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THE CHIMNEY

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How Chimneys Work

An effective chimney is an important part of any successful wood-burning system. Many of the complaints about poor performance of wood-burning systems are traced to chimney problems of various kinds. Knowing how chimneys work is not only necessary in selecting the correct chimney and designing the installation, but is useful in the day-to-day operation of the system.

Modern, efficient appliances need modern, efficient chimneys. The selection, location and installation of the chimney is at least as important as the type of wood-burning appliance you choose. A properly designed and installed chimney will give many years of reliable service and will allow your appliance to perform properly.

Chimneys operate on the principle that hot air rises. The hot gas in a chimney tends to rise because it is less dense than the cold air outside the house. The rising hot gas creates a pressure difference called draft which draws combustion air into the appliance and expels the exhaust gas outdoors. The hotter the gas compared to the outdoor air, the stronger the draft.

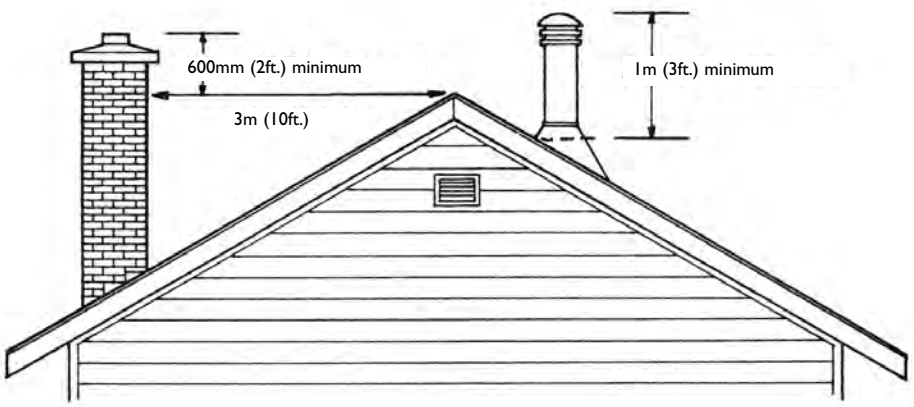
The chimney's function is to produce the draft that draws combustion air into the appliance and safely release the exhaust gases to the outdoors. To fulfil this role, the chimney must:

- Isolate nearby combustible materials from flue gas heat.
- Conserve flue gas heat to produce strong draft.
- Be resistant to corrosion on the inside and to weather effects on the outside.
- Be sealed to prevent leakage.
- Tolerate the high gas temperatures that can result from chimney fires.

Here are some guidelines for effective chimney installations. Some are code requirements, others are recommended for good chimney performance:

- Building codes require that the top of the chimney extend not less than 1 m (3 ft.) above the point it exits the roof, and 60 cm (2 ft.) higher than any roof, building or other obstacle within a horizontal distance of 3 m (10 ft.). These rules are intended to place the top of the chimney higher than any areas of air turbulence caused by wind. In practice, chimneys must sometimes be higher than this to clear air turbulence caused by nearby obstacles.

- **The chimney should be installed up through the house rather than out through a wall and up the outside.** When chimneys run up outside walls, they are exposed to the outside cold and this chilling effect can reduce the available draft at the appliance. Even worse, outside chimneys create cold backdrafts when the appliance is not in use, particularly if it is a basement installation. A



The top of a chimney should be high enough to be above the air turbulence caused when wind blows against the house and its roof. The chimney must extend at least 1 m (3 ft.) above the highest point of contact with the roof, and at least 60 cm (2 ft.) higher than any roof line or obstacle within a horizontal distance of 3 m (10 ft.).

backdraft allows cold air and odours to flow down the chimney, through the appliance and into the room. A backdrafting chimney also makes it hard to build a fire without getting smoke in the house. Chimneys that run up through the house benefit from being enclosed within the warm house environment. Inside chimneys produce stronger, more reliable draft and do not cold backdraft.

