TECHNICAL NOTES on Brick Construction

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Technical Notes 19 - Residential Fireplace Design
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Abstract: This *Technical Notes* covers the components, design and dimensions of residential wood-burning fireplaces. The recommendations are limited to single-face fireplaces. Concepts for increased energy efficiency as a supplemental heating unit are also addressed. Recommendations for the selection of materials as they relate to the construction of fireplaces are included.

Key Words: brick, building codes, damper, design, energy efficiency, fireplace, heating, masonry, mortar.

INTRODUCTION

In past years, fireplaces were mostly decorative and seldom used for heating residences. Recently, there has been a revival of the use of fireplaces as a supplemental heating source. This use requires that fireplaces be built as a more functional unit.

The combustion process, the variety of firebox configurations and the varying rates at which fuel is consumed are complex. Development of test methods to take into consideration the many variables affecting fireplace performance has been conducted for several years. However, the comparative performance of different fireplace configurations is not yet well documented. Thus the design suggestions in this *Technical Notes* are based on past proven performance. Although governed by the laws of thermodynamics, fireplace design is not an exact science, instead it is an empirical art to be applied with knowledge of basic principles and good judgment.

Successful concepts that were discarded when fireplaces became mostly decorative are now finding new relevance. In addition, several new concepts have been developed which can increase the energy efficiency of conventional fireplaces.

The purpose of this *Technical Notes* is to provide basic information for the design of successful, single-face, wood-burning fireplaces and to introduce concepts that can increase their energy efficiency. Other *Technical Notes* in this series discuss design, detailing and construction of other styles of residential fireplaces and the design of residential chimneys and masonry heaters.

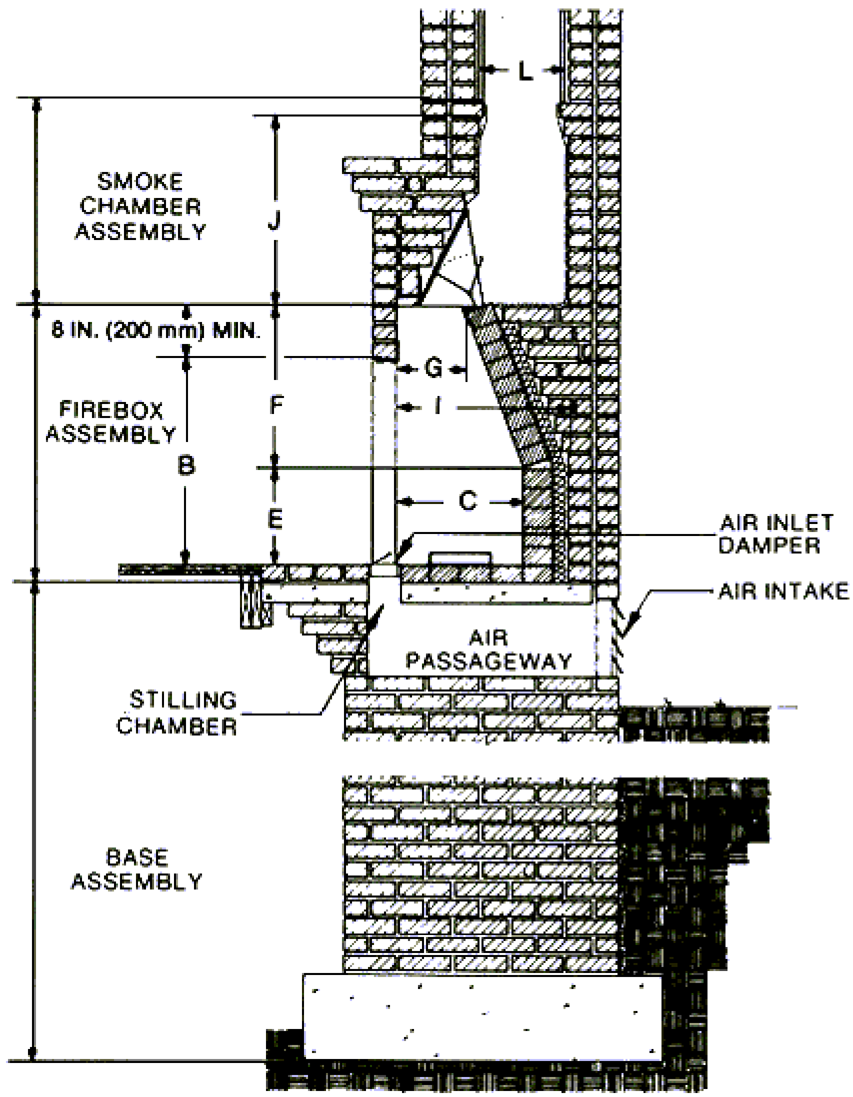
TYPES OF FIREPLACES

There are several distinct types of fireplaces currently in use for residential applications. There are many individual variations within each general type, but most of the functional principles are similar.

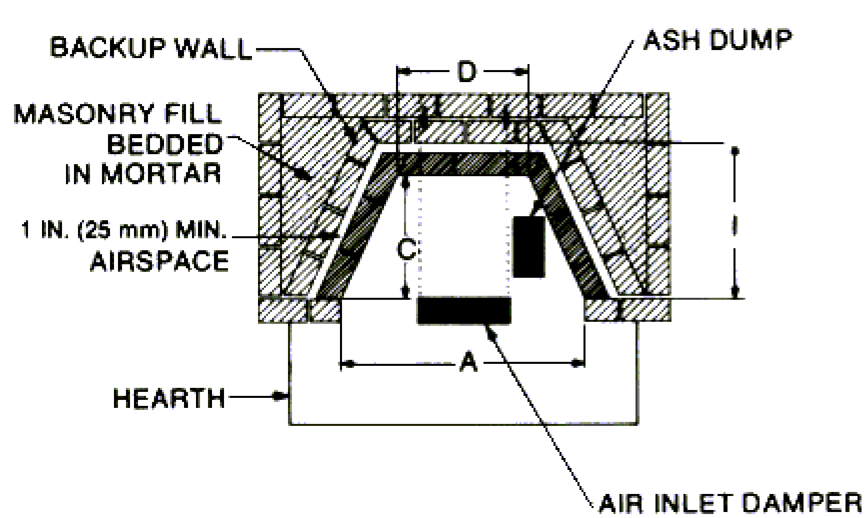
Single-Face

Single-face fireplaces have been in use since early recorded history with developments in design through most of the major architectural periods. Most of the available information on the proper opening sizes, dampers, and flue sizing is based on empirical developments.

