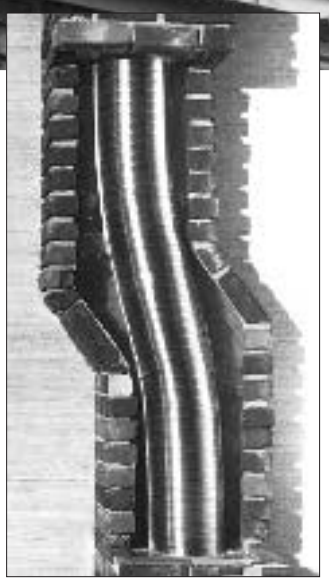
Is This Chimney Safe?

by Peter Scripture

Match the liner to the fuel type before hooking up a new furnace to an old chimney

Z-FLEX



Flexible stainless-steel pipe is a good choice for lining an old masonry chimney. It comes in several alloys to match different fuel types, and it easily installs in any chimney configuration, even one with an offset (left).

Every remodeler will eventually be asked, "Can we use this chimney?" Obviously, if the exterior masonry is cracked, bricks are loose, and mortar is falling from the joints, you have to assess the integrity of the chimney structure. But usually evaluating an old chimney comes down to evaluating the flue, and matching a new liner with the combustion appliances you will hook up to it. The information in this article will help you make the right choices.

Avoid Tile Liners

If an old chimney has a liner, it will most likely be clay tile. Most codes allow tile liners for use with virtually all appliances. But code assumes proper installation, and in my experience, that's a bad assumption. In the thousands of chimneys I have inspected or taken apart, I have never found a chimney (not one!) in which the tile liner was properly installed.

The biggest problem is that masons always cement the tiles into place, usually by grouting around them at the bottom and top of the chimney. Sometimes the space around the entire length of the liner is filled with mortar. This prevents the liner from moving freely as it expands and contracts with normal use.

Tile expansion. Tile expands a lot when it gets hot. I have seen tile liners that have expanded 4 to 5 inches upward when heated by a chimney fire. An inch or two is not unusual under normal conditions. This movement is particularly noticeable at the crown, which cracks almost as soon as it is installed because the liner pushes up when it gets hot. A chimney crown must have a bond-breaker between the flue and mortar (see Figure 1).

Corrosion. Even when installed correctly, there's ample evidence that tile does not perform well. Tile is very susceptible to corrosion from moisture and other compounds in flue gases. If the chimney gets cool enough, the vapor condenses on the inside of the chimney as a very acidic solution. Consequently, most codes require acid- and water-resistant refractory cement in tile joints. Yet this is rarely done in new chimneys, and was never done in older chimneys. The acidic water rapidly eats away the tile joints, exposing the unglazed ends of the clay tile and the masonry of the chimney, which will then rapidly degrade.

If there is enough moisture, it will be absorbed into the masonry. At excess levels, it can cause water staining and paint blistering inside the house. When this problem begins to show up, most people think they have a roof leak, but no amount of tar slapped over the chimney flashing will cure the problem.

More typically, the moisture absorbed by the tile and masonry freezes, causing the tile to break up and collapse inside the chimney. Sometimes the masonry of the outer chimney will also crack. If freezing occurs only rarely, it can take years for problems to appear. In northern climates, however, problems can surface very quickly.

Code exception. To meet code, every lining material *except clay tile* must have a UL 1777 listing. Tile has been grandfathered in, even though it failed heat shock resistance and heat transfer tests conducted by the National Bureau of Standards in 1949. In tests similar to those required for the UL standards, 21 masonry chimneys were subjected to 200 test procedures using coal, wood, and gas fuels. After the fires, examination showed that all the tiles were cracked, a few were badly broken, but all remained in place. Also, all the chimney walls were cracked, and in 24 cases, the wooden test structure caught fire. I have found no evidence to show that clay tiles are any better now than they were then.

Hopefully, you get the idea that tile is not a good choice for a chimney liner. But if you must use tile liner, try to limit its use to fireplaces or oil-burning appliances. Gas causes too much corrosion (see "Match the Liner to the Appliance," page 34). Make sure the chimney is inspected by a chimney expert before installing the appliance. To find one, look in the yellow pages under "Chimneys, Cleaning and Repair." In most parts of the country you will find someone who offers *Chim-Scan* inspections. A Chim-Scan is a video camera that can be moved up and down inside the chimney, plus a monitor to view what the camera sees. With this instrument, an inspector can literally see if the chimney is safe to use. If the tile liner is not safe, it should be removed and a new, better liner installed.

