FACTORS INVOLVED IN THE DESIGN OF HIGH RISE CHIMNEY AND CHUTE SYSTEMS

J. F. SCHULZ
The Flintkote Company
East Rutherford, New Jersey

ABSTRACT

This paper presents the natural building pressures created by the temperature difference between the chimney and the outside atmospheres. It also reviews the effect of wind upon building pressures and chimney terminations. These factors are considered for effective chimney design. Pointers on chimney construction to solve wet and leaky chimneys are presented together with simple formulas for the calculation of the various data for chimney design purposes.

INTRODUCTION

The design of chimneys and chutes for high rise construction has become more complex as building heights increase. The expansion and contraction of the building, of the chimney, the difference in expansion between outside walls and inside walls, the sag of reinforced concrete, building sway and other forces create situations which were once foreign to the usual chimney construction. It has intensified the problems of poor workmanship and masonry construction, so that openings into vertical shafts and chimneys due to these dynamic forces [1], settling cracks, etc. can create serious problems not only to the heating and air conditioning systems, but also to the operation of the chimney and/or chute system. The natural building negative pressures may exhaust air from refuse chutes to carry odor, bacteria or products of combustion into the living area. Chute fires are frequent particularly if the chute is undersized. Smoke entry into living areas under these conditions is very common.

Leaks in boiler or incinerator chimneys allow products of combustion to enter the living area or air to enter the chimney depending upon the location in the building. When the latter occurs, a cold chimney results. This in turn creates a wet chimney that will lead not only to rapid deterioration, but also to a discharge of dense pollutants at low velocities allowing them to reenter the building. Wet walls, peeling paint, buckling floors and other problems can also be symptomatic of a wet chimney.

Wind pressure on high rise buildings affect the internal pressure [2] and when added to the natural building pressure and the ventilating pressures, can be of a substantial nature and must be considered in chimney and chute design.

A chimney that is too low will allow products of combustion to enter the building. A tall chimney will avoid this, but can create conditions for a wet chimney.

It is the purpose of this paper to present some of the building conditions of high rise construction so they may be recognized and incorporated into the design of chimney systems.

The use of prefabricated chimney [3] components and the enclosure of an incinerator chimney, a boiler chimney and a refuse chute within a firerated enclosure assists in overcoming wet chimneys. The prefabricated chimney also provides expansion joints and fittings that not only accommodate the dynamic building forces to maintain a tight chimney, but also provides design flexibility to the architect and engineer.
NATURAL BUILDING PRESSURES

The natural pressure of a building is the pressure which is produced by the difference in weight between the inside building air and the outside air. If we assume a building with no floors, we would in effect have a chimney for which we could calculate the draft [4].

If we open the tops of each cylinder of Fig. 1 and connect the bottoms, the cold, heavy outside air will push up the warmer, lighter cylinder air and motion will occur. If a source of heat is supplied to heat up the cold air, Fig. 2 the action will be continuous. This is a simple chimney, wherein the amount of theoretical draft produced is that calculated by height $H_c$.

If we now connect the two cylinders at the bottom, close the top of cylinder $C$ of Fig. 3 and open the top of cylinder $O$ to represent a constant level in cylinder $O$, another phenomenon occurs.

The heavy outside air compresses the lighter air of cylinder $C$. We will assume for simplicity that the fluid in cylinder $O$ is such that it will not dissolve or mix.

The compressed air in cylinder $C$ exerts a pressure against the sides of the cylinder. If we were to measure this pressure, we would find that it does not equal the theoretical draft at height $H$, but some lower value. When we look again at the diagram, the reason becomes obvious. The material in cylinder $O$ has compressed $C$, but has also flowed into cylinder $C$, thus the actual weight on the air in cylinder $C$ is written: total force on $C$ = $(H - h) \times$ (density of air) assuming a one sq ft chimney. The pressure in cylinder $C$ may now be determined by calculating the theoretical draft for the distance $H-h$.

![Diagram](image1)

**FIG. 1 THEORETICAL DRAFT = WEIGHT OF OUTSIDE AIR – WEIGHT OF CHIMNEY GASES**

![Diagram](image2)

**FIG. 2 OUTSIDE AIR PUSHES UP INSIDE WARM AIR**

![Diagram](image3)

**FIG. 3 OUTSIDE AIR CREATES A PRESSURE IN A WARM BUILDING**
The interface between the air in C and the material in O is a point of "zero" pressure difference where the pressure of the outside atmosphere is equal to the pressure of the inside atmosphere.