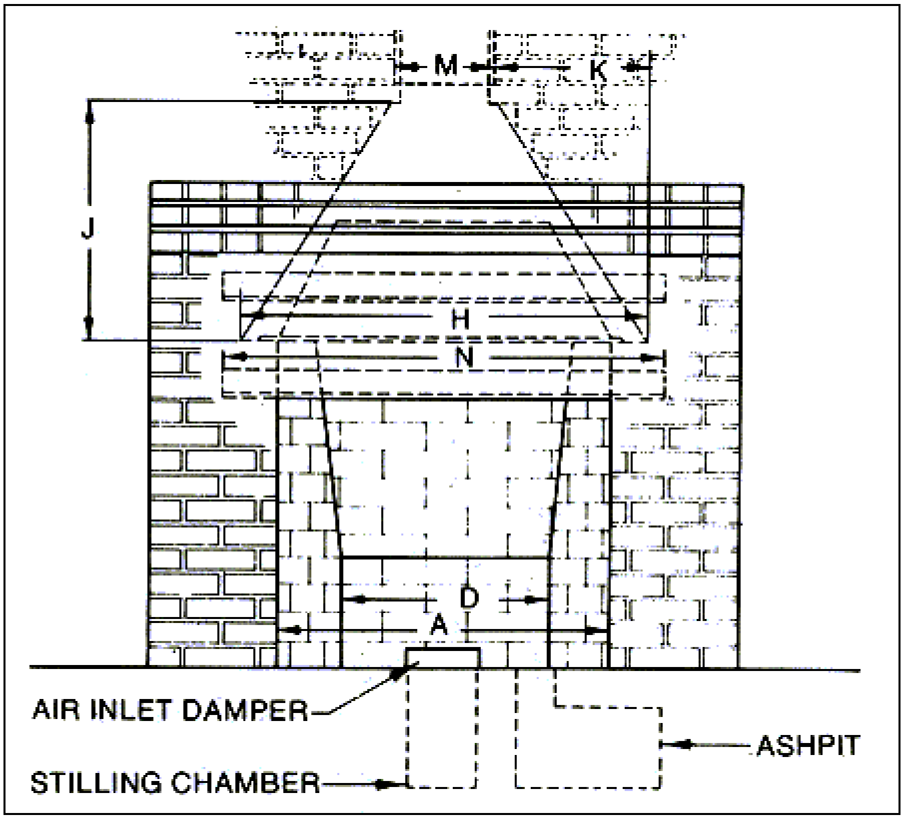
Single-face fireplaces can provide relatively efficient room heating. The amount of radiated and reflected heat produced increases with the amount of brick masonry surrounding the fire. The amount of brick masonry surface area exposed to the fire, its distance from the fire and the size of the fire determine the amount of reflected and radiated heat. Also, the mass of the fireplace assembly stores heat and radiates the heat into the room after the fire is extinguished. Key elements of a single-face fireplace are shown in Figures 1a through 1c.



Typical Single-Face Fireplace (See Table 1 for Dimensions)
FIG. 1a



Typical Single-Face Fireplace (See Table 1 for Dimensions)
FIG. 1b



Typical Single-Face Fireplace (See Table 1 for Dimensions)

FIG. 1c

Rumford Fireplaces. The Rumford fireplace is a single-face fireplace with a firebox which features widely splayed sides, a shallow depth and a high opening. These features increase energy efficiency. Performance tests indicate that the radiated and reflected heat output from a Rumford fireplace is higher than that from a conventional fireplace. Information on the design and construction of Rumford fireplaces is provided in *Technical Notes* 19C Revised.

Rosin Fireplaces. The Rosin fireplace is a single-face fireplace with a specially curved back to the firebox, designed to increase energy efficiency. The Rosin has a cast refractory firebox with widely splayed sides which increases radiation and heat storage. The Rosin firebox can be retrofitted into an existing masonry fireplace or built into a new fireplace.

Air-Circulating Fireplaces. Air-circulating fireplaces are so named because they circulate room air behind the combustion chamber through a series of brick baffles or steel plates. As a result, additional heat output can be distributed to the room or other areas of the residence by convection.

Examples of this type of single-face fireplace are the Heatilator and the Brick-O-Lator [7]. This type of fireplace can be used as a supplemental heat source. Brick has the advantage of radiating the heat stored in the mass of the fireplace after the fire is out. Additional heat can be distributed to the room by continuing to circulate air long after the fire is out.