- Keeping flue gases hot is the best way to produce reliable chimney draft. If you experience problems such as sluggish draft or smoking when you open the loading door to add fuel, low flue gas temperature may be the problem. You can increase chimney temperature by building smaller, hotter fires made with smaller pieces of wood. A 90 degree elbow in a flue pipe assembly may be replaced with two 45 degree elbows to reduce the horizontal run and improve flow. If your chimney is made of brick, you could have a stainless steel liner installed. The new liner will improve draft by keeping the flue gases hotter as they rise in the chimney.
- Taller chimneys usually produce stronger draft. A rule of thumb for minimum height states that the total system height (from the floor the appliance is mounted on to the top of the chimney) should never be less than 4.6 m (15 ft.). Most normal installations exceed this height, but installations in cottages with

shallow-pitch roofs may not. If draft problems are experienced with a short system, consider adding to the chimney height. However, if draft problems are experienced with systems higher than the recommended minimum system height, adding to the chimney may have little or no effect.

- The chimney flue should be the same size as the appliance flue collar. Over-sized chimneys were common in the past, partly because people used to think that bigger is better. Now it is clear that bigger is not better when it comes to chimney sizing. A given volume of flue gas flows faster and has less time to lose heat in a small chimney flue than in a large one. In planning wood heating systems, experienced installers will sometimes choose a chimney that has a smaller inside diameter than the appliance flue collar. This is usually done when the chimney runs straight up inside the house and is very tall. Chimneys that are more than 8 m (about 25 ft.) in height sometimes produce more draft than the appliance needs, so a smaller chimney can be used without any reduction in performance. The decision as to whether the flue size may be reduced from that of the appliance flue collar must be left to an experienced technician.

Suitable Chimney Options

There are two general types of chimneys that are approved for use with wood-burning appliances:

Factory-built metal chimneys of particular types may be used with wood-burning appliances. Wood stoves, central heating furnaces and some factory-built fireplaces must use the 650°C (1,200°F) metal chimney. The continuous gas temperature it is designed for is higher than for chimneys intended for other fuels. Most factory-built fireplaces are also approved for use with a special chimney that has the same upgraded liner found in the 650°C type. Your wood heat retailer can show you the differences between these types and which one you will need to use for your installation. All factory-built chimneys must be installed exactly according to the manufacturer's instructions and only certified components should be used.

Masonry chimneys that are built according to the rules found in building codes may be used with wood-burning appliances. These chimneys have a clay tile liner surrounded by a brick or stone shell. If you are planning to have a masonry chimney built, be sure to get a building permit and make sure the mason who builds it knows and follows the code rules. Insulated stainless steel liners can be used as an alternative to clay liners in new masonry chimneys to reduce heat loss and improve performance.

If you see any deterioration of the bricks or mortar joints near the top of the chimney, or if there are dark stains on the brick work, you should have the chimney inspected immediately. Hire a chimney sweep certified under the WETT program to clean and inspect the chimney. Masonry chimneys that have been damaged by a chimney fire or are too large for the appliance you want to connect can be relined with a certified stainless steel liner. These liners can be of either rigid or corrugated flex design.

Unsuitable Chimneys

Type A Chimneys are an older type of metal chimney used before 1981 and are not considered suitable for wood-burning appliances. Type A chimneys were originally designed for oil furnaces and are unable to withstand the high temperatures of a chimney fire. If your chimney has a painted exterior or if the outside casing is square, it could be a Type A. If you have a Type A chimney, upgrade it to the new 650°C chimney as soon as possible. Deteriorated metal chimneys can be hazardous.

Bracket masonry chimneys are not supported on proper concrete foundations and should not be used. Bracket chimneys are brick chimneys built on wooden supports within a wall of the house. They are common in older houses, particularly in rural areas. Bracket chimneys cannot be upgraded to meet current building code requirements and should be replaced.

Unlined masonry chimneys should not be used because all masonry chimneys must have a liner made of clay tiles, firebrick or stainless steel to be considered suitable. In some cases old, unlined chimneys can be upgraded by the installation of a certified stainless steel liner.

Air-cooled chimneys are used for some decorative factory-built fireplaces. Air-cooled chimneys use a flow of air between inner and outer layers to keep the outer surface cool. Wood-burning heating appliances, such as stoves and furnaces, should never be connected to air-cooled chimneys.

Creosote and Chimney Fires

Wood smoke can condense on the cool inner surface of a chimney, producing a build up of creosote deposits. Creosote is a highly-flammable material and if it ignites at the base of the chimney, it can produce a raging fire that travels up the chimney causing extremely high temperatures as it spreads. The high temperature can damage the clay liners in a masonry chimney or the metal liner in a factory-built chimney. Although 650°C chimneys can withstand chimney fire temperatures, the heat still causes extreme stress in the chimney.