If in Fig. 4 we apply an artificial source of pressure in cylinder C, the zero point is lowered as the pressure inside of cylinder C is increased.

If we drill very small holes in the cylinder C and place a heat supply in it, as we did with the chimney, we now have a way to provide the warmer and lighter air supply in cylinder C. The material in cylinder O will once again be considered as the heavier and cooler outside air. We will find that the larger these holes, the higher the zero level rises, as in Fig. 5.

We first used cylinder C to represent a cylinder containing warm, light air. It finally resolved into a cylinder closed at the top with small holes placed along its sides. Cylinder O represented the outside air and for calculation purposes, and we showed it to be connected at the bottom of cylinder C as it would be in the case of a chimney. It we now consider cylinder C as a building with small openings along its sides, such as cracks around windows, ventilation openings, wall porosity etc., we must immerse the entire building in outside air.

We will, therefore, consider cylinder C to be a heated building surrounded by cool outside air, as in Fig. 6.

The same forces act upon it as those we have just considered, but we now have small holes throughout the cylinder even below the zero point. This point has previously been identified as the point where the pressure of the warm air is equal to the pressure of the outside air, thus outside air will flow in below this point and out above this point. The greatest flow of cold air in will be at the bottom where the depth of the cold, heavy air is the greatest. Flow in becomes less until it reaches the zero point where there is no flow. Flow out just above the zero is impeded by the pressure of cold outside air upon it, but increases as the depth of cold air becomes less toward the top of the building.

In these discussions, the inside pressure has been assumed to be constant throughout the pressurized part of the building, but in actual practice, this is not the case. There are floors throughout the building. These are penetrated by stairwells, elevator shafts, conduit openings,
pipe openings, ventilator systems, etc.; thus some air can flow from floor to floor. This air flow meets with resistance because of doors and other construction. This resistance is in direct relationship to the size of the opening. We will now determine how this resistance affects the pressures. Thus far, we have assumed that $A_f/A_w$ approached infinity, that is the area of the window openings were very small as compared to the area of the floor openings.

Fig. 7 illustrates that the same flow patterns occur as before, i.e., the cold air flows into the building below the zero point. Air flows out of the building above the zero point with increasing intensity above the zero point.

It will be noted, that air will flow into the vertical shaft below the zero point and out of the vertical shaft above the zero point. This effect is brought about since there is only minor pressure loss in the shaft from top to bottom and there is a substantial loss from floor to floor because of the high friction losses through the small floor openings.

If we assume a zero shaft opening, the air flow within the building must take place through the floors or the areas $A_f$ [5]. The floor openings represent a series of openings, thus frictional losses increase as we proceed upward in the buildings. It is therefore evident that even if these openings are relatively large as compared to the window openings, they represent additive pressure losses from floor to floor. When we examine the shaft openings, we find the pressure at each floor to be undiminished within the shaft, thus a shaft opening of equal friction loss to that in a floor will have more effect upon the building pressures than the floor opening.

The shaft openings are thus an extremely important factor. Elevator doors, stairwell doors, etc. must have tight seals if building pressures are to be kept at minimum.
values. Refuse, trash, or laundry chute openings should be kept as small and as tight as possible and should be equipped with a device that closes entry of air to the chute when the chute is open. The chute doors should be sized so that the maximum opening is no greater than 1/3 the cross sectional area of the chute, and should never exceed 160 sq in. no matter what the chute diameter. Minimum door size should be 10 x 12 inches [6].

This type of door and this sizing procedure should be used on all types of chute openings if building pressures due to chimney action are to be minimized, and if odor and smoke problems from the chute are to be kept out of the living areas. Bacteria and infection carried by the outflow of air from hospital chutes can create serious problems unless this situation is clearly understood.

We can avoid outward flow from chutes to buildings only if we place the chutes under a pressure negative to that of the building pressure. All flow of air will then be into the chute, removing the odor and infection problem.

We have thus far discussed the natural building pressures that occur during the heating season when the inside temperature is 70 F and the outside temperature 0 F. Let us consider now the conditions when the outside air is 100 F and the inside air 70 F, as shown in Fig. 8.

We see here that the air conditioning season produces a reverse effect. Warm air enters both the building and the chute above the zero line and is forced out of the building and the chute below the zero line.