Multi-Face

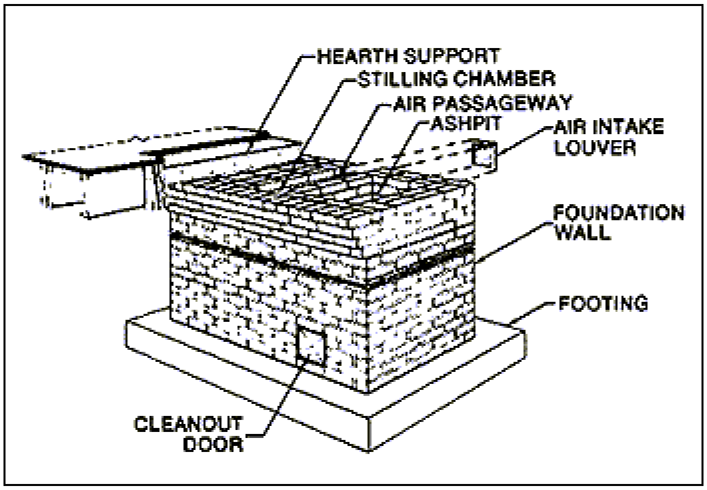
Multi-face fireplaces have adjacent, opposite or all faces open to the room. Although generally associated with contemporary design, the multi-face fireplace is also of ancient origin. For example, the so-called corner fireplace which provides two adjacent open sides has been in use for several hundred years in Europe. Some multi-face fireplaces have unique design requirements which have to be met before satisfactory performance can be reached. These fireplace configurations are less energy efficient than single-face fireplaces. This is due to the lack of radiating surfaces and increased use of room air. Multi-face fireplaces are usually selected for aesthetics rather than energy efficiency. Multi-face fireplaces are discussed in *Technical Notes* 19C Revised.

FIREPLACE DESIGN

The performance of a fireplace is primarily governed by three factors: fuel combustion, air pressure differential between the firebox and the top of the chimney and temperature differential between air in the room of the fire and that at the top of the chimney. All must be considered in order to achieve successful combustion and exhaust performance. All fireplaces include the same four basic components. These are the base, firebox, smoke chamber and the chimney. Of these, all but the base influence burning performance.

Base

The base consists of the foundation and hearth support, as shown in Figs. 1a and 2. It is not necessary that all of the components shown be present. For slab-on-grade construction, the slab can provide both the foundation and the hearth support, providing it is adequately designed to support the weight of the fireplace assembly.



Typical Base Assembly

FIG. 2

Foundation. Masonry fireplaces must be supported with an adequate foundation. The foundation consists of either footings which support foundation walls or a structural slab. Local building codes should be reviewed for design soil pressures for foundations. The minimum requirements contained in most building codes for the foundation components are included in the following discussion. The foundation must be designed to carry the weight of the fireplace without excessive or differential settlement.

Footings-Footings should be made of masonry or concrete and at least 12 in. (300 mm) thick, and extend at least 6 in. (150 mm) beyond the fireplace walls on all sides. The footings should penetrate below frost line unless they are located within a space maintained above freezing. Footings should be placed on undisturbed or properly prepared soils.

Foundation Walls-Foundation walls raise the fireplace to the desired level and should be constructed of masonry or concrete with a minimum thickness of 8 in. (200 mm). There should be no voids except for the ash pit and external combustion air ducts formed in the base assembly, as shown in Figs. 1a and 2. Typically the shape of foundation walls matches the perimeter of the fireplace structure above.

Structural Slab-The structural slab must be properly designed to support the weight of the fireplace assembly. When the fireplace is constructed on a slab-on-grade it is usually necessary to thicken the slab under the fireplace to support the loads from the fireplace and chimney.

Hearth Support. Support for the hearth can be provided in a number of ways. These include the use of corbeled brickwork, a structural concrete slab or cantilevered reinforced brick masonry. The maximum projection of each brick in a corbel should not exceed one-half the height of the unit nor one-third its thickness. When corbeling from walls, the overall horizontal projection should be limited to one-half of the wall thickness unless the corbel is reinforced. These maximum horizontal individual and overall projections are consistent with current model building code requirements. Hearth support featuring corbeled brickwork and a structural slab are shown in Figs. 1a and 2.

A structural concrete slab or reinforced brick masonry is used to span the foundation walls and may cantilever to support the hearth extension.

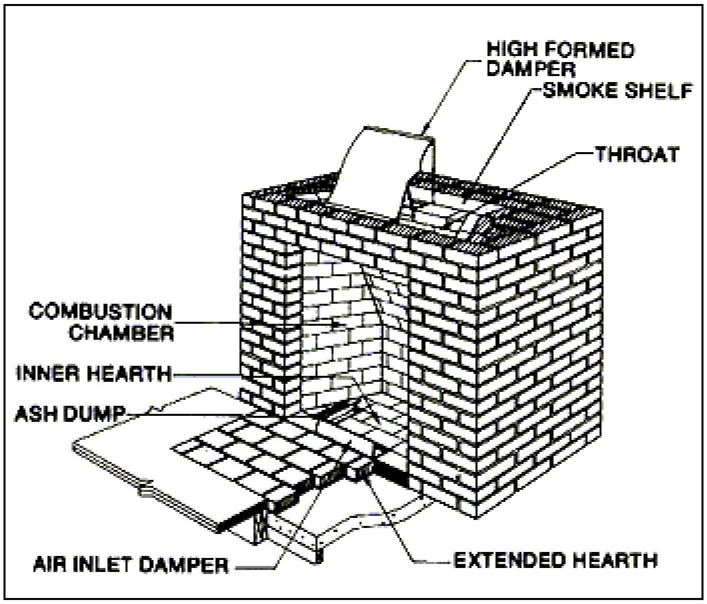
Firebox

The firebox consists of the hearth, fireplace opening, combustion chamber, throat and often a smoke shelf as shown in Figs. 1 and 3. The thicknesses of the firebox walls are set by the model building codes. When refractory brick or firebrick are used to line the walls the total thickness may be reduced.

Hearth. The hearth consists of two basic parts, the inner hearth and the extended hearth. The hearth can be raised or flush with the floor surface. A fireplace hearth flush with the floor is shown in Figs. 1a and 3.

Inner Hearth-The inner hearth is within the firebox area and forms the floor of the combustion chamber. All model building codes require that the inner hearth and the hearth support be noncombustible and a minimum of 4 in. (100 mm) thick.

