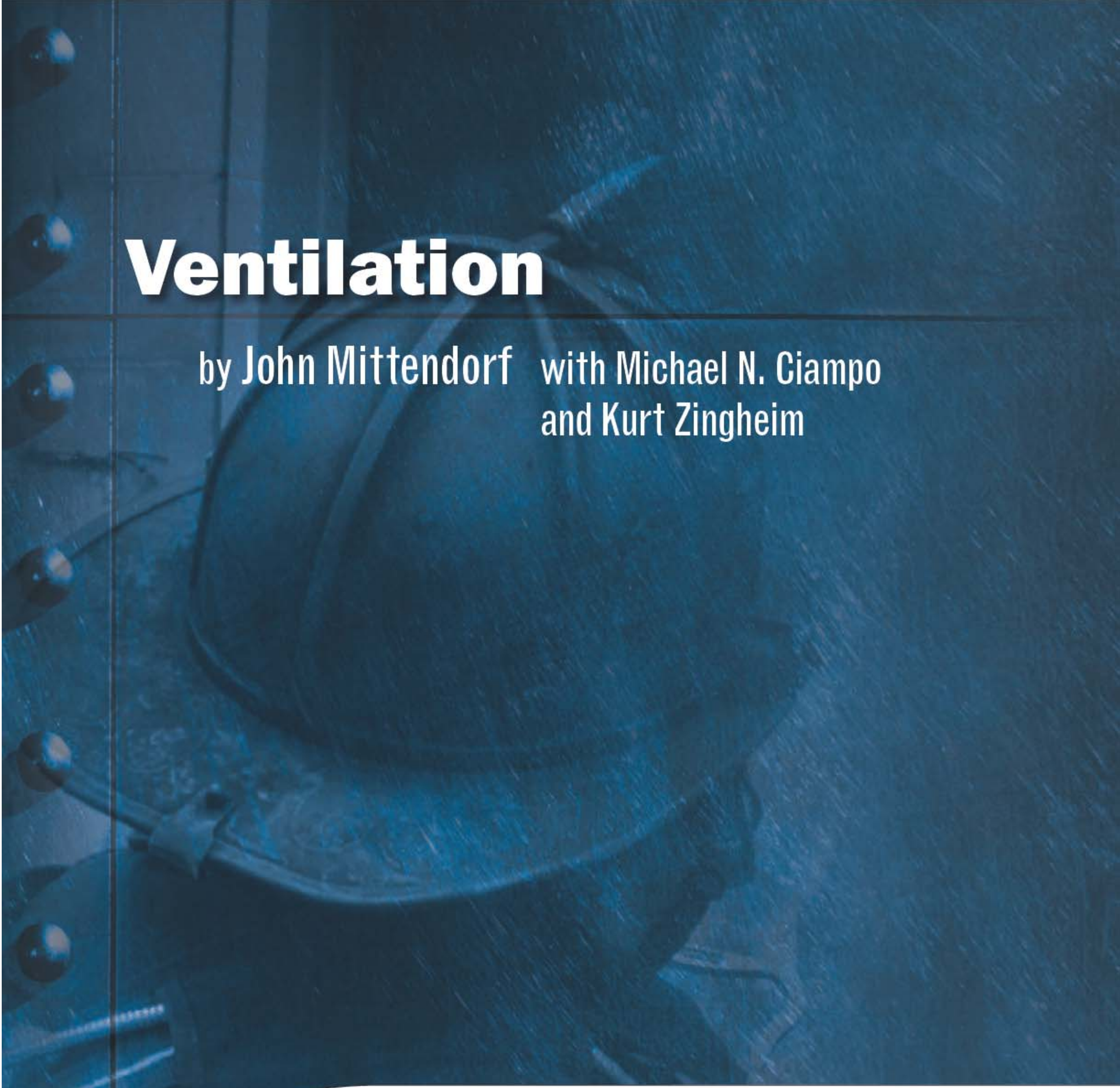


Ventilation

by John Mittendorf with Michael N. Ciampo and Kurt Zingheim

This chapter provides required knowledge items for the following NFPA Standard 1001 Job Performance Requirements:

FFI 5.3.11

FFI 5.3.12

FFI 5.3.20

This chapter contains Skill Drills. When you see this icon, refer to your Skill Drill book for step-by-step instructions.

SKILL DRILL

OBJECTIVES

Upon completion of this chapter, you should be able to do the following:

- Define the term ventilation in regard to fire service operations
- Describe principles of venting for fire and venting for life
- Describe the importance of smoke and fire gases in relation to ventilation
- Identify those items needed to perform an effective ventilation size-up
- Identify and describe seven types of ventilation
- Identify common construction features in a building that aid in ventilation operations
- Describe the proper methods for venting a window
- Identify the equipment used to perform ventilation
- Identify the firefighting tools used to vent windows and roofs
- Describe the proper procedures for venting flat and pitched roofs
- Identify safety procedures to use when performing a roof ventilation
- Identify the type of roof cuts used in ventilation
- Describe the procedures for performing a “trench/strip cut of a roof”
- Identify the hazards associated with venting truss constructed roofs
- Identify tactical considerations for venting five types of occupancies

INTRODUCTION

Similar to the term firefighting, the word ventilation has several definitions and may be successfully performed using a variety of operations and techniques. In spite of its potential complexity, the word **ventilation** is easily defined and applied to firefighting operations as follows: “Procedures necessary to effect the planned and systematic redirection and removal of fire, smoke, heat, and fire gases from a structure.” However, this definition may be too simplistic when we consider that safe, timely, and effective ventilation operations are often performed in hazardous atmospheres and under dangerous conditions.

FFI 5.3.11 Ventilation does not put out fires. However, safe, timely, and effective ventilation is integral to control and extinguish structure fires. According to the International Society of Fire Service Instructors (ISFSI) 2013 *Position Statement on Fire Dynamics Research,* "Fire departments should manage and control openings to the structure to limit fire growth and spread, and to control the flow path of inlet air and fire gases during tactical operations." Controlling ventilation reduces fire development as well as firefighter risk from increased heat release rates.

To understand how fireground conditions dictate the need for ventilation, consider a simple example: An unconfined fire will draw cold air into the bottom of a fire as heated smoke, gases, and air rise vertically. Because the fire is unconfined, it can draw as much cold air (as compared to the heated air from the fire) as necessary to sustain combustion. Any fire must have heat, fuel, and oxygen in the appropriate ratio for combustion.

As our fire utilizes the correct amount of oxygen, heat, and fuel, the result is a free-burning fire. Now, transfer our free-burning fire to a confined room in a building. Initially, the fire has the proper ratio of fuel, heat, and oxygen, which is about 21% in air. As this process continues, the quantity of hot gases and smoke in the room increases, and available oxygen necessary for combustion is reduced. As the oxygen content is reduced below 21%, the burning rate will decrease and the production of smoke and fire gases will increase. The increased smoke will fill the interior of the room and try to exhaust through any available openings.

As the fire continues to burn, the oxygen content will be reduced to about 17%, levels of carbon monoxide and other products of combustion will increase, and temperatures can exceed 1,300°F (704°C). At this point however, another condition will rapidly become significant. As the fire continues to burn, the ratio of heat, fuel, and oxygen becomes unbalanced, with levels of oxygen approaching 13%–15%, which is not adequate to support a free burning fire. When the percentage of oxygen reaches 13%–15%, the fire will begin to smolder due to insufficient oxygen.

Several interesting events will have taken place simultaneously with the fire smoldering and the subsequent reduction of oxygen in the room. First, fire gases will rise vertically until they reach the highest level in the room and then spread horizontally across the underside of the ceiling. Secondly, if this process continues, the structure will become filled with heated smoke and fire gases, offer poor visibility, and develop a level of heat within the structure that can be intolerable for occupants and suppression personnel. At this point, if fireground personnel must enter this environment to conduct a search and/or extinguish this fire, then they are faced with a choice:

- Enter the structure without ventilation and encounter a hot, flammable environment that is dangerous to suppression personnel.
- Use horizontal, pressurized, and/or vertical ventilation to improve visibility, reduce the dangerous concentrations of heat, smoke, and fire gases, and allow suppression personnel to effect a timely and safe extinguishment.

This simple ventilation example points to a common problem. Whether a fire is small or large, smoke, fire gases, and other products of combustion are by-products of any fire and can be expected to be encountered by building occupants and/or suppression personnel.

VENTILATION PRINCIPLES

Some fire departments classify ventilation operations into two basic principles: venting for fire and venting for life.

Venting for fire

Venting for fire assists the engine company's advance and extinguishment of the fire (fig. 14–1). Normally, this type of ventilation is performed and coordinated in unison with the engine company's advance on the fire. Proper communication must be coordinated between the outside and inside firefighting teams when performing this type of ventilation. Venting prematurely or venting prior to the engine company having water and preparing to attack the fire can increase a fire's size and intensity.

Venting for life

Venting for life is accomplished to assist a firefighter's movement into an area where there is a known or suspected life in danger. There is a calculated risk of pulling the fire, smoke, heat, and gases toward this opening; but it is performed to help firefighters reach trapped victims as soon as possible. Again, proper communication must be coordinated between the outside and inside firefighting teams when performing this type of ventilation.

Fig. 14–1. A firefighter using a 6-ft. (1.8-m) hook to vent a window from the outside. Stay upwind and lower than the window using the reach of the tool to avoid fire, smoke, and gases.

SMOKE

FFI 5.3.11 From a simplistic perspective, **smoke** is nothing more than by-products from a fire. Therefore, as the burning substance changes, so does the composition of smoke. This is best illustrated by considering the basic elements of smoke. Smoke is a mixture of three basic elements: solid particulates, liquid particulates (aerosols), and fire gases. Unburned particulates are primarily comprised of the materials that are burning and carbon. These particulates can burn if their ignition temperature is sufficient.

Fire gases are a combination of various gases released by burning materials, and are also capable of burning if their ignition temperature is sufficient. However, fire gases are much more complicated than particulates, as burning materials can yield a wide range of fire gases. Here are common examples of fire gases that are released during the combustion process:

- Carbon monoxide
- Sulfur dioxide
- Hydrogen fluoride
- Hydrogen chloride
- Hydrogen cyanide
- Aldehydes
- Benzene
- Acrolein
- And the list goes on . . .

Firefighters should be aware that all of the aforementioned fire gases can be harmful or fatal to any human. However, if asked to choose the most common and deadly fire gas, an average firefighter would most often choose carbon monoxide. Carbon monoxide is well known for its ability to be present in smoke and cause death by asphyxiation if inhaled in sufficient quantities. However, hydrogen cyanide may be the most dangerous fire gas encountered by fireground personnel. It is estimated that hydrogen cyanide is more than 30 times more toxic than carbon monoxide!

This fact was underscored in 2006 when a firefighter at a "routine" fast-food restaurant fire was hospitalized and diagnosed with toxic levels of cyanide. Interestingly, over the next 14 hours, two additional fires in the same area were responsible for four more firefighters being hospitalized. They were also diagnosed with toxic levels of cyanide, and one of the firefighters suffered a heart attack. These incidents have generated a new look at this common combustion product that may be present in high quantities at structure fires. Let's take a brief look at hydrogen cyanide and its inherent risk to fireground personnel.

Hydrogen cyanide can be found in either a liquid or gas form and is a powerful poison that reduces the capacity of blood to carry oxygen. Bodily organs that are vulnerable to cyanide poisoning are the brain, heart, and central nervous system. The toxicity of hydrogen cyanide is emphasized by its use in gas chambers and as a chemical warfare agent. Unfortunately, hydrogen cyanide is found in common materials such as wool, paper, wood, and cotton. However, it is also found in elevated levels in synthetic materials such as foam, pesticides, plastics, synthetic fibers, polyurethane, fiberglass insulation, and other similar modern materials.

These materials are common in the typical residential structure fire as well as other types of structure fires, resulting in hydrogen cyanide likely being present in readily detectable amounts in smoke from smoldering fires, free-burning fires, and overhaul operations. Stated from another perspective, hydrogen cyanide is an extremely toxic gas that is released during the combustion process from any material that contains nitrogen, which is commonly found in structural occupancies. Although there are numerous other toxic gases released during the combustion process, carbon monoxide and hydrogen cyanide are prime examples of why ventilation should be an initial consideration at structure fires, and a primary reason why fireground personnel should not breathe smoke. That statement applies to structure fires, automobile fires, dumpster fires, and other similar incidents. Toxic gases that are inhaled by fireground personnel give credibility to the phrase "when firefighters breathe smoke, they can die."

Ventilation, therefore, is critical for the survival of both building occupants and firefighters.

GENERAL VENTILATION PROCEDURES

Ventilation operations should be governed by a set of standard operating procedures (SOPs), the values of which determine the course of a ventilation operation. Personnel must know how to accomplish the various types of ventilation operations, tactics, and techniques for a specific fire scenario. Other than actual fireground conditions, there is no substitute for training to help determine how to accomplish these types of operations. Discuss and practice ventilation on a frequent basis. If you do so, basic operations will be automatic at a fire, giving personnel a greater opportunity to focus on the specifics. The fireground provides the opportunity to hone operational skills.

Initial ventilation size-up

When sizing up for ventilation operations, firefighter must ask the following questions:

- What is the type of building and the time of day?
- Is there a fire and, if so, what is its severity?
- Is it a small food-on-the-stove fire that may only require opening a few windows to vent the area or a room-and-contents fire that will need immediate ventilation to assist in firefighting operations?
- What are its extension or auto-exposure possibilities before venting?
- Are any occupants endangered?
- Is immediate ventilation needed?
- Is horizontal or vertical ventilation feasible?

It is crucial to take a few seconds and determine the size and location of the fire and the building type before haphazardly venting.

Building type, age, and characteristics

What type of building is on fire? Suppose it is a multistory hotel. Depending on conditions, personnel may consider venting the stairs and hallways to aid in evacuation. In some larger multiple dwellings, it may be important to ventilate the roof's **bulkhead**, an extension of the stairwell shaft above the roof, or **scuttle**, a hatch in the roof of a building, to alleviate the mushrooming affects of the smoke and permit residents a means of egress down the interior stairs. It is also wise to consider the age of the building. Does it appear to be an older style of construction? If so, it could be balloon frame construction, and introducing forced air into the building could rapidly extend the fire. In newer contemporary homes, firefighters often see numerous skylights on the roof, which aid in vertical ventilation. Often, factory windows are covered with security mesh or grating, which may delay ventilation operations. It is important for firefighters to be familiar with the basic types of construction and buildings in their response district to help them determine appropriate ventilation operations when a fire occurs.

Location, size, and extension of fire

First, what are the fire's location, size, and extension possibilities? If there is a small rubbish fire on the first floor of a five-story apartment house, going to the roof to cut ventilation openings into the roof may not be vital. It may only be necessary to open the bulkhead or scuttle, relieving the stairwell of smoke and gases, and vent the windows in the immediate fire area. However, if the fire is on the top floor of a five-story apartment house, venting the top floor windows first and then cutting the roof open over the fire is an appropriate tactic (fig. 14–2).

Fig. 14–2. Fire and smoke pushing from the top floor of a five-story building

Type of roof

It is important for firefighters to be familiar with the different types and styles of roofs and construction in their response district (fig. 14–3). In some situations it is vital to know the types of construction on which personnel are working.

Inverted roofs (flat roof construction with a relatively slight pitch that allows water to flow to a roof drain) are normally *spongy*. Firefighters must know how to use the roof construction to their advantage when cutting ventilation openings, and also the approximate time available for ventilation operations. Firefighters must also be familiar with types of roof coverings such as clay tile, slate, wood shingle, and asphalt shingle on a peaked roof of a single-family home or a "built up" roof consisting of successive layers of asphalt and felt paper on the flat roof of a multiple dwelling.

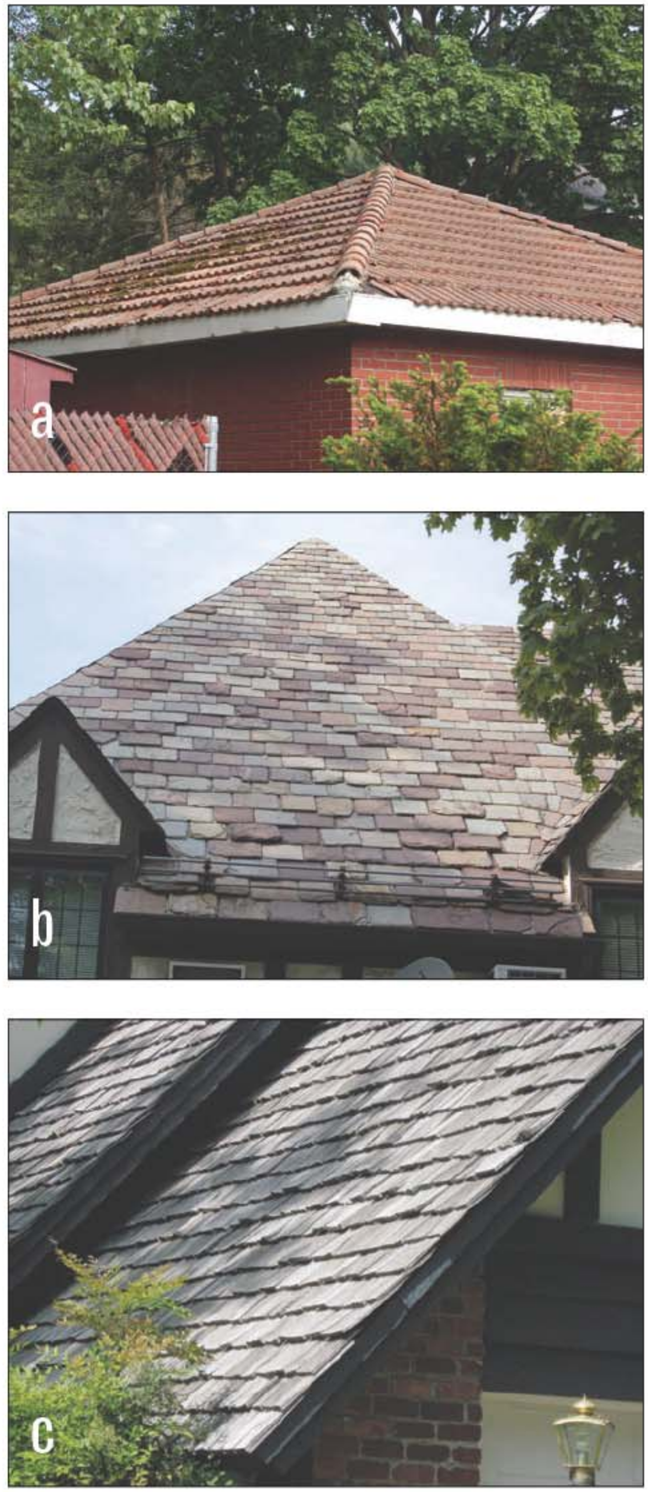


Fig. 14–3. a) Clay tile roof b) Slate roof c) Wood shingle roof

Fig.14–3 (continued). d) Asphalt shingle roof e) Built-up roof

A relatively new type of roof surface is the "rubber roof," a membrane made of synthetic rubber or certain types of plastic. This material is used on flat roofs to provide a more leakage-resistant barrier. They are often laid down using a torch; sometimes the rubber roof itself is ignited, causing a rapidly moving fire with heavy black smoke.

When ventilating a rubber roof, it is beneficial to remove the rubber first before cutting the roof deck below, if possible. This will make the saw more efficient and speed up the ventilation process if using a rotary saw, as the rubber membrane can become entangled in the guard. However, membranes can be easily cut without entanglement if using a chain saw with a sharp chain run at full rpm.

Ladders

Determining the type of building and the roof's pitch helps firefighters determine the type and length of ladders needed for roof access or horizontal ventilation. In some instances, an aerial ladder, a tower ladder, or portable ladders (extension and roof) are needed in ventilation efforts.

Hazards

Often, hazards stand in the way of ventilation operations. For example, consider the problems and solutions necessary if electrical wires or razor wire security measures block ladder placement to a roof (fig. 14–4). Also once on the roof, firefighters must use caution and be aware of any air and light shafts or slipping off of a high pitched roof. In one recent incident, a firefighter removing a scuttle cover received numerous electrical shocks. The occupant of the building was tired of break-ins from the roof, so he or she created a homemade security device. Another hazardous condition may be a chain-link fence or steel fences blocking emergency egress to the adjoining roof.

Fig. 14–4. Caution should always be used when working around electrical lines. They are just one of many hazards on rooftops that can have fatal consequences.

TYPES OF VENTILATION

Firefighters should begin ventilation operations by identifying the direction that smoke, heat, and fire gases will travel to exit the structure. Once the direction of travel has been determined, the appropriate method of ventilation should be used. Ventilation can occur both horizontally and vertically. The two methods most commonly used are natural and mechanical (or forced) ventilation. Normally, both methods are used for vertical or horizontal ventilation of a structure.

Natural ventilation

Natural ventilation at most fire scenes consists of opening up doors, windows, scuttles, and skylights to let the by-products of combustion (smoke, heat, and gases) rise naturally and escape to the outside atmosphere (fig. 14–5). Unfortunately, natural ventilation can be enhanced or limited by prevailing wind currents or atmospheric conditions. This method of ventilation works well when there is a light smoke condition and time to vent the structure out. Small fires such as food on the stove, light ballast odors, or a small rubbish fire may be areas to use natural ventilation procedures.

Fig. 14–5. Natural ventilation

Another process for providing natural ventilation is to cut a hole in a roof to relieve the building of smoke, gases, and heat (fig. 14–6). These elements naturally rise up and out of the ventilation hole. Although the means to cut the hole might be mechanical (power saw), the natural tendency is for smoke, gases, and heat to follow the path of least resistance to the outside atmosphere.

Fig. 14–6. A firefighter venting a roof with a saw.

Mechanical ventilation

SKILL DRILL

FFI 5.3.11 Firefighters often rely on mechanical means to ventilate a structure. The items or systems to provide mechanical ventilation can include an electric, gas, or hydraulic powered exhaust fan or blower; a hoseline to provide hydraulic ventilation; a building's heating, ventilation, and air conditioning (HVAC) system; or a building's smoke management system (covered in more detail in chapter 30, Fire Protection Systems).

These types of ventilation practices are also referred to as pressurized ventilation. This type of ventilation can be used to assist or replace natural ventilation operations at a fire (fig. 14–7). Mechanical ventilation can enhance horizontal and vertical ventilation operations, but must be used when fireground operations favor its implementation.

Fig. 14–7. Mechanical ventilation

Pressurized ventilation is normally classified into two different types: **negative pressure ventilation (NPV)** and **positive pressure ventilation (PPV)** (fig. 14–8). The following material describes the difference between the two types of ventilation.

Fig. 14–8. A firefighter has set up a PPV fan and checks to ensure that the entire doorway is covered by the flow of air into the building.