Let us now investigate the intensity of the pressures we will encounter in chutes. To do this, we must first es-

\[
A_W = \text{OPENINGS CREATED BY CRACKS AROUND WINDOWS - WALL POROSITY ETC.}
\]

\[
A_f = \text{OPENINGS IN THE FLOOR FOR PIPES DUCTS ETC.}
\]

\[
A_S = \text{SHAFT OPENINGS}
\]

**FIG. 7  AN AIR FLOW PATTERN IN HEATED MULTI-STORY BUILDING**
establish the zero point. This will be a function of the air leakage area of the walls, floors, and shafts, but these values are usually not precisely known. If the value is available from the design criteria, it should certainly be used. If it is not, we must rely upon actual field investigations. The zero level has been found by field investigations of a variety of high rise structures to range from 35 to 52 percent of the building height during the cooling season [7]. The variation is due to the nature of the ventilation system and the tightness of the building. It is our feeling that the 35 percent value should be used in all cases where the location has not been established by the criteria.

Field studies have also shown the building pressures to range from 0.82 to 0.91 of the theoretical pressures. We will use the 0.91 figure in our calculations.

When these factors are incorporated into the basic formula for theoretical draft, we obtain the relationships:

![Figure 8: An Air Flow Pattern in a Cooled Multi-Story Building](image)

<table>
<thead>
<tr>
<th>Heating Season</th>
<th>Cooling Season</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inside Temperature F</td>
<td>70</td>
</tr>
<tr>
<td>Outside Temperature F</td>
<td>0</td>
</tr>
<tr>
<td>Natural Building Pressure at top of building (inches of water)</td>
<td>+0.0013H</td>
</tr>
<tr>
<td>Natural Building Pressure at bottom of building (inches of water)</td>
<td>-0.007H</td>
</tr>
</tbody>
</table>

Where H is equal to the over-all building height.

Thus, a 600 ft building during the heating season would have a pressure of 0.78 inches of water on its upper floors.
CHUTE OR ENCLOSURE PRESSURES

It has been observed that air flows out of a building and out of a chute above the zero level, into the building and into a chute below the zero point for the heating season. The reverse is true during the cooling season. If this is true, we can assume that the chute is at a higher pressure than the building or vice versa as the case may be.

If we are to insure that the chute is more negative than the building, that air flow will be into the chute or enclosure, that odor smoke, products of combustion, etc. will not escape from the chute into living areas, then we must design the exhaust system to overcome the natural building pressures involved.

WIND – ITS EFFECT UPON HIGH RISE BUILDING PRESSURES

The wind effect is always considered when calculating the heating load. Unfortunately, it is usually not considered for high rise non-exposed chimney design. The same factors that affect the heating load affect the chimney. If these factors are not considered, the problem of smoke infiltration into the living areas will become serious.

We will not concern ourselves with maximum velocities because of the infrequent occurrence, but we must concern ourselves with velocities in the 20 to 30 mile/hour range [2]. This range occurs with fair frequency in most all parts of the country. Wind is affected by friction, thus surface winds may be as much as 30 percent lower than those at higher levels. With high rise construction, we must consider the wind pressures at 100 ft or more above the ground level or friction surface. We have elected to use 30 mile/hour as a practical design value. This should be increased if the area is subject to higher wind velocities.

Wind or moving air will tend to continue in the direction in which it is flowing until it encounters some exter-
nal body or force. A mountain, a forest or a building or other object will direct the wind and change its direction. If we assume an open plain and a high rise building, we have the least complicated situation [8]. The air pattern is shown in Figs. 9 and 10.

It is obvious that for a chimney terminated in the eddy area, the products of combustion or odors will be carried to the building on the leeward side in concentrations above acceptable limits [9,10] depending upon the relationship between building pressures and the pressure in the eddy area. We must examine these pressures on all sides, since eddies involve the top, back and both sides of a structure.

A typical pressure differentiation on the various portions of a building as determined by wind tunnel tests on models shows positive pressures up to 0.95 of the wind pressure on the windward side and negative pressures up to 0.8 of the wind pressure on the leeward side [2,11].

