Basic Design Calculations for Flue Gas Stack Design for a Diesel Genset in India

This article will talk about the basic design calculation of flue gas steel stack or chimney design of a diesel genset.

A flue gas stack or chimney is typically a vertical tubular structure used for ejecting exhaust flue gas to the atmosphere. You can see the chimney or flue gas stack in thermal power plants, diesel gensets, kilns, and many other plants, where gases evolving from the combustion process need to be exhausted. The design calculation for flue gas stack varies from application to application. Here in this article we will discuss the basic design criterion of diesel engine-driven genset flue gas stacks. See below how to calculate the diameter and height of the flue gas stack of a diesel genset:

### Calculate Flue Gas Stack Height

- Calculate the specific fuel consumption of your diesel genset. Say it is $X$ kg. Per hour.

- Find out the percentage of sulphur content in the diesel you are using. Say it is $P\%$.

- Now, you have to calculate the sulphur dioxide (SO2) percentage in flue gas. Since the atomic weight of SO2 is double the atomic weight of sulphur, the percentage of the SO2 in flue gas is $2P\%$.

- The height of the flue gas stack (in meters) according to SO2 emission can be calculated as:

  \[
  \text{Height (H)} = \frac{X \times 2P}{100} \quad \text{Eqn. 1.1}
  \]

- Now, you have to check out the recommended minimum chimney height by the Central Pollution Control Board (CPCB). In case the height calculated from the Eqn. 1.1 is higher than the recommended height by CPCB then you go ahead with the calculated height or else you have to stick to the CPCB recommended height.

### Calculate Flue Gas Stack Diameter

- Calculate the exhaust gas quantity. Say it is $Y$ kg per hour.

- Select the flue gas velocity you want to keep inside the stack. Say $Z$ meters per second (Recommended flue gas velocity inside the stack is 16 to 20 m/sec as per IS: 6533).
Diameter (in mm) of the flue gas stack can be calculated as:

\[
Diameter (D) = \sqrt{\frac{4Y}{3.142Z}} \quad Eqn.1.2
\]

**Conclusion**

The design of the steel stack or chimney is important from the diesel genset performance as well as air pollution point of view. While doing the flue gas steel stack design calculations you should consider the design formulas and local pollution control norms.

Read more:
http://www.brighthub.com/engineering/mechanical/articles/53359.aspx#ixzz13WHimDex
LINING OLD CHIMNEYS

*Please note: This section is due for revision and some references (British Standards, etc.) may be out of date*

**A. INTRODUCTION**

The most appealing focal point in any room must be the fireplace. Be it an open fire, closed stove or solid fuel effect gas fire, the leaping flames and glowing coals are the real heart of the home. However, for any fire to work successfully, it must be connected to a sound chimney and correctly sized flue. The functions of a chimney are to safely remove the products of combustion from the fireplace or appliance to outside without causing danger to the occupants of the house or risk setting the house itself on fire.

A chimney works because hot air rises. Factors such as running the appliance at a very slow rate or cold air leaking into the flue will cool the gases down and affect the performance of the chimney. To keep the flue gases warm, consideration must be given to the insulation value of the lining system chosen. In houses built since the introduction of the 1965 Building Regulations, all flues have to be built with liners during their construction. This is usually done with clay liners, which should last the life of the building. However, in houses built prior to 1965 lining was less common.

Flues were usually "parged" (rendered) on the inside with lime mortar. This parging suffers attack from acids and tars produced during combustion and gradually deteriorates. The flue is then in poor condition, often leaking fumes or tars into the walls or other parts of the building. Sadly, many houses built since 1965 also suffer similar problems due to badly installed flue liners and need further attention.

**B. DEFINITIONS**

Before proceeding further, it is important to understand the terms used when talking about chimneys. These are briefly as follows:

1) **FLUE** - The flue is the void or passageway through which the products of combustion are removed from the fire to the outside.
2) CHIMNEY - A chimney is the structure surrounding one or more flues.

3) FLUE LINER - The flue liner is the material used to form the flue or flues within a chimney.

C. REASONS FOR LINING

There are a number of reasons why an old chimney may need lining. These can be summarised as follows:

1) The flue is leaking smoke and fumes into other rooms or parts of the building.
2) Condensates or tar are seeping through the chimney walls causing staining either inside or outside the building (a common problem with wood burning stoves).
3) The flue is much too large for the type of fire or appliance being used.
4) The flue is too cold, particularly if on an outside wall, and is consequently not drawing properly.
5) If the chimney was built since 1965, but with the liners installed the wrong way up (regrettably this is quite a common occurrence!) tar and condensate leakage may occur.
6) The old flue surface is eroded and rough causing frictional resistance to the flow of the flue gases and resulting in poor updraft.
7) When a new gas fire is installed to an unlined chimney, lining should be considered if the old parging is crumbling with mortar debris continually falling onto the hearth, or if there is evidence of condensation. (see BS5440 pt. 1 -4. 1.9.).