Negative pressure ventilation. **FFI 5.3.12** To better examine both negative and positive pressure ventilation, assume that the room in fig. 14–9 will be ventilated. In this example, the room is filled with the various by-products of combustion. The warmer gases rise toward the ceiling, and the cooler gases settle toward the floor (thermal layering), assuming that the door and window are closed. In fig. 14–10 the room is now being ventilated by means of negative pressure. The door has been opened and a blower has been placed inside the window frame, or attached to a ladder on the outside of the building. The blower will be turned on to exhaust the contaminants in the room, coaxing them to the exterior by creating suction within the room.

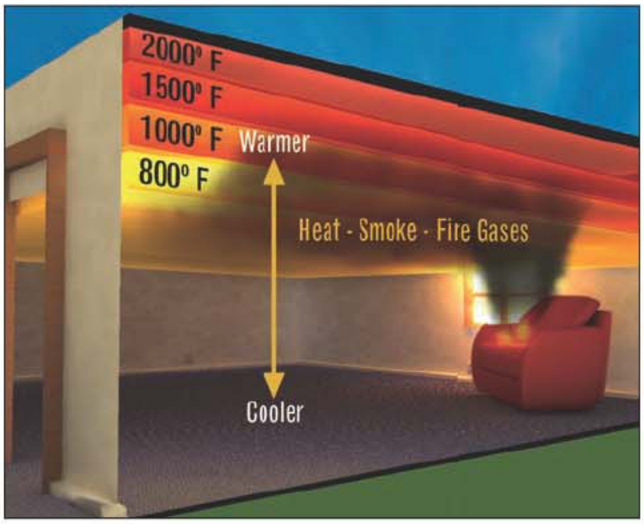


Fig. 14–9. When contaminants fill a room, thermal layering causes the lighter, hotter gases to rise to the top, and the cooler, heavier gases settle to the bottom.

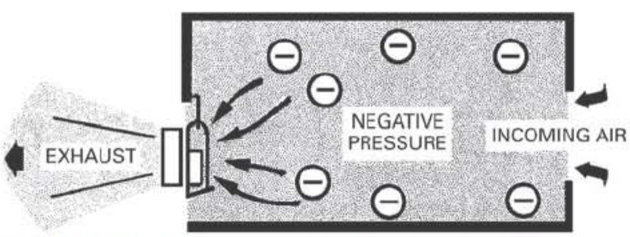


Fig. 14–10. Negative pressure involves placing a blower inside a room to exhaust the contaminants to the exterior.

Although NPV can prove satisfactory, it has several disadvantages, not the least of which is that personnel may be exposed to hazardous contaminants when positioning the blower. Also, when the blower is placed in the window, the suction pulls in air from the room and recirculates some of the exhausted air and gases if the opening around the blower hasn't been sealed with a salvage tarp or plastic. Another problem is that the contaminants from the fire are drawn through the blower, creating a need for additional equipment cleanup and maintenance. Smoke from a wood fire always contains some unburned gases and a fog of unburned tar-like liquids. When plastics burn in a fire, they release hydrocarbon particulates and heavy dense black smoke particulates. When these materials and particulates come in contact with the blower's mechanisms, they stick and form a film that is often difficult to remove. A buildup of materials or a dirty blower passageway can restrict air flow and prevent the unit from functioning up to its capabilities.

Remember, blowers placed in doorways, windows, or hallways can block pathways in and out of the building and firefighters must use caution to avoid striking them with their heads while operating on the fireground. To position blowers effectively, you must often suspend them in doors or windows using straps, ladders, or other accessories. Blowers placed inside buildings can add to the overall noise and confusion, hindering communications. Gasoline-powered blowers should not be put inside a structure because of the addition of more carbon monoxide into the area. Finally, interior blowers aren't totally efficient at removing all the contaminants from the tops of rooms. Air follows the path of least resistance, normally a straight line, from the fresh air inlet to the blower, which can limit the flow of air in the areas near the ceiling.

Positive pressure ventilation. Over the course of the years, with the continual improvement of firefighting equipment such as portable fans and blowers, positive pressure ventilation (PPV) has been an increasingly used tactic on many firegrounds. In fig. 14–11, the same room is pressurized by a blower placed on the outside of the structure to create PPV. Firefighters using this method of ventilation are forcing fresh, pressurized air into the room, creating a positive pressure within the entire room. As in a balloon, the pressure is equal at the top, bottom, and corners of the room. When the window is opened, it becomes an exhausted opening and the contaminants from all parts of the pressurized room ventilate to the exterior. Remember, implementing PPV effectively depends on controlling the flow of pressurized air between an entrance point and exhaust opening.

Compared with negative pressure ventilation, PPV has some distinct advantages in certain fire situations. First, personnel aren't normally exposed to hazardous interior contaminants while positioning exterior blowers. Second, the contaminants aren't drawn through blowers, thereby reducing the need for cleanup and maintenance. Also, doorways, windows, and halls don't need to be blocked by blowers, reducing the chance of a firefighter striking their head on suspended blowers. Some exterior blowers aren't dependent on additional equipment or accessories for setup, because they are self-propelled and self-sufficient for ventilation operations. Placing these types of blowers into service on the fireground requires fewer personnel to deploy them. Exterior blowers may have a minimal effect on the interior noise levels, but many add to the noise level on the outside of the structure. In addition, if gas blowers are not equipped with the proper exhaust flow extensions, the blowers may add to the carbon monoxide level in the structure.

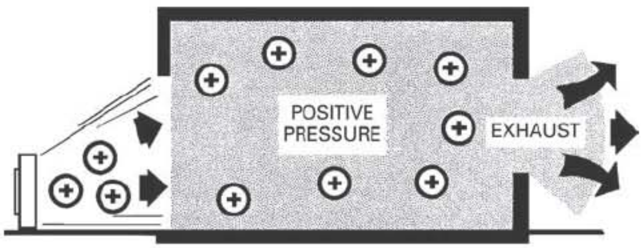


Fig. 14–11. Positive pressure ventilation involves placing a blower outside of a room to force pressurized air inward, thereby driving contaminants to the exterior.

Compared with negative pressure ventilation, PPV is approximately twice as efficient at removing contaminants from a building as long as specific requirements are met. First, exhaust openings should be selected to provide either horizontal or vertical channels for escape of the by-products of combustion. *The exhaust openings should always be created prior to pressurizing the structure or area to be ventilated.* If this is not followed, the pressurized airflow and by-products of combustion have no means of escape from the structure.

Second, it is imperative that the flow and path of pressurized air between an entrance and exhaust opening is controlled to achieve maximum ventilation. If pressurized air is directed from an entrance to an appropriate exhaust opening without being diverted to other openings, contaminants are removed in a minimal amount of time. Simultaneously opening unwanted windows and doors won't facilitate successful PPV operations.

As with many tactics and techniques used on the fireground, a proper size-up must be made to choose the right tactic for the right situation. There are times when PPV may not be a viable option to use on the fireground:

- **Positive pressure ventilation** is used by many departments both just prior to fire attack and for smoke conditions after the fire has been knocked down. Some fire departments, however, use PPV *during* fire attack; this tactic can have deadly results if not conducted properly. If used during fire attack, PPV should only be conducted if the location, extent, and spread of the fire has been established. Additionally, PPV should only be conducted during fire attack if hoselines are in place and operating. The use of PPV during fire attack—which does not meet this criteria—can drive fire at trapped victims and firefighters operating in the building.
- **Balloon construction:** Fire traveling up the walls of these structures could rapidly spread if PPV is initiated before a sufficient exhaust opening is opened. Fire in such structures is difficult to chase if it is in the walls, so use caution in feeding the fire with forced air if fire is in more than one location. In balloon-frame construction, only use PPV if the exhaust opening is opened first.
- **Vent, enter, and search (VES):** Creating an opening to perform VES can become an exhaust opening for PPV and possibly make the area to search untenable for the firefighter.
- **Location of the fire:** If the location of the fire is unknown, carefully analyze the consequences before putting PPV into service. A large structure with a complex layout may make PPV operations unsuccessful if it has multiple exhaust openings.
- **Search and rescue:** While these tactics are deployed, the incident commander must evaluate and size up the fire prior to performing any PPV operations.

For more tactical considerations and PPV operations, refer to the end of this chapter.

EQUIPMENT FOR VENTILATION OPERATIONS

Portable fans, blowers, and smoke ejectors

Although natural ventilation is a viable method, it can be assisted or replaced with portable exhaust fans, blowers, or **smoke ejectors** (figs. 14–12a and 14–12b). These fans and blowers can rapidly force the by-products of combustion out of a contaminated area. They also allow you to use openings remote from heat, smoke, and fire, directing such contaminants through preselected, controlled openings or openings not normally viable by natural means. Portable fans, blowers, and ejectors can overcome interior and exterior temperature differentials, as well as the effects of humidity. Overall, they reduce the time necessary to ventilate a building as compared with natural ventilation.

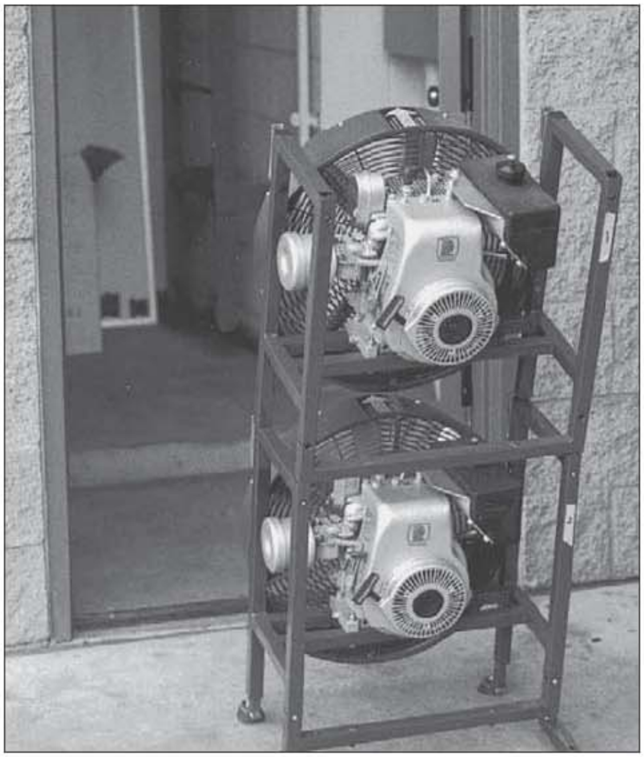


Fig. 14–12a. Various tools may be used to perform both positive and negative ventilation, such as fans, blowers, smoke ejectors, and fog streams.

Fig. 14–12b. A smoke ejector placed in a doorway to remove smoke via negative pressure ventilation

Hydraulic ventilation

SKILL DRILL

Fog streams from hoseline can also be used for ventilation purposes; this is called **hydraulic ventilation**. Simply direct a fog pattern out of a window so that the resultant venturi action expels the contaminants to the outside atmosphere. You can obtain maximum effectiveness by holding the nozzle a few feet back from the door or window. Direct the fog pattern toward the window so that it almost fills the entire opening, leaving some room around the edges. Fog stream effectiveness depends on the size of the opening, the area to be ventilated, the size of the nozzle and hose, the quantity of smoke present, and the discharge pressure. Although some textbooks advocate that hydraulic ventilation must be performed within a few feet of a window (after having first placed the nozzle outside the window, opening it to the correct pattern, then moving it inside the building), it can be applied from a further distance away from the window. If the room in front of the nozzle has burned out floor boards or is possibly compromised, the nozzle can be directed from the door opening to the window frame. The resulting pressure from the stream will pull smoke and contaminants from the structure but may take more time to ventilate the structure. It is also important to note that when firefighters are fog venting, they must remain aware of the fire reigniting or **lighting up** behind them, because more air is introduced into the area.

If a smooth bore nozzle is used for initial fire attack, it can still be used to fog vent out the window. The firefighter can crack the nozzle open slightly to make a coarse pattern that fits inside the window frame. This stream will also ventilate the structure but possibly not as good as a fog nozzle.

Hydraulic ventilation is normally accomplished by a firefighter standing in a contaminated environment and using a spray/fog nozzle to direct contaminants from interior to exterior through available openings such as windows. Although this method can be beneficial, a drawback is that it requires a firefighter to stand in the contaminants while they are being exhausted to the exterior.

For more information on fog venting, see chapter 16, Fire Streams.

HVAC systems

Many multistory buildings use **heating, ventilation, air conditioning (HVAC) systems** to control the environment inside the structure. Such systems draw in outside air, change it to the desired temperature, circulate it, and exhaust it to the exterior. It is possible to use an HVAC system to rid a building of contaminants; however, doing so depends on the capabilities of the system and the expertise of the personnel operating it. It is imperative that the capabilities and operational techniques of a particular system be thoroughly understood, because an HVAC system is also capable of spreading contaminants and fire to uninvolved portions. Initially, during a fire, firefighters must determine if the system was automatically shut down by its safety overrides. All other operations should be handled by the appropriate building engineer or other similar responsible person in conjunction with firefighters.

VENTILATION PRIORITIES

FFI 5.3.11 Integral to any ventilation operation is determining appropriate priorities. The top priorities in any ventilation operation are improving the interior environment to aid in evacuation and increase a victim's chance of living and enhancing the working environment for suppression personnel. Ventilation operations also reduce fire loss and damages to the structure and its contents. The priority of specific ventilation operations is predicated on fireground conditions. Normal ventilation operations are usually performed using a horizontal or vertical ventilation method.

Horizontal ventilation

FFI 5.3.11 For reasons of ease and safety, horizontal ventilation is the most popular method. It is often accomplished simply by opening doors and windows. Using horizontal ventilation to remove heat, smoke, and fire gases can be effective; however, its effectiveness depends on the size of the opening and its proximity to the contaminants. Horizontal ventilation does not take advantage of the natural vertical path of heated gases and smoke. It also has a minimal effect on the hottest portion of a room (ceiling), where most flashovers originate. Therefore, horizontal ventilation will ventilate that portion around the opening (open door or window) but could have a minimal effect on a flashover.

Before using horizontal avenues, consider these factors regarding wind and fire location:

1. Determine whether the direction of wind could carry contaminants to uninvolved areas of the fire building or exposures. If the building has multiple stories and windows that will be opened on the lower floors, will the direction of smoke then contaminate the upper floors?

2. Consider the speed or force of the wind. When windows are opened on the windward side, will the wind accelerate the fire and enhance extension?

3. Open the windows on the leeward side of the building first. Windows on the windward side can then be opened to allow the wind to force contaminants from the structure (fig. 14–13).

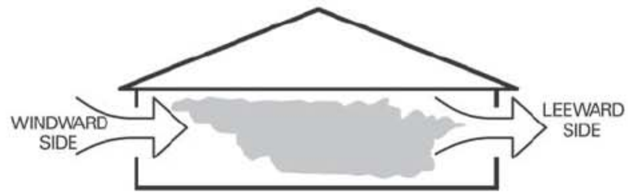


Fig. 14–13. When the wind can be used for horizontal ventilation, open the leeward windows before the windward windows.

4. Opening windows close to the seat of the fire is a top priority. This provides ventilation to the fire area and allows the expanding gases and steam from fire-suppression operations to escape. It also reduces the chances of the fire, heat, and gases from lighting up overhead or wrapping around the nozzle team, because they are escaping through controlled openings.

5. Remember, prematurely opening windows in a fire area can increase the supply of oxygen and cause the fire to accelerate. Therefore, coordinate communication between the hoseline's advance and ventilation operations to maintain a safe working environment.

Once windows in the fire area have been opened, open others away from the fire area if doing so ventilates other contaminated areas without enhancing extension. Firefighters should remove blinds, curtains, and shades when opening windows to ensure that they won't restrict the removal of contaminants. In addition, it is vital to ensure that screens are removed, because they can restrict the movement of air by at least 50%.

When firefighters open **double-hung** or **casement windows**, there are normally two rules to follow. If there is a light wind blowing toward the ventilation opening, the window can be opened in the following manner: two-thirds down from the top and one-third up from the bottom (fig. 14–14). Doing this allows some fresh cool air to enter the bottom of the window while the hot contaminated air exits at the top. When there is no prevalent wind, the windows may only need to be pulled down from the top to allow the room to ventilate. Pivoting windows must be opened according to their design. If a window can't be opened, you may need to break or force it open.

Fig. 14–14. A double-hung window opened two-thirds down from the top and one-third up from the bottom

Horizontal ventilation can be enhanced by mechanical means. If multiple areas need ventilation, ventilate each area by using doors as partitions to reduce the size of each. This maximizes the flow of fresh air through each area to be ventilated. When opening these doors, remember to wedge or chock them open so that they don't inadvertently close.

Vertical ventilation

FFI 5.3.12 Depending on conditions and building construction features, vertical ventilation can be the preferred method when the heated products of combustion rise and collect at the highest levels of the structure (fig. 14–15). Vertical ventilation takes advantage of the natural travel path of heated contaminants and ventilates the area that needs it most—the ceiling area, which prevents mushrooming. This is the common term for when contaminants collect at the highest level of a structure and deflect downward, or bank down, onto lower floors.

Firefighters should try to open a vertical artery to displace these contaminants. This decreases both the amount of explosive gases, heat, and smoke collecting at the structure's upper levels and the chances of fire extension. In addition, the release of these by-products also pulls in and introduces cooler fresh air at the lowest levels. This can improve conditions at the floor level and assist firefighters in their fire attack operation.

Vertical ventilation permits firefighters to proceed and perform a more thorough search for victims and fire extension on the floors above the fire. It also relieves the interior hallways and stairwell of smoke, which can assist in the evacuation process.

Note that not all fires require vertical ventilation; a small rubbish fire in a structure doesn't require immediately cutting the roof open to provide vertical ventilation. Firefighters must use an appropriate size-up to decide which ventilation tactic to perform. Vertical ventilation takes additional time, staffing, and equipment for completion, and can also place ventilation personnel in a dangerous location (over a fire).

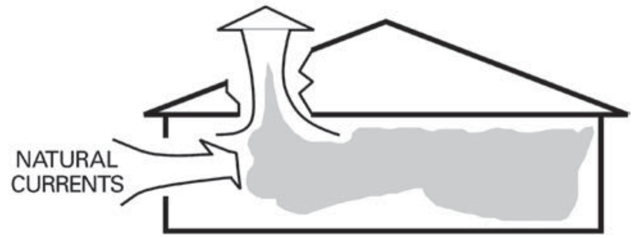


Fig. 14–15. Vertical ventilation takes advantage of natural convection currents.

VENTILATION USING NATURAL CONSTRUCTION FEATURES

It will always be easier for firefighters to use the natural construction features of a structure for initial ventilation operations. Building features such as windows, scuttle covers, bulkhead or penthouse doors, and skylights can be a fast and efficient means of ventilating a structure. There are a variety of tactics to follow when opening the following construction features for ventilation operations:

Air shafts. **Air shafts**, also know as **light shafts** or **light wells**, may be found in many different types of structures, such as row frames, multiple dwellings, tenements, and hotels. They are intended to provide air and light to inner rooms of a structure. In a situation where there is a small fire and no concerns of a direct flame exiting the structure, an air and light shaft can be used for ventilation purposes by opening windows within the shaft to rooms that need ventilation (fig. 14–16). However, firefighters must close windows within the shaft as appropriate to prevent fire extension into the shaft or autoexposure to the floors above or an adjoining building. In some instances, a skylight is at the top of the shaft to prevent inclement weather from entering it. If the shaft is covered, the skylight may have to be removed to provide ventilation.

Fig. 14–16. An exterior light well may be used to aid in ventilation provided upper story windows are closed prior to venting.

Skylights. Skylights in dwellings are normally located over a stairwell or hallway. In commercial occupancies, larger skylights are often placed over manufacturing areas. Depending on the type of structure, individual skylights may also be placed over stairways, light shafts, and air shafts. If a building has an attic or cockloft, the area below the skylight is normally boxed off from the attic/cockloft space. Therefore, when the skylight is opened, the interior of the building is ventilated but the attic space is not. These small walls that extend down from the inside of the skylight are commonly referred to as the returns. When checking for fire extension inside the attic or cockloft, firefighters can open up the returns to size up the conditions. In some instances, firefighters should not open up returns that are remote from the original fire because it could possibly pull the fire in that direction and assist in horizontal spread.

Skylights may be opened for ventilation purposes by removing the entire assembly, removing the glass panels, or breaking the glass panels (fig. 14–17). If the glass panels are removed individually, additional time may be required and broken glass may fall into the building. When a firefighter isn't equipped with a portable radio and is going to break a skylight, a good procedure to follow is to break a small section of it first. This should give warning to the members operating below that ventilation operations are going to take place overhead.

Once any skylight has been vented, the firefighter should take a hook and reach down into the hole to ensure a **draft-stop** (a piece of glass, Lexan®, plastic, or drywall installed at the ceiling level, preventing the loss of heat up into the skylight—not to be confused with a draft stop in an attic) isn't secured below and interfering with ventilation operations. If conditions below reveal a fire is evident under the draft-stop, a hand tool tied to a utility rope can be dropped down to vent the area. This safety measure keeps the firefighter a safe distance away from the escaping flames exiting the skylight.

Fig. 14–17. A skylight

Glass skylights. The most effective method to remove the skylight assembly is by completely prying it up from its attachment points or tipping it onto the roof. This takes minimal time and reveals the entire opening. It also allows you to replace the skylight later.

Skylights can also be opened as follows: If it appears that tar hasn't been used around the edges of the glass and the panels can be quickly and easily removed, then remove the metal tabs or metal stripping along the bottom edge of the panels. This will allow them to slide out. If tar has been used as a sealant and the glass panels can't be removed easily, then attempt to remove the entire skylight's frame attached to the roof if possible. If these attempts do not work, break the glass panels (fig. 14–18). Remember, if you break the glass panels, the resulting shards of glass within the building will be a hazard to interior operations.

It is important to note that on many bulkheads or penthouses, roofs are slanted and dangerous to climb up on and operate on these spaces. Breaking the glass may be the only safe option for firefighters to perform.

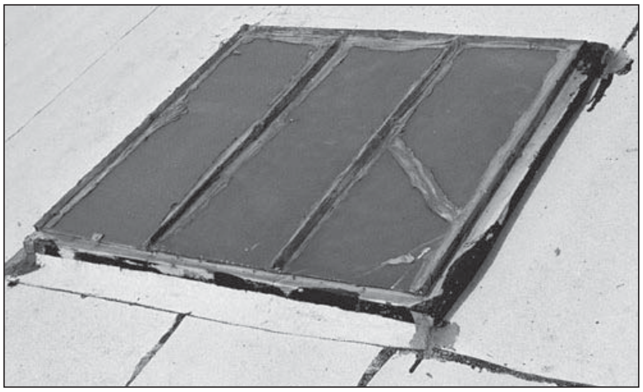


Fig. 14–18. Older skylights are often sealed with tar, making them difficult to remove.

Plastic skylights. Newer buildings have plastic skylights, usually a plastic bubble in a metal frame attached to a metal riser. First, try to pry the skylight away from the roof (fig. 14–19). If this can't be done easily, you may have to cut the plastic around the junction of the metal and plastic. Use an axe or power saw to make the cut. If conditions on the roof necessitate operations must be done quickly, attempt to break the plastic bubble with a hand tool for rapid ventilation.