We have elected to use 30 mile/hour as our design velocity. This provides an impact pressure of 0.434 inches of water, thus:

Positive Pressure on Outside of Building (inches of water) = 0.95 (.434) = 0.41
Negative Pressure on Outside of Building (inches of water) = 0.8 (.434) = 0.35

Additional tunnel testing on models with various openings indicate that about 50 percent of the pressure on the outside will be transmitted to the interior of the building, thus at 30 mile/hour:

Inside Positive Pressure Due to Wind (inches of water) = + 0.21
Inside Negative Pressure Due to Wind (inches of water) = -0.18

These pressures must be considered when designing the exhaust system for chutes, enclosures or chimneys.

BUILDING POLLUTION FROM IMPROPERLY TERMINATED CHIMNEY

When a chimney is terminated in the eddy zone as in Fig. 11, it allows pollutants to be carried to the building where they may enter the living area by following the normal air flow patterns.

If chimney pollutants are to be carried away from the building, to avoid re-entry, the chimney must be terminated above the eddy zone, as in Fig. 12.

DETERMINATION OF PROPER CHIMNEY HEIGHT TO AVOID POLLUTION WITHIN THE BUILDING

Air patterns around buildings have been subject to considerable investigation. Extensive wind tunnel tests and field confirmation has provided some general rules. It has been found that for a single basic cube, that is, a building...
where the length equals the width equals the height, the height of the eddy above the ground will be 1.5 times the building height and the height of unaffected air will be 2.5H from the ground [12]. Fig. 13 illustrates these findings.

The height of the eddy above the roof will equal 0.5H.

As we increase the number of cubes in height, we find that this cavity height above the roof remains unchanged, shown in Fig. 14.

We will assume a building of approx. 100 ft x 200 ft x 600 ft, shown in Fig. 15.

The basic cube here is 100 ft x 100 ft x 100 ft. Thus, the dimension H is equal to 100 ft. The top of the eddy is 0.5H above the roof, thus for this building a chimney 0.5 (100 ft) = 50 ft high above the roof is necessary to be above the eddy currents.

Let us now examine a 50 ft x 100 ft x 200 ft building, as in Fig. 16.

In this case, the basic cube is 50 ft x 50 ft x 50 ft, thus 0.5H = 0.5 (50 ft) = 25 ft chimney height above the roof to be above the eddy zone.

For a 80 ft x 120 ft x 240 ft building, as in Fig. 17 a similar calculation may be made.

The relatively tall chimney above the roofline has often been handled, by placing the mechanical room above the roof and using this height to provide some of the chimney height, as in Fig. 18.

If we assume the chimney chute enclosure to be 8 ft x 8 ft x 16 ft, we actually have two 8 ft x 8 ft cubes, Fig. 19, thus to place the chimney terminal above the eddies of the chimney enclosure, we would have to add another 4 ft.
FIG. 14 EDDY ZONE NEAR TOP OF BUILDING

FIG. 15 BASIC CUBES FOR LARGE BUILDING
CHIMNEY HEIGHT TO BE OUT OF EDDY ZONE = 25'

FIG. 16 BASIC CUBES FOR MEDIUM BUILDING

CHIMNEY HEIGHT TO BE OUT OF EDDY ZONE = 40'

FIG. 17 APPROXIMATED CUBES
Air pollution criteria indicate that a chimney must be 0.5H above the roof. (Where H is the height of the basic cube and in most cases is equal to the width.) This requires that the chimney must extend from about 30 ft to about 60 ft. Above the normal high rise roof, this not only creates an aesthetic problem, but presents another requiring more serious consideration.

The normal high rise will utilize at least two packaged boilers. These will be breeched into a single chimney. This boiler chimney will be sized to suit the operation of the two boilers. The design may consider a minimum chimney velocity of 2000 ft/min with both boilers operating. This velocity is necessary to carry out moisture that may be deposited in the chimney. The quantity of combustion products is low. The result of all this is low chimney velocities, cool chimney surfaces, low chimney temperatures and condensation of water.

The problem becomes critical above the roofline where the chimney is exposed to wind and where it may in effect act as a condenser.
What is the problem of a wet chimney? Obviously, the prime problem is water. If the chimney is of masonry construction, the masonry becomes saturated. With time, the moisture will creep through mortar joints and can enter the living areas spoiling floors and wall coverings. A water saturated chimney becomes a serious problem during the winter season. If it freezes, the mortar becomes loosened providing more access to water flow and in time can seriously weaken the structure.

If the fuel is oil, the problem becomes even more serious [13]. The condensed water is highly acid. This accelerates the damage to the mortar and to any metal parts it may come in contact with.