D. METHODS OF LINING

Several methods are available for inserting a lining into an existing flue. A brief list of these is as follows:

1) Rigid sections of clay or refractory liner installed by cutting into the flue wall or by lowering down from the top of the chimney.
2) Insulating concrete pumped in around an inflatable former by a specialist contractor.
3) Rigid metal (usually high grade stainless steel) pipes lowered down from the top.
4) Flexible metal liner in a continuous length, either lowered down or pulled up the flue (refer to the relevant manufacturers instructions).

Any of the above methods which has approval for solid fuel, should also be suitable for gas or oil. However the light weight flexible metal liners designed for gas must not be used for solid fuel, wood, or open decorative fuel effect gas fires. All of these methods have some advantages and some drawbacks. Their suitability will depend on the individual circumstances. Good professional advice on the most appropriate system is essential. Ask at your local N.F.A. member showroom. For solid fuel, British Coal area offices can also help.

Before any new lining is installed, it is essential to have the chimney thoroughly swept to remove all soot and tar deposits. This means with stiff polypropylene or steel scraper
brushes. Preferably use a member of the National Association of Chimney Sweeps, who will work to a code of practice and give a certificate on completion. It is possible in some situations to ream out the old flue to take a larger liner than would otherwise fit. This work is done by a specialist contractor who may also offer a video camera inspection of the flue (see also section 1). In all cases it is advisable to use a system that has a recognised test approval, and if a guarantee is offered or important, it should be underwritten by insurance. The following sections will look at each of the above methods in more detail:

**E. RIGID REFRACTORY LINERS**

This is the most traditional method of lining, using refractory concrete, clay or ceramic liners of the same type now used to build a new chimney. There are also some pumice liners designed specifically for relining. The chimney often has to be opened at frequent intervals to insert the liners, essential if there are bends in the flue. The resulting dust, mess and subsequent re-plastering and redecorating are not popular with the housewife! If the old flue is large enough and straight, it is often possible to lower liners down from the top without opening the flue inside the house. Several specialist companies offer this system.

The liners used must either have rebated and socketed joints or steel jointing bands. (NOTE - rebated and socketed joints must be installed the correct way up. The rebates are there to prevent condensates running down the flue from leaking out, therefore the socket end must be uppermost with the spigot end fitting down inside the lower pipe). A possible drawback with this method is the wall thickness of the liner, usually 20 - 25 mm. Twice this dimension plus a clearance needs to be deducted from the size of the original flue, resulting in a much reduced flue cross section. For a nominal 225 x 225 mm (9" x 9") flue, this probably means only a 150mm (6") or at best 175mm (7") flue can be achieved.

This reduced size will be too small for an open fire, so a closed appliance may have to be fitted. (See section K re correct flue sizing). (Some liners are available with a wall thickness of about 10mm). Clay liners used in this method must comply with BS 1181 (1989). Refractory concrete liners, with a much higher insulation value, and ability to withstand thermal shocks, such as in a chimney fire, are to be recommended, particularly for wood burning stoves. Liners made with pumice and high alumina cement are best and comply with building regulations. Alternatively the product should have a British Board of Agrement certificate. (See also Building Regulations J.2. 12.). Provided the correct flue size can be achieved, this is an excellent method of lining and should last the life of the building.

**F. PUMPED REFRACTORY CONCRETE**

This system consists of lowering a rubber former or 'sausage' down the chimney, inflating it slightly, and then pumping in a lightweight refractory concrete mix. When the concrete has set, the former is deflated and withdrawn, leaving a smooth flue, filling all voids/cracks, and generally strengthening the chimney structure. As with the rigid method in E above, the minimum wall thickness of this system is about 20mm, reducing the flue size within the existing chimney, which may limit the type of fire or appliance that can be used. The critical
factor with this system is in the skill of the installer, who must ensure that the mix is correct
and the former is centralised within the old flue. There are various patent techniques used to
achieve this. It is also a requirement of the code of practice for this system that the flue is
opened up every two metres and at any bend. This may mean mess and disruption within the
building, and subsequent re-plastering and redecorating.

The installation is permanent and, if properly installed and regularly swept, should last the
life of the building. The system is not so suitable for the very large voids found in the lower
sections of Inglenook chimneys.