Extended Hearth-The extended hearth is that portion of the hearth that projects out into the room beyond the face of the fireplace and must be noncombustible. Model building codes require the extended hearth to be supported by noncombustible materials with no combustible material against the underside. Wooden forms or centers used to construct the hearth extension must be removed when construction is completed. The extended hearth may be a reinforced brick masonry cantilever.



Typical Firebox Assembly

FIG. 3

Model building codes also require that the hearth extend a minimum of 8 in. (200 mm) on each side of the fireplace opening and 16 in. (400 mm) in front of the fireplace opening. If the fireplace opening is greater than 6 ft^2(0.55 m^2), building codes require hearth extensions of 12 in. (300 mm) on either side of the opening and 20 in. (500 mm) in front of the fireplace opening.

Fireplace Opening. The fireplace opening is a very important element in fireplace design. The configuration and dimensions of most other components of the fireplace and chimney are based primarily on the dimensions of the fireplace opening selected. Figure 1 shows details and Table 1 provides the widths and heights of fireplace openings found to be the most satisfactory for appearance and successful operation. These dimensions may be varied slightly to allow for brick coursing.

Proper Sizing-Firebox dimensions should be selected so that the fire fills the combustion chamber during operation. This provides greater heating efficiency. Careful consideration should be given to size of the fireplace opening best suited for the room in which it is to be located. Location and size are important not only from the standpoint of appearance, but also of operation. If the fireplace opening is too small, it may function properly but will not produce enough heat to warm the room. If the opening is too large, a fire that would fill the combustion chamber may overwhelm the room. In such a case, the firebox opening would require a larger flue area and consume larger amounts of interior air even if exterior combustion air is provided. Table 2 provides suggested widths of conventional fireplace openings appropriate for various room sizes. For example, a room with 300 ft^2 (28 m^2) of floor area is best served by a fireplace with an opening 30 in. (750 mm) to 36 in. (900 mm) wide.

The shape of the fireplace opening is important aesthetically and functionally. Higher openings increase the radiant heating, increase the demand for room air and require taller chimneys.

TABLE 1
Singel-Face Fireplace Dimensions[a], Inches[b]

Finished Fireplace Opening							Rough Brick Work[c]				Steel Angle[d]
A	B	C	D	E	F	G	H	I	J	K	N
24	24	16	11	14	18	8 3/4	32	21	19	10	A-36
26	24	16	13	14	18	8 3/4	34	21	21	11	A-36
28	24	16	15	14	18	8 3/4	36	21	21	12	A-36
30	29	16	17	14	23	8 3/4	38	21	24	13	A-42
32	29	16	19	14	23	8 3/4	40	21	24	14	A-42
36	29	16	23	14	23	8 3/4	44	21	27	16	A-48
40	29	16	27	14	23	8 3/4	48	21	29	16	A-48
42	32	16	29	16	24	8 3/4	50	21	32	17	B-54
48	32	18	33	16	24	8 3/4	56	23	37	20	B-60
54	37	20	37	16	29	13	68	25	45	26	B-66
60	37	22	42	16	29	13	72	27	45	26	B-72
60	40	22	42	18	30	13	72	27	45	26	B-72
72	40	22	54	18	30	13	84	27	56	32	C-84

[a]Adapted from *Book of Successful Fireplaces,* 20th Edition.

[b]SI conversion: mm = in. x 25.4.

[c]L and M are shown in Fig. 1 and are equal to outside dimensions of flue lining plus at least 1 in. (25 mm). Determine flue lining dimensions from Fig. 5. L is greater than or equal to M.

[d]Angle sizes: A - 3 x 3 x 1/4 in., B-3 1/2 x 3 x 1/4 in., C-5 x 3 1/2 x 5/16 in.

Support Above Fireplace Opening-The brickwork above the fireplace opening must be adequately supported. There are several alternatives for support. These include brick arches, reinforced brick masonry lintels, stone, precast concrete and loose angle lintels.

Brick arches usually require no steel reinforcement and are an attractive option. When determining the height of a fireplace opening which incorporates an arch use the maximum height to the arch soffit. Information on arch design may be found in *Technical Notes* 31 Series.

Reinforced brick masonry (RBM) lintels may be built in place or prefabricated. The advantages of using RBM lintels are numerous, but include more efficient use of materials and exposed brick rather than steel at the top of the opening. RBM lintel design procedures are given in *Technical Notes* 17H. Loose steel angle lintels are the most prevalent means of support. For this reason, Table 1 gives recommended steel angle dimensions. If opening sizes other than those listed in Table 1 are used, information found in *Technical Notes* 31B Revised can be used for design of the loose steel angle lintel.

TABLE 2
Suggested Width of Fireplace Openings
Appropriate to Size of a Room[a,b]

Size of Room in Feet	Width of Fireplace Opening in Inches	
	in Short Wall	in Long Wall
10 x 14	24	24 to 32
12 x 16	28 to 36	32 to 36
12 x 20	32 to 36	36 to 40
12 x 24	32 to 36	36 to 48
14 x 28	32 to 40	40 to 48
16 x 30	36 to 40	48 to 60
20 x 36	40 to 48	48 to 72

[a]Reprinted with permission of Structures Publishing Company from *Book of Successful Fireplaces,* 20th Edition.

[b]SI conversions: mm = ft. x 0.305; mm = in. x 25.4.

General recommendations are: the steel angles should be at least 1/4 in. (6A mm) thick; the horizontal leg should be at least 3-1/2 in. (89 mm) for use with nominal 4 in. (100 mm) thick brick and 3 in. (75 mm) for use with nominal 3 in. (75 mm) thick brick. The minimum required bearing length on each end of the fireplace opening is 4 in. (100 mm). Steel angle lintels should have a space at their ends to permit thermal expansion.

Combustion Chamber. The shape and depth of the combustion chamber will greatly influence draft, combustion air requirements and the amount of heat reflected and radiated into the room. Figure 1 illustrates the shape and Table 1 provides recommended dimensions for the combustion chamber. These dimensions may be varied slightly, but the information given is based on successful designs. Significant changes should not be made without consulting a fireplace design consultant.