Metal chimneys are subject to the same conditions with rust and corrosion. Stainless steel liners in chimneys help little unless all joints are vapor tight. If the joints are not tight, moisture, vapor and combustion products penetrate the annular area and pressurize it. The water is then deposited in the annular area free to corrode metal parts.

Insulation above the roof line would help this situation to some degree, however, it has been observed that temperatures are sometimes so low that condensation occurs in the breeching. It is strongly recommended that chimneys be insulated above the roof line, but it must be clearly understood that this is not the complete answer. All factors must be considered and all precautions taken to maintain the highest possible temperature in the chimney.

**ENCLOSED CHIMNEY ABOVE THE ROOF**

The most successful method of insulation is to locate the chimney in such a position (Fig. 20) that it may be enclosed as part of the mechanical room or stairwell enclosure or other roof projection. Chimney heat will maintain the enclosure at acceptable levels if the floor openings are kept open. It is also helpful to incorporate an incinerator chimney or other means to keep the temperature in the enclosure up.

**MAINTAIN SPACE BETWEEN CHIMNEY AND THE ENCLOSURE**

Floor openings are usually cast to allow chimney penetration through the building. These openings should be at least 4 in. larger in diameter than the outside chimney diameter. The annular space between the chimney and the opening should be left open at all floors except that floor above the attached appliance. This should be adequately fire stopped.

An annular area of at least ½ in. width should be maintained around the chimney at the roofline to allow escape of warm air from the enclosure. The enclosure should be at least 4 in. from the chimney to allow circulation of the cold air, as shown in Fig. 21.

The air flow within this system brings cold air down the enclosure walls and warm air up alongside the chimney. This serves several useful purposes:

1) It helps to cool the lower enclosure walls to avoid the “hot wall” problem.
2) It warms up the entire chimney to assist in reducing the condensation problem.
3) If condensation does occur, there is no way for it to enter the living area to damage floor or wall coverings.

**DRAIN IN PIER SECTION – SLOPED BREECHING**

All low temperature chimneys should have a minimum 1½ in. drain at their lowest point to allow condensed water to escape.

The breechings should also be sloped toward the chimney for the same purpose.

**CHIMNEY VELOCITY SHOULD BE MAINTAINED AT OR ABOVE 2000 FT/MIN**

Modern packaged boilers whether using oil or gas will operate at from 220 F to 300 F to provide the greatest
FIG. 21 FLOOR OPENINGS AND CLEARANCES AROUND CHIMNEY

- MIN ½" OPENING
- CHIMNEY ENCLOSURE
- 4" CLEARANCE TO ENCLOSURE
- 2" CLEARANCE TO FLOOR
- FIRE STOP
- INSULATED BREECHING
- DRAIN
FIG. 22 DRAFT INDUCER APPLIED TO CHIMNEY
heating efficiency. It would be easy to indicate that terminal chimney temperatures should be not less than 250°F, but this will certainly be wishful thinking. This temperature would end the many problems with the chimney and would avoid some air pollution problems, but it appears impractical since boiler temperatures would be over 300°F. Other means must be taken to assist in creating chimney velocities that will sweep the chimney free of condensation products.

It has been established that a chimney velocity of 2000 ft per minute is required to do the job. If velocities are any lower, it then becomes important to install a draft inducer in the chimney to provide this velocity. This inducer can be arranged to operate only when the velocity falls below 2000 ft/min. It must be located at the top of the chimney so the entire chimney can be maintained under negative pressure. This assists in keeping the moisture from penetrating the chimney walls. A positive pressure in a chimney tends to accelerate moisture penetration by pushing it into crevices and porosities. Thus, inducers at the bottom of the chimney must be avoided.

The inducer has another function, particularly if it is of the type that achieves an induced draft through air jet action. This working air may be pulled partially from the chimney enclosure and partially from the outside. We may thus keep the enclosure under a negative pressure to avoid possible odor or smoke penetration into the living area through shaft openings. A tight chimney will avoid this problem, but it is sometimes the case that poor workmanship may allow an open joint. When the natural chimney effect achieves the proper magnitude, the enclosure will exhaust into the living area if holes exist. And they do exist when pipes penetrate the enclosure where electrical outlets are placed on the walls, where poor workmanship allows open joints or where differential expansion provides openings. This pressure difference could and has pulled odors and products of combustion from chimney fissures. A common exhaust area appears to be floor mouldings and electrical outlets. If the shaft is exhausted so as to be under negative pressure, this problem will be avoided.