Stainless-Steel Liners

Stainless-steel pipe is a much better choice than tile for a chimney liner. Stainless-steel liner is available in almost any size or shape, and in either flexible or rigid form. Stainless steel is made in many types, depending on the alloys used, and the type must be matched with the intended use (see table, facing page).

All stainless-steel liners require insulation, which reduces creosote buildup and condensation by keeping flue gases warm (see Figure 2, page 32). In addition, every liner, regardless of the material, requires a cap to meet code. The cap keeps out rain and snow, and reduces the chance of downdrafts from wind

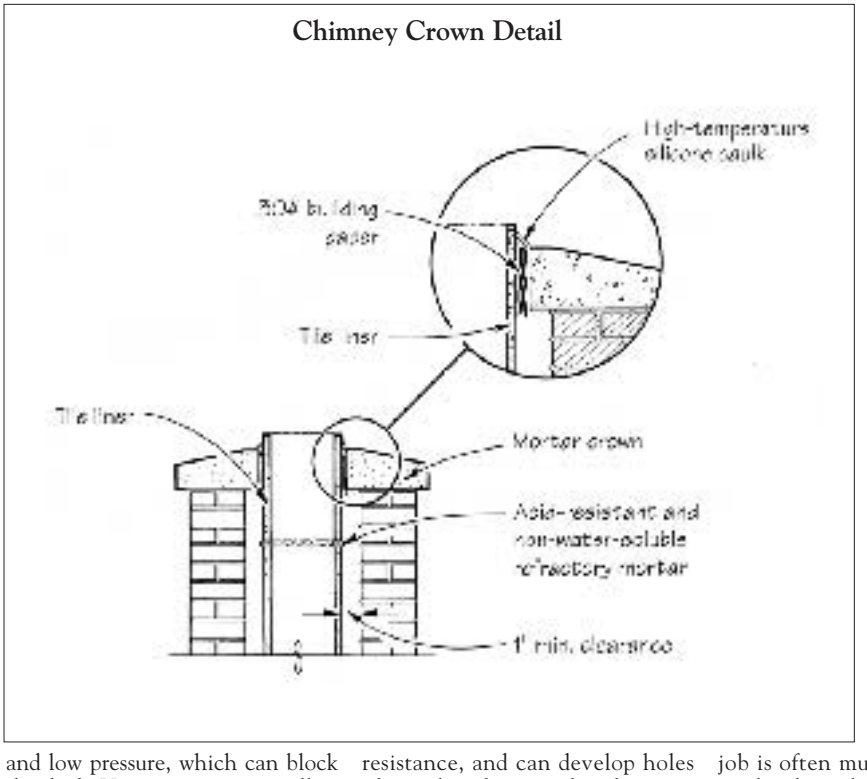


Figure 1. *A proper crown installation requires a bond-breaker such as 30# felt between the tile and the crown. After the mortar crown has set up, cut back the building paper just below the surface of the concrete and apply a bead of high-temperature silicone caulk. This creates a slip joint, which allows the chimney to expand upward when it is hot.*

and low pressure, which can block the draft. However, many installers do not include a cap in their bids. Do not accept a bid without one.

Insulation critical. The most common installation problems I have found with stainless-steel liners relate to the insulation systems. The type of insulation and how it should be applied is specified in each liner manufacturer's manual. Most liner insulation comes in foil-faced sleeves that are secured by a stainless-steel mesh. Using an insulation system approved by one manufacturer with liner pipe produced by another violates the UL listing and may be unsafe. And under no circumstances should a loose insulation be poured into the chimney around the liner pipe. I have found vermiculite, perlite, fiberglass, and even cellulose. None of these is approved for use by any manufacturer, and all can create a dangerous chimney.

All masonry absorbs water when it rains or snows. If loose-fill insulation fills the cavity between the chimney and flue, water is transferred through the insulation from the masonry to the hot flue pipe, creating steam. I have seen chimneys literally hopping up and down on the roof, "burping" steam with each hop, during normal operation of a wood stove. If a chimney fire occurs in this situation, the release of steam can be explosive.