The sides and lower portion of the back of the combustion chamber should be vertical. Above the vertical portion of the back, the brick should be sloped forward towards the fireplace opening to support the metal damper and the clay flue lining. For the maximum amount of reflected heat into the room, the sloped portion of the back should be plane rather than concave. If it is concave, more heat will be reflected back into the fire rather than into the room. Greater splay of the sides also increases the amount of heat reflected into the room.

The combustion chamber should be constructed of nominal 4 in. (100 mm) thick brick. When refractory brick or firebrick are used, model building codes permit the total wall thickness to be reduced. Thin mortar joints, not more than 1/4 in.(6.4 mm), should be specified. A 1 in. (25 mm) air space should be provided between the combustion chamber wall and the backup wall, although not required by building codes. This air space provides for thermal expansion of the combustion chamber. A noncombustible, compressible, fibrous insulation or similar material should be wrapped around the combustion chamber to ensure that this air space is maintained. The backup wall should be no less than 4 in. (100 mm) in thickness around the back of the combustion chamber to support the loads from the smoke chamber and chimney above.

Throat. The throat is a slot-like opening directly above the top of the firebox through which flames, smoke and combustion gases pass into the smoke chamber and upward through the chimney. Because of its effect on draft, the throat of the fireplace should be carefully designed. It should be a minimum of 8 in. (200 mm) above the highest point of the fireplace opening. The throat is illustrated in Fig. 1a and appropriate dimensions are found in Table 1.

Cast refractory and formed clay throats are available, built to certain angles and dimensions to fit most conventional fireplace dimensions. These elements are positioned on top of the firebox walls and eliminate the need of constructing brick courses to form the throat. Once in place, brick masonry can be built around the throat to give the appearance of conventionally built throats in the breastwork of the fireplace.

Damper-The damper closes the fireplace opening to exterior air infiltration and can be used to control the burning rate of the fireplace. A metal damper may be placed in the throat, extending the full width of the throat opening, or at the top of the chimney.

A throat damper should have an open area of approximately twice the area of the flue. The damper should have a valve plate which opens toward the back of the fireplace. Such a plate when opened, forms a barrier to deflect any down draft which may occur. Many different damper shapes are available. A high formed damper is recommended because it extends the throat with its construction and forms a critical portion of the smoke chamber. This damper type reduces the possibility of masonry blocking the valve plate of the damper. The damper should be spot bedded in mortar for a good fit and support, but not mortared in solidly at the ends because expansion could cause cracking in masonry. A noncombustible, compressible, fibrous insulation or similar material should be placed between the damper ends and adjacent masonry to allow differential movement.

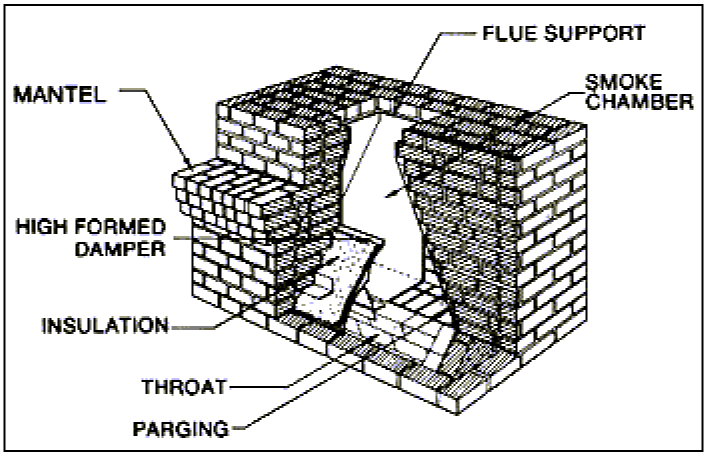
A chimney top damper is an alternative to the damper installed at the top of the throat. The damper is operated by a control chain which extends down into the firebox. This type of damper permits the chimney and flue to be heated when the fireplace is not in use and may help reduce water penetration into the flue. Chimney top dampers must be weighted or spring loaded to be in the open position if the operating mechanism fails. This is necessary so the damper remains open during operation of the fireplace.

Smoke Shelf. The origin of and need for a smoke shelf is not clear. Some say its purpose is to provide a location for chimney sweeps to work from when cleaning large chimneys. Others contend it deflects down drafts and prevents direct access of water entering the top of the flue to the firebox. It also serves as a depository for ash which does not clear the chimney. The smoke shelf, if used, should be designed so that a uniform air flow results. The smoke shelf should be directly under the flue, be level across the face and in plane with the base of the damper. The smoke shelf should also extend the full width of the throat. It can be flat, extending back to and perpendicular to the rear wall of the smoke chamber, or curved to blend with the rear wall of the smoke chamber. Refer to Figs. 1a and 3 for details and Table 1 for recommended dimensions.

Some designs, such as Rumford fireplaces, do not include a smoke shelf. These types of fireplace designs are often referred to as having "the streamline effect". In this instance, the flue tile is vertically aligned with the top of the last course of brick at the back of the firebox wall. Such a design provides a clear vertical passageway from the firebox to the top of the last chimney flue liner.

Smoke Chamber

The smoke chamber forms the chimney flue support, as shown in Figs. 1a, 1b and 4, and conveys by-products of the combustion process up to the chimney. The back wall of the chamber is built vertically and the side walls are sloped uniformly toward the center. The front wall above the throat is also sloped to meet and provide support for the bottom of the clay flue liner. Flue liners should be supported on all sides. The front wall above the throat should be supported by reinforced brick masonry or a steel angle, *not* by the damper.