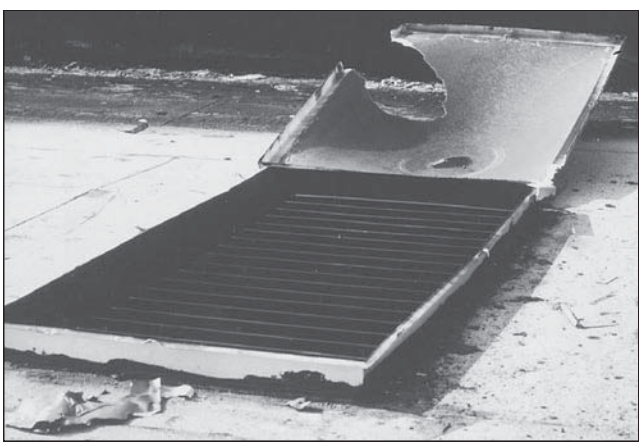


Fig. 14–19. Plastic skylights can often be removed by prying upward.

Often, because of water leakage or to beef up security, roof skylights have been replaced with plywood/oriented strand board (OSB) and lightweight support beams or just tarred over. Thus, firefighters should avoid walking on any skylight or alteration. In situations such as these, firefighters may have to use a power saw to open up the roof or skylight area. Remember, once a skylight is removed, it should be placed near the ventilation opening to warn firefighters of an open shaft on the roof.

Bulkheads and penthouses. Opening the door to a **bulkhead** or **penthouse** can provide significant ventilation to the interior stair shaft and any hallways open to it. Because of the importance and simplicity, opening it up should be a primary consideration. If it has a lower door at the bottom of the stairs, verify the conditions on the other side before opening it. Firefighters proceeding down the interior stairs to open this door could be subjected to severe smoke and fire conditions behind it, so they must use caution.

Depending on the type of door (wood or metal) located on these structures, firefighters can use normal forcible entry tactics to open them up. Usually, these doors are outward opening because they are an exit door. In some cases they may have added security such as a slide bolt or eye bolt and hook, and if they are difficult to force, firefighters should size up the hinge size of the door. As always, remember our cardinal rule of forcible entry: **try before you pry**.

Another typical feature of these structures is that they often have a skylight mounted on top. This skylight provides additional vertical ventilation. In some instances, the skylight has a draft stop mounted on the ceiling of the bulkhead. If the skylight is vented and no smoke issues from it, check for the presence of the draft stop. It may be possible for the firefighter to strike the draft stop from the door of the bulkhead with a hook to ventilate it.

Often, firefighters encounter a bulkhead or penthouse with high walls, making it difficult to climb in bunker gear and reach the skylight mounted above. If an aerial ladder is placed to the roof and it has a folding, attic, or scissor ladder mounted at its tip, it can be removed and used to access this skylight. If not, there are a few other options.

A firefighter can remove the bulkhead's door and lay it on an angle on the wall of the structure. If the firefighter has two tools, one tool punctures the roof at the base of the door to act like a brace, preventing the door from sliding outward as they climb. Once on top of the bulkhead, vent the skylight (fig. 14–20).

If the firefighter has a hook and Halligan tool, he or she can place the Halligan alongside the bulkhead's wall with the fork pressed into the roof and the adze resting on the wall. This tool creates a step or small platform. The hook's head is placed on the top edge of the bulkhead's wall and the handle of the tool hangs downward. Now the firefighter can step on the Halligan and use the hook to pull him- or herself upward while climbing.

Fig. 14–20. Sometimes we need to be creative when gaining access to vent.

It is *extremely* important that firefighters enter and exit the roof of the bulkhead in the same location. Many bulkheads are aligned next to a shaftway; and exiting in the wrong place can cause a firefighter to fall many stories, possibly suffering a severe injury.

Remember, any time a firefighter opens one of these doors and is met with a heavy smoke condition, he or she should still probe inside the landing with a tool to check for victims. Also, opening the door to reveal little or no smoke may indicate that the fire apartment door hasn't been opened yet. Also, don't forget to chock the door open to prevent it from relocking if it accidentally closes.

There are a few variations in the type of bulkheads prevalent on buildings across the country (fig. 14–21). Many have two doors and are a larger sized bulkhead that provides access to the roof in two separate locations. Also, it isn't uncommon to find the elevator motor room located inside the larger sized bulkhead. Firefighters must be careful when working around the **walk-through bulkhead**. This bulkhead normally cuts the roof section of a building into two sections and has doors at both ends. Firefighters must resist the urge to transverse through the interior of the bulkhead under heavy smoke or fire conditions, as this places them in peril. Access to the other side of the roof should be done by aerial ladder, tower ladder, or the top of the bulkhead if sufficient room exists.

Fig. 14–21. Bulkhead and penthouse

Roof scuttle. As shown in fig. 14–22, a **roof scuttle** is a small, covered opening providing access to the roof. Some scuttles consist of a wood cover over wooden risers on the roof. The cover is normally protected by a composition covering. Unless the cover has been attached to the risers, it can be removed by prying it up with an axe, Halligan, or similar tool. Newer scuttles consist of metal risers with a spring-loaded metal door that is fastened and locked from the inside. These are difficult to open and may take more time and effort to open. Sometimes it may be easier to cut the scuttle with a saw in these situations. If a scuttle is found tarred over, it also may be easier to cut the scuttle cover open with a power saw to provide vertical ventilation.

In many buildings with scuttles, an interior vertical ladder is mounted inside the scuttle's opening, providing access to the roof (fig. 14–22). These are normally located in the top floor hallway or in a closet in the hallway. Once the scuttle cover has been removed and no smoke is present, position yourself so that only your arm is placed over the open scuttle; and reach down with a hook to probe the walls, looking for a door. Use caution and do not subject yourself to climbing down the narrow scuttle opening and on the steep vertical ladder to open this door. That is a dangerous practice and could seriously injure you if there is fire behind the closed door.

In many of the commercial occupancies, for increased security, these scuttle covers are made of heavy steel plating with heavy security locks. A rotary saw and metal cutting blade may be the best tool to provide rapid ventilation.

Fig. 14–22. A roof scuttle with a fixed access ladder

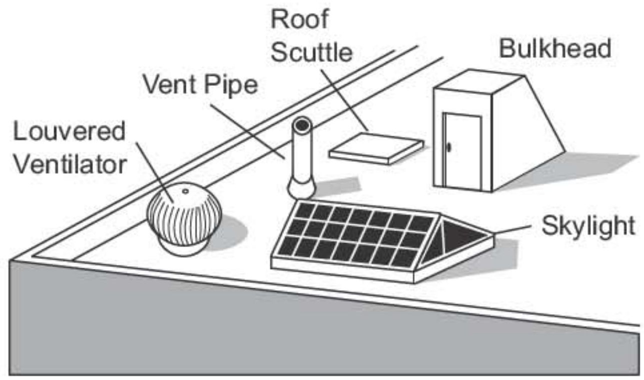


Fig. 14–23. Roof ventilation personnel should be able to recognize and use various types of natural construction features to assist ventilation.

Elevator house or bulkhead. Structures with elevators may have an equipment or motor room located on the roof. **Elevator houses** vary in size according to the number of elevators they service. They are above the elevator shafts and open, by varying degrees, to the shafts. Opening the door and skylight can provide ventilation to the elevator shafts, reducing concentrations of heat and smoke within the structure.

Additionally, the equipment in an elevator house supports the full weight of the attached elevators. Therefore, any fire that has extended to this area may weaken the structural integrity of the elevator equipment supports, possibly causing collapse of the equipment and elevator cars. The resultant hazards and damage that this might cause cannot be overemphasized. Firefighters must use caution if they enter into these rooms; there are holes in the floor that are normally covered with steel grating to allow air currents in the shaft to flow while the cars move up and down. It is common to find these gratings in poor shape or missing.

Ducts. Heating, air conditioning, and other **ducts** of various sizes are often found on roofs (fig. 14–23). Because these passageways may lead to the interior of a building, they must be checked for heat and smoke. If heat and smoke are present, open the duct to provide some ventilation to the interior of the building, as well as to check for extension (fig. 14–24). Also, when firefighters are faced with a grease fire in ductwork, it may be necessary to do the following:

- Tear open the top of the ductwork to allow proper ventilation
- Open the roof near the ductwork to ensure that no fire has left the duct at its seams and extended into the cockloft or roofing materials

Fig. 14–24. A rooftop duct

Dumbwaiter bulkheads. Some older multiple-dwelling structures may still have their **dumbwaiter shaft's** bulkheads on the rooftops. Although the shafts are now illegal to use in most parts of the country, they haven't been removed from the structure. Most shafts served more than one apartment and were located in the kitchen area so tenants could send down their trash to the basement for the maintenance people to remove. Often fires in the kitchens or apartments can extend into the unused shaft and upward (fig. 14–25).

Venting these shafts allows the fire to vent vertically and possibly prevent it from extending to other apartments. Often, fires in these types of buildings have smoke showing from the dumbwaiter bulkheads on the roof (fig. 14–26). Venting these bulkheads is important and must be a quickly accomplished task. The bulkhead may or may not have a skylight on the top and can easily be ventilated by prying up on its sides and hinging it open. Also, the dumbwaiter bulkhead normally has an access door on it, providing access to the pulley and gears located at the top of the shaft. These doors are now normally sealed up and covered with roof tar.

Fig. 14–25. A dumbwaiter shaft door inside an apartment.

Fig. 14–26. There are many avenues for fire to travel horizontally, as well as places to perform ventilation, such as this dumbwaiter bulkhead.

The doors open outward and can be forced open using outward-opening-door techniques. One of the best methods is the baseball swing with the Halligan tool. The point of the tool can be embedded in the door, opposite the side of the hinges. Now the tool can be pulled or pushed toward the door's hinge side to force it open. In some instances it may take a few attempts to force the door open in this manner because of the magnitude of tar that has sealed the shaftway.

Vent pipes and soil pipes. Plumbing **vent pipes** extend through a given roof at various locations and sometimes can indicate the locations of bathrooms and kitchens. Although they aren't considered ventilation avenues, they do travel vertically within a building. Therefore, they are capable of spreading heat and fire. Smoke issuing from acrylonitrile butadiene styrene (ABS) plastic vent pipes is an excellent indicator that the pipe is burning somewhere within the building. ABS plastic pipes can burn readily and serve as extension avenues wherever the pipe travels. After a firefighter feels the base of a metal or plastic vent pipe and notices signs of heat or smoke, the roof must be opened and checked. Additionally, a vent pipe that appears to be growing upward is an excellent indication that the roof is sagging and possibly about to fail.

Ventilators. Many types, sizes, and shapes of **ventilators** may be found on roofs. Ventilators can be classified as either venting a particular area within a building or providing some type of ventilation for a device or appliance, such as kitchen appliances. The size and shape usually reveal the type; or if it is covered with grease or oil residue, it can inform the firefighter that it is connected to a cooking device. Ventilators for heat-producing appliances generally have a serrated top suspended over the pipe, whereas those that vent the attic or top floor usually have a capped top or the familiar turbine.

Smoke or heat coming from a ventilator indicates that the area it serves is affected by smoke or a fire, or a fire exists in the ductwork itself. If a ventilator is equipped with a screen or cover, it should be removed, because it restricts the efficiency of escaping smoke. Don't remove the top of a rotating ventilator, because the ventilator stack can easily be damaged and restricted. Rotating ventilators are 30% more efficient when the turbine is operational, compared with when the turbine has been taken off. Be aware that these ventilators can detach and fly off the pipes with fire venting from it. If these items are the only ventilation objects on the roof and a firefighter has to check the cockloft for smoke and fire conditions, remove them. It is easier to remove them for a quick size-up of the conditions in the cockloft and the construction features.

WINDOWS

Firefighters encounter numerous different types, sizes, and shapes of windows on the fireground. It is important to learn and identify the basic concepts of windows and how they operate for ventilation tactics to be performed rapidly. Most windows in residential structures have **double hung** (upper and lower sash), **casement** (hinged window, pivots to one side), and **solid frame** (non-opening).

These windows are also constructed in a wood, metal, or vinyl frame with single, double, or triple pane glass. In addition, in areas near the ocean, a new laminated or hurricane-resistant glass is becoming a regular feature. It is also common to find Lexan™ and other heavier gauge plastic laminates used for windows, because of their high security features.

Again, it is important for firefighters to size up the fire conditions and then decide or be told to open a window or vent a window with a hand tool. Remember, it is important to communicate with the interior teams and coordinate ventilation efforts with extinguishment operations. When venting windows, a common theme exists in the fire service: Remove everything and make the window turn into a door. Remove the screen, shades, blinds, cross members, sash, glass, and any other obstacle. This allows unimpeded access for firefighters to enter or exit the structure without becoming hung up on anything.

Venting the windows

SKILL DRILL

Prior to venting windows, firefighters should size up the window for any cracks from the heat or if the glass is discolored. These conditions could be a good indication that fire exists directly behind the window, so firefighters must use caution when venting begins. When firefighters ventilate a window with a hand tool on a level surface, they often maintain a safe distance away from the window and position on the windward side of the window (wind at their backs) at a level lower than the window. Firefighters often crouch when ventilating windows at this level. Crouching ensures that the firefighter remains low and out of the flow of hot air, gases, smoke, and possibly fire venting from the new ventilation opening.

Using a tool to its maximum length or choosing a tool with a long handle helps firefighters maintain a safe distance away from the window. It is important to maintain a safe distance away from a window because the escaping by-products of combustion could ignite or explode when escaping to the fresh air. Now that a safe distance has been attained, the firefighter uses the tool to strike the upper sash or pane of glass to vent the window. The upper pane is struck first because it may already be compromised by the heat generated by the fire and break easily. It also doesn't really mater what part of the tool strikes the window with single pane glass; a metal tool is often no match for glass. When firefighters are faced with double or thermo-pane glass, it may be more advantageous to strike the window with the sharp end or point of the tool to break the glass.

As the firefighter strikes the upper pane of glass, it is usually in a downward motion; and the center sash and bottom pane of glass may also break with the downward swing. If so, once both panes are broken, the center sash can be pulled out and then the window can be trimmed.

Trimming a window means that the firefighter goes around the outside of the frame with a hand tool and removes the leftover shards of glass from the window (fig. 14–27). This allows a safer means of egress and access if the window must be used by the firefighter. Once the large glass shards are removed by striking or trimming, the firefighter must ensure the blinds, curtain, shades, and screens are removed.

Figure 14–27. Trimming the window by removing remaining glass shards with a tool.

When operating on a level surface, it is okay for a firefighter to pull out any remaining glass, curtains, and blinds from the inside of the structure to assist ventilation efforts. Dropping them inside the structure could cover a victim. Once ventilation efforts are concluded on a window, the firefighter should always sweep the floor just inside the window to check for a victim who may have attempted to reach a point of safety.

Ventilating windows with a portable ladder

SKILL DRILL

The extension ladder can be used either in the beam or flat position to break a window. Some firefighters believe that the weight and structural makeup of throwing the beam into the window works better than flat, whereas others believe that the flat position covers more surface area and breaks more glass than the beam throw. Either technique can be used to vent the window.

The ladder is raised vertically to the proper level, near the top third of the window. Then the ladder is dropped or pushed into the window with some force by the firefighter positioned at the base of the ladder (fig. 14–28). As the ladder strikes the window, the firefighter should remove his or her hands from the ladder, in case glass slides down the beams of the ladder. Hands should be in the vicinity of the ladder in case it bounces off the window; this way they can grab the ladder's rungs or beams to maintain its stability. It is very important to note that firefighters performing this tactic must have the proper eye protection and wear all personal protective equipment. Also, sometimes it may take one or two attempts to sufficiently break out the window for ventilation. If this ladder evolution is properly executed, often it also breaks the window's center sash and bottom window pane.

Fig. 14–28. A ground ladder venting a window on the second floor

Roof ladder's hooks used to ventilate a window

SKILL DRILL

Another method of performing window ventilation is to use the roof ladder. The roof ladder has two large roof hooks attached to its tips that resemble the firefighting hooks or pike poles firefighters use daily. To perform this tactic, the roof hooks are placed into the open position. Then the ladder is placed at the proper height and thrown or pushed into the window by the firefighter positioned at the base of the ladder.

After the ladder has broken the top pane, the firefighter has a few options. If the window has a wood frame, the ladder's hooks can be placed on the center sash. Next, the firefighter can pick up the base of the ladder and give it a slight tug or pull backward or out of the window. Normally, this additional pressure lets the hooks break the bottom pane of glass and remove the center sash of the window. If the ground's terrain is in bad condition, avoid this method and drop the ladder into the window again to complete ventilation efforts of the lower panes of glass.

Remember, all eye protection and personal protective equipment must be used when performing these tactics.

The arm-lock maneuver—venting windows from a portable ladder. The arm-lock maneuver is a tactic that can be performed for venting windows while working off a portable ladder. It is relatively easy to perform and requires minimal time to get into position on the ladder, thus saving critical time for other important tasks. It can be used in conjunction with the leg-lock maneuvers previously described, or it can be used by itself (fig. 14–29).

To perform the arm-lock maneuver, the firefighter should use the following steps for ventilating a window to the right side of the ladder:

- A firefighter reaches the proper working height on the ladder with both feet placed on the same rung. Note that when venting the window off the side of the ladder, place the leg and foot up against the ladder's beam. This offers more support and balance when swinging the hand tool. It also can help brace the firefighter onto the ladder.
- The hook is then held in the right arm, and the left arm is placed between the two rungs directly in front of the firefighter.
- The butt end of the hook is now placed behind the ladder and grabbed with the left hand.
- Next, position the hook to the window, checking that no part of the ladder or structure will interfere with the swinging motion. Now the window can be ventilated.

For more in-depth information on the ladder tactics mentioned, see chapter 13, Ladders.

Fig. 14–29. A firefighter demonstrates hand position for the arm-lock maneuver.

Ventilating top floor windows. Ventilating windows at top floor fires is a vital tactic to follow because it allows fresh air to enter the structure and helps the superheated gases and smoke escape through the roof ventilation hole. If the top floor windows can be reached using a hook, position above and slightly to the windward side of the window. Swing the hook inward toward the window to ventilate it (fig. 14–30). Once the glass breaks, pull the body backward and away from the rising smoke, heat, and gases. Remember to coordinate communication with the inside teams prior to ventilating any windows.

Fig. 14–30. Breaking a window with a hook

In some instances, a hook might not reach the window; however, with a piece of utility chord and a hand tool such as a Halligan bar, a different tactic can be used. The first step is to secure the tool with a knot and a safety to one of its ends. Next, the tool is lowered to the window to be ventilated. Secure the rope by using the foot to step on it at the roof level; maintain this position for the method to work effectively. The rope and tool are then pulled up to the roof. Finally, toss the tool out and away from the building, causing it to arch into the window with sufficient force to break it (fig. 14–31).

Whenever this tactic is used, firefighters operating in the vicinity must use caution. Flying glass drops from the window, and occasionally utility ropes, are severed by the glass and the tool flies into the structure or down to the ground. Unfortunately, this tactic does not clear all the glass, screens, or curtains from the windows; but it can afford some ventilation efforts when there are limited means to do so.

This technique works well in many fireground situations, and some fire departments have made adjustments to their tools and tool inventory to accomplish the task. In addition, some tool manufacturers have made tool modifications for the utility rope to *clip* to the Halligan bar. Also, the hook and Halligan can be secured together by a short chain and safety clips that allow this tactic to be performed.

Fig. 14–31. A Halligan bar secured with a rope can be an effective ventilation tool.

Ventilating windows covered with security grating or steel mesh. Many factories place metal grating or mesh over their windows to prevent vandalism and illegal entry into the building. These security devices are normally comprised of a steel frame with the grating or mesh welded inside the frame, which is then attached to the building by lag bolts or through bolts. The following are a few options to choose from when encountering these windows that need to be ventilated:

- A forcible-entry saw can be used to cut a section of the grating or mesh out so that a hand tool can be used to ventilate the window.
- A forcible-entry saw can cut the brackets where the security frame attaches to the building (fig. 14–32). This releases the frame from the building, exposing the windows for ventilation operations. Use this method on small frames, but use caution if the frame is large. A large falling frame could injure unsuspecting firefighters operating around the building.
- Some fire departments have created a homemade hand tool to combat these windows. The tool is a piece of ½-in. (13-mm) metal rod or rebar about 4 ft (1.2 m) long, with one end bent downward to form a handle and the other end left blunt. The tool is inserted between the grating, and the glass is punched out. The method works well but requires additional time because it must be inserted and removed numerous times to ventilate the windows.
- In some instances, the distance between the grating is large enough to insert the butt end of a hook to ventilate the windows.

Fig. 14–32. Firefighters use a power saw to cut attachment points of mesh grate to ventilate windows at a one-story commercial building. The tower ladder bucket facilitates the operation.

Note that operating a power saw on a portable ladder is a difficult tactic to perform; use caution when doing so. If possible, working out of a tower ladder's basket can make this operation easier and safer.

Ventilating windows protected by security bars. Many structures around the country have steel security bars placed over their windows for security and protection. Normally, these bars are either attached to a frame or individually embedded into the bricks of the building. There is usually sufficient space between the bars to insert a hand tool to ventilate the windows. Once the windows have been ventilated, remove the bars to permit a secondary means of egress for firefighters operating inside the structure.

After a complete size-up of the installation and types of the security bars, firefighters can chose a particular method of removing them. There are a few ways to attack the bars, and each situation may require a different method (fig. 14–33). One method is to attack the ends of the bars, where they are embedded into the brick walls. Breaking the bricks may release the bars. This may also work when the lag bolts are set into brick or blocks. Another method is to use the forcible-entry saw and cut the bars for removal. A hydraulic forcible-entry tool may also help: Place the jaw behind the bar frame and push the lag bolts out of the building's walls, releasing the bars or their frame. In other instances, cutting the bars with a rebar cutter or torch may also work. Many of these installations can be defeated with a set of forcible-entry tools; they may be pried off the building, forced off, or even sheared off.

For more information on removing security bars, see chapter 12, Forcible Entry.

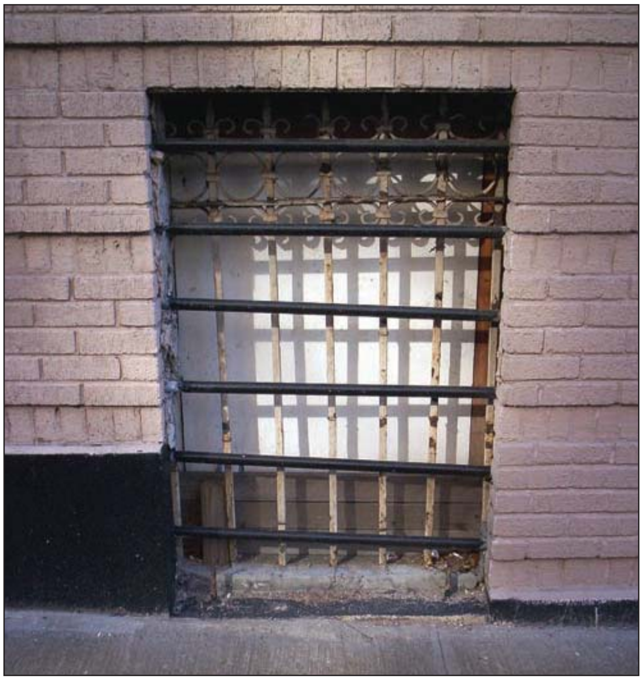


Fig. 14–33. Window bars vary. Some are flush mounted, some are recessed. Look at your district and consider which tools and techniques can negate these security devices.