**COMBINED CHIMNEY AND CHUTE SYSTEMS**

The wet chimney and other problems may be minimized by combining the boiler chimney, the incinerator chimney and the refuse chute in the same cluster [14] as in Fig. 23. This provides higher enclosure temperatures at the upper levels, thereby reducing condensation problems. It also utilizes a minimum building area and provides greater safety especially if a refractory lined refuse chute is used. Refuse chutes frequently catch fire disgorging their products of combustion into living areas. An installation with bypass from the refuse chute to the incinerator chimney at the top of the chute will insure removal of these unpleasant products and maintain an operating chimney system as well. It is essential in these cases to maintain continuous operation on the draft inducer.

We have discussed only boiler chimneys as examples, but we must also consider incinerator chimneys equipped with gas washers or any other low temperature operation where the same circumstances hold true. In the case of incinerators, chimney temperatures can be controlled at higher temperatures than boiler chimneys.

**SUMMARY OF PRACTICES TO REDUCE WET CHIMNEY PROBLEMS**

The condensation problem in low temperature chimneys may be reduced by adhering to the following:

1) Design chimney velocity for a minimum of 2000 ft/min.

2) If 2000 ft/min can not be achieved by natural factors, a draft inducer must be installed at the top of the chimney. Do not install an inducer at the bottom of a chimney.
3) Draft inducers required for scrubbers on incinera-
tors should create a velocity of 2000 ft/min as well as
overcome the losses through the washer and incinerator
and must be installed at the top of the chimney.
4) Chimneys should be within an enclosure for their
entire length, even above the roof line to provide proper
insulation.
5) The enclosure should be 4 in. from the chimney.
6) The floor opening should be at least 4 in. wider
than the O.D. of the chimney.
7) There should be a minimum of 0.2 in. annular area
at the top of the enclosure.
8) The chimney exit temperature should be at 250 F
or above if possible.
9) When draft inducers are used, barometric dampers
should be placed in the breeching system.
10) When draft inducers are used, some of the working
air should be drawn from the chimney enclosure to main-
tain it under negative pressure. The remainder should be
ducted to the outside of the enclosure to avoid openings
that will cool the top portion of the chimney.

**RECOMMENDATIONS**

Fig. 24 provides guidance for the design of refuse chute
and incinerator system for buildings up to 10 stories.
Fig. 25 applies to buildings of any height. Refuse chutes are most effectively purged by heat from the in-
cinerator burners. This may be accomplished without
requiring door locks and without entrance of odor and/or
smoke into living areas when the configuration of Fig. 25
is used.
The enclosure shall be as recommended for low tem-
perature chimneys and the inducer may be sized as for incinerators for buildings up to 10 stories.
Fig. 26 illustrates the condensation problem of tall inside chimneys. Because of the sulfur content of fuel
oil, the dew point is appreciably above 212 F.
Fig. 27 illustrates the causes of leakage of chimney
gas into the building. Positive pressure in the chimney
must be prevented.
Fig. 28 is a recommended arrangement to maintain
adequate temperatures in a chimney.

Fig. 29 is a recommended chimney installation when
a draft inducer is not required. The terminal temperature
is above 250 F.
Fig. 30 illustrates the installation in which a draft in-
ducer is required because of the gas washer (cool gas).

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EXIT VELOCITY NOT LESS THAN 2000'/MIN