If properly installed, however, a tested and listed liner can usually contain a chimney fire. But after the fire the liner must be replaced, even if it looks undamaged. Most fire codes require this, and for good reasons. When stainless steel is overheated (generally above 800°F to 900°F), it loses its corrosion-resistance, and can develop holes after only a few months of continued use. Overheated liner pipe can also become very brittle. I have seen pieces of 24-gauge stainless steel that you could snap as easily as a potato chip.

Class A and B Chimneys

Aluminum and galvanized-steel liners — sometimes referred to as factory-built chimneys — are sometimes used as liners, but are more appropriate for free-standing chimneys or vents inside a wooden chase.

Class A chimneys — often referred to in the field by the tradename *Metalbestos* — can be used with all fuels (see Figure 3, next page). These are made in two types: solid-pack-insulated double-wall pipe and air-insulated triple-wall pipe. The chief problem in using factory-built chimney sections as liners is that the old chimney is usually not large enough to allow for their installation. Also, you can use these sections only in a straight chimney, and they are extremely heavy — you'll need a power winch and cable to lower one into a chimney. For this reason, the installed cost for a retrofit job is often much higher than an insulated stainless-steel liner.

Class B (double-wall air-insulated) chimneys — commonly called *B-vent* — are designed for venting noncondensing gas appliances only. Typically, these have an aluminum liner inside a galvanized steel sleeve. Although usually installed inside a wooden chase, this type of vent can be installed as a liner in a masonry chimney if space allows. B-vent is much lighter than a Class A chimney, and so is much easier to install.

No factory-built chimney has a zero-clearance listing, so all Class A and Class B chimneys must be installed with the clearances specified by the manufacturer. Most of the builder installations I see violate these clearances.

Cast Liners

From my experience, cementitious, cast-in-place liners are the best choice for all fuels. In general, the insulation properties and moisture resistance of these lining systems are superior. This means they are more resistant to heat shock and condensation problems and therefore offer the longest expected

Stainless-Steel Liner Types

Combustion Appliance	Stainless-Steel Liner
Wood	Type 304
Pellet	Type 304
Coal	Type 316 or 321
Oil (noncondensing)	Type 304
Mid-efficiency gas (noncondensing)	Al 29-4C

Note: *Do not use stainless-steel liners with any condensing gas appliance. Use only high-temperature plastic vent.*

lifetimes. They are often the most expensive option, but not by a lot. Material costs vary by the amount of cement required. An 8x8 chimney with a 6-inch flue, for example, doesn't require a lot of cement, and so can be a less expensive option than an insulated stainless-steel liner, depending on conditions.

The most common brand names are Ahrens, Golden/Flue, National Supaflu, and Solid/Flue. All of these products, except Ahrens, are installed in a similar manner (see Figure 4, facing page). A rubber "tube form" is inserted and centered in the chimney, then inflated to the diameter of the flue required by the appliance being installed. A "gate form" is positioned in the thimble opening (where the vent pipe connects,) and then the liner material is mixed and pumped into the chimney. In general, these liner materials should not be bucketed and dumped in the chimney. Bucketing is slow and can cause cold joints in the concrete and consequent damage to the liner.

Ahrens uses a different installation method. A vibrating steel bell of the correct flue size is suspended in the chimney. Then a very stiff liner mix is dumped into the chimney while the bell is winched to the top. This vibrating bell compacts the mix and forms the flue opening.

Look for UL rating. Most cast liners are tested and UL-listed. The exception is Insulcrete. If you run across someone who installs this brand, be warned that this product is not tested and listed.

To pass the test for a UL 1777 listing, a liner must survive a series of high-temperature burns (with flue gas temperatures ranging from 1,000°F to 2,100°F). The test procedures monitor the liner for resistance to *heat shock damage* and *resistance to heat transfer* (see "Common Chimney Terms," facing page) to make sure that liners can withstand even the worst chimney fire without causing a fire in the building. All listed products have passed these tests with a one-inch air space around the chimney. However, chimney liner installers wanted the products to be tested to zero-clearance standards, since few chimneys outside the laboratory have an air space around them. UL devised an optional, second series of tests, but only Solid/Flue passed the original tests for a zero-clearance listing. Manufacturers then lobbied UL to reduce the burn times. Now all the cast liners have a zero-clearance listing.