Ventilating hurricane resistant glass windows. Hurricane resistant glass windows are a common construction feature in areas where hurricanes are prevalent. Because they are difficult to penetrate and offer increased security, they are becoming more widespread and found in all types of communities. These windows are designed to take an impact load from the outside and can hamper ventilation efforts severely.

The windows are constructed with either two or three layers of glass that are laminated together with a polyvinyl-butyrate and argon gas. They are attached to either a metal or vinyl frame, which is securely mounted into the building. Their locking devices are heavy-duty mechanisms and help prevent intrusion from the outside.

Attacking these windows for ventilation operations can be difficult. They normally cannot be broken by a firefighter swinging a hand tool. When faced with these windows, firefighters must revert to using power tools in order for rapid ventilation operations to be successful. The chainsaw with a carbide-tip blade is perhaps the quickest tool to deploy against these windows. A rotary power saw with a carbide-tip blade also works well. Tests have shown that a reciprocal saw can cut these windows, but the blade can quickly dull. Some firefighters have had success using an auto extrication hand saw or pruning saw when faced with these windows. These saws can cut the material but it may take considerable time to do so.

It is of utmost importance that all personal protective clothing and eye protection be used when cutting these windows. Small glass shards and fragments can cause serious injury to firefighters that aren't properly protected.

Because these windows are designed to take the brunt of a load from the outside, they are weaker and sometimes easier to remove from the inside. Any time firefighters come across these windows on the fireground, the incident commander should be notified immediately.

For more information on these windows, see chapter 12, Forcible Entry.

Ventilating Lexan™ windows. Firefighters often encounter Lexan™ windows on commercial occupancies. Lexan™ is a high-grade plastic material that is resistant to impact loads. It is often chosen for windows in these occupancies for increased security measures. When Lexan™ is exposed to high heat conditions it melts, creating its own ventilation process. Unfortunately, it is no easier to strike and remove the Lexan™ once it has melted and cooled; it still retains its impact resistance.

Firefighters can ventilate these windows with either a rotary or chainsaw. Full protective equipment and eye protection must be used to prevent an injury. Cutting Lexan™ is dangerous because fragments can become projectiles, so use caution when performing these tasks. If firefighters don't have the necessary power tools available, they can attack the frame and molding and attempt to remove the Lexan™ in this manner. If Lexan™ windows are present in a structure, communicate to the incident commander by way of a radio.

Ventilating blocked-up windows. Frequently, firefighters face fires in vacant structures that have had their windows blocked up with either cinder or concrete blocks or bricks for security measures. In other instances, factories block up large windows to reduce energy costs. Ventilating these structures often requires more time than normal ventilation operations. Firefighters must use hand tools to remove the brick or blocks to ventilate the structure.

If firefighters are operating on ground level, they should attempt to break the brick or block slightly higher than waist high. Here they have a good baseball swing and can use the momentum of their body to help break out the brick. It is important to attempt to swing in the same area and penetrate a brick or block with a few blows to make an entry point. Once the entry point is made, begin to work either next to it, above it, or below it, knocking out the next brick.

Also, when the brick or block is broken just above waist level, it leaves much of the upper portion unsupported. Many times the weight of the brick or block allows it to collapse when it is no longer supported from below, or a few simple strikes with a hand tool cause the remainder of the brick or block to tumble down. Firefighters often leave this unsupported piece in place as they complete knocking out the bottom portion of the brick. Leaving in the top section at this point sometimes keeps the area free from smoke and allows the firefighter to see the work area in front of him or her. Firefighters must keep the upper portion under constant watch; knocking out the lower section can create movement and vibrations, and the unsupported top section could come crashing down without notice. Clearing the entire window allows a better means of egress and escape if it is needed later in the operations. This tactic of opening up brick or blocked windows reduces the time and energy the firefighter must use to ventilate these windows.

When faced with these windows at upper levels, the easiest way to ventilate them is from the safety of a tower ladder's bucket. The bucket is placed slightly below the intended work area and the firefighter swings a hand tool to knock out the brick. The area below must be safeguarded by a firefighter to prevent anyone from possibly being struck by a falling brick or mortar. When working out of the tower ladder's bucket, the firefighter must remain cognizant of the fact they could strike their arm or hand on the bucket's safety rails while swinging.

Ventilating wired glass windows. Many windows in walls that require a level of fire resistance—exterior walls near a property line or near other buildings—have glass with wire safety mesh embedded in its layers. These windows are also found in high-traffic areas of structures such as hallways and stairwells. Ventilating these windows often takes a little longer than regular windows because of the wire mesh holding the glass together.

The glass can be struck with a hand tool and broken, but it may only shatter. Firefighters may need to strike it again to break a section out or create an entry point. Once an entry point has been made, a firefighter has a few options:

- A hand tool can be inserted into the entry point and can cut the glass and wire mesh with its sharp end. Once a substantial section has been cut into the glass, it can be pulled in one direction to ventilate the window.
- A firefighter can punch out a *U*-shape around the edge of the glass and then pull it in the direction of the bottom of the *U* to release the glass.
- In some instances it may be easier to attack the mullions around the window's frame and release the entire piece of glass to ventilate the window.
- Punching out the center and pulling the glass often takes numerous attempts to ventilate the window. It often leaves exposed wire and glass dangling from the window that could cause an injury.
- Some firefighters smash the perimeter section of glass out around three sides of the window. Next they cut the wire mesh with cutting pliers and pull the glass toward the attached side, ventilating the window.

Ventilating windows covered with plywood/OSB. Many vacant structures have their windows protected by plywood/OSB that has been nailed or screwed into their window frames to prevent intruders and protect the vacant structures from vandalism. Most of the time, these sheets of plywood/OSB are easily removed by a firefighter prying it off with a hand tool (fig. 14–34). Some firefighters prefer to start at the top and release those fasteners and then pull the entire sheet down and out of the window. Others prefer to work around the base of the window, pry outward to release it on both sides, and then lift the plywood/OSB sheet up to gain access to the window. In both situations, firefighters must use caution, because a sheet of plywood/OSB can be heavy and cause an injury when it is dropped or released.

Fig. 14–34. Use a prying action with the Halligan to remove plywood/OSB that has been nailed or screwed into window frames.

Firefighters can also use a baseball swing technique with a Halligan tool, pick-head axe, or hook's head to pry these sheets off. Simply position the tool about 6 in. (150 mm) from the edge of the plywood/OSB and drive the point through the sheet. Next, pry back on the tool's handle and push it toward the sheet of plywood/OSB, pulling the screws or nails out of the window frame. This technique may only release one side of the plywood/OSB, and the firefighter must perform this same technique on the opposite side of the window.

These types of security measures are also being modified to make it even more difficult to enter the structure. Often the plywood/OSB is now covered with a thin metal mesh and then a **skim-coat** of concrete mastic is layered over the plywood/OSB. This step reinforces the plywood/OSB and makes removal more difficult. The same method used previously can be attempted, but it may be more advantageous to take a rotary power saw with a carbide-tip blade and cut along the outside edges of the plywood/OSB sheet to release it. If the plywood/OSB sheet is recessed into the window frame, the operator may have to cut a few inches in for the saw blade's assembly to access the plywood/OSB. Firefighters *must* use caution and not plunge the saw's blade entirely into the plywood/OSB sheet. This could cause the saw to hit the glass, window sash, or another obstacle such as security bars behind the plywood/OSB, which could cause damage to the saw and injure the operator. Plunging a chainsaw through the plywood/OSB sheet can also be dangerous for the same reasons, so firefighters should avoid doing this. In addition, if another firefighter or victim comes to that window from the inside, a serious injury could occur.

Ventilating windows covered with HUD window coverings. Firefighters may encounter vacant buildings that have been covered with a HUD-style window covering, a means of sealing up vacant buildings accepted and approved by the U.S. Department of Housing and Urban Development (HUD). Although they are less prevalent than in years past, they are still present in numerous areas.

The **HUD window,** as it is called by firefighters, is made up of a sheet of plywood/OSB that is attached to a window frame by four cross members: 2 × 4–in. (50 × 100–mm) pieces of wood (fig. 14–35). Two smaller pieces of this material can be seen from outside the structure, whereas the other two longer pieces cannot. These two pieces are supported on the inside of the building, spanning the window frame on each side, adding strength and rigidity to the device. All the pieces of wood are connected by through bolts or a piece of threaded metal rod and become secure when they are tightened up. Normally, there are two bolts on each of the upper and lower cross member supports for a total of four. These devices can be installed with the windows opened and left in place, or the entire window and frames may have been removed prior to their installation.

Fig. 14–35. Notice the 2 x 4 cross members that tip off the firefighter that these are H.U.D. window security devices.

To ventilate these windows, there are a few options to consider after sizing up the material. If the wood shows signs of being compromised or rot, it may advisable to attack it. A hand tool such as an axe or Halligan tool can be used to split the outside 2 × 4–in. (50 × 100–mm) cross members, exposing the four metal through bolts. The bolts can then be pushed or struck into the structure to release the inside cross members. Firefighters must use caution because the sheet of plywood/OSB can now become loose and swing down and out from the window, and the cross members are now unsupported. Firefighters must maintain some type of grip on the plywood/OSB to prevent it from falling away from the building and causing an injury. One way to tackle this is to drive a hand tool into the plywood/OSB and maintain a hold of the tool. This controls the sheet of plywood/OSB once its cross members are released.

Another method to remove these devices if they are present on the upper levels of a building is to operate from the safety of a tower ladder basket and use a forcible-entry saw or rotary saw blade capable of cutting the metal through bolts. Once the tower ladder's bucket is placed slightly below the window, place the point of a hand tool through the plywood/OSB as a safety hold; this *must* be maintained the entire time to prevent the plywood/OSB sheet from falling from the building. Another firefighter then uses the saw to cut the upper and lower head of the bolts on one side of the window. The saw's blade cuts through the 2 × 4 at an angle and cuts the bolt head and rod at one time. Next, they cut the top and bottom bolt on the opposite side of the window. Firefighters can now either strike the bolts back into the building, releasing the device, or they can pry up the outside 2 × 4s. These actions normally release the inside cross members and the sheet of plywood/OSB. If no window is present, the sheet of plywood/OSB can be put back into the fire building rather than dropping it down onto the fire scene and possibly causing an injury. If it can't and there is room inside the tower ladder, it may be placed inside the bucket rather than dropping it to the ground.

Some firefighters prefer another method of removing these devices. They use a chainsaw and cut a small triangle in the middle of the plywood/OSB sheet. If fire conditions behind the sheet are severe, they can move onto another window. If they aren't, the chainsaw can be inserted into the hole (once it is safe) to cut the upper and lower inside cross members, releasing the tension of the device. In some instances, when performing this tactic, the plywood/OSB may have to be pried toward either side to remove the inside cross members from the window frame after the cuts are made. When performing this tactic, firefighters must remember to maintain a grip onto the plywood/OSB to prevent it from falling to the ground and causing an injury to an unsuspecting firefighter operating below.

It is also important to assert that plunging a live chainsaw through a HUD window can be a dangerous evolution. This could cause the chainsaw to hit the glass, window sash, or other obstacle such as security bars behind the plywood/OSB, which could damage the saw and injure the operator. In addition, if another firefighter or victim comes to that window from the inside, a serious injury could occur.

Metal casement windows. Many older structures have single-pane glass set in metal casement window frames (fig. 14–36). The glass panels are usually 8 × 8 in. (200 × 200 mm) or 12 × 12 in. (305 × 305 mm) and are easy to ventilate with a hand tool. The windows may or may not have a hinge section(s) that pivots and opens outward with the turn of a handle. If these windows need to be removed for the rescue of a trapped civilian or firefighter, it can be time consuming using hand tools. It often requires numerous strikes of the cross members and uprights to remove them if that's even achievable. Sometimes all they do is bend and warp from the hand tool's impact. A much faster way is to use a rotary saw equipped with a metal cutting blade to remove the uprights and cross members. This reduces the firefighter's exertion level and requires less time to make an opening in the window frame for the rescue.

Post fire control window ventilation. After the fire has been extinguished and the structure is still full of toxic smoke, gases, and heat, the building still must be ventilated. Firefighters should resist the urge to break windows after the fire has been extinguished; this looks unprofessional and increases the workload of those performing salvage operations. Firefighters should size up the windows and see if they can be opened or removed to assist in ventilation efforts.

Fig. 14–36. These casement windows on this Tudor-style multiple dwelling will be difficult to force.

Many newer types of double-hung windows have release clips mounted on the sash that allow the windows to be removed to help clean. Firefighters can release these tabs, then lift one side of the window up and the other side slid downward and the window comes out of the tracks. In some instances, the tracks are spring loaded and slight tension or compression on one side prevents the window from releasing from the track. By performing this technique, we're reducing fire damage and looking more professional (fig. 14–37).

Fig. 14–37. Taking the time to open a window instead of breaking it during post control ventilation helps to reduce fire damage and makes us look more professional.

VENT, ENTER, AND SEARCH

The **vent, enter, search (VES)** technique of search and rescue is used by some fire departments in certain fire situations. Most commonly, it occurs when access to a trapped victim is unattainable through the main entrance of a structure. This technique allows a firefighter to access the alleged location of the victim by another avenue. In some fire departments around the country, the VES technique is used daily in their firefighting operations, while in others it is only used for specific rescue operations. Firefighters must understand and learn this concept prior to operating on the fireground.

Prior to discussing the VES technique, it is important to note that firefighters must understand and grasp the meaning of two ventilation concepts: venting for life and venting for fire. Venting for life is performed to permit firefighters access into an area where there is known or suspected life hazard exists. There is a calculated risk of eventually pulling the fire toward the area to be searched with this tactic, because a ventilation opening has been created to release the by-products of combustion. However, these calculated risks are performed to reach potential victims as soon as possible.

Venting for fire is performed to assist the engine company's advance into the fire area to extinguish the fire. The venting is usually performed once the engine has water in the hoseline and prepares to move in and attack the fire. This venting assists the by-products of combustion and steam from the hoseline's water to escape from the building, lessening the burden on the firefighters operating inside. These two concepts *must* be understood, because premature ventilation can increase the fire's intensity, speed, and location as well as decrease the chances of a trapped victim's survival. Remember, all types of ventilation efforts must be coordinated between firefighters operating inside and outside the structure.

Normally, the VES tactic is performed by one or more firefighters going through a remote opening, such as a window to access a suspected or known life hazard area. Prior to window entry from a ladder, porch roof, fire escape, deck, or platform, the firefighter should size up the entry point (fig. 14–38). They should recognize the amount of smoke, heat level of the smoke, and its condition (puffing, rolling under pressure, or a haze) prior to opening the entry point. Once the window is opened, firefighters should position themselves away from the escaping heat, gases, and smoke and probe inside with a tool to see if an unconscious victim is on the floor and tap the floor to check its structural stability.

Fig. 14–38. A firefighter venting from an extended roof, preparing for entry

Once the floor has been checked and found to be clear, the firefighter should vent the window with a hand tool and remove any sash in between the clearing. They should also remove any screen, drapes, blinds, or curtains to promote ventilation efforts and prevent these items from entangling the firefighter entering the area. Next, the firefighter enters the structure with one leg first and then the other, rather than going in headfirst. The weight of a firefighter diving into a room can cause an impact load to the floor and a possible collapse if the floor is of questionable stability. Also, if a firefighter *dives* into the window and hits a piece of furniture, he or she could go flying across the room and lose all sense of direction and whereabouts.

Once the firefighter has entered the window, the search begins. There are two basic concepts firefighters may use:

1. Firefighters can probe the area with a hand tool looking for a victim while keeping one hand on the wall to maintain his or her bearings while searching the room.
2. Firefighters can use a hand to search for a victim while using the tool to maintain contact with the wall to keep their bearings.

Following the wall, proceed across the room to shut the room's door. With a 6-ft (2-m) hook in one hand, you may be able to close the door to the room from your initial entry point. The hook can be run along the midsection of the walls feeling for the door, so use all your senses and listen for the sound of the door closing if it is struck with the hook. If you hear the distinct sound of glass, do not immediately break it because you feel it will vent the room more quickly. Remember where you are operating. Premature venting could allow autoexposure of the fire right into the search area. Remember that the sound of glass in the room could also be a mirror, television set, or even a fish tank. Your hands and senses can tell you what you're feeling in a severe smoke condition.

Closing the door to the room can help in a few ways. It decreases the chances of pulling the fire into the room entered. Closing the door may increase visibility in the room and make finding a victim easier. Finally, it creates a safety factor with the door holding back the fire while searching the room.

If a victim is found in the room prior to finding the door, you must decide if conditions allow for the door to be closed or if you'll have to immediately retrace your way back to the entry point with the victim in hand. Remember, if the victim is large and you need time to remove him or her, closing the door to the room increases the overall safety margin of the rescue operation. If the fire has been controlled below, the victim may also be removed through the interior of the structure.

If no victim has been found, searching firefighters can leave the room's door closed and exit the room to safety. Or they can size up conditions out in the hallway to see if an interior search of other rooms may be feasible; if not, a portable ladder can be used to gain entrance to a window in another section of the structure to perform the VES tactic. VES can be a dangerous tactic to perform, so firefighters must operate in pairs and in conjunction with the tasks of the interior teams to make this a safe evolution. If done properly, this tactic can save numerous lives.

WINDOW GATES AND CHILD BARS

In some situations firefighters find window gates or scissor gates behind a window to protect the occupants from intrusions (fig. 14–39). These gates are normally a hinge-style gate or in a slide track and both locked from the inside. In newer installations, a release button is mounted on the wall to unlock these gates; the button can be located at the base of the wall or somewhere on the wall next to the gate. Unfortunately, these devices can delay VES operations and can be difficult to force open from the outside.

Fig. 14–39. Although typical in residential multiple dwellings, scissor gates can be found in commercial occupancies as well, and will delay egress through these windows.

If firefighters encounter these devices while trying to make entry, they should first attempt to see if they are unlocked and can be pushed or slid open. If they are not, they must begin forcible-entry procedures on them. For scissor window gates in a slide track, it may be easiest to work on the stationary side and insert a hand tool behind the frame to pry it out and away from the wall. These installations are normally screwed into the framing and pull out with the use of leverage. If smoke is issuing from the window, pull down the top sash first and pry the top of the gate off first. Then push the window back upward to cut down on the smoke exiting and use it for a protection measure. Next, lift up on the lower sash and attack the gate at the bottom. Once the gate is released from the stationary wall, slide it in the track toward the lock side or hinge it and push it inward. Remember, if this window is going to be used for VES, it should be cleared entirely out.

In heavier installations with steel bars, the same method of attacking the gate may be feasible. In some situations it may call for additional tools such as a forcible-entry saw or hydraulic forcible-entry tool to gain entry. In some installations it may also be possible to pry on a set of bars to make an opening to insert a gloved hand into the building. Next, attempt to lift the lock guard and then turn the locking mechanism to open the gate.

Some cities require that windows have child bars on them to prevent a child from falling out of a window. These bars are different from regular security bars; they are a two-piece system that includes interconnected bars and uprights that normally run horizontally across the bottom of the window (fig. 14–40). They are screwed into each side of the window frame and, if struck with a hand tool on one of the center uprights, can be pulled out from the side of the frame. The frame then can be pushed inward or struck in the other direction to remove the opposite side, permitting entry into the building.

For more information on these devices, see chapter 12, Forcible Entry.

Fig. 14–40. Child bars are installed with good intentions

ROOF VENTILATION

Tools used for roof operation

When firefighters are performing horizontal or vertical ventilation operations, the following tools or complement of tools (some of which are shown in fig. 14–41) can be used to perform the ventilation tactics:

- Full personal protective clothing with eye protection
- Breathing apparatus
- Axe (pick-head or flat-head)
- Pike pole, rubbish hook, or other suitable tool
- Power saw (chain or rotary saw)
- Communications (portable radio)
- Halligan tool
- Utility rope
- Flashlight

Fig. 14–41. These are various tools that can be very useful for roof ventilation operations. It is important to understand the strengths and weaknesses of various ventilation techniques.

Pick-head or flat-head axe. The axe is an indispensable and dependable tool for ventilation operations. The pick-head axe is versatile, because the pick can be used for a variety of tasks:

- Driving the pick-head into the roof and using the axe as a foot brace if cutting with a saw
- Prying off scuttle covers or lifting up skylight frames
- Making quick inspection holes in the roof and tearing off roof coverings

Also, when traversing a pitched roof, firefighters should keep the pick-head axe ready. The pick can be used to pierce the roof and act as an anchor in case you slip or fall.

Most training material regarding axes suggests cutting at a 60° angle to the roofing material. Although this can provide acceptable results, it has several drawbacks:

- Not all of the energy expended for cutting is effectively used.
- It is an inefficient way of cutting plywood/OSB and difficult to cut through shingles and sheathing.
- The axe head may plunge beneath the surface being cut and become trapped.

These problems can be overcome by bringing the axe downward in a smooth arc motion so that the cutting edge is 90° to the work surface at contact. This results in more cutting power due to the velocity and natural swing of the axe requiring less effort. Remember it's very important to position your feet properly apart so that the axe doesn't accidentally strike your leg or foot. If the head of an axe becomes trapped in or below the work surface, simply use the toe end of a boot as a fulcrum at the junction of the axe head and the handle to lever the axe out again (fig. 14–42).

Fig. 14–42. An axe head that is trapped below roof decking can be levered out by placing the toe of your boot between the roof and the junction of the head and handle.

When firefighters are cutting a roof with an axe, they should try and determine the location of the rafters by sounding the roof with the head of the axe. To sound the roof, the firefighter bangs down on the roof with the top of the axe and listens to the sound it makes. A solid thump can alert the firefighter to the position of the joist. A hollow sound means an area between the joist. Cuts should be made as close to the rafter as possible, providing a firmer foundation for the cut.

Although less versatile than the pick-head axe on the roof, a flat-head axe can also be used to cut open roofs. The axe is swung and used the same way as mentioned above. In addition, if the roof sheathing is made up of plywood/OSB or pine boards covered with shingles, another method of using the axe is available. Firefighters can first sound the roof and attempt to cut alongside a joist. Next they'll use the flat end of the axe and swing downward and strike the roof. Each strike makes a cut into the roof; and when these cuts abut each other, they make a cut line. Using this method it is easy to make a louver in a roof. Some firefighters use the maul or a splitting maul to perform the same tactic of opening the roof.