FAIL SAFE DAMPER
CLOSED DURING
CHARGING - OPEN
DURING PURGE OR
POWER FAILURE

REFRACTORY WALLS
TO PROTECT CHUTE
AGAINST FIRE AND TO
REDUCE SOUND

CHUTE SHOULD BE NOT
LESS THAN 27 INCHES
IN DIAMETER 30 INCHES
RECOMMENDED

DAYLIGHT OPENING OF
DOORS NOT MORE THAN
ONE THIRD CROSS-
SECTIONAL AREA OF
CHUTE

DOORS SHALL BE
DESIGNED WITH AIR
CLOSURES

NEGATIVE PRESSURE
IN CHUTE

NEGATIVE PRESSURE
IN CHIMNEY

CHUTE GATE OPEN
DURING PURGING

CHUTE PURGED BY IN-
CINERATOR BURNERS

BYPASS ALLOWS AIR
FLOW WITHOUT
EFFECTING INCINERA-
TOR AIR

DRAFT INDUCER AT TOP OF CHIMNEY

NATURAL BUILDING PRESSURE 0.001\(\frac{a}{h}\)
WHERE H = BUILDING HEIGHT

BUILDING PRESSURE CREATED BY 30
M.P.H. WIND

VENTILATION PRESSURE

FRICTION LOSS IN CHUTE

ENTRANCE LOSS ASSUMING 25% OF CHUTE
DOORS OPEN

FRICTION LOSS IN APPLIANCE

DRAFT REQUIRED BY APPLIANCE

FRICTION LOSS IN CHIMNEY

LOSS TO INITIATE AIR FLOW (VELOCITY
PRESSURE)

TOTAL STATIC PRESSURE REQUIRED
OF DRAFT INDUCER

FIG. 24 REFUSE CHUTE AND INCINERATOR SYSTEM FOR
BUILDINGS UP TO 10 STORIES
BYPASS ALLOWS AIR FLOW WITHOUT EFFECTING INCINERATOR AIR

DAMPER CLOSED DURING PURGING

DAMPER TO BE CLOSED AT ALL TIMES EXCEPT PURGING AND POWER FAILURE. THE OPENING IN THE CLOSED POSITION SHOULD BE SUFFICIENT TO CREATE A NEGATIVE PRESSURE IN THE TOP OF THE CHUTE WITHOUT CREATING AIR FLOW (10% OPENING APPX) THIS MUST BE DETERMINED BY BUILDING CONDITIONS

EXPANSION JOINTS AS REQUIRED

CHUTE GATE OPEN DURING PURGING

CHIMNEY DAMPER CLOSED DURING PURGE

FIG. 25 REFUSE CHUTE AND INCINERATOR SYSTEM FOR BUILDING OF ANY HEIGHT
Moisture penetrates chimney walls.

Moisture collects on floors and is absorbed in wall.

Wind blows into chimney cooling it.

Low exit velocity 400 ft/min to 1000 ft/min. This is too low should be a minimum of 2000 ft/min to purge chimney of condensed water and to resist downdrafts.

Chimney exposed to wind and cold.

Inside skin temp. below 100°F (moisture condenses).

Flue temp. often below 100°F.

Tight seal.

Chimney sized too large.

Floor openings sealed.

Temperature near room temp. does not warm chimney.

High temperature.

Hot walls since there is no air circulation.

Uninsulated breeching.

No drain.

Fig. 26 Usual low temperature installation that results in a wet chimney.

200°-300°F 200°-300°F

Boiler

Boiler

268
FIG. 27 INSTALLATIONS THAT ALLOW ODORS AND COMBUSTION PRODUCTS INTO LIVING AREAS

CHIMNEY TERMINATED IN EDDY AREA

EXIT TEMP, BELOW DEWPOINT (100-120°F) FOR GAS (UP TO 325°F FOR OIL)

ELECTRICAL OUTLETS, PIPES, CRACKS IN FIRE ENCLOSURE, OPENINGS IN ENCLOSURE ALLOW ENTRANCE OF ENCLOSURE ATMOSPHERE TO THE LIVING AREA

OPEN JOINTS DUE TO POOR WORKMANSHIP OR DUE TO THE LACK OF EXPANSION JOINTS AND SEALED FLOOR OPENINGS EXPANSION RAISES CHIMNEY FLOOR SEAL HOLDS IT UP CREATING AN OPEN JOINT

FLOOR OPENINGS FILLED WITH CONCRETE UP TO CHIMNEY CREATES PROBLEMS UPON EXPANSION

ODORS WILL BE FORCED OUT OF CHIMNEY THROUGH CRACKS OR OPENINGS IN THE CHIMNEY BECAUSE OF POSITIVE CHIMNEY PRESSURE

ELECTRICAL OUTLETS OR OTHER OPENINGS ALLOW ODORS TO ESCAPE INTO LIVING AREAS

AMBIENT AIR FOR INDUCER COOLS CHIMNEY GASES - INDUCER PRESSURIZES CHIMNEY

INCINERATOR

GAS WASHER

DRAFT INDUCER

LOW EXIT VELOCITY

POSITIVE PRESS.

POSITIVE PRESS.

POSITIVE PRESS.

POSITIVE PRESS.