Conflicting requirements. To pass the tests, cast liners must have a low coefficient of expansion (to prevent heat shock that will crack the material when heated). But they must also insulate well (to prevent heat transfer to the structure) and be lightweight (so the wet mix will not push the chimney outward when it's

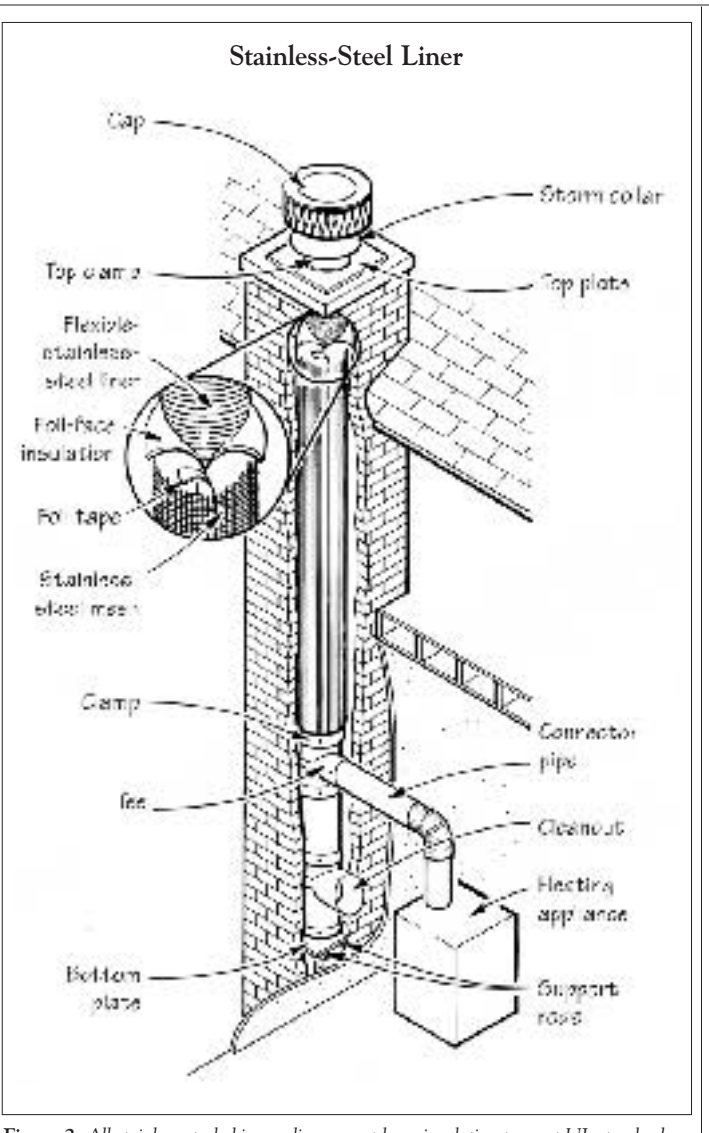


Figure 2. *All stainless-steel chimney liners must have insulation to meet UL standards. The insulation jacket prevents flue gases from condensing inside the flue. Also, every liner, regardless of the material it is made from, must have a cap to meet code. The cap keeps out rain and snow and reduces the chance of downdrafts that can block the draft.*

Figure 3. *A Class A chimney is suitable for all fuel types, but it works better as a free-standing chimney than as a liner for an existing masonry chimney. The sections can be installed only in a straight chimney, and are extremely heavy, requiring a power winch and cable to lower them into place.*

Common Chimney Terms

Chimney and flue: The terms "chimney" and "flue" are often used interchangeably, but this is incorrect. A *flue* is a shaft designed to vent the products of combustion from a stove, furnace, or water heater to the outside air. The *chimney* surrounds and supports the flue. Many chimneys have just one flue. But a chimney can have more than one flue, such as a colonial center chimney with flues for several fireplaces, or a wooden condo chimney with several metal chimney flues inside.

Draft, buoyancy, and flue sizing: The tendency of hot air to rise is called the *buoyancy* of air. In a flue, hot air venting from the furnace is confined by the flue and "floats" upward, allowing the surrounding air to flow into the furnace. This is what we know as *draft*.