Pike pole or hook. Firefighters must bring a pike pole or hook with them when reporting to the roof for roof ventilation operations. Once the roof has been cut open, the roof sheathing must be pulled up or louvered to create the roof opening. To pull up the sheathing, the hook's head is placed into the knockout and then the sheathing is pulled upward away from the roof (fig. 14–43). If a knockout was made on both sides of a cut, two firefighters can pull up the roof sheathing. If the sheathing or roof planks are difficult to remove by pulling upward, the hook can be used as a giant pry bar. Simply place the hook's head on the joist and pull it so that it bites under the roof planks or sheathing. Now simply push up and away from your body to pry the sheathing upward and off the joist.

Fig. 14–43. Pulling roof boards with a Halligan hook

Once the roof planks or sheathing is removed, the ceiling must be pushed down to ventilate the room and area below. If it is not, the cockloft or attic is the only space ventilated. Using a hook rather than a shorter hand tool allows the firefighters to position themselves away from the ventilation opening. This helps them keep out of rapidly escaping smoke and gases that could ignite without warning. In some buildings with deep cocklofts, hooks longer than 6 ft (1.8 m) are needed on the roof to reach the ceiling below. The hook can also be used to sound the roof as a firefighter proceeds across the roof to check its stability. Also, the hook can used as a safety brace when operating on a peaked roof.

Rubbish hook. The rubbish hook was originally designed as a companion to the pike pole to move debris during rubbish fires, during overhauling operations, and to strip shingles from roofs. Although the pike pole is versatile, the rubbish hook also benefits firefighters performing roof operations. The hook can be used as a sounding tool as firefighters transverse the roof. Firefighters can use the wide heel of the hook's head to strike and sound the roof as they proceed. The width of a rubbish hook's head also simplifies pulling up cut portions of a roof. Firefighters can place the head of the hook over the joist, with both hook tines on either side of the joist; this creates equal pressure on both sides of the sheathing when it is pulled open by the firefighter. The head's large size also assists firefighters in pushing down the ceilings once the roof is open. Remember, it is possible for a hook to catch onto wiring, cable, or ductwork when pushing down the ceilings.

Power saws: rotary and chainsaw. Power saws are versatile tools that can simplify ventilation operations by reducing the time it takes to open a roof with a hand tool. Using power saws also reduces the physical exertion level on a firefighter, increasing his or her effectiveness to perform other tasks once the roof is open. Although power tools are beneficial, they do have some drawbacks (bulky, cumbersome to operate at some angles) and can break at a moment's notice (the saw's starter chord can snap or tear out of the saw), requiring firefighters to use hand tools to provide ventilation.

Rotary power saws are excellent tools to use for cutting the thick or heavy roof composition usually found on older roofs. The saw's rotating blade is very good for cutting through thick tar and expelling the material through the blade guard and out of the saw. For these reasons, the rotary saw is better equipped to handle these types of roof operations on these structures.

As with a rotary saw, a chainsaw can simplify numerous ventilation operations to a significant degree. The chainsaw can be effective on roofs with asphalt shingles and wood plank decking or plywood/OSB sheathing. Depending on the type of chain used, the saw should be able to cut directly through the shingles and sheathing in one operation, enabling the roof to be opened in less time.

FIREGROUND NOTE

When faced with thick tar roofs, firefighters often attempt to pull the whole cut section of tar off the roof first. Then they attack the roof planks or sheathing to complete the roof opening.

Using a rotary saw or chainsaw to perform roof ventilation tactics presents a variety of hazards to firefighters. All safety measures must be followed and all firefighters must be aware of the dangers when a live saw is operating.

For more information on operating saws, see the saw sections of chapter 11, Tools.

Radio

Firefighters performing either vertical or horizontal ventilation efforts must carry and use a radio to communicate with interior teams on ventilation tactics. This is extremely important when performing horizontal ventilation, because it must be coordinated with the hoseline's advance on the fire. Firefighters *must* keep this in mind when ventilating top floor windows from the roof. It is also vital for firefighters to communicate when performing roof ventilation operations.

A firefighter opening up a roof's bulkhead door when a fire is in a large multiple dwelling can simply relay to their officer that the **roof is open**, meaning that initial vertical ventilation over the stairwell is complete. This informs the officer that the firefighter has gotten to the assignment and the mushrooming effects of the smoke and hazardous gases may have been eliminated.

Another simple communication statement should be made to units operating on the fire floor once the roof has been cut open. Prior to the ceilings being pushed down, the roof firefighter should quickly announce over the radio that it is going to be performed. By stating this message, firefighters operating on the floor below can prepare for a falling ceiling to crash down. A simple safety measure is for a firefighter to be positioned in a doorway, thus protected by the door frame when a ceiling is pushed down from above.

It is of the utmost importance for all firefighters to relay any pertinent information (heavy loads on the roof such as HVAC units, etc.) or delays that may affect ventilation operations to the incident commander.

Halligan tool. Firefighters often carry a Halligan tool to the roof for roof operations. The tool has a number of uses and is an excellent tool to force open doors on bulkheads, elevators, and penthouses. It also helps firefighters open up scuttle covers and make a safety step for peaked roof operations.

For more information on the Halligan tool, see chapter 11, Basic Firefighting Tools.

Rope: utility rope and life-saving rope. FFI 5.3.20 Firefighters should carry some type of utility rope; it is another tool on which they often rely. During roof operations the rope can be used to tie a hand tool to ventilate top floor windows. It is also good for hoisting additional tools and equipment to the roof. Firefighters can also use this rope to section off a dangerous section of the roof, preventing a fireground mishap.

In some areas it is necessary to carry a lifesaving rope to the roof. This rope is not to be used for ventilation efforts; its intended use is to save any life that may be trapped by the fire and to provide an emergency escape device for firefighters operating on the roof if no other avenue of escape is accessible.

Access to the roof

SKILL DRILL

Firefighters must have a pre-formulated plan on how to reach the roof of the fire building. For many private dwellings, access to the roof is by portable, aerial, or tower ladder. In many instances, because of the roof's high pitch, a roof ladder is needed as well. For larger multiple dwellings, firefighters should communicate with the inside teams to see if there is an alternate enclosed stairwell other than the attack stair that has access to the roof. If another stairwell is not available, firefighters should use the following:

- The adjoining building. Cross over at the front of the roof if the buildings align. Remember, if they are on a slope or hill, it is always better to choose the higher building and drop down to the fire building than it is to try and climb up to the fire building from the building below.
- An aerial or tower ladder to gain roof access to the fire building. If necessary, use one of these devices to reach the exposure, and use a portable ladder for access to the fire building.
- A fire escape that provides roof access (fig. 14–44). The fire escape should be the last resort because of their age and maintenance issues. Also, they can be narrow and be difficult to maneuver on, often requiring firefighters to perform the reduce profile maneuver.

On row-frame dwellings, using an adjoining building is not always wise, because of the **common cockloft**. A firefighter could get injured climbing up an interior scuttle ladder if the fire breaks out while he or she is climbing. A safer means of travel is to use a portable, aerial, or tower ladder to gain access to these structures' roofs.

Fig. 14–44. At times, the quickest way up is via an exterior fire escape.

Encountering obstacles during roof access and operations. Access to the roof to perform ventilation tactics can often be hampered by a variety of obstacles, such as trees, overhead electrical wires, and street lights, to name a few. These obstacles can often delay placement of ladders to the roof and overall roof operations, because a firefighter may have to find an alternate way to the roof. Many times, using the adjoining building for roof access can be the quickest and simplest method available. Firefighters should notify the incident commander whenever they encounter obstacles that severely delay their work assignment.

Security fences. On many structures that have adjoining roofs, security fences have been placed on the adjoining parapet walls to prevent rooftop intrusions. These fences may be chain link, steel bars, or ornamental aluminum fences. In some instances, the top of these fences have razor wire or barbed wire strung across them for increased security. Also, many of these fences jut out over the front and rear cornice or parapet walls. This prevents access around the ends of the fence.

For access through a chain-link fence, a firefighter should locate the small wire tie bands that wrap around the piping of the fence. These ties secure the chain-link fence to the pipe structure. A firefighter should attack these ties starting at the bottom of the fence. Inserting the point of a hand tool into the chain link next to the wire band and prying in one direction normally pops the tie or pulls it off the fence. Some firefighters carry small wire cutters, which can also cut the wire ties off the fence.

As the bottom ties are removed, the firefighter cuts or releases a few vertical ties on the vertical pipes of the fence. Once a small area has been released, the firefighter can lift up the bottom of the fence and place a hook under it to keep it suspended. Now he or she can transverse to the other rooftop for roof ventilation operations.

When steel bar fences are in between rooftops, access to the adjoining roof can be more difficult. Attacking the welds or trying to bend the individual metal bars is often time consuming and still does not permit access to the adjoining roof. If these fences are visible from the street level, a firefighter should take a forcible-entry saw to the roof. Cutting the steel bars of the fence provides a quick means of egress to the adjoining roof for ventilation operations.

Cell phone sites. Many buildings are now leasing their rooftop space and **air rights** to cell phone service providers. The roofs of such buildings are now loaded with new structures that increase the weight load on their structural components and presents other problems for roof operations (fig. 14–45). In numerous installations, wire conduit and pipe chases provide power and signal service for equipment, and antennas run along the rooftop surface. These conditions can restrict the area available for cutting the roof for vertical ventilation.

It is also important to note that these antennas emit microwaves and are harmful to the health of human beings. If firefighters are within 10 ft of an operational cellular antenna when it is transmitting, serious or fatal damage can occur from radiofrequency (RF) radiation. When operating on the roof, firefighters must restrict the time they must operate in front of these antennas, and stay as far outside a 10 ft radius from a cell tower as possible (fig. 14–46). This reduces exposure levels to the microwaves and increases overall safety while working on the roof. In some installations, natural gas lines are run along the roof from an auxiliary generator in case of an electrical malfunction. These gas lines can become severe exposures and a hazard if the roof is engulfed or compromised due to fire.

Fig. 14–45. Cell site equipment introduces new hazards to roof operations.

Fig. 14–46. Cell site antennae add more risk from RF wave radiation, which can be dangerous or fatal if standing within 10 ft while transmitting. Look for cell site installations on tall buildings or buildings built on high ground in your district.

Remember, inform the incident commander whenever a **cell phone site** is found on the roof or tied into the roof's parapet walls.

Multiple roofs. **Multiple roofs** are common on many renovated buildings. When the building was retrofitted instead of removing the original roof, a new roof was just placed on top of it (fig. 14–47). If firefighters perform roof ventilation operations and find a second roof below the original roof, they should immediately inform the incident commander. Judging from the fire conditions below, the incident commander may have firefighting operations on the roof cease or attempt to cut the roof below the original roofline. Remember, the addition of the new roof also adds a significant weight load to the structure.

Fig. 14–47. During some building renovations, peaked "rain roofs" are sometimes added over existing flat roofs, which makes ventilation operations difficult.

Determining feasibility. **FFI 5.3.12** Beyond reading the status of the roof, personnel must determine whether or not ventilation operations on it are feasible. This entails knowing such factors as the location, size, and extension of fire and the type of roof construction present. The roof may be constructed of 2 × 12 in. (50 × 305 mm) joists/rafters and 1 × 6 in. (25 × 150 mm) sheathing, 2 × 3 in. (50 × 75 mm) wooden I-beams and ⅜-in. (10-mm) plywood or OSB, heavy wood timber beams, lightweight wood truss systems, or open-web steel bar joist construction covered by corrugated metal.

All these roofs may look similar from the top, yet each reacts differently when exposed to fire. Before committing personnel onto an unknown roof, determine whether it is structurally sound and whether it provides adequate time to perform the intended operations. The roof must also be sized up for items on the roof such as air conditioning units, HVAC units, billboard frames, cell phone sites and antennas, and any unusual conditions. These items can increase the weight load on the structural joist and supports and could cause an early collapse in adverse fire conditions. Remember to communicate the location of these things to the incident commander.

The type of construction can determine the location of a ventilation opening. For example, conventional construction obtains its strength from the size of its structural members. This often allows ventilation openings to be made over or near the fire if the roof is deemed safe. The key ingredient is the time available between impingement by flame and structural collapse. Conversely, lightweight construction is subject to fast failure rates and may not allow adequate time for these operations. Therefore, any ventilation operations on lightweight roofs should focus on uninvolved portions. While working on a roof, consider the potential of fire underneath. Start ventilation cuts in the weakest portion of the roof (near the fire) and work away toward the strongest portion. Spend as little time as possible on the weak portion. Also, work away from the fire and toward the means of egress.

To underscore an important point, consider the following about roof construction: Roofing material is usually made up of an under-laminate or sheathing, corrugated steel decking covered by composition-type materials (insulation board, polystyrene [Styrofoam]), or shingles (asphalt or cedar). It is important for firefighting personnel to be familiar with a particular building and roof and the structural members because sheathing or plywood/OSB decking can weaken or burn away without burning through the composition covering. Therefore, although a roof may look normal from the top, it may not support any weight.

Once firefighters have vented the natural roof openings and the top floor fire or attic area needs additional ventilation, the longer task of cutting the roof open begins. When the first firefighter assigned to roof ventilation accesses the roof, he or she should have a tool to sound the roof as they proceed. The firefighter is also trying to determine if the roof is strong enough to support the weight of personnel or if the decking has been burned away under the roofing material. The strength of a roof can easily be determined by sounding it with an axe, pike pole, rubbish hook, or other such tool. Always evaluate the integrity of a roof before stepping onto it (fig. 14–48).

Fig. 14–48. Always sound the roof ahead of you to evaluate its integrity.

The firefighter on the roof should also use his or her feet in conjunction with the sounding tool. Being sensitive with the feet can reveal a roof's bounce, flex, or sponginess. Sounding a roof also provides an additional benefit; firefighters can often determine the location of its supported and unsupported sections, particularly on lightweight roofs. In addition, firefighters can always cut inspection cuts into the roof to determine roof construction and roof joist layout.

When the first ventilation member sounds a roof to determine its safety, that member also determines the path of travel for other firefighters. Inexperienced members shouldn't determine the path of travel across a roof. A good rule to follow on flat roof structures is to walk along the building's perimeter to access the area of the fire. The roof beams are normally supported at the ends of the building; and in many cases if a firefighter must seek an alternate means off the roof, he or she may be able to cross over to safety on the next building. When operating on peak roofs, the firefighter should work on a portable ladder, on an aerial ladder, or from the safety of a tower ladder basket.

Before venturing off the ladder, personnel must take the appropriate time to read the roof. What is the location of the fire? Is it burning in a specific location, or is it extending from its original location? How long has the fire been burning? Is fire showing through the roof? Is a portion of the roof sagging? Does the roof have ventilators, and are they issuing smoke or fire? Consider evaluating the building as a building under demolition. What type of roof is it? Is it of conventional construction? Is the roof covered with slate or tile, making it difficult to traverse? Such materials can be deceptive, changing the way the roof feels underneath you. Do you know where your means of egress is located? Know where and how to exit the roof and whether or not you have an alternate means of escape (fig. 14–49). If roof ventilation personnel discover that skylights are available and appropriately located, they may be able to accomplish ventilation without cutting the decking.

Fig. 14–49. A good practice is to set up an additional ladder as a second means of egress from the roof in case access to the primary ladder is compromised.

Determining where to cut. Normally, firefighters are directed to cut the roof directly over the fire when performing roof operations (fig. 14–50). Sometimes it may be difficult to determine where to cut the roof. Firefighters can look for certain clues to assist them in choosing a cutting location. The following items should be surveyed for clues:

- Melting or bubbling tar
- Asphalt shingles curling upward
- Wood shingles smoldering or smoking
- A wet roof with a dry area
- A snow- or ice-covered roof with a melting area
- Location of the fire area gathered from a perimeter search
- Checking the base of soil or vent pipes for heat
- Radio communication from the interior firefighting teams

Although cutting directly over the fire is a good theory for firefighters to follow, sometimes it needs adjustment. If a roof is not structurally sound, firefighters should not position themselves over the fire to cut it; moving back to a safer location may be more beneficial. *Firefighters should never attempt to ventilate a roof of lightweight wood construction involved in a fire*. Also, if a fire is already ventilating out of the windows, firefighters should position the cut a little further back, not directly over the fire. Because the fire is already venting to the outside from this specific location, it may be advisable to cut a little further back to assist vertical ventilation. This channels and ventilates the heat, gases, and smoke upwards and also relieves the punishing conditions in the immediate area of the fire. This can assist the engine company's advance into the fire area with their hoseline.

Fig. 14–50. Use visual clues and communication to determine where to cut.

Making the cut. When possible, firefighters should plan ventilation cuts so that the wind is at their backs, with smoke and heat moving away from the cut. They should also attempt to make the long side of the ventilation cuts parallel to the roof joist. Following this method allows more joist channels to be ventilated. When cutting the roof decking open, don't make the cuts deeper than the thickness of the decking, this can cause the saw's blade to hit a joist and possibly damage a structural member.

Remember, to adequately ventilate any building, make the opening commensurate with the amount of heat and smoke inside. Observe the pressure of the venting smoke. If the contaminants are coming out lazily, the opening probably doesn't have to be enlarged. However, if the contaminants are venting under significant pressure, the opening is too small. Keep increasing its size it or create additional openings as necessary.

Openings made in roof decking involve specific considerations to make them quickly and efficiently. This doesn't imply that the openings should be small and made in haste. They should be easy to open and of a size appropriate to the needs of the incident. Therefore, when cutting and removing roof decking, don't cut a ventilation opening that cannot be easily and completely opened. A common recommendation for roof ventilation openings is 4 × 4 ft (1.2 × 1.2 m) or 3 × 6 ft (1 × 2 m) for dwellings and 8 × 8 ft (2.4 × 2.4 m) for commercial properties. Remember these are only guidelines and some fire departments have changed SOPs in roof cut's sizes because of the fire load of today's fire environment.

Often firefighters face stone or gravel placed over the roof membrane on the structure's roof. Placing a rotating saw blade into these materials can create flying projectiles and injure a firefighter. It is important for firefighters to use their boot and sweep or drag the material away from the cutting line. Another option is to use a shovel or brush broom to remove the material from the cut line.

After the cut: pushing down the ceiling. Once the cut in the roof has been made and the roof sheathing is pulled and detached from the roof joist, ventilation operations are not completed. Just cutting and pulling up the roof sheathing only affords ventilation of the cockloft or attic space. To properly ventilate the fire room or rooms below, the ceilings must be pushed down from the roof (fig. 14–51). A good firefighting tactic to perform is to verbally announce this over the radio to inform the interior firefighting crews of the impending ceiling situation.

When firefighters are going to push down the ceiling from the roof, they should position their bodies to the windward side of the ventilation hole. They should be in line or parallel with one of the sides of the hole and only expose very few body parts over the hole to push the ceiling down. In this situation, if they were to slip on the roof surface or loose their balance and fall forward, they could keep from falling directly into the ventilation hole. Using this technique also keeps them out of the direction of escaping heat, smoke, and gases that could ignite once they escape to fresh air. Firefighters should not bend over and square themselves up to the hole and push downward with a hook. If they slip, they might fall directly into the ventilation opening and be injured.

Fig. 14–51. After cutting the roof and removing the sheathing, the task is completed when the ceiling is pushed down.

If another firefighter is assisting with roof operations, he or she should hold onto the bottom of the firefighter's coat or hold onto the safety harness for support while the firefighter pushes down the ceiling. If operating on a roof ladder, the firefighter pushing down the ceiling can also hook into the roof ladder with his or her safety belt to ensure he or she stays on the roof.

When using a hook to push down the top floor ceiling, some fire departments encourage their members to push the ceiling down with the butt end of the hook's handle. By using this technique, the hook's head is less likely to hit and snag on any wire, cable, or ductwork in the attic or cockloft space as it is pulled upward. Some fire departments use larger hooks such as rubbish hooks; this increases the area of the ceiling the hook's head can penetrate. Another method to use for pushing down the ceiling is to use some of the roof planking that was pulled up off the joist. The roof planks are wider than standard roof hooks and can also push down a greater area of ceiling. In addition, if the plank slipped out of the firefighter's hand, he or she would not lose the tool.

Safety considerations for roof operations

FFI 5.3.12 In most cases, these safety considerations apply to both flat and peaked/pitched roofs, except where peaked/pitch roofs are specifically identified.

- When faced with severe smoke conditions, firefighters should crawl on the roof with a tool out in front of them, probing the area for any open shaftways or hazards. Many firefighters have accidentally walked off roofs in smoke.
- Initially, when firefighters arrive on the roof, they should size up an alternate means of escape in case of an emergency retreat. Placing at least two ladders to a roof can provide a secondary avenue of escape. Ladders placed to each side of a building can ensure an avenue of escape to all sides.
- Cutting an inspection hole in a roof can reveal the type of construction of the roof's framing system.
- When firefighters proceed with a live rotary saw, they can push the saw across the roof like a wheelbarrow, eliminating the chances of the blade striking another firefighter.
- As firefighters proceed across a roof, they should sound the roof with a tool to ensure its stability. Skylights may have been removed and covered up with skimpy materials, which could collapse under a firefighter's weight. It is also recommended that firefighters proceeding across a roof with a large area make inspection holes/cuts if the roof is of questionable stability.
- If time and conditions permit, firefighters can cut a rubber membrane covering off a roof prior to cutting it (fig. 14–52). This inhibits the membrane from gumming up the blade and interior of the blade guard of a rotary saw, but more importantly it prevents the membrane from catching on fire. This can create a flash fire condition and fire extending across the roof's surface rapidly, making a firefighters retreat a priority. *Note:* Membranes can be easily cut without entanglement if using a chainsaw with a sharp chain run at full RPM, rather than a rotary saw.
- When a roof cut is pulled open or skylight removed, the section or skylight should be laid on the roof in the vicinity of the cut or opening. This piece of material should serve as a warning to firefighters that a hole or opening exists in the roof.
- Firefighters operating on peaked or pitched roofs should work from the safety of a roof ladder, tower ladder, or aerial ladder. Wearing an approved safety belt or harness is recommended.
- If footing on a pitched roof is questionable, the firefighter can place the point of the Halligan bar or the blade of an axe into the roof to make a safety step (fig. 14–53).
- For additional safety considerations, see the "Size-up" section in chapter 31, Advanced Fire Attack.

Fig. 14–52. A firefighter using a knife to remove roof membrane to avoid having rubberized material bind the rotary power saw

Fig.14–53. A tool such as a pick-head axe can be driven into the roof as a safety step while working on a peaked roof.

> **FIREGROUND NOTE**
>
> Many of today's roofs are insulated with thick materials that also create a pitch in the roof for drainage. These thick materials can prevent the rotary saw's blade from reaching the roof sheathing in the initial cut. If an inspection cut reveals thick insulation, firefighters can use a knife to cut off the roof covering, expose it, and cut the insulation away from the sheathing. This helps overall roof operations.