Typical Smoke Chamber Assembly

FIG. 4

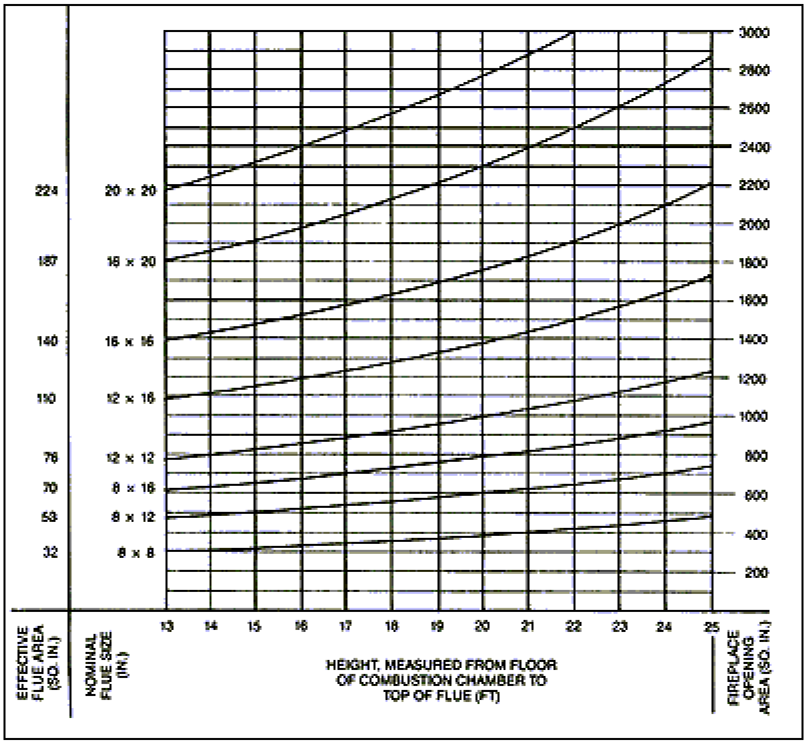
The slope of the smoke chamber should be smooth, with each course of brick corbeled to achieve the required angle. The inside of the smoke chamber should be parged with refractory mortar to reduce friction and prevent smoke leakage. Figures 1a and 4 show the shape of the smoke chamber and Table 1 gives recommended dimensions.

There are alternative means of building the inside surface of the smoke chamber. Cast refractory materials or cut pieces of clay flue liner may be used. Dimensional coordination is important so that all components are correctly fitted without cracks or leaks of combustion products.

Chimney Flue

Draft of the fireplace is affected by the dimensions of the firebox opening, the shape and cross-sectional area of the flue and the height of the chimney. Figure 5 provides a graphical determination of the appropriate flue size for fireplace opening area and overall height [3]. For purposes of Fig. 5, the height is defined as the distance from the combustion chamber floor to the top of the last chimney flue liner. When using Fig. 5 it is normally best to use the smaller flue size when the opening and height selected intersect between standard flue sizes. Taller chimneys have a better draw than shorter chimneys with the same flue size.

For fireplace openings greater than those given in Table 1 and Fig. 5, the area of the flue and height of the chimney can be determined by methods in *Technical Notes* 19B Revised. Chimney design and construction are also covered in *Technical Notes* 19B Revised.



Flue Size Nomograph

FIG. 5

Structural Considerations

Masonry fireplaces must withstand wind and seismic loads resulting from local conditions. In areas of high wind and seismic activity, vertical and horizontal reinforcement may be required. Vertical reinforcement is located at least at each corner of the fireplace. Such reinforcement must be anchored to the foundation and properly lapped to be continuous for the entire chimney height. The size and spacing of reinforcement depends on design loads, overall dimensions of the fireplace and chimney, location of the reinforcement and means of attachment to the structure. Fireplaces and chimneys are typically attached to the structure by steel straps located at each floor or ceiling line. Consult the local building code for design loads and prescriptive requirements. For more information on chimney design see *Technical Notes* 19B Revised.

Aesthetic Considerations

The appearance of the fireplace has evolved through the centuries from the elaborately carved mantels of the Georgian Period to the smaller, streamlined fireplaces found in contemporary style homes. The aesthetic design of a fireplace is often based on the style of the house or room. The fireplace may project from adjacent walls to add emphasis to the fireplace or may be flush with its surroundings. The effect of a fireplace can be simple, just a rectangular opening with a brick surround in an otherwise blank wall. Conversely, a focal point can be created with an ornate brick area filling an entire wall. Functional aspects such as wood storage areas or seating can be incorporated. Brickwork can be combined with materials in other locations.

The most prominent features of the fireplace are the fireplace surround, the mantel, and the hearth. Although certain aspects of these features must conform to building code requirements, the resulting appearance is limitless.

Mantel. The mantel is a shelf or facing ornament above the fireplace opening. Depending on the architectural style of the room, the mantel may be recessed into the wall or may project out from the wall. Mantels may be built integrally with the fireplace or may be anchored to it. Specially carved mantels are sometimes used to surround the fireplace. Projecting mantels are usually made of corbeled masonry, wood, stone or other materials. All combustible materials used for the mantel must be at least 6 in. (150 mm) away from the fireplace opening. Combustible materials projecting out more than 1-1/2 in. (38 mm) must be 12 in. (300 mm) away from the top of the fireplace opening. Corbeled masonry must conform to the corbeling limitations listed in the *Hearth Support* section. All mantels should be securely attached to the masonry. The wall above the mantel is an area which is often integrated with the fireplace design. This may include patterned brickwork, brick sculptures or art work. Figure 6 is an example of a mantel and the possibilities above the mantel.

FIG. 6

Fireplace Surround. The fireplace surround is the area immediately surrounding the fireplace opening. The first 6 in. (150 mm) adjacent to the fireplace opening must be noncombustible material. The fireplace surround may be integral with the mantel in the case of decorative tile, marble or other noncombustible material placed on either side of the opening. Alternately, a wooden surround may be combined with the mantel. The lintel forms the top of the fireplace opening and may also be made of various noncombustible materials. The shape of the lintel can be modified to add a certain look to the fireplace. A semi-circular arch is one simple way of dressing up the fireplace. An example is shown in Fig. 7. Other options include using a contrasting material such as cast stone for the lintel.