From this you can see the importance of proper *flue sizing*. If a small amount of hot gas venting from a furnace mixes with a large amount of cool air in an oversized flue, the gas will cool rapidly and reduce the draft. If the flue gas cools to the temperature of the surrounding air, the draft stops altogether.

Heat shock: This occurs when a cold liner undergoes a rapid change in temperature. When outside temperatures are below freezing, any part of the chimney not enclosed by the house will be frozen, too. So just building a rip-roaring fire in the fireplace can crack a liner. Tile, which is not UL listed for resistance to heat shock, is particularly susceptible.

Heat transfer: This is simply the insulation value of the liner material, and is important since virtually all old houses, and some new ones, have framing that touches the chimney. Therefore it is very important that the liner you choose has passed the UL zero-clearance test, and even more important that the liner is installed according to the manufacturer's instructions.

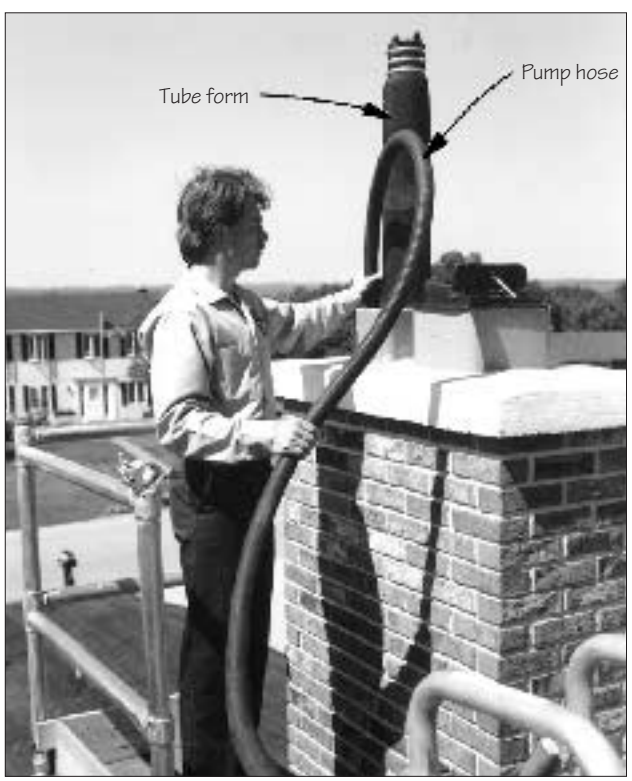
Liner: This term is often used interchangeably with "flue." This is okay, though the term *liner*, when correctly used, refers to the material that the flue is made of, while "flue" denotes the space inside the liner. An *unlined chimney* is a chimney without a flue, which is not suitable for any use. Using an unlined chimney to vent any type of combustion appliance is a violation of all fire codes. But just because a chimney has a liner does not automatically make it suitable for all uses.

Pyrolization: During a chimney fire, temperatures inside a flue can exceed 2,000°F. This will heat the outside of the chimney to extremely high temperatures, causing combustibles such as framing or lath that touch the chimney to catch fire. Wood normally combusts at just over 400°F. But if chimney fires have occurred in the past, the combustion point of the surrounding wood can be much lower. Repeatedly heating wood to temperatures near its combustion point causes a chemical change called *pyrolization*. This change can cause the wood to combust at temperatures below 200°F.

Vent: The term *vent* is commonly used to refer to a flue of any type, but in the official language of building codes, it specifically refers to a flue for a gas-burning appliance.

— *P.S.*

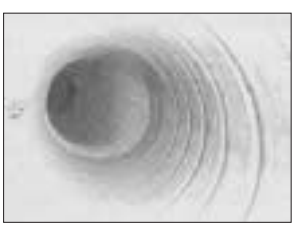
Cast Liner Installation



NATIONAL SUPAFLU SYSTEMS

A.

B.



C.

Figure 4. *Cast liner installation.* *Starting with an unlined chimney (A), a rubber tube form is inflated with air, then centered between the chimney walls. Next, the liner material is mixed and pumped into the chimney (B). After the mix sets up, the tube is deflated and removed, creating a flue (C). Depending on the fuel to be burned by the appliance, the flue may have to be sealed.*

Match the Liner to the Appliance

Different residential appliances have varying flue requirements, both in size and material. Here's a look at the common types, starting with fireplaces.