G. RIGID METAL LINERS

Rigid metal flue pipes can be used to line flues in some circumstances. For Gas burning
complying with this standard is suitable. There is no British Standard for metal flue linings
for Solid Fuel. However, stainless steel flue pipes are allowed in Building Regulations J.2.7.
if they comply to BS 1449 pt. 2 1983, i.e. are made of 316 grade stainless steel of minimum
1 mm thickness. This material has been used for some years to reline old flues for wood
burning stoves. Care should be taken on the following points:

1) 316 Stainless steel is a very tough material, but it is still prone to corrosion from the
fumes given off by certain types of processed solid fuel. Its anticorrosion properties are also
reduced if it is heated above 900°C for more than about 15 minutes. This could happen in a
chimney fire.
2) An average 8m of rigid liner can expand and contract by around 30mm between hot and
cold. Incorrectly fixed liners have been known to 'climb out of the chimney'. Rigid liners of
this type should be firmly anchored and supported at the base of the chimney, the top end
passing through a closing plate and into the base of the pot, but not fixed, to allow for
movement.
3) The space around the liners should be back filled with insulating material such as Perlite,
Vermiculite or Leca to keep the flue warm and reduce the risk of tar build up.
4) The pipe sections must be joined with proprietary clips or stainless steel screws.

With this method, the wall thickness being only 1mm, a larger size of flue can often be
achieved than using one of the methods described in E and F above. For Inglenooks, the
lower section can be insulated by wrapping it in rockwool and wire netting, back filling the
upper part as in 3). With correct use, for wood burning stoves and avoiding the more
corrosive types of solid fuel, this material should have a normal life of say 10 to 15 years. It
is possible to remove this type of liner if future requirements change.

NOTE: Mild steel, vitreous enamel or lower grades of stainless steel, which may be suitable
for gas appliances if they comply with BS 715, must never be used for solidfuel lining.

H. FLEXIBLE METAL LINERS
There are two distinct types of flexible metal flue liners available and it is very important to distinguish between them.

1) Gas flue liner, sometimes known as "Gas flex." A light gauge single skin liner only suitable for closed gas fires and boilers, and for some inset live fuel effect gas fires (consult manufacturers instructions). This type of liner is commonly available in coils at Builders & Plumbers merchants. It must under no circumstances be used for solid fuel or wood burning appliances, or open solid fuel effect gas fires. Readily available sizes are 100mm (4"), 125mm (5"), and 150mm (6") diameters. The minimum size permitted for closed (glass fronted) gas fires and stoves is 125mm (5") (BS 5440 pt.1.1990 4.1.5).

2) Solid fuel liner. This is a double skinned liner made from an extremely high quality stainless steel, usually 31 6Ti (Titanium) austenitic grade. It is smooth on the inside, corrugated on the outside and must be installed the correct way up. It is specifically designed for relining flues for solid fuel, wood and open gas log/coal effect fires. The same points mentioned in section G 1) regarding corrosion resistance and life expectancy apply to this type of lining. There is at present no British Standard for solid fuel flexible liners. However, the Building Regulations can be satisfied by referring to an approval by the CSTB in Paris, members of the European Union of Agreement.

This type of lining is relatively easy and clean to install. It is usually drawn down the chimney by rope from the top and will pass round most bends without opening up the flue. Support is provided by 'hanging' the lining from a clamp or plate mounted at the top of the chimney. It should also be firmly clamped at the base before forming the connection to the appliance or flue pipe. Unlike rigid pipe, expansion and contraction will be taken up by the flexible construction of the pipe itself. For the gas type of lining, an air space is normally left between the liner and the old flue. However it is a requirement to seal this void at the top and bottom. This can be done with a 'plug' of rockwool or glass fibre insulation quilt, or a register plate of fireproof board or sheet metal can be used.

The solid fuel liner can also be left with an airspace as insulation. This may be satisfactory for open fires with relatively high flue gas speeds and temperatures, which will reduce the likelihood of condensation. A better solution is to back fill round the liner with a loose fireproof insulation material such as Perlite, Vermiculite or Leca granules. Some systems offer an insulation 'wrap', well suited to the large voids found in inglenook situations where back filling would be impractical. (Fibreglass insulation should not be used for solid fuels). Insulation is really essential with wood burning stoves. In all cases, a small ventilation hole, usually 1 5mm diameter should be provided at the top of the chimney stack to allow any moisture trapped in the old flue void to escape freely. Always follow the liner manufacturers instructions carefully.

Care should be taken when sweeping flexible metal liners, as the use of an incorrect brush can damage or tear the inner skin. Only polypropylene brushes of the correct diameter and with a plastic ball top should be used. It is a good idea to get one of these at the time the
liner is supplied.