Hearth Extension. The hearth extension is necessary for the safe operation of a fireplace and may also be a focal point of the fireplace. The hearth extension may be flush with the floor or may be raised. The extended hearth may be made of brickwork, slate or any other noncombustible material. The hearth extension may be only as small as allowed by the building code or may extend along the entire front face of the wall. The raised hearth may serve as additional seating for the room. A raised hearth brings the level of the fireplace up to eye level when seated. Raised hearths are shown in Figs. 6 and 7.

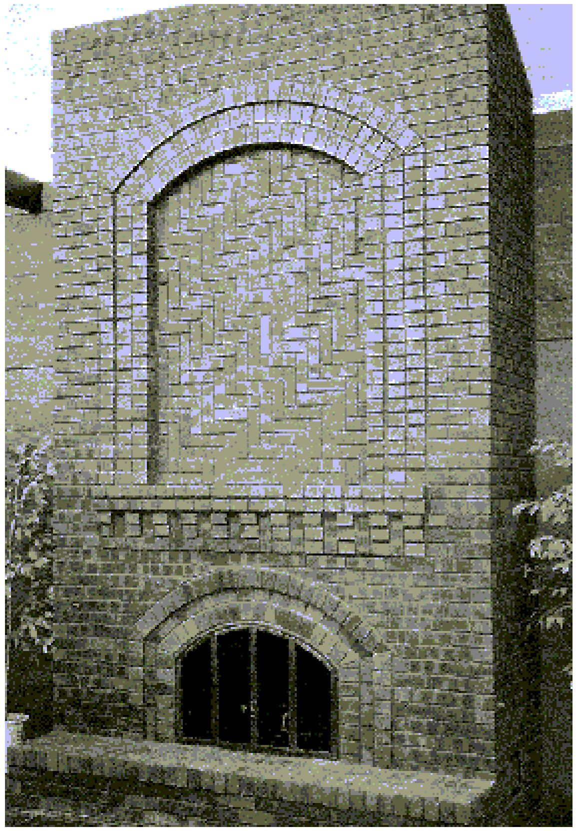


FIG. 7

ENERGY EFFICIENCY WITH FIREPLACES

Energy efficient fireplaces may be used for supplemental heating and to decrease the consumption of non renewable resources. Several modifications to conventional fireplace design make them more energy efficient. The modifications discussed here are appropriate to most conventional fireplace designs. Other energy efficient modifications to the shape and size of the firebox are the Rosin and Rumford fireplace designs.

Location
For maximum thermal benefit, the fireplace should be located entirely within the structure. This enables the mass of the fireplace to store heat within the residence. Heat stored in the brickwork is then radiated into the room long after the fire is extinguished.

By choosing a central location, a more even heating of the living area results. Fireplace walls can be exposed in several rooms. Cold spots in areas away from the fire are kept to a minimum and, if the fireplace is an air-circulating type, heat can be vented into adjacent rooms more efficiently.

Outside Air
One way to increase the efficiency of a fireplace is to use air from outside the structure for combustion and draft. Conventional fireplaces draw air from the room, air that has already been heated to some extent. The drop in room air pressure, caused by the air loss, may result in increased infiltration from other areas of the structure. In very tightly built houses less air is available for proper combustion, so outside air must be intentionally provided. Even when outside air is provided, some interior room air is always necessary for proper combustion.

There are many ways in which outside air can be brought into the firebox area. Each method requires three basic parts: the intake, the air passageways and the inlet. One example is shown in Figs. 1 and 2. Thight-fitting inlet dampers are tight-closing intake louvers and recommended to keepthe fireplace from becoming a source of air infiltration when not in use.

Intake. The intake should be located on an ouside wall or on the back of the firplace. A screen-backed, closeable louver is required. Preferably, this will be a type that can be operated from inside the structure. Many building codes will not permit the intake to be located within a garage because of the presence of fuel fumes. Other possible locations for the intake are in a crawl space, attic or other unheated spaces. It is advisable to check local building code regulations for the appropriateness of other intake locations.

Passageway. A passageway or duct connects the intake to the inlet. It must be formed of noncombustible material. Ducts with cross-sectional area ragning from 6 in.^{2} (3870 mm^2) have been used successfully. The passageway can be built integral withthe fireplace base assembly or channeled between floor joists. It can aslo enter throught inlets located in the sides ofthe firebox. In any case, the passageway is usually insulated to reduce heat loss.

Inlet. The inlet brings the outside air into the firebox. A damper is required to control the volume and direction of the air flow. This is necessary because cold outside air channeled into the fireplace expands and could possibly result in more air than is needed for draft and combustion. this can create a spill over effect into the room proior to the air being warmed. The inlet can be located in the sides or the floor of the combusiton chamber, preferably infront of the grate for best performance. If the inlet is located toward the back of the combustion chamber, ashes may be blown into the room by drafts for the inlet. As an option, the inlet can be located on or near the floor within 24 in. (600 mm) of the firebox opening. Any inlet should be closeable and designed to prevent burning material from dropping into concealed comustible spaces. A potential problem due to oncreased velocity of the air coming throught the inle is that the temperature within the combustion chamber can increase significantly. This can result in grates and inlet dampers being destroyed or distorted by the higher temperatures. To help decrease the velocity of the air through the inlet, a space before the inlet should be constucted as a stilling chamber, as shown in Figs. 1a and 2.