Fireplaces

A properly-sized fireplace flue will go a long way towards assuring that the new fireplace will draw well and not leak smoke into the home. The size (cross-sectional area) of the flue and its height above the damper determine the size of the fireplace opening. For a conventional style fireplace (one in which the opening is wider than it is high), follow the sizing rules shown in the chart, below. If you are considering a Rumford fireplace, the flue size should be even larger, as shown.

Gas Appliances

Gas-burning appliances vary widely in their venting needs, depending on how efficiently they produce heat. Old-style furnaces (less than 78% AFUE) send so much heat up the flue that there is rarely a problem, because the exhaust gases stay hot until they are safely past the flue cap. But as furnaces have improved, more heat goes into the house and less goes up the flue. If the flue gases cool below about 130°F before they leave the flue, the water vapor that is a natural product of combustion will condense in the flue.

High-efficiency furnaces. These run at 83% to 97% AFUE and always condense. They should never be hooked up to a conventional chimney. Instead they must be direct-vented through a special noncorrosive plastic vent pipe made with GE *Ultem* plastic. Two brands are available — Plexvent (Plexco, 3240 N. Manheim Rd., Franklin Park, IL 60131; 708/455-0600) and Ultravent (Hart and Cooley, 500 E. 8th St., Holland, MI 49423; 616/392-7855). These vents must have a drain line to carry the acidic condensate to a floor drain.

Mid-efficiency furnaces. Like most of the high-efficiency models, any mid-efficiency (78% to 83% AFUE) boiler or furnace must have a fan-induced draft to drive the cooler combustion gases up the vent. These also have a tendency to condense and may require high-temperature plastic vents. Follow the manufacturer's recommendations closely.

This is not to say that furnaces designated "noncondensing" can't cause condensation in the chimney. In fact, damage from condensation is the most common problem I see in chimneys with mid-efficiency furnaces connected to them. If you add a new gas furnace to an existing tile flue, you're likely to see flue damage within a couple of years.

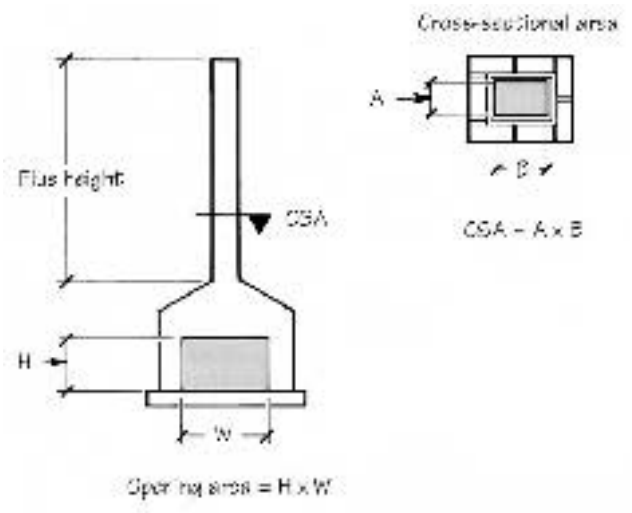
Proper vent sizing is the most important way to ensure that combustion gases stay warm. If the vent is too big, the combustion gases won't be able to warm the large column of cold air in the flue and will condense immediately. Familiarize yourself with the new sizing tables in the National Fuel Gas Code (available for $22 from the American Gas Association, 1515 Wilson Blvd., Arlington, VA 22209, or the National Fire Protection Association, 1 Battery March Park, Quincy, MA 02269). This code, which is referenced as NFPA 54 ANSI Z223.1, includes new vent sizing tables. To make sense of these in "real world" vent configurations, get a copy of Simpson DuraVent's *Sizing Handbook* (see "Sources of Supply" at end of article).

If your client has an outside chimney, lives in a very cold climate, or heats the house only intermittently, the chances are high that the gases from a natural-draft appliance will condense. Where the possibility of condensation exists, use Al 20-4C stainless steel or one of the cementitious liners. Be aware, however, that recent evidence indicates that even A1 20-4C may not resist corrosion well if the furnace draws chlorine vapor in its combustion air (as may occur if the laundry area is near the furnace). The chlorine and water vapor produce hydrochloric acid, so even the slightest wetting of the flue liner leads quickly to corrosion.

