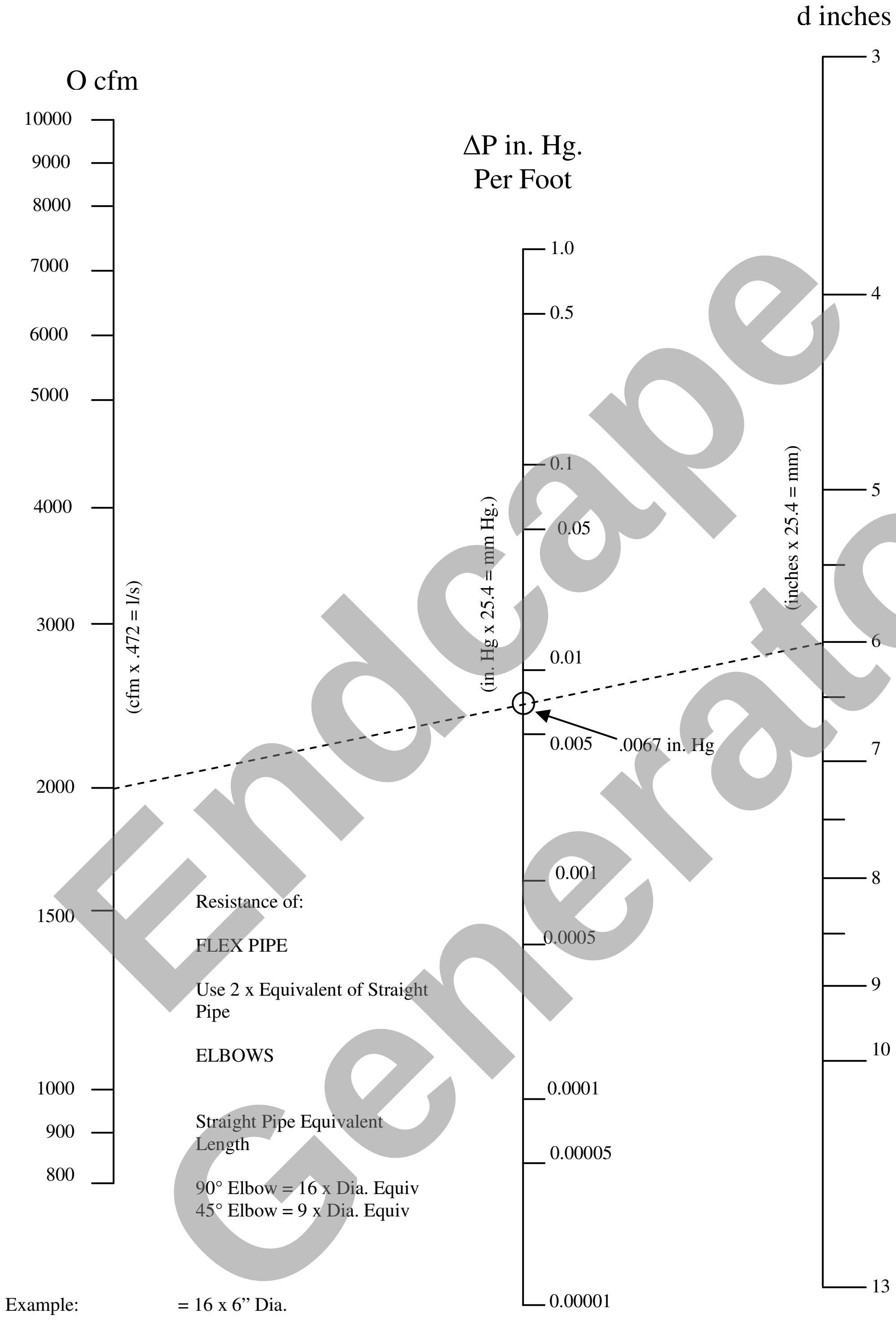

Resistance of:

FLEX PIPE

Use 2 x Equivalent of Straight Pipe

ELBOWS

Straight Pipe Equivalent Length

90° Elbow = 16 x Dia. Equiv
45° Elbow = 9 x Dia. Equiv

Example: = 16 x 6” Dia.

= 96 in. Length Equivalent

2000 cfm thru 6 in. Dia. Elbow = 8ft of 6” Pipe

= .0067 x 8 = .0536 in. Hg

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