Glass Fireplace Screens

Glass screens can be used on both conventional fireplaces and fireplaces with an outside air supply. these screens should be sealed around the edges and have tight-fittingdoors and vents so that the fireplace is not a source of air infiltration or heat loss when not in use. The screens are normally closed when the fireplace is not being used.
During a fire, glass screens provide a barrier which reduces the amount of heated air being channeled up the chimney, but still permit smoke and comustion gases to escape. The screens should be kept closed until it is safe to close the damper.
Caution is necessary whenb fireplaces are operated with the glass screens in closed position. Increased temperatures due to higher air velocities through intakes can warp grates or metal in conjunction with the glass doors, cause expansion of the glass doors and the steel lintel above the fireplace opening and lead to early disintegration ofthe firebox mortar joints.

SELECTION OF MATERIALS

The proper selection of quality materials is essential to the successful performance ofthe fireplace and chimney. No amount of design, detailing and construction can compensate for the imporoper selection of materials.

Brick

Building codes require that solid masonry units, i.e. cored up to 25 percent, be used for fireplace construction. Brick should conform to ASTM C 216 or C 62 for facing brick and building brick, respectively. In areas of hight seismic activity, the option exists to use hollow brick conforming to ASTM C 652 which can be vertically reinforcedand fully grouted. Grade SW should be specified for durability since the fireplace assembly is usually subject to severe exposure conditions.
For the firebox, the use of refactory brick or firebrick which conform to ASTM C 27, low duty, permit a reduced wall thickness. Refractories are more resistant to high temperatures and thermal shock. Grade SW building brick or facing brick may be used as an alternative when exposure to wood-burning firesis anticipated. Currently, ASTM Committee C-15 is working ona standard specification for firebox brick which will replacethe discontinued ASTM C 64 previously used in most model building codes.
Salvaged brick should not be used because they may not provide the strength and durablility necessary for satisfactory performance. The use of salvaged brick is discussed in Technical Notes 15 Revised.

Mortar

Combustion Chamber, Smoke Chamber and Flue. Mortars used in these locations are subject to high surface temperatures and possibly corrosive effects from combustion gases. The mortar joints at the top of the chimney flue may be subjected to periodic wetting and freeze-thaw cycling. The mortar must withstand these conditions while providing adequate support and a barrier to combustion gases. Mortars used for these three parts of the fireplace can be a refractory mortar or a conventional mortar.
Refractory mortar should conform to ASTM C 199, medium duty, and may be one of several types. The properties of each should be evaluated for the intended use and exposure. Fireclay is the primary ingredient of refractory mortars, often mixed with calcium aluminate or sodium silicate as a binder. Refractory mortars must be used with thin joints.
High-lime mortars, such as ASTM C 270 Type O portland cement-lime mortar, have been found to be more resistant to heat in the combustion chamber than high portland cement content mortars. The joint size also effects the performance of the mortar. In any case, mortar joints in the combustion chamber should be no greater than 1/4 in. (6.4 mm) thick to protect against the effects of cracking or deterioration through fireplace use.

Conventional Brickwork. It is often more convenient and economical to use only one type of mortar for all components of the fireplace and chimney. Type N portland cement-lime mortar and Type S masonry cement mortar conforming to ASTM C 270 are good all-purpose mortars for most residential fireplaces and chimneys. Chimney wind loads in excess of 25 psf (1.2 kPa) may require Type S portland cement-lime mortar. Masonry in contact with earth should be laid with a Type M mortar.

Clay Flue Liners

Flue liners should conform to ASTM C 315. They should be free from cracks or other damage that might contribute to smoke or gas leakage. Clay flue liners come in rectangular, round and oval shapes. Rectangular flue liners are either modular or nonmodular in cross-sectional dimensions. Sizes stated in ASTM C 315 for rectangular and oval liners are outside dimensions. Modular sizes start at 3.5 in. (90 mm) and increase in 4 in. (100 mm) modules and may be specified by nominal dimensions. Round clay flue liners are specified as nominal inside diameter. See Technical Notes 19B Revised for a list of clay flue liner sizes.

Steel Lintels

Steel conforming to ASTM A 36 should be used for lintels supporting brick masonry in fireplace construction.

Ties and Reinforcement

Corrugated Metal Ties. Corrugated metal ties may be used to tie brick of the fireplace walls and the exterior brickwork to wood frame backups. Ties should be corrosion resistant, at least 22 gage, 7/8 in. (22 mm) wide, and long enough to be embedded at least half-way into each wythe thickness.

Wire Ties. Wire ties are recommended for tying brick construction together. They should be at least wire size W1.7 (9 gage) and corrosion resistant. Ties should be fabricated from wire which conforms to ASTM A 82 or A 185.

Prefabricated Joint Reinforcement. Prefabricated joint reinforcement should be corrosion resistant and fabricated from wire which conforms to ASTM A 82 or A 185.

Bar Reinforcement. Reinforcement should conform to any of the following applicable standards: ASTM A 615, A 616 or A 617.

Corrosion Resistance. Corrosion resistance is usually provided by zinc coatings or by using stainless steel. To ensure adequate resistance to corrosion, coatings or materials should conform to any of the following applicable standards: Zinc-Coating of Flat Metal-ASTM A 153, Class B-2
Zinc-Coating of Wire-ASTM A 641, Class 3
Copper-Coated Wire-ASTM B 227, Grade 30 HS
Stainless Steel-ASTM A 167, Type 304

SUMMARY

This Technical Notes describes the components of masonry fireplaces and covers design and material selection. Dimensions recommended for components of single-faced fireplaces are based on empirical data from field performance of fireplaces and the expertise of the technical staff of the Brick Institute of America. The recommendations contained herein will produce a functional and durable fireplace. The information and suggestions contained in this Technical Notes are based on available data and the experience of the engineering staff of the Brick Institute of America. The information contained herein must be used in conjunction with good technical judgment and a basic understanding of the properties of brick masonry. Final decisions on the use of the information contained in this Technical Notes are not within the purview of the Brick Institute of America and must rest with the project architect, engineer and owner.

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