Oil Appliances

In general, oil-fired appliances have fewer flue problems, because flue temperatures are higher and the exhaust gases contain less water vapor. Type 304 stainless steel is suitable for noncondensing oil-fired

Flue Sizing for Fireplaces



	Flue height		
	11 to 15 ft.	**15 to 25 ft.**	**25 ft. or more**
Conventional fireplace	CSA = 1/10 opening area	CSA = 1/12 opening area	CSA = 1/14 opening area
Rumford fireplace	CSA = 1/8 opening area	CSA = 1/10 opening area	CSA = 1/12 opening area

In determining the size of a fireplace flue, the cross-sectional area (CSA) of the flue must be proportional to the area of the fireplace opening. The proportion varies with flue height. Note that the proportions differ for Rumford fireplaces.

Match the Liner, cont.

appliances. Nevertheless, the safest liner choice is A1 20-4C stainless steel or one of the cementitious liners. Oil soot contains sulfur, which combines with water to make highly corrosive sulfuric acid. To avoid this, do not vent a gas water heater into the same flue with an oil-fired furnace. Also have the chimney cleaned before hooking up a new gas appliance to a flue that used to vent an oil-fired appliance. Even if you stick with oil, the chimney should be inspected and cleaned yearly.

Solid-Fuel Appliances

Solid-fuel appliances include wood, coal, and pellet-burning stoves and furnaces.

Wood. Any cementitious liner or Type 304 stainless steel is suitable for use with wood or pellet fuels. However, the flue must be cleaned regularly.

Most wood furnaces regulate heat output by damping down the fire. This causes inefficient combustion, which creates a lot of creosote in the chimney flue, particularly if the flue is too large. A heavy creosote accumulation in a flue is a significant fire hazard. The chimney should be cleaned to remove this creosote whenever the deposits inside the flue reach 1/4 inch in thickness. Since this amount can form in a few weeks (or sometimes in a few days), any homeowner planning to use a wood furnace should be prepared to inspect and clean the chimney often. If the chimney is not cleaned, the accumulating creosote will eventually cause a chimney fire.

Wood stove flue requirements are similar to those for wood furnaces. Wood stoves are the most common type of heating appliance I see in my area and they have the most problems, chiefly because the draft required for combustion is directly regulated by the owner.

In general, wood should always be burned in a flaming fire, not a smoldering fire. If more than a few wisps of smoke are visible coming out of the chimney, wood heat is being wasted. If less heat is required, the owner should put less wood in the stove instead of reducing the draft.

Pellet. In some areas, pellets are the cheapest fuel available on a heat output basis. Pellet fuels look like feed-grain pellets and are produced with similar equipment. They are made from various organic materials, usually considered waste, that are high in cellulose. These materials include lumber mill trimmings and sawdust, used cardboard, corn cobs, and shells from pecans and walnuts. Pellet furnaces require a small flue, usually 4 to 6 inches in diameter. Combustion residue in the flue consists of a fine noncombustible ash, which accumulates quite slowly.

Coal. Unless you go with a cementitious liner, Type 316 or 321 stainless steel is required for coal. Coal combustion produces considerable ash and some of it collects inside the flue. This ash has a lot of sulfur in it and is hydroscopic, drawing moisture out of the air when the furnace is not operating. This creates sulfuric acid, which attacks the mortar joints between flue tiles and will rapidly destroy the vent pipe on a furnace as it sits idle for the summer in a damp basement.

Coal stoves, in common with coal furnaces, require very precise draft regulation to operate properly. But stoves tend to have more draft problems because they are usually not installed by professionals. Coal stoves require a barometric damper in the vent pipe; this damper must be adjusted with a draft gauge when the stove is operating. In my experience this is usually not done, and creates incomplete combustion with its attendant problems.

Combining Appliances

The National Fuel Gas Code prohibits mixing the combustion gases from any solid-fuel appliance with any gas appliance. If a client wants to hook up a wood stove to a chimney that vents a gas furnace, for example, each appliance should have its own properly-sized flue. If you need two flues, say for a wood stove and a gas furnace, and the existing chimney is not large enough for both, the safest choice may be to replace the furnace with a direct-vented model. Then line the chimney to accommodate the wood stove.