**I. INSULATION**

As previously mentioned, for a flue to work successfully, it must be kept warm. The draw up a flue is directly related to the difference in temperature between the flue gases and the air outside. The more efficient the appliance, the more critical this becomes. An old chimney serving an open fire, where a high proportion of the heat went up the chimney, may have worked satisfactorily. Install a modern high efficiency wood stove, room heater or gas appliance and serious problems may result due to the reduced flue temperatures and resulting condensation. Due care must therefore be taken that the new chimney lining will give an improved insulation appropriate to the type of fire to be used. Generally, for solid fuel and wood burning the space around the new lining should be filled with an insulating material such as Perlite, Vermiculite or Leca. Better still, the lining material itself should have a high insulation value, i.e. liners made with pumice.

**J. FLUE SIZING**

To clear the smoke and fumes from a fireplace or appliance successfully, the flue must be correctly sized. If it is too small, an insufficient volume of air will pass through it—result, a smoky fire. Too large a flue will cause cooling of the flue gases, slowing down the flow with similar results.

*Table 1 - Minimum Flue Sizing Chart*

<table>
<thead>
<tr>
<th>Type of fire</th>
<th>Flue size (diam. or equivalent square)</th>
<th>Sizes are taken from:</th>
</tr>
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<tbody>
<tr>
<td><strong>SOLID FUEL FIRES</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16/18&quot; open fire</td>
<td>best: 225mm - minimum: 200mm</td>
<td>Building Regulations 1991 (1992 amendment) J.2.table 2</td>
</tr>
<tr>
<td>Larger open fire</td>
<td>15% of fire opening area (W. x H.)</td>
<td>BS6461 1984 pt. 1 para 4.2.3 pt. 2 para 4.3</td>
</tr>
<tr>
<td>Small closed stove or room heater</td>
<td>150mm (125 for smokeless fuel)</td>
<td></td>
</tr>
<tr>
<td>Large stove or wood burner</td>
<td>150mm min. or 175mm preferred</td>
<td></td>
</tr>
<tr>
<td></td>
<td>All the above should be increased by 25mm if there are bends in the flue</td>
<td></td>
</tr>
<tr>
<td><strong>GAS FIRES</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Closed gas fires and stoves</td>
<td>125mm dia. (12000 sq.mm area)</td>
<td>Building Regulations 1991</td>
</tr>
</tbody>
</table>
The above table gives the recommended flue sizes for most types of fireplace and appliance. Always refer to manufacturers installation instructions for their recommendations, and seek advice from your local NACE member. Building Control approval may be needed and you should check with the local Building Control office before any work begins.

**K. CHIMNEY TERMINATION**

An open topped chimney pot or open stack with no pot fitted will allow some rain into the flue. With old unlined flues, this moisture was readily absorbed by the porous mortar parging in the upper part of the chimney and then evaporated away by the warmth from the flue gases. This usually caused no problem. However, once the flue is lined with a new smooth impervious liner, this can act as a drain pipe, resulting in water reaching the hearth or appliance. This can prove very messy and unpopular! Some form of chimney termination that will keep most of the rain out without impairing the performance of the flue is therefore often desirable. For small solid fuel open fires and closed stoves, the MARCONE, LOUVRE or D.F.E. type of chimney pot will prove most effective. For larger open fires, the Slab Top is generally most suitable.

There are specific rules about terminals for gas fires. Closed (glass fronted) gas fires and stoves (previously known as class II) where a 125mm flexible liner has been fitted should be terminated with a GC2 terminal (often supplied with the liner).

Open fuel effect gas fires must have a terminal with openings totalling twice the area of the flue. There is a suitable hooded chimney pot for this type of fire called the D.F.E. pot. Models are manufactured by Redbank and Hepworth. Hooded and other styles of inserts, commonly available as an 'add on' to a plain chimney pot, are not allowed for fuel effect gas fires.

NOTE: Any person carrying out work to a gas appliance installation, which includes work to flues and chimney terminations, must be registered with CORGI. This is a legal requirement of the Gas Safety (Installation & Use) regulations 1984 (1990 amendment).

**L. FURTHER SOURCES OF INFORMATION**


British Flue and Chimney Manufacturers Association. (BFCMA), 2 Waltham Court, Milley Lane, Hare Hatch, Reading, Berkshire, RG10 9TH. Tel. 0118 940 3416
Email: bfcma@feta.co.uk. Website: www.feta.co.uk

National Fireplace Association, Technical information leaflets;

1) Making the most of OPEN FIRES for coal and wood.

2) CHIMNEY PROBLEMS and how to cure them - This leaflet has been produced to give general guidance on the various methods currently available for the relining of old and defective domestic flues. Whilst brief descriptions of the systems has been given, it is strongly recommended that experienced professional advice is sought as to their suitability for any individual case.

For further help contact your nearest National Fireplace Association member showroom, as listed in the N.F.A. directory, or telephone 0121 288 0050 for a list of members. For solid fuel, help can also be obtained from British Coal area offices.

part of the NACE website

http://www.nace.org.uk/