POSITIVE PRESS.

NEG. PRESS.

NEG. PRESS.

NEG. PRESS.

ZERO LEVEL

POLLUTANTS ENTER HERE

POSITIVE PRESSURE IN CHIMNEY

SMOKE EXHAUSTS HERE
WHEN INDUCER IS USED THIS HEIGHT MAY BE MAINTAINED AT MINIMUM VALUES NOT MORE THAN TWO FEET

DRAFT INDUCER ARRANGED TO PULL AIR FROM ENCLOSURE AND FROM OUTSIDE

MACHINE ROOM OR STAIRWELL ENCLOSURE

$H_B = \text{Height of basic cube, usually width of bldg.}$

EXIT TEMPERATURES SHOULD BE ABOVE 150°F FOR GAS 250°F FOR OIL

TEMPERATURE IN ENCLOSURE SHOULD BE ABOVE 120°F THIS CAN BE OBTAINED IF FLOOR OPENINGS REMAIN OPEN

IF NOT A HEATER OR INCINERATOR CHIMNEY SHOULD MAKE UP THE DIFFERENCE

EXIT VELOCITY TO BE MAINTAINED AT MIN OF 2000' PER MIN. DRAFT INDUCER SHOULD BE ON WHENEVER BOILERS OPERATE

ENCLOSURE TOP SEALED WHEN DRAFT INDUCER USED

INSIDE SKIN TEMP. SHOULD BE ABOVE 120°F

ROOF LINE

FOUR INCH CLEARANCE TO ENCLOSURE

TWO INCH CLEARANCE TO FLOOR

MINIMUM OF ONE HOUR FIRERATED ENCLOSURE (NONCOMBUSTIBLE)

TEMP. FROM HOT ZONE OF CHIMNEY CARRIED UP ALONG CHIMNEY TO KEEP IT WARM

CHIMNEY PROPERLY SIZED TO PROVIDE 2000'/MIN EXIT VELOCITY

NEGATIVE PRESSURE IN CHIMNEY

WALLS COOL TEMPERATURE DISTRIBUTED THROUGHOUT ENCLOSURE

FIG. 28 RECOMMENDED LOW TEMPERATURE CHIMNEY INSTALLATION

FIRE STOP

BAROMETRIC DAMPER

INSULATED BREECHING

300°F

300°F

BOILER

BOILER

FORCED DRAFT ADJUSTED TO REQUIRE ONLY MINIMAL OPENING OF BAROMETRIC DAMPERS
DESIGN FOR .5 ENCLOSURE WIDTH

\[ H_B = \text{Height of basic cube usually width of building} \]

MECHANICAL ROOM

EXPANSION JOINTS AS REQUIRED

TERMINAL TEMP. ABOVE 250°F

MIN. ONE HALF INCH ANNULAR OPENING AROUND CHIMNEY

IF A COMBUSTIBLE ROOF - AN INSULATING THIMBLE MUST BE USED

CHIMNEY MUST BE TERMINATED ABOVE THE EDDY AREA

4" CLEARANCE TO ENCLOSURE

2" CLEARANCE TO FLOOR

FLOOR OPENINGS MUST BE KEPT OPEN

MIN ONE HOUR FIRE RATED ENCLOSURE

FIRE STOP

BAROMETRIC DAMPER

INCINERATOR

FIG. 29 RECOMMENDED CHIMNEY INSTALLATION WHEN A DRAFT INDUCER IS NOT REQUIRED
DRAFT INDUCER FOR APPLIANCES SHOULD BE PLACED AT TOP OF CHIMNEY TO AVOID CHIMNEY COOLING AND TO AVOID EXCESSIVE FRICTIONAL LOSSES DUE TO HIGH CHIMNEY VELOCITIES CREATED BY THE ADDITIONAL VOLUME OF DRIVING AIR.

FIG. 30 RECOMMENDED CHIMNEY INSTALLATION WHEN A DRAFT INDUCER IS REQUIRED

INDUCER ARRANGED TO PULL AIR FROM ENCLOSURE AND FROM OUTSIDE

CHIMNEY MUST BE TERMINATED ABOVE THE EDDY AREA

ALL CLEARANCES SAME AS FIG 29

MIN. ONE HOUR FIRE RATED ENCLOSURE

EXPANSION JOINTS AS REQUIRED

BAROMETRIC DAMPER

INCINERATOR

GAS WASHER