The code does allow mixing gases from oil and gas appliances in the same flue, provided the flue is sized and connected properly. But while this practice is legal, I don't think it's wise. By introducing the "wet" gases from a gas-burning water heater into a flue that vents an oil furnace, for example, you are increasing the risk of creating a highly-acidic condensation that will degrade a chimney rapidly.

In general, I don't recommend combining the combustion gases from two different fuels in one flue. However, if you must, mixing oil and wood is the least likely to cause problems. And, of course, it's all right to vent the gases from like fuels — a gas water heater and a gas furnace, for example — provided the flue is big enough to handle both appliances.

— *P.S.*

installed). These requirements call for a low-density cement with a lightweight, insulating aggregate. But resistance to abrasion, high strength, and low water-absorption are also required, and for these you really need a heavy, dense cement.

Different manufacturers solve these conflicting requirements in different ways. To meet the heat transfer requirements, different brands require various minimum thicknesses. For the one-inch clearance requirement, Solid/Flue requires only 3/4 inch of material. The other brands require one inch to meet the revised UL 1777 zero-clearance standard. Because of the testing expense, Ahrens and Solid/Flue have not been tested to the new standard and still require 1 1/2 inches for a zero-clearance listing.

These differences in thickness may seem small, but they can be very important. Suppose the furnace you need to connect has a 7-inch-diameter outlet pipe. The lined flue in this case would need to be 7 inches in diameter, too. If the existing brick chimney has a typical interior dimension of 8 1/2x12 1/2 inches, only Solid/Flue could line this chimney and meet code. (Ahrens could do it too, if an oval bell 5 1/2x9 1/2 inches were available, but to my knowledge the smallest oval bell is larger than that.)

To pass the strength requirements, manufacturers vary the compressive strengths of the concrete mixes. Compressive strengths range from a low of 693 psi for National Supaflu to a high of 2,090 psi for Solid/Flue. A high-strength mix allows you to save an old chimney made with soft bricks and weak mortar joints. A chimney like this may require temporary support while it is being lined, but once lined, the liner material in effect supports the chimney.

Finally, cementitious materials must have good resistance to water absorption. Ahrens requires coating the inside of the cast liner with a sealer before using the flue for any type of fuel. Some of the other brands require a coating only when using gas-burning appliances. All of these coatings must be redone periodically to maintain the service life of the flue — except Solid/Flue, which does not require a coating for any fuel.

New Liners

There are also a few brands of tile liner, usually imported, that are very different from common clay tile. For example, Ahrens produces a ceramic liner called Ceramu-Flue, which can be lowered into a chimney in sections. It seems equivalent in durability to the best of the cast-in-place liners, but can be used only in a straight chimney without any offsets.

Another product to watch for is made from precast sections of Solid/Flue concrete. This product is not yet available, but when it is, it promises to handle much like tile liners, without all of their attendant problems. ■

Peter Scripture has been in the building trades for 30 years. For the last 12 years he has specialized in building, repairing, lining, and cleaning chimneys.

Sources of Supply

Cast liners:

Ahrens Chimney Technique
200 Industrial Ave.
Sioux Falls, SD 57104
800/843-4417

National Supaflu Systems
P.O. Box 89
Walton, NY 13856
800/788-7636

Golden/Flue
Rt. 3, Box 237
Rutherglen, VA 22546
804/798-1089

Solid/Flue
4937 Starr St. S.E.
Grand Rapids, MI 49546
800/444-3583

Metal liners:

Copperfield Chimney Supply
304 S. 20th St.
Fairfield, IA 52556
515/472-4126

Heat Fab
38 Haywood St.
Greenfield, MA 01301
800/772-0739
413/774-2356 (in Mass.)

Metal-Fab
P.O. Box 1138
Wichita, KS 67201
800/835-2830
316/943-2351 (in Kan.)

Michigan Chim Flex
39210 W. 9 Mile Rd.
Northville, MI 48167
800/289-2446

ProTech Systems
25 Ganesvoort St.
Albany, NY 12202
518/463-7284

Selkirk Metalbestos
17120 Dallas North Pkwy.
Evergreen Center, Ste. 205
Dallas, TX 75248
800/635-6507

Simpson Duravent
P.O. Box 1510
Vacaville, CA 95696
800/227-8446
800/922-1611 (in Calif.)

Z-Flex
P.O. Box 4035
Manchester, NH 03108
800/654-5600