- In some instances it may be necessary to make a hole in the peaked roof on the opposite side of the ridgepole for the roof ladder's hook to sit in. This ensures the roof ladder's hook bites into the roof, securing the ladder over a high ridge vent.
- Prior to transferring from a ladder to a roof ladder, a firefighter should pull down on the roof ladder to ensure it is secured to the roof.
- If when cutting a roof a white/gray powdery residue is found, firefighters should relay this information to the fireground commander and evacuate the roof. This indicates a lightweight gypsum roof, which is prone to collapse.
- When operating at attached row frames, brownstones, or multiple dwellings, firefighters should cross over at the front of the buildings. Open-ended shaftways between buildings can exist toward the rear, and a firefighter could fall.
- If climbing up onto a bulkhead to vent its skylight, always get on and off the bulkhead in the same location. One side of the bulkhead could face an open shaft between buildings.
- Prior to removing slate or tile from a roof, advise the fireground over the radio that this tactic is being deployed to reduce the risk of injury from flying debris.
- Wearing an approved safety belt or harness when operating on the roof ladder can allow the firefighter to work with both hands while properly attached to the ladder.
- Prior to getting to the roof, firefighters should have a preplan regarding what they will be performing and a back-up plan in case the first plan of action cannot be achieved or fails.
- Once on the roof, the presence of any heavy equipment such as air conditioning units, billboard frames, and cell phone sites should be relayed to the incident commander. These things can lead to an early collapse of the roof under fire conditions.
- If a fire wall is separating a common cockloft or adjoining buildings and there is fire inside the cockloft space, consider cutting an inspection hole into the building not on fire. The adjoining building's joist pockets may have deteriorated over the years and fire could spread horizontally, despite the fire wall.
- If a life-saving rope is part of a firefighter's standard equipment, it should be placed near a substantial object on the roof, where it would be tied off to perform an **emergency escape slide** or a **rescue pickup evolution**.
- Because of the complexity of roof operations and their danger levels, firefighters should always operate in teams of two. Whenever a saw is removed from the roof cut, the saw operator should engage the chain brake, if using a chain saw, or place the blade of a rotary saw onto the roof to stop it from spinning. Engaging the chain brake or stopping a blade from rotating reduces the chances of striking and injuring another firefighter.
- Whenever noise levels on the roof make it difficult to monitor radio communications, one firefighter should move to a quieter location to monitor the radio. This firefighter should be in line of sight of the cutting operations, in case they must relay information to the saw team.
- Firefighters should not use satellite dishes mounted on the roof for foot support; they may be insufficiently attached to the roof.
- If a firefighter must use a fire escape for roof access, he or she should always shake the gooseneck ladder before climbing to ensure it is attached to the building's wall and roof.

- Firefighters operating on the roof should always perform a perimeter search, looking for trapped or fallen victims who may be in shrubbery or shafts. They should also check for the fire's location, extension, and autoexposure possibilities.

Inspection holes

SKILL DRILL

When firefighters operate on roofs of burning structures, it is vital that they operate safely. An important safety tactic to follow is to cut **inspection hole(s)**. Inspection holes provide a firefighter with a lot of information pertaining to the conditions below a roof covering if the firefighter is uncertain about the extent of fire in the roof structure. These conditions may include the following:

- The nature of the smoke (i.e., color, volume, temperature, pushing under pressure)
- The volume of fire, direction of fire travel, and the fire's extension
- The type, size, and run of the structural elements supporting the roof

The three most common types of inspection holes firefighters' use on a variety of roof types are a **punched hole**, a **kerf cut**, and a **triangular cut**.

When making an inspection hole, make it small enough that a firefighter cannot accidently step in it and break an ankle when visibility is low.

Punched hole. It is normally relatively easy to punch a hole in most roofs. Firefighters can forcibly drive the following tools through the roof to create an inspection hole:

- Pick end of a pick-head axe
- Sharp point of a hook
- Pry bar end of a hook
- Pick end of the Halligan bar

Once the tool has been driven into the roof surface, the firefighter can pry the tool back and forth to expand the hole; this also helps release the tool from the roof. Once the tool is released, the firefighter can judge the smoke and fire conditions below (fig 14–54).

The punched hole inspection method has a drawback: The hole that the tool creates is not that large (fig. 14–55). This can cause a firefighter to miscalculate; the actual fire or smoke conditions under the roof covering and construction components. The punched hole inspection hole does offer the firefighter an additional safety benefit at fires. As a firefighter proceeds across a roof, he or she should sound the roof with the sharp end of a tool or its butt end. In this manner, if the roof's stability is questionable or the roof's tar is melting, the tool may perforate the roof covering, which can alert firefighters to the dangerous condition below or help them find a good area for roof cutting operations.

Fig. 14–54. A firefighter punching a hole in a roof to make a quick inspection hole using a hook.

Fig. 14–55. An inspection hole punched in an asphalt shingle roof.

Kerf cut. The kerf cut is a quick and easy inspection hole to use during roof operations; it is also commonly referred to as a plunge cut. Firefighters can use an axe, power saw, or chain saw to cut one blade's width into the roofing material. If a power saw is used to make the cut, the firefighter should bring the saw up to full rpm prior to contacting the roofing material. This will prevent the blade from binding into the roof or the saw from stalling. As the blade is pulled out of the roof, it creates an opening the width of a single blade (known as the kerf). This kerf allows the firefighter to judge the conditions below. The kerf cut is often used when a firefighter is quickly trying to determine the boundaries of the fire's extension. The downside of the kerf cut is that it is also small, and often on membrane roofs or rubberized roofs the kerf can close up if the roof is subjected to heat from the fire (fig. 14–56).

Fig. 14–56. The Kerf cut is a quick way to make an inspection hole during roof operations.

Triangular inspection hole. The **triangular inspection hole** is also commonly referred to as a tepee cut or an A cut because of its resemblance to them. The cut is far superior to the other types of inspection cuts and holes because it is larger and gives the firefighter better visibility into the attic or cockloft space. This helps firefighters quickly identify today's modern lightweight construction features. The only setback in making this cut is that it takes a little longer time to cut the three legs of the triangle.

To complete the triangular inspection hole, stand in a well-balanced position, with feet spread open and aligned. Next, flex and bend at the knees, so the saw touches the roof surface. Hold the saw out in front at all times, performing the cuts in the leg space area (fig. 14–57).

Fig. 14–57. An inspection hole can be used to indicate the type of roof, size of structural members, thickness of the roofing material, and the presence of any fire or smoke. Limit the size of the inspection hole to avoid stepping in it.

The sequence of cuts should be preplanned and become second nature to all firefighters. The first cut should be diagonal. The firefighter starts at the center, and cuts down toward the right boot. The second cut is vertical, starting at the top of the first cut and cutting down toward the center of the firefighter's stance. It is extremely important that all cut lines overlap, so the roofing material is cut all the way through. The last cut is the easiest cut to make. It is performed from left to right, overlapping both cut line and forming the bottom leg of the triangle.

Once the cuts are completed, the roofing material can be removed by striking it downward, pulling it out of the cut; or it may fall into the hole once the cut has been completed. In some instances, the roof material may hinge on a joist once the cut has been made.

Roof ventilation cuts

SKILL DRILL

Pullback method. The **pullback** method of roof ventilation uses three cuts in the roof deck for removal and is designed to work on a roof sheathed with roof boards or planking of 1 × 6, 1 × 8, or 1 × 12 in. (25 × 152, 25 × 200, or 25 × 305 mm). It cannot be used successfully on roofs with plywood or OSB decks, as it is too difficult to pull. Once the cut is made it resembles an upside down U.

To perform this cut, first make a head or top cut across three joists/rafters. If on a pitched roof, make the head cut approximately 1 ft below the ridge. Avoid cutting into the rafters by rolling the saw up and over when it makes contact with a rafter. Use chain saws in the vertical position (at a 90-degree angle) for the head cut.

- Then make two downward cuts (the sides of the U), starting at the head cut and moving toward the bottom of the roof, parallel with the rafters between the center and outside or between both outside joists/rafters. Remember to overlap the cut lines with the saw to permit the roofing to be pulled. These joists/rafters are on 24-in. (610-mm) centers.
- To make pulling up the roof boards easier, make a simple crossover or knockout cut in the top corner of the cut. This allows a tool to be inserted under the sheathing to assist in removal. Remove the top board using a hook to pull upward, which separates the board from the joist. When performing this on a roof with joist spacing on 16-in. (406-mm) centers, two firefighters may find it easier to release the roof boards with hooks at each end.

- Continue to remove the decking material with a steady hooking motion adjacent to the center rafter. If necessary, roof covering can be scored (a light cut in the surface material only) at the bottom portion of the opening to ensure a clean and easy break.

Some benefits of using this method are as follows:

- The head cut reveals the location and spacing of the roof joist.
- A ventilation opening can be initiated near the ridge and opened toward the point of egress.
- A section of decking to be removed is only nailed to a single rafter, or possibly two.
- The decking material doesn't drop into the structure, possibly injuring operating members or trapped civilians.
- The cutting process is a quick method, reducing time for other important tasks to be accomplished.
- Firefighters can use this method with or without a roof ladder on pitched roofs, depending on the pitch.

Some fire departments have another version in their arsenal of cuts and one referred to as the *tepee cut*. Normally, this cut is used in forcible entry on roll-down gates but can be used in roof ventilation. It is much like the pullback method of roof ventilation; instead of cutting an upside down U, the firefighter cuts a tepee design with one crosscut. This cut also reduces the time it takes to cut open a planked roof and only employs three cuts to be performed. The tepee cut can be performed on plywood/OSB-sheathed roofs, but it may be difficult to remove the sheathing once the cuts are made. It is also easy to perform the teepee cut out of the tower ladder's bucket or off of an aerial ladder.

To perform this cut, make one diagonal downward cut from the ridge about 3 to 5 ft (1 to 1.5 m) long. Next put a small crosscut about 8 in. (200 mm) down from the peak; this is a knockout for tool insertion to pull the roof. Ensure that the crosscut overlaps and goes across both downward cuts. The last cut is the second diagonal downward cut. Now that the cuts are complete, a hook can be inserted into the knockout and the roof planking pulled off the roof (fig. 14–58). Remember, once the roof planks have been removed, the top floor ceiling must be pushed down to ventilate the top floor (fig. 14–59).

Fig. 14–58. Roof sheathing is removed after a teepee cut has been made.

Fig. 14–59. Knowing how to use your tools can get the job done faster and easier.

Dicing. The **dicing** method of roof ventilation consists of making multiple downward cuts between and with the direction of the roof joist. This method can be used on roof planking systems and sheathed roofs. A head cut may not be required if there is a ridge vent, but it is required when there isn't one present. Dicing the roof is performed by following these three steps:

1. Make a head cut perpendicular to and across the joist, measuring the desired length of the ventilation opening. This cut should be located near the ridge if on a pitched roof. It is also good practice to make a knockout or crossover cut to allow the roofing to be opened up.

Note: After the head or top cut is made, the firefighter can look into the space and see where the joists/rafters are physically located. Also, visible rafter tails present under the eaves of the structure can indicate where to make the next series of cuts.

2. Make two downward cuts on either side of a single rafter. The length of these cuts should be less than the length of the tool used to remove the severed section. This ensures that personnel stand on uncut portions of the roof while they remove the decking.

3. Step 2 is continued as necessary to achieve the desired length of the ventilation opening. Firefighters must remember to overlap all cut lines to permit the roofing to be pulled.

The cut sections of decking are then removed by beginning near the start of the head cut. Loosen the first section of sheathing to be removed by hitting the end of the first-cut board with an appropriate tool if no knockout cut was made. Then with the same tool, use an upward pulling motion to remove the decking. Firefighters should work down and across the slope of the roof until the entire cut portions of the roof have been removed.

Some benefits to using this method are as follows:

- The head cut can reveal the location of the joist and their spacing.
- Firefighters can remove the decking away from the fire and toward their means of egress.
- Removing decking that is nailed only to a single rafter can be quick and easy.
- A large section of roof is opened with minimal cutting operations.
- The decking material doesn't drop into the attic or into the structure.

If the need to increase this opening is necessary, firefighters should have the foresight to remove the pulled up roof decking a sufficient distance away from the bottom legs of the cut. Doing so allows the cut to be quickly expanded downward.

Louvering. The **louvering** method (also known as the butterfly or hinging method) can be effectively performed on most types of roofs and roof decks, often more quickly than the coffin cut described below. A power saw and the principle of leverage do most of the work. The following five steps are followed to louver a roof:

1. Make a head cut perpendicular to and across the joist, the desired length of the ventilation opening. This cut should be made near the ridge if performing this tactic on a pitched roof. Remember, when making contact with a joist, roll the saw up and over it to prevent doing structural damage. Chain saws must be used in the vertical position (at a 90-degree angle, perpendicular to the roof). Typically, chain saws are more effective than rotary saws for this operation.

2. Next look into the kerf of the head cut and spot the joist's location. Then make downward cuts between the centers of the joists/rafters. The length of these cuts is determined by the size of the ventilation opening; however, 4 to 6 ft is an approximate rule of thumb.

3. The last cut is a parallel cut made along the entire bottom of the cut, similar to the cut in Step 1.

4. Remember where all the cuts intersect; they must continue to cut several inches past the intersections to ensure that the decking has been completely severed. Remember to avoid compromising structural members.

5. The cut section of decking can now be louvered on the rafter to complete the opening. Use an appropriate tool to push down or pull up on one side of the panel to open it. It may be possible to use one tool to push down and another tool to pull up on the opposite side. The object is to open the roof and not push the material into the hole. The material remains attached to the center of the joist and will be in a *hinged* position.

The benefits of using this method are as follows:

- The head cut can reveal the location and spacing of the rafters.
- Louvered decking that is nailed only to a single rafter can be opened easily, because personnel can use the weight and leverage of the panel against itself.
- Firefighters can louver the decking away from the fire and toward their point of egress.
- The decking material isn't usually dropped into the structure. This point depends on how the covering is secured to the base material. Composition material shouldn't slide into an attic. It must be removed from the decking and placed on the roof.

Note: A cut section of decking must be removed if it cannot be louvered because of contact with sprinkler pipes, bracing, conduit, or other obstacles. Remember, this method is faster and requires less effort than the pullback or dicing method of roof ventilation.

FIREGROUND NOTE

If it is difficult to remove or pull up on roof boards or sheathing, remove them using a hook. Place the head of the rubbish hook/hook onto the roof joist and slide it under the roof decking. Next pry the hook's handle upward and away from the body so that the hook acts as a giant lever to remove the roof decking material (fig. 14–58).

Coffin cut or expandable cut

SKILL DRILL

When a serious fire occurs on the top floor of a structure or in the attic or cockloft space, it is important to provide ventilation. Initially, windows, scuttle covers, bulkhead doors, and skylights should be ventilated first, prior to the slower task of opening up a roof with a saw. When the roof is going to be **opened up**, firefighters should have a preformulated plan or sequence of cuts to follow. A good plan of action to follow is to make an expandable opening or coffin cut in the roof.

The **coffin cut** is a relatively easy cut to make and for firefighters to remember the formula: the 7, 9, 8 cut sequence. Normally, the hole's size runs somewhere between 3 × 6 ft (1 × 2 m) or 4 × 8 ft (1.2 × 2.4 m). Prior to cutting, a firefighter should attempt to determine the run of the joists/rafters. Sometimes this requires making an inspection cut, whereas at other times it may be figured out by looking at the size of the building. For example, a row frame dwelling or narrow building may have the joist run side to side; the distance is short and the joist will rest on the outside bearing walls.

Once the run of the joists/rafters has been determined, the long leg of the coffin cut runs perpendicular to the joist; this enables ventilation of more area of the attic or cockloft space. As with all cutting sequences, firefighters try to have the wind blowing at their backs. In this manner, once the cut is made, the wind drives the smoke and gases away from the firefighters. This increases visibility and also puts the firefighters in a clean atmosphere. Unfortunately, many times this may not feasible because of a blowing or swirling wind condition, so firefighters must use the best approach they can.

Firefighters should perform the following sequence of cuts when cutting the coffin cut (fig. 14–60):

1. Cut line #1 is the top of the seven, approximately 3 to 4 ft long.
2. Cut line #2 is a knockout cut, which allows for tool insertion to pull the roof boards.
3. Cut line #3 is approximately 6 to 8 ft.
4. Cut line #4 and #5 is approximately 3 to 4 ft, making the number 9.
5. Cut line #6 and #7 is approximately 3 to 4 ft, making the number 8.

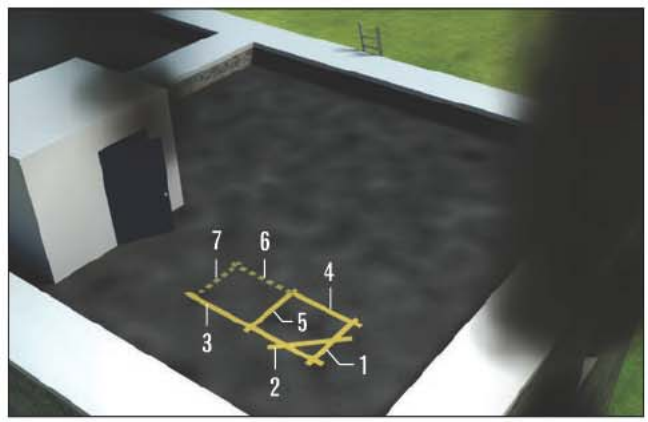


Fig. 14–60. The sequence of cuts needed to make an expandable coffin cut.

If there is time, a second knockout cut can be made just before making cut #4. This enables both sides of the cut to be pulled open by two different firefighters using hand tools.

It is extremely important that the roof cut is not pulled open until all cuts are complete. If conditions on the roof begin to deteriorate before the whole cut is complete, the first box section of the coffin can be pulled open for ventilation efforts prior to firefighters retreating from the roof. If the opening needs to be enlarged, the coffin can be continued in either direction of the rectangle. In addition, it is extremely important that, once the roof has been cut and pulled, the top floor ceilings are pushed down to permit ventilation of the top floor. Also, the top floor windows must be ventilated for a draft of air to flow into the floor and out through the roof opening. By following this procedure, firefighters decrease the chances of horizontal fire spread in the attic or cockloft space.

Trench cut/strip cut. Often in the fire service, firefighters face a large fire in control of an attic or cockloft space. Many fires occur in large buildings that may be shaped in a wing-type design, such as *H*, *U*, *E*, *L*, or even a double *H* type. It is common in such structures to lose or give up a wing to protect the rest of the building. A **trench cut** (also known as a **strip cut**) is a defensive operation that helps firefighters prevent the extension of fire in the attic or cockloft space and reduces the chances of loosing a large portion of the building to fire (fig. 14–61).

Fig. 14–61. A trench cut must extend from one side of the building to the other side and be wide enough to stop the spread of fire.

Firefighters must remember that before any trench cuts are made or opened, a sufficient ventilation hole should be made over the fire. A trench can be cut while a vent hole is being cut, but it should not be opened (if possible) until there is an adequate opening over the fire. One of the main ideas of the trench is that it introduces air into the cockloft space from this remote opening and allows the initial vent hole to pull a draft toward its opening. This reduces the chances of horizontal fire spread in the cockloft and ventilates the area of fire, gases, heat, and smoke.

The trench cut should be made about 20 to 25 ft (6 to 7.6 m) from the initial vent hole or in an advantageous position on the roof. This may be achieved by using the narrowest available roof section or taking advantage of other building characteristics such as the throat section between wings, bulkhead, elevator bulkhead, skylights, or outside walls of the building. The cut must run from wall to wall or another suitable fire stop and be approximately 3 ft (1 m) wide or wide enough for a firefighter to safely transverse it (fig. 14–61). While cutting across the building, a firefighter can make crosscuts and knockout cuts, similar to those used when making a coffin cut, to assist in opening up the roof. The initial position of the trench should also be chosen in an area that isolates the fire to a certain section of the building and allows the firefighter sufficient time to make the cut, before the fire overruns his or her position.

Inspection cuts can be made on the fire side of the trench, and these holes should be monitored for smoke and fire conditions below. Normally, these holes are located about 5 to 8 ft (1.5 to 2.4 m) in front of the trench. Once the fire has reached these holes, pull open the precut trench. In some cases, inspection holes can be made on both sides of the trench. These additional holes inform the firefighter if the fire has overrun the trench while pulling it open or if there is other fire extension.

If firefighters are overrun by fire while pulling open the trench, they must retreat and possibly begin a second trench in a safe area, if conditions warrant. A charged hoseline positioned on the roof allows firefighters to protect themselves and the trench opening. An additional hoseline positioned at the top floor and the ceiling, removed where the trench is located, can also help prevent the fire from extending across the trench.

Performing a trench cut is a time-consuming tactic, so the need for additional saws and personnel on the roof is of paramount importance. If at any time during the cutting operations firefighters feel that this cut may not stop fire extension, they can pull back to a safe position and begin a second trench.

The ridge vent: ridging the roof. On many new homes, condos, and townhouses, the construction can and normally has a ridge vent incorporated into the peaked or pitched roof. The ridge vent is an area at the peak of the roof, where a space is made between the sheathing and covered with a ridge vent (decorative aluminum vent) or roofing material that allows the roof to vent the hot air from the attic space. Many times the ridge vent is just a mesh fiber covered with shingles; firefighters can easily pull this up with hooks to ventilate the attic space. Unfortunately, the ridge vent space is narrow and permits inadequate ventilation for fire conditions.

However, buildings with ridge vents can aid firefighters in roof ventilation. A common technique used by firefighters is known as **ridging the roof**. Prior to describing the technique, it is important for firefighters to understand a common construction practice. When a building is constructed and the roof is being sheathed with 4 × 8 ft (1.2 × 2.4 m) material, roofers start at the bottom of the roof and work upward, with each course of sheathing staggered. When the last course of sheathing is laid in place, it is normally a smaller section of sheathing and can measure anywhere from 8 to 24 in. × 8 ft (203 to 610 mm × 2.4 m) (in some instances it may be wider).

When firefighters reach the roof, they can pull off the ridge vent and attempt to pry up the last sheet of sheathing from the roof. In many instances it can be pried up and allow a larger ventilation hole. In some instances it may be difficult for it to be pried up in 8-ft (2.4-m) lengths. In these cases a saw or axe can be used to cut the sheet in half and then pry it upward to vent the roof. Firefighters can work right along the peak of the roof and continue opening it up in this manner to allow vertical ventilation.

Another method of ridging the roof is to use a saw and cut downward on both sides of the ridge vent. The length only needs to be as much as the last piece of sheathing applied to the roof. This distance can easily be figured out by a firefighter removing the shingles from the roof in a small area to size up the distance needed to cut. Then relief cuts are made about every 4 ft (1.2 m) to make it easier to remove the sheathing on both sides of the roof. Now a sufficient roof ventilation hole has been made for a fire that involves the attic space or cockloft. Note that if a top floor must be ventilated in this fashion, it may take a long hook to push down the top floor ceilings from this higher position on the roof. Also, when performing this tactic, it is very wise to have a ladder or means of egress off the roof on both sides of the building. A firefighter doesn't want to be cut off from his or her access if the fire lights up out of the ridge vent.

Ridge venting is a newer technique used in firefighting and also performs well when working out of a tower ladder or off an aerial ladder when working on buildings with lightweight truss construction.