Chimney fires are the result of poor appliance firing techniques combined with a lack of proper chimney maintenance. When wood-burning appliances are operated properly using the techniques outlined later in this book, some creosote may still be deposited, but it will be of a less combustible type. Instead of the black, tarry type of creosote that results from smouldering fires, the creosote that results from proper firing is soft, flaky or powdered.

Chimney fires can be prevented. Your chimney should be checked for deposits regularly until you know how quickly creosote builds up. Older, conventional wood stoves and furnaces can produce creosote quickly because they are unable to burn the wood as completely as the advanced designs. In severe cases, enough creosote to sustain a damaging chimney fire can be deposited in only a few weeks. The newer, low-emission wood stoves burn the wood so completely that when they are operated properly their chimneys normally need cleaning only once each year.

Never assume that the chimney is clean. Check it regularly to be certain, especially during the spring and fall. If you do have a chimney fire, have the chimney inspected and repaired if necessary before using the system again.

Preventing Smoke, Smells and Cold Hearths

The spicy smell of wood smoke in the air on a cold winter evening can be pleasant. But the smell of wood smoke inside your home is a sign that the wood-burning system is not functioning properly. The smoke contains harmful air pollutants that can be irritating or even dangerous in high concentrations. Properly designed, installed and operated wood-burning systems do not spill smoke into the house. There are three main reasons why some wood-burning systems smoke:

Bad system design: There are design characteristics that can make a wood-burning system more likely to spill smoke. Most of these characteristics result in low flue temperatures and low draft. For example, chimneys that run up the outside wall of the house can rob the heat from the exhaust and produce very little draft. Long flue pipe assemblies allow too much heat to be given up before the gases reach the chimney. Each elbow in the flue pipe assembly slows down the flow of gases and causes a small restriction to flow. When an assembly includes more than one elbow, the restriction can be enough to cause spillage. Any one of these problem characteristics is not usually enough to cause smoke spillage on its own. However, when, for example, an outside chimney is combined with a long flue pipe assembly with several elbows and serves an appliance located in a basement, it is almost certain that smoking will be a problem.

Negative pressure in the house: Canadian houses are more tightly sealed than in the past through the use of better doors and windows and construction techniques. Modern houses are more energy efficient, but are also more sensitive to depressurization when air is exhausted from the house. Where problems arise, the cause is often a powerful kitchen range exhaust.

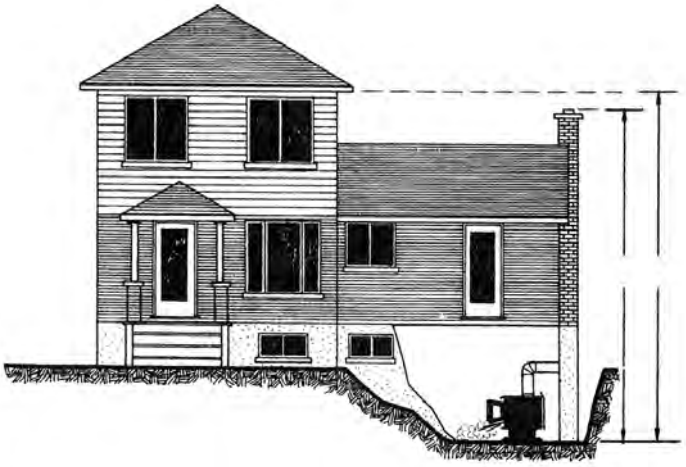
Because new houses are tightly sealed, there are few holes to allow replacement air to enter, and the house pressure becomes negative compared to atmospheric pressure outside. This negative pressure works against chimney draft and can cause a wood burning appliance to spill smoke, especially when a fire is started or as it dies down to coals. Because it is difficult to predict when or if spillage due to house depressurization will occur, it is important to have a smoke detection and alarm system installed. Such a system includes at least one smoke detector on each level of the house and at least one carbon monoxide detector. The risk of smoke spillage in a house with a large kitchen range exhaust can be eliminated if the exhaust fan is electrically interlocked to a make-up air system that forces air into the home to replace the exhausted air. Contact your wood heat retailer or heating contractor for details.

Improper appliance firing technique: When a wood fire is starved for air it smoulders, producing a relatively cool, smoky fire. The problem usually happens when the air control is turned down too low. During a smouldering fire the temperatures throughout the system are low, meaning that the chimney will not be receiving the hot gas it needs to produce strong draft. Smoke will spill into the room if the appliance loading door is opened as a fire smoulders. A smouldering fire is the single most common reason for smoke spillage. By using the suggestions on proper firing technique later in this book, you will be able to avoid these smouldering fires.