Cutting peaked or pitched roofs. When firefighters conduct ventilation operations on roofs that are slightly sloped, walking, operating, and maintaining a solid footing on them are normally minor concerns. However, as the pitch of a roof increases, the firefighter's balance, footing, and stability decreases. The importance placed on maintaining stability during ventilation can't be stressed enough. When faced with a high pitched roof, firefighters must properly use a roof ladder or cut from the safety of a tower ladder or aerial ladder to conduct a safe and efficient roof ventilation operation. Unfortunately, because of overhead obstructions such as wires and trees, aerial or tower ladders may be unable to reach the roof on some structures. If this is the case, use an extension ladder and a roof ladder. Place the roof ladder next to the section of roof to be ventilated on the windward side, allowing the escaping smoke to blow away from the operator. The roof ladder's base should be near the top of the extension ladder in case the firefighter must retreat from the roof. When the roof ladder is attached to the ridge, the firefighter must ensure that it *bites* into the ridge of the roof. Normally, this is done by the firefighter pulling back down on the roof ladder to ensure it is attached.

Once the roof ladder is secured into the roof, a firefighter can proceed up the ladder with a power saw or hand tools. Most firefighters will bring either an axe or Halligan tool up the ladder with them; the tool will be used to make a safety brace into the roof so the firefighter can place one foot on it for balance while making the cut. Remember, a safety brace can assist in maintaining a safer work environment but if the attic is well involved with fire, it can release smoke and pressurized gases around the tool.

If a second firefighter is available, he or she should proceed up the ladder behind the first firefighter, be equipped with a hook to help remove the roofing material, and push down the interior ceiling once the cut has been completed. While the first firefighter cuts, place the hook on a ladder rung, keeping it out of the way, or its head can be driven into the roof across from the work location. The hook can act like a safety brace in case the upper firefighter slips and loses balance.

The following method is presented as a simple and effective method of working off a roof ladder with two firefighters when cutting on a pitched roof:

- To facilitate working away from the roof ladder, insert the pick end of the axe or the point of the Halligan tool into the roof about 2 ft (0.6 m) from the ladder and below the work area.
- The firefighter operating the saw can now use the embedded tool as a foot brace.
- The second firefighter can now act as a safety person, enabling the saw operator to cut away from the ladder.
- The saw operator can now cut either one or two louver panels, depending on his or her reach and position from the ladder. The firefighter may also cut by using the pullback method of roof ventilation if faced with roof planking.

- Once the cuts have been made, the saw operator should shut down the saw or engage the safety brake and then reposition onto the roof ladder.
- Once on the roof ladder, the firefighter can open up the roof section by louvering or pulling it. Remember, the top floor ceilings should be pushed down once the cut is made.

Using this method results in the following:

- The firefighters maintain stability and efficiency while operating on the roof ladder.
- Decking that is nailed only to a single rafter is easily louvered.
- Decking material should not drop into the building.
- A ventilation opening is easily enlarged as necessary.

Another technique to use for a foot brace and for the saw operator to maintain balance is for the backup firefighter to position the head of a rubbish hook into the roof as a foot brace. The head is placed into the roof out from one side of the ladder, and the butt end of the hook is supported on the roof ladder and braced by the backup firefighter who stands on it. The handle of the hook is now a few inches above the roof and can be used as a support for the saw operator's feet as he or she cuts.

Personnel can also use two roof ladders on either side of an area of roof to be ventilated. Although this is a safe and proven method, its effectiveness is minimized by the number of personnel required and the time necessary to raise two roof ladders, which may be long enough to negate the effects of timely ventilation. Additionally, one of the roof ladders may be in the the path of escaping heat and smoke, depending on the direction of the wind.

When using this method on tile or slate roofs, remember that you may have to remove ridge tile to increase the stability of the roof ladder and ensure positive engagement of ladder hooks into the ridge. You must remove tile to embed an axe and before using power saws or axes to cut the decking. Tile and similar materials can be heavy and may reduce the structural integrity of a roof under fire conditions. In addition, they can cause injuries to members below if they are being removed and slide off the roof.

Operating on a severely pitched roof is a dangerous activity; add some rain, sleet, or snow and it becomes even more dangerous. Firefighters should attempt to work on these roofs from the safety of a tower ladder's bucket or from an aerial ladder. If using the tower ladder, place the bucket below the intended cutting area at roof level. The saw operator can now open one door of the bucket, place one foot on the roof, and keep one in the bucket. Remember, whenever operating in the tower ladder bucket, wear the installed safety belts or an approved belt tied into the bucket. The saw operator can perform either the louver or pullback cut from the safety of the bucket.

The aerial ladder can be used in place of the roof ladder if it can be placed onto the roof for ventilation operations. These same procedures mentioned earlier can be used on the aerial ladder. In some instances, the aerial ladder accesses the roof, and the roof ladder must be used off the aerial ladder.

FIREGROUND NOTE

In some communities, homes with high peaks are spaced closely together. Firefighters may be able to place a 35-ft extension ladder in line with the pitch of the roof and footed by the adjoining home. Performing this task reduces the time it may take to ventilate the roof, because the roof ladder evolution did not need to be performed. The extension ladder acts as the roof ladder in this scenario.

Another tactic to use is to place the tip of the aerial ladder about 4 ft (1.2 m) back from the intended site to be cut open. The saw operator can kneel on the rungs and lean forward and cut the roof with the saw. The firefighter should be wearing a safety belt and can hook onto the rail behind him or her for added support while cutting. The Charlotte Fire Department developed a method of sending a second firefighter up behind the saw operator. This firefighter ties the safety belt into the belt of the saw operator. The saw operator's belt should be placed with the safety ring on the back side. This way, while they are tied together, the saw operator has more reach with the saw. This method of roof cutting works well with practice and is achievable when cutting open truss roof construction.

Gable end venting. On many homes with attic spaces, **gable end vents** are placed into the exterior walls to permit air flow. Usually, these vents are placed in between the wall studs and near the top peak of the side of the home. The vent is usually either an aluminum louver vent or plastic decorative louver vent and can be easily removed by a firefighter with hand tools for ventilation efforts.

When firefighters are faced with severe weather conditions such as ice, snow, or rain and it may be difficult to perform roof operations for an attic fire, they can attack the gable vent (fig. 14–62). Working from the safety of a tower ladder's bucket or off an aerial ladder is the preferred method of performing this tactic. Once the device is placed to the side of the home, just below the vent a firefighter can quickly remove the louver with a hand tool. The firefighter performing the operation must position himself to the side of the louver so as not to be directly exposed to the venting smoke and fire. Once the louver is removed, the firefighter can use a power saw and cut downward along both sides of the vent, removing the exterior sheathing of the home. If the interior wall is finished, the hand tool can be used to knock in the wall and complete the ventilation tactic.

Fig. 14–62. A gable vent being opened for a concealed space helps the ventilation process.

Although most walls in homes are constructed with the wall studs being on 16- or 24-in. (406- or 610-mm) centers, this type of ventilation doesn't provide an excellent means of smoke and gas removal; but it works well and doesn't chance a firefighter from falling off the roof. In some instances, once firefighters have opened up one bay using this technique, they'll open up the adjoining bays to provide more ventilation to the attic space.

Miscellaneous types of roofs

Open-web steel bar joist. **Open-web steel bar joist** construction usually supports a metal deck roof or a metal built-up roof that may be covered with multiple layers of insulation material, tar, and composition (fig. 14–63). The building industry considers the metal built-up roof to be an efficient form of construction because the materials are widely available, the cost is less than that of a comparable wood roof, and it is an easy roof to install. Unfortunately, the steel bar joist and metal deck roof can be dangerous when exposed to fire. Steel loses a large portion of its strength at 1,000°F (538°C), and such roofs have a quick failure rate with minimal warning, resulting in an unannounced collapse. In addition, the joists can be spaced from 2 to 8 ft (0.6 to 2.4 m) apart, leaving a large section of roof unsupported between the joists. These roofs demand specific ventilation techniques after a comprehensive size-up of the fire conditions below. It is imperative that safety be the number one priority when deciding to vent a metal deck roof. Moderate or heavy fire conditions in the building below will dictate that firefighters will not be positioned on the roof because of the substantial collapse potential.

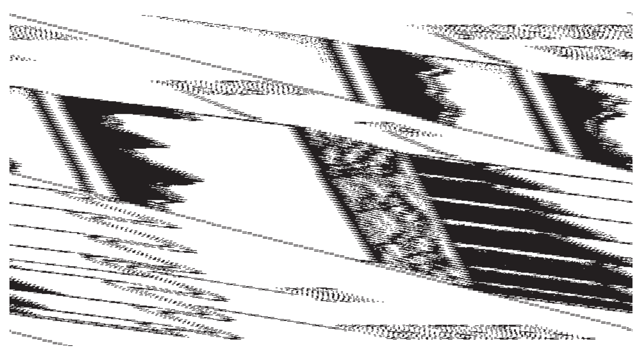


Fig. 14–63. The decking of an open-web bar joist roof normally consists of corrugated metal covered with multiple layers of insulation, tar, and composition.

In many instances these roofs are equipped with glass or plastic skylights, permitting easy initial ventilation tactics to be performed after a detailed size-up. When faced with severe fire conditions in this type of operation, roof operations may be considered too dangerous to perform. In many instances firefighters must rely on horizontal ventilation operations: opening up windows and garage doors when faced with steel bar joist construction.

When dealing with steel bar joist construction, firefighters may face a specific type of fire that does not involve the interior of the building. Many times, vents extending through the roof from grease duct equipment can ignite a fire in the roofing materials. These fires can often spread between the metal deck and the composition covering. Cutting these roofs with a roof saw can be achieved to limit the extension of fire and extinguish the fire. When faced with a fire that only involves the roofing material, firefighters can cut the roof tar, membrane roof, and composite coverings while avoiding the metal decking. Once the cuts have been made, the material can be pulled away from the steel decking.

Remember, when corrugated metal is heated, it expands and the tar liquefies and then gasifies. The gases cannot escape upward, so they travel between the corrugations in the steel decking and burn (fig. 14–64). As the gases burn, they generate more fuel. Thus, the fire can be self-sustaining and independent of the original fire in the room below. This type of fire can exhibit several hazards. For one, the insulation becomes a source of fuel. The fire is difficult to access, and it can cause or contribute to roof collapse if the fire should extend rapidly. Such a fire also creates large volumes of dense smoke, which may hamper suppression efforts.

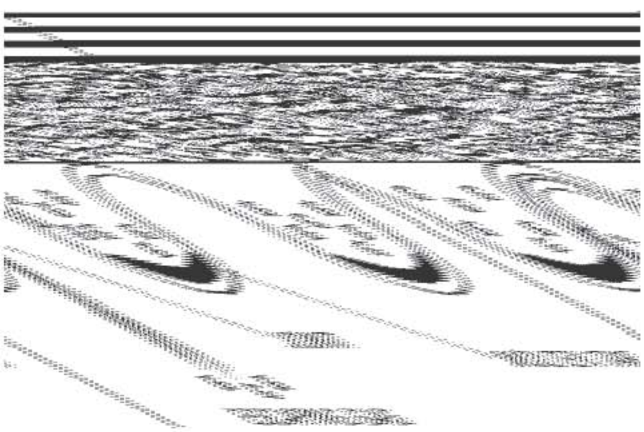


Fig. 14–64. When corrugated metal is heated, the tar liquefies and then gasifies. These gases can easily travel between the corrugations in the steel decking and burn, creating a self-sustaining fire that is difficult to reach.

Lightweight wood truss roofs. Unfortunately, because of costs, many of today's homes are constructed with **lightweight wood truss** and even lightweight wooden I-beams (fig. 14–65). The truss components are normally connected by thin galvanized metal gusset plates that only penetrate into the wood about ¼ to ⅜ in. (6 to 10 mm). Under moderate to severe fire conditions, these metal plates can start to expand and pull out of the wooden truss, which could cause a collapse of the roof. Firefighters must make an initial inspection hole into a roof to size up the roof's construction features. In truss construction, there is no **ridgepole** and normally a ridge vent exists. Firefighters can simply remove the ridge vent to size up the type of roof construction.

Fig. 14–65. Lightweight wood truss roofs make up most of the new construction today. (Courtesy of Emergency Training Solutions)

Working on or under roofs with a severe fire can be a dangerous and deadly practice (fig. 14–66). Firefighters should strive to make a ventilation hole in these roofs by operating out of a tower ladder's bucket or off of an aerial ladder. Working off of a roof ladder should not be an option because there is no ridgepole to support the roof ladder, and the ladder cannot bite into the roof.

Fig. 14–66. There is considerable danger involved in working on or under roofs with severe fire.

In many cases it is preferred to move to a safer location—surrounding areas not involved in fire—and make a trench cut to stop the horizontal spread of the fire. Draftstopping (vertical non-fire-rated barriers such as gypsum board or plywood/OSB installed to compartmentalize an attic space; draftstopping is often compromised when holes are made in them for cable TV, electrical wires, etc.), if properly installed, will help slow the spread of fire in the attic. Remember, firefighters must be deployed to the interior of the structure below the trench to open the ceiling with the protection of a charged hoseline. After notifying the incident commander, the hoseline may be used into the attic or cockloft space to stop the horizontal spread of the fire. Safety is again the number-one priority—if the fire is quickly "running" the attic and is spreading faster than firefighting forces can be deployed, firefighters should not be committed to the building.

All operations in lightweight wood truss roofs must be evaluated prior to employing interior operations. *Never trust a truss.*

Bowstring truss roofs. Perhaps one of the most dangerous roofs for firefighters to face is the **bowstring truss roof** (fig. 14–67). This roof is commonly used on large structures where a wide open floor space is required. The most telltale sign of spotting a truss roof is its two large humplike ends. A comprehensive size-up must be performed before committing any firefighters to roof operations. These trusses have failed without warning and killed numerous firefighters over the years.

Equally dangerous are other truss roof types such as gable truss, bridge truss, or the tied truss (which is the most dangerous of all). The differences are in the roof shapes, but the construction is the same.

It is recommended that if any fire involves the truss area or fire is impinging on the truss, no firefighters should be committed to roof operations. The failure of one truss can result in a very large collapse area since they are spaced far apart.

Fig. 14–67. Bowstring truss roofs can be dangerous for firefighting operations. (Courtesy of ETS)

If ventilation must be performed, a tower ladder can be used to access the humplike ends of the roof. Here, firefighters can cut a ventilation hole into the roof from the safety of the tower ladder basket. Some of these roofs also have skylights in them. Again, after firefighters perform a comprehensive size-up, the decision must be made on whether or not it is safe to let a firefighter operate on the roof to vent these skylights. Many firefighters have been killed in buildings in which bowstring roofs have collapsed. Six firefighters were killed in a Brooklyn, N.Y., supermarket in 1978, and five were killed in a Hackensack, N.J., auto dealership in 1988.

Gypsum roof decking. Gypsum concrete is a prefabricated material made up of calcined concrete and wood chips or shavings milled together. The material is then molded and laminated into planks, which are normally 2 in. (52 mm) thick, 2 ft (0.6 m) wide, and 8 ft (2.4 m) long. These planks are supported by bar joists and subpurlins and then grouted together at all of their ends. Unfortunately, the ends of these planks are often unsupported and end in an area between joists. Once the grout material dries, a roofing material such as a rubber membrane covers the planks. **Gypsum roofs** are vulnerable to moisture and conducive to an early collapse under fire conditions.

As with any type of roof installed over steel metal bar joists, firefighters must use caution and perform a comprehensive size-up before attempting roof operations. When a roof is cut with a power saw and a white or gray powdery residue emits from the saw, a gypsum roof is present. Many fire departments inform their members that if a gypsum roof is found while ventilating the roof with the saw, they should notify the incident commander and exit the roof.

Slate roofs and terra-cotta slate roofs. Many dwellings have roofs covered with slate. The slate is nailed to the roof and laid in rows over each other. The slate is slippery and dangerous to work on without the use of a roof ladder, aerial ladder, or tower ladder. Firefighters operating around the outside of the fire building must be aware of the **slate roof**. These slates can detach easily from each other, slide down the roof, and severely injure or cut a firefighter operating below.

One of the easier tactics to follow for venting these roofs is to use a maul or the pick of a pick head axe to strike the slates. This causes the slates to crack, break, and slide down the roof, exposing the roof decking. Normally, this decking is either plywood/OSB sheathing or wood planking and can be cut with a roof saw with one of the tactics mentioned above.

New materials are always created, and it is common to find slate or terra-cotta made of a plastic material and attached to the roof. From the street level it resembles slate, but closer inspection reveals that it is a type of man-made plastic. The same procedure for venting these fake slate roofs can be performed. Firefighters may also cut right through the plastic slates with a roof saw to perform roof ventilation.

C-joist roof construction. Pre-engineered metal **C-joists** are another product used to support roofs. Like steel bar joists, they are directly affected by fire and heat and prone to a quick collapse under severe fire conditions (fig. 14–68). After an inspection hole is made in the roof and C-joist are determined to be supporting the roof, the incident commander must be notified. A comprehensive size-up determines if roof operations should be performed or firefighting forces pulled off the roof. If the roof needs ventilation, performing this tactic from the safety of a tower ladder's bucket or aerial ladder is recommended.

Fig. 14–68. A "C" joist

Lightweight steel-tile roofs or tin roofs. **Lightweight steel tile** or **sheet tin roofs** have become popular, because they can be installed over tar and gravel, wood shakes, shingles or composition, fiberglass shingles, plywood/OSB- type materials, or open rafters. Installation often involves placing the panels on wood battens that have been nailed to an existing or new roof (fig. 14–69). Although these panels result in an attractive roof, they can be difficult to remove by hand and cause severe cuts to the hands, even through gloves. In addition, when pulling on the light-gauge steel with firefighting hand tools, it often tears and makes ventilation efforts more difficult.

When you encounter this type of roof and ventilation operations are necessary, an opening is best created by using a carbide-tipped power saw. Simply simultaneously cut the steel panels, the batten substructure, and the original roof decking. One roof cutting technique mentioned earlier can be used. Remember, it is important to cut deep enough to sever the various layers of materials to permit roof ventilation.

Fig. 14–69. Lightweight steel-tile roofs are often comprised of stone coated interlocking panels of 26-gauge steel that are nailed to 1 x 4 in. (24 x 102 mm) wood battens nailed to an existing or new roof. (Courtesy of Jim Plaster)

VENTILATION OPERATIONS FOR VARIOUS TYPES OF STRUCTURES AND FIRES

The preceding material presented in this chapter is the foundation of ventilation theory, tactics, and techniques. The following section of this chapter reviews the ventilation concepts and principles in relationship to structure fires as they pertain to certain types of fires in residential, commercial, and high-rise type occupancies.

Basement fires

Because of their subterranean location and lack of openings such as windows and doors, providing either vertical or horizontal ventilation to a basement can be a difficult process (fig. 14–70). In addition, because of the pressure of the smoke and gases created by the fire, they travel into as many cracks, crevices, and voids as they can. Fire, smoke, and gases can fill up an entire building and expose its occupants to these dangers.

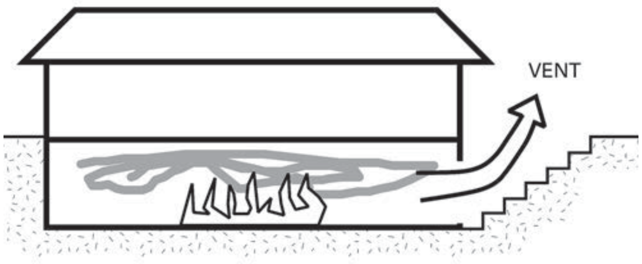


Fig. 14–70. In a basement fire, often the only available ventilation opening is the route that will be used by personnel.

Also, many basements may have limited access and are partitioned off into many rooms with a high fire load because they are used for storage. Partitioned rooms present a problem for searching for the seat of the fire and can make ventilation operations difficult. Another hazardous condition inherent during basement fires is exposed beams, which can lead to a collapse situation when exposed to fire.

Tactics

Timing. Initiate timely ventilation of a basement fire to permit the stretching of attack lines, to reduce vertical extension to other portions of the building, and to minimize rapid development of the fire. Normally, venting operations should be performed in conjunction with the attack lines' initial advance and progress whenever possible.

Openings. **FFI 5.3.2** To ventilate the basement, use any of the available openings to the area: doors (outside entrance doors to the basement, garage doors, **Bilco-type fold-up doors**, old coal chute hatches or doors), windows, and dead lights. In some instances in the larger structures, it may be important to open the elevator bulkhead or dumbwaiter shafts at the roof level that begin at the basement level to provide additional ventilation.

If the initial attack line is entering the outside entrance of the basement to attack the fire, opening and controlling the interior basement door at the top of the stairs for additional ventilation is necessary. Remember, this door should only be opened if it does not expose firefighters to punishing conditions, and first-floor windows must be ventilated for the smoke and gases to escape. A hoseline positioned at the interior door can protect the first floor and the firefighters operating there.

If there is only one route into the basement and no openings to ventilate, the hoseline uses this avenue for fire attack, and ventilation is still necessary, consider opening the floor over the fire, adjacent to exterior windows or doors. (For more information on basement fires, see chapter 20, Basic Fire Attack.) This may be a time-consuming operation, but relief of the heat and gases in the basement is needed to assist the firefighters operating in there. Always ensure that the first floor is well ventilated, vertical passageways are controlled, and a charged protective hoseline is in place. Remember, vertical passageways begin in the basement and can travel to the top floor of a multistory building, requiring search and ventilation of the upper floors and attic area. These conditions appear in balloon-framing structures and many larger multiple-dwelling buildings.

Always keep in mind that, from a simplistic viewpoint, the floor over a basement (normally the grade floor) is also the roof of the fire. So, until the fire in a basement is extinguished and/or the integrity of the floor is verified, remember where you are standing.

Pressurized ventilation. Pressurized ventilation can be used effectively for basement fires if there are openings in the basement and/or first floor to channel the heat, gases, and smoke out of the building. Remember, unlike platform construction, balloon construction can allow fire to travel unrestricted from the basement into the attic. PPV can rapidly enhance the fire if an exhaust isn't opened prior to the pressurization. If an exhaust opening is created prior to PPV, most of the pressurized air flows toward the opening and has little affect on the spread of fire in open walls. Therefore, when you encounter fire extension in balloon construction, the key is to create an exhaust opening before initiating positive pressure. For more information of basement fires, see chapter 20: Basic Fire Attack.

Single-family dwellings (single story)

Single-family dwellings (sometimes referred to as ranch or shotgun homes, bungalows, or single-frame dwellings) may be ventilated by using either vertical or horizontal ventilation tactics. Because most homes are usually accessible from the exterior, horizontal ventilation operations should be the firefighter's first consideration. Remember, just because a window is in reach of a hand tool, indiscriminate ventilation should not be performed; proper and initial ventilation should be initiated as close to the fire as possible (fig. 14–71).

Fig. 14–71. Single story, single-family dwellings are usually accessible; however, indiscriminate horizontal ventilation should be avoided. Always size up and follow your plan.