Does an Outdoor Air Supply Prevent Smoke Spillage?

It has been widely believed that smoke spillage could be reduced or eliminated by supplying outdoor combustion air through a duct, either directly to the appliance firebox or indirectly to the room in which the appliance is installed. However, research shows that outdoor air supplies do not work. When an exhaust fan is running, smoke spillage from an appliance can occur at the same pressure level, whether or not an outdoor air supply is installed. The same research shows that wind effects around the house can reverse the flow in these ducts, drawing air and possibly smoke through the duct to outdoors. This reverse flow can be hazardous if the duct is directly connected to the appliance firebox.

Some building codes still require that outdoor air be supplied to wood-burning fireplaces. You must comply with this rule, but be aware that performance will not improve, and take steps to protect combustible materials around the duct from overheating if the gas flow reverses.



The wood stove in this house will almost certainly have operating problems. Fires will be fussy to light because draft in the system will be weak until the chimney is thoroughly warmed. Smoke may spill from the door when it is opened for loading and there will be some risk of smoke spillage as the fire dies down to a coal bed. Note that the chimney top is lower than the ceiling of the second story, meaning that the house is a higher effective stack than the chimney. The chimney is also located outside the building where it will be cooled. This installation could be improved by moving the appliance and chimney to the wall next to the two-storey section of the house. The chimney would run inside the house up through the second floor and be protected from the cold. It could also be made tall enough to clear the roof of the taller section of the house without being unsightly.

How Chimneys and Houses Interact

The location of the chimney has a big effect on how it functions and on the operation of the wood burning appliance connected to it.

A chimney is an enclosed column of warm air or gases surrounded by colder outside air. The warm air or gas in the chimney is more buoyant than the dense cold outside air so it rises, producing draft in the system.

In winter, your house is also an enclosed column of warm, buoyant air creating a form of "draft." In effect, the rising warm air pushes up towards the top of the house, creating higher air pressure there. At the same time, the pressure in the basement is lower than the pressure outside. That is why the basement of a leaky house feels drafty, as the cold outside air is drawn through leaks into the area of lower pressure, while rooms on the second floor are more comfortable. The difference in pressure at various levels of the house is called **stack effect**. This stack effect can work against upward flow in an outside chimney that serves an appliance installed at the lowest level of a house.

The "Cold-Backdraft-at-Standby"

Many people who heat with wood have experienced this: they go to the basement to build a fire in the wood stove and when they open the door to put in the newspaper and kindling, they can feel cold air. When they light the kindling, the smoke comes into the room instead of up the chimney. This is a cold-backdraft-at-standby. Although this reverse flow can be caused by negative pressure in the house produced by a kitchen range exhaust, it is most often the combined effect of an outside chimney and a basement appliance location.

Here is how it works. When there is no fire in the stove, fireplace or furnace, the air in the chimney cools to the outside temperature and the chimney produces no draft at all. The very slight negative pressure in the basement caused by stack effect in the house is enough to pull the air down the chimney and out through any openings in the stove. The cold air does not fall down the chimney, but is sucked down by stack effect.

Homeowners who have installations like this have found ways to get the fire started without smoke spillage. The usual remedy is to open a basement window or door to neutralize the negative pressure while the fire is lit. Although it does work, this technique only masks the problem, it does not correct it.

If you never want to experience a cold-backdraft-at-standby, don't combine an outside chimney and basement stove location in your installation plans.

Some houses produce more stack effect than others. Two- or three-storey houses produce more stack effect than bungalows because their column of warm air is taller. A house with most of its leaks at the upper levels tends to produce more stack effect because the leaks offer a ready path for warm air to escape—like the open top of a chimney.

Uninsulated, outside chimneys can reverse if the stack effect is strong enough, allowing smoke or cold outside air to spill into the house through the appliance.

Stack effect is always present in houses during cold weather, but its influence can be virtually eliminated by installing the chimney inside the building and routing it so that it exits the house at the top of the highest heated space. Good chimneys—ones that are insulated and run up through the house—are able to overcome the influence of stack effect.

One situation in which the influence of stack effect is most troublesome is where an appliance connected to an outside chimney is installed in the basement of a single-storey addition to a two-story house, as shown in the illustration on page 48. This form of installation should be avoided if possible.