Tactics

Horizontal ventilation. Ventilating the appropriate windows can improve the interior environment of a structure, aid in search and rescue, and speed the advancement of attack lines (fig. 14–72). Normally, the venting and removal of windows close to the fire or fire area should be sufficient. Ventilating these windows provides an exit for the expanding gases when water from the hoseline is applied. However, just opening windows generally only ventilates the bottom (moderate heat) and central (high heat) portions of a structure and has little effect on the upper (extreme heat) regions. Remember that the upper portions are where the highest concentrations of heat accumulate, supporting flashover. These areas must be cooled down by the attack hoseline and can be ventilated to the outside once fire-suppression is completed.

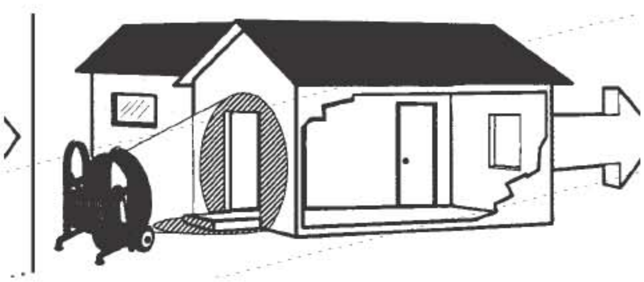


Fig. 14–72. Air blowing in one side and out the other is a form of horizontal ventilation.

It is important to note that opening the wrong windows or premature ventilation can supply additional oxygen to a fire, causing it to accelerate. Numerous broken windows in unfortunate areas can also reduce the effectiveness of pressurized ventilation. Windows away from the fire area should only be broken if they cannot be opened easily or are being used for VES operations. Remember, breaking windows may put broken glass inside the structure, hindering interior operations and causing an injury to a firefighter. If security bars are evident on the windows, inform the incident commander, and attempt to remove the bars if firefighters will be operating inside the structure.

Vertical ventilation. If a fire in these structures is extensive and backdraft conditions are present or a fire is present in the attic space, firefighters should consider vertical ventilation of the roof after a proper size-up (fig. 14–73). Although horizontal ventilation operations should be performed first, the need for vertical ventilation may be necessary. Ventilation of the attic can improve the interior environment of the structure, particularly at the ceiling and upper levels of the structure. The roof openings should be located over the fire and at the peak of the roof. Attic windows or louvered vents can also be removed as appropriate to accelerate venting or if weather conditions don't allow roof operations. Firefighters must use caution when opening an attic vent or a ventilation hole at the far end of the structure; it may draw fire throughout any uninvolved portions of the attic.

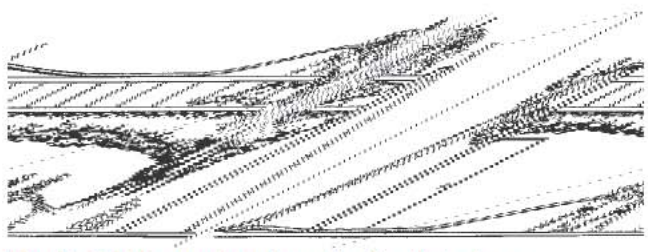


Fig. 14–73. An opening above the fire that allows fire, smoke, and gases to rise and exit the building is vertical ventilation.

Pressurized ventilation. Pressurized ventilation can be used effectively for fires in these types of structures (fig. 14–74). Remember that the exhaust openings should always be created prior to pressurizing the structure or area to be ventilated. If this is not followed, the pressurized airflow and by-products of combustion have no means of escape from the structure. In addition, it is also imperative to control the flow and path of pressurized air between an entrance and exhaust opening to achieve maximum ventilation. If pressurized air is directed from an entrance to an appropriate exhaust opening without being diverted to other openings, contaminants are removed in a minimal amount of time. Simultaneously opening unwanted windows and doors does not facilitate successful PPV operations.

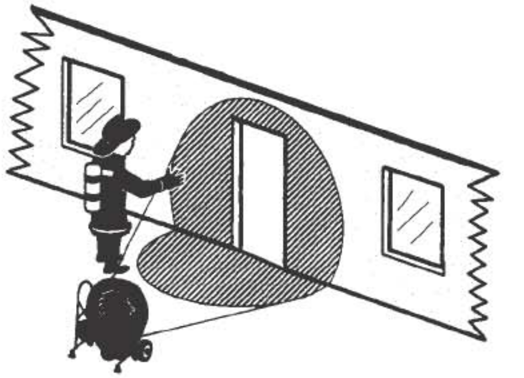


Fig. 14–74. The cone of air pushed towards a building opening during PPV operations should cover the entire opening.

Single-family dwellings (multistory)

These structures are commonly two-, two-and-a-half–, and three-story dwellings, each of which is normally inhabited by a single family. Firefighters should not be surprised to find single-family dwellings turned into multiple-family residences or containing a separate apartment. The age of these dwellings is an indicator of potential vertical extension avenues. Old construction may conceal balloon construction, which provides open passageways within the exterior walls from the lowest floor to the highest. Newer construction uses open space floor plans, which can have features such as fascia, zero-clearance fireplaces, ductwork, balconies, and cathedral ceilings, which can allow fire to spread rapidly. These structures come in a variety of shapes, sizes, and designs and firefighters must become familiar to those structures prevalent in their response areas.

The location of the fire determines where the firefighter must perform ventilation operations. A fire on the first floor of a multistory dwelling calls for coordinated horizontal ventilation, whereas fire on the top floor may place initial emphasis on horizontal ventilation followed by vertical ventilation operations (fig. 14–75) Firefighters must remember that depending on the height of the building, access above the ground floor requires ladders before ventilation operations can be initiated. Firefighters can ventilate upper windows by using the portable ladder throw, roof ladder throw, or the arm-lock maneuver with a hand tool (described earlier in this chapter).

Tactics

Ventilation. If a fire is only on the first floor, the first priority should be to ventilate this floor horizontally. The immediate fire room and area should be the first priority, in coordination with the attack line's advance. Firefighters searching on the floor above the fire must use caution and not indiscriminately ventilate any windows they come across. Doing so could cause an autoexposure problem by pulling the venting fire into the floor they are searching. Firefighters operating on the outside of the structure must use caution and not ventilate windows on the upper floors if they are in jeopardy of fire entering them from the floor below. Remember, in most instances performing vertical ventilation for a first floor fire could draw the fire and contaminants to the upper floors.

If extension above the first floor has occurred, horizontally and vertically ventilate the second floor. This reduces the heat and smoke in the building and minimizes mushrooming on the top floor. If the fire is on the top floor, perform horizontal ventilation and then begin vertical ventilation operations. For fires involving the attic space, perform vertical roof ventilation or remove the attic vents at the gable end of the structure.

In newer or contemporary homes, removing skylights can benefit ventilation operations of the upper floors. Many such homes have high pitch and irregularly angled roofs, on which it can be dangerous to operate; firefighters should use roof ladders or work from the safety of an aerial or tower ladder. Accurate roof ladder placement depends on determining the location of the fire and the appropriate location for the opening. Firefighters should place these ladders on the windward side when possible, directly adjacent to the likely roof opening. This allows firefighters to ventilate with the wind at their backs, and the by-products of combustion escape in the opposite direction.

Fig. 14–75. Single-family multi-story dwelling. A fire on the first floor of a multistory dwelling calls for coordinated horizontal ventilation, whereas fire on the top floor may place initial emphasis on horizontal ventilation followed by vertical ventilation operations. (Courtesy of Mike Blatchly)

Pressurized ventilation. If a multiple-story dwelling needs ventilation, always start at the lowest level with PPV and ventilate toward the top. To ventilate the first floor, ensure that all the exterior windows on the upper floor are closed or that a stairwell door to the upper floor is closed. Position a blower at an appropriate entrance opening, and then ventilate the contaminated areas on the first floor to provide maximum pressurized air for ventilation on the first floor and no flow of air on the second floor (caused by a lack of an exhaust opening). To ventilate the second floor, leave the blower in the same position and ensure that all the exterior windows and doors have been closed on the first floor. If a stairwell door has been closed, open the door and sequentially ventilate the contaminated areas on the second floor.

Multiple dwellings and center-hallway buildings

Multiple dwellings, multiunit apartments, and some condominiums are normally designed with a hallway in the center of the structure and units on either side, which allows for the maximum number of rooms in a building. Normally present in these structures is an open interior stair running from the first floor to the roof. Buildings with a **center hallway layout** may also have one or more skylights, bulkheads, scuttle ladders and covers, penthouses, and fire escapes. Fire doors may or may not exist in the interior hallways of these buildings. A prior knowledge of these types of buildings in a specific district is essential for firefighters (fig. 14–76).

Fig. 14–76. Multiple dwelling and center-hallway buildings. A prior knowledge of these types of buildings in a specific district is essential for firefighters to learn. (Courtesy of Ed Evers)

Determining the location of the fire in these structures often indicates the ventilation priorities. The main concept to understand is that vertical ventilation in these buildings is a priority. It relieves the upper floors of smoke, prevents mushrooming, and allows occupants to survive or escape from the building. Opening up the bulkhead or skylight is considered vertical ventilation and allows the gas and smoke build up in the hallway and the stairway leading to it to be relieved. This allows the truck companies to access the upper floors while searching and allows the engine company to advance to the fire floor in moderate smoke conditions.

The stairs and public hallways must be checked for fire, heat, and smoke, as well as any victims overcome by smoke. The presence of smoke and its quantity in the public hallways is an excellent indicator of the fire's extension and location. The presence and status of fire doors can dramatically affect this; closed fire doors limit an area and the smoke, whereas open doors allow the smoke to enter the entire public hallway. Opening a bulkhead door ventilates the stairway and public hallways while indicating the smoke level in the stairway. Firefighters must remember that if there is a light smoke condition or no smoke condition in the hallway, the fire apartment's door may still be closed and preventing any smoke from entering the stairs or hallway. It is imperative that vertical ventilation still be completed. Although smoke conditions could be light, the buildup of carbon monoxide could be high and overcome individuals or firefighters.

Tactics

Horizontal ventilation. If the fire is on a floor below the top floor, use an appropriate combination of horizontal, vertical, and pressurized ventilation. Firefighters must ensure they do not create an autoexposure situation when performing horizontal ventilation.

If horizontal ventilation is to be performed off of the fire escape, the firefighter should size up the situation first. If any occupants use the fire escape as a means of escape, no windows should be vented; occupants could be overcome by smoke or burned if fire vents from the windows. If the windows are to be ventilated, the windows farthest from the fire escape should be broken first and then those nearest the fire escape.

In some fireground situations, the aerial ladder may be used for ventilating windows and firefighters must adhere to their fire department's SOPs in these matters.

Vertical ventilation. Vertical ventilation operations should focus on three basic priorities: stairwells, skylights, and, for a top floor fire, cutting a hole in the roof over the fire. Opening a bulkhead door or skylight provides initial ventilation of the stairwell and public hallway. In some cases the skylight may have been removed and covered up with a new roof. When faced with these conditions, firefighters can use a power saw to cut an opening where the skylight was, which enables stairwell ventilation. If there are operable sprinklers in the skylight openings, they can form a water curtain and hamper ventilation. If ventilation is necessary under these conditions, consider eliminating the flow of water in the appropriate skylight opening by wedging the sprinkler head. Remember, only stop the flow of water from the sprinkler if it has controlled the visible fire below. If fire reappears and takes control of that area below, remove the chock with a hand tool to avoid a burn injury.

If there are doubts of fire in the attic or cockloft space, the **returns** in the skylight should be opened for a fast and easy way to check for extension. Firefighters should avoid opening up returns in skylights remote from the fire, as they could draw the fire toward the open returns.

For fires on the top floor, it is still important to ventilate the bulkhead or skylight and then provide initial horizontal ventilation to the top floor windows. Ventilating these windows in conjunction with cutting a hole in the roof provides vertical ventilation and extension into the cockloft. Venting the top floor windows creates an influx of fresh air and allows that air to be drawn into the room and up and out of the ventilation hole in the roof. The process of cutting some of these roofs may take some time if they have been built up over the years.

Firefighters should cut a hole in the roof over the fire. They must also size up the building's features and what the fire is doing. If a fire is venting out of two windows of one room, they should not cut directly over the room, because it is already self-venting. The cut can be pulled back a few feet to attempt to cut over two rooms and assist the engine company's advance into the fire area.

Condominiums and townhouses

Condominiums and townhouses are a common type of structure scattered across the country. Condominiums can have an interior or exterior stairway that serves the individual units. **Townhouses** are normally one, two, three, or even four stories, constructed side by side in a row with an open interior hallway within the unit. Both occupancies normally consist of a common attic that may have draftstopping or fire walls constructed within them and are supported by dimensional lumber or prefabricated truss roof systems (fig. 14–77).

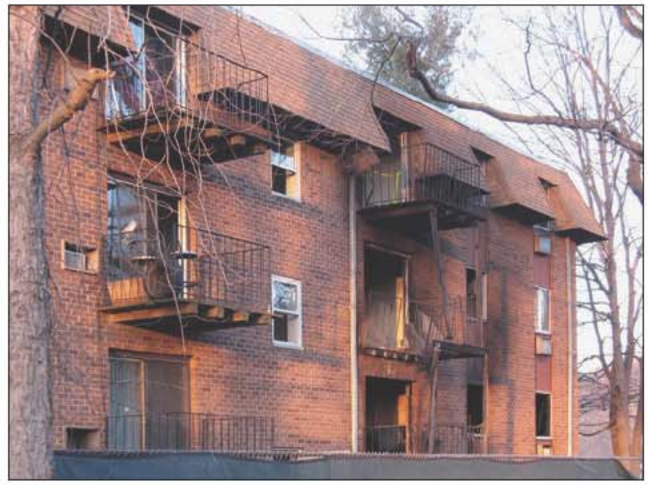


Fig. 14–77. Condominiums and townhouses. Both of these occupancies normally consist of a common attic that may have draftstopping or fire walls constructed within them and are supported by dimensional lumber or pre-fabricated truss roof systems.

Ventilation operations in condominiums should focus on improving the interior atmosphere in the public hallway and stairwell to facilitate the evacuation of occupants and entry by firefighting personnel. Many such structures have a skylight or scuttle over the stair enclosure, which permits rapid vertical ventilation. Horizontal ventilation should be performed and used for fire in a unit. If the unit is two stories, they can be ventilated by both horizontal and vertical means. It is extremely important to check the attic space for fire and extension throughout the operation.

Ventilation in townhouses may be of a different strategy than condominiums. Although horizontal ventilation is performed for most fires, the townhouse unit should be checked for a skylight. Ventilating the skylight can relieve the open interior stairs of smoke and gases, making the interior tenable for firefighting operations. Townhouses may also have offset windows on the end units; these windows normally provide light into the stairwell area. They are good windows to ventilate to assist in vertical ventilation efforts.

The attic or cockloft space is a main concern with fires on the top floor of these units. Firefighters must check this area for fire extension and involvement during the course of the fire. A visible inspection of the roof may reveal that a fire wall extends through the roof, separating the individual units. Unfortunately, because of builders running wires, ductwork, or plumbing through this space, the fire walls can be compromised. Firefighters must not rely on fire walls alone. A simple procedure for checking the cockloft is to find a hatchway in the unit providing access to the space. It is normally located at the top of the stairs, on the top floor hallway, or in a closet on the top floor. If it takes too long to find, inspection holes can be made in the top floor ceiling with a hook to check on conditions above.

Garden apartments

Garden apartments lack several features that are typical of the center-hallway dwellings. They lack an interior stairwell and enclosed hallway. Many have an unenclosed exterior stairwell serving a few units and exterior balconies on the upper floors. The layouts of the units are less complex in design and have units that open directly to the exterior (fig. 14–78). These apartments also have common attics that run the length of the entire building. Typically, the roofs have a low or zero pitch and rafters that support the roof decking, making roof operations feasible.

Fig. 14–78. Garden apartments. Garden-type structures, whether residential or commercial, have units that open directly to the exterior.

Tactics

Ventilation operations. The floors below the top floor must be horizontally ventilated. This is easily done by natural or pressurized ventilation of an individual unit. A fire on the top floor can be ventilated by horizontal or vertical ventilation operations. A size-up of the fire and its extension possibilities can help decide whether or not to open the roof. Sometimes it is more feasible to open the top floor ceiling to check the cockloft area for extension and then cut the roof open. If a fire has extended into the attic or cockloft space and a ventilation hole has been made, it may be necessary to cut a defensive trench or strip cut in the roof to suppress the travel of the fire.

Commercial occupancies

Strip stores, taxpayers, shopping centers, and mini-malls include multiple occupancies attached to each other that may share a common attic or cockloft space. The cockloft area can be as small as a few inches high to as large as a few feet high. It also provides an open channel above the ceilings where fire can rapidly spread undetected. Many older buildings may have old gas lines that once provided lighting to the store, running through the cockloft. The risk of escaping gas can also lead to increasing fire conditions in this space.

When entering the structure, immediately check the cockloft for conditions above the firefighters. It may also be feasible for firefighters to determine whether the space is common to the entire structure or only a portion. Firefighters operating on the roof should check for division walls, fire walls, smoke from vents, and other such indicators.

Such a structure may have a fascia attached to the front, which may hide the actual age of the building (fig. 14–48). Consider a fascia to be an additional common attic built onto the exterior wall of the building. In some older buildings, ventilating the front fascia exposes the joists and the cockloft and allows access into the cockloft for the penetration of a master stream device for fire attack. Newer buildings are most commonly built of lightweight construction (steel bar joist, lightweight trusses, C-joist construction), and firefighters should make inspection holes into the roof to check for construction features. On these newer buildings, consider a fascia to be an ornamental feature and an additional common attic running only on the exterior of the building (fig. 14–79).

Tactics

Horizontal ventilation. Horizontal ventilation is generally limited to ventilating the front store windows once the engine company has water in the attack line and is ready to proceed into the fire. Firefighters must use caution in ventilating these heavy plate-glass windows, as they can break in large sections, fall outward, strike the firefighter, and cause a severe injury. Firefighters should attempt to use a long hook to ventilate the window from the side so that they don't place their bodies in front of the opening. Rapidly expanding smoke, gases, and heat exit the space and could ignite, causing a serious injury to a firefighter.

Fig. 14–79. Many commercial occupancies have fascias attached to the front of the building and it may hide the actual age of the building. Consider a fascia to be an additional common attic built onto the exterior wall of the building.

It may also be feasible to use PPV, pressurize each contaminated unit, and use the rear door as the exhaust port for minor fires inside the store. Many such structures have rear doors but no windows for security purposes and are perfect for PPV. A fire involving the cockloft area should not be fed by the forced air from a PPV operation.

Remember, fires in these types of occupancies are prone to backdraft conditions. Vertical ventilation can be accomplished before horizontal ventilation is performed.

Vertical ventilation. If possible, vertical ventilation operations should begin over the seat of the fire, reducing the chances of horizontal extension into the common cockloft. Initial operations should be to ventilate any skylights, scuttles, or other openings present on the roof. Cutting the roof open is a longer, more involved process; and these openings take less time to open up, thus possibly preventing flashover conditions inside the building.

When roof cutting operations are to begin, firefighters should cut over the store involved in fire. Unfortunately, this operation may not be possible because of the fire's progress; it may be difficult to conclude where the point of origin is, what store is on fire, or where is the largest body of fire located. Communications with the inside crews can relay the fire's location to the outside crews to ventilate the roof in the proper location.

If horizontal extension within a common attic is verified, it may be possible to cut a trench or strip ventilation ahead of the fire as long as the roof area isn't too large and the fire isn't rapidly spreading. Although strip ventilation is extremely effective, it is time consuming. When selecting a location for strip ventilation, cut the initial strip between the fire and the longest portion of the uninvolved attic to protect the greatest portion of the uninvolved building. Also, leave enough room between the strip and the fire to allow enough time to complete the strip. Two strips may be necessary to cut off an attic fire emanating from a single source but extending in opposite directions. In this case, protect the greatest portion of the building first and the smaller portion second. Strip ventilation should not be used in lieu of a primary ventilation hole over the fire, if possible.

Vertical ventilation for basement fires may have to be accomplished by cutting opening the first story's floor beneath a skylight, cutting open the floor near the front showroom windows, and in some cases removing the stepped up displays or platforms in the front of the store to help ventilate the basement. Remember that a charged hoseline should be near these openings for protection.

Fascias. Fascias in these structures can readily promote fire extension under their sheathing. If the fascias are a separate decorative structure added to the building at a later date, any fire involved in the space may not be as important as if it had access to the cockloft. If opening a fascia to check for extension or to ventilate, consider these three methods. Openings underneath or on top of the fascia can be dangerous to personnel, because they could pull material on top of themselves and be injured. It also puts the firefighter in a dangerous area, operating under a portion of a structure that could collapse if it was fire ravaged. Openings can easily be made by cutting the vertical projection above the roof if the sheathing extends above the roofline. In some instances, this fascia ties into the brick parapet wall, and access with this method will not work. Using this method, a fascia would collapse away from personnel on the roof. Opening this fascia up from the safety of a tower ladder's bucket is another proven method.

Note that commercial structures often have heavy equipment such as air conditioning units, HVAC, billboards, and cell phone sites directly on their roofs or supported by steel I-beams above the roof. These features can add a tremendous weight load to the roof; and if fire involves the cockloft, the weight of these items can lead to an early collapse of the roof. In some instances, these frames may be tied into the parapet walls and can cause the failure and collapse of these walls under fire conditions. Firefighters should relay all pertinent information on the whereabouts of these items to the incident commander (fig. 14–80).

Fig. 14–80. Heavy equipment on the roof—this information should be relayed to the I.C.

Factories and warehouses

Many different construction methods are used to build industrial structures and complexes. Often, multiple manufacturing processes or tenants are housed in the same building with different hazards. Older buildings tend to have been modified and retrofitted throughout the years. In these cases it is common to find older construction in one section of the building and newer construction features in others. Most of the newer buildings are constructed of lightweight materials and are not conducive to firefighting operations like the older buildings.

Industrial occupancies may have large, open floor plans with a large amount of stock. These conditions can rapidly enhance the spread of fire. Although division walls may be present, the fire doors may be inoperative or blocked open, rendering a division wall ineffective and exposing additional areas of the building to fire and smoke. Larger buildings and roofs may require extensive operations to adequately ventilate. Firefighters must always consider the type of roof on a structure before ventilating it. Many industrial buildings may have flat or truss roofs. They may be of lightweight wood, concrete, steel bar joists with built-up metal decking, mill construction, or conventional wooden construction.

Windows of many such industrial structures may have been removed and covered with bricks for security purposes, whereas others be covered with wire mesh security screens. These obstacles may mandate the use of vertical ventilation and increase the time it takes to provide horizontal ventilation. If horizontal operations aren't feasible in some situations, it may have to be limited to the building's entrances, exits, and loading docks.

> **FIREGROUND NOTE**
>
> During a size-up of factories or warehouses, firefighters should also check for items such as the name and type of business on the front of the building. They should look for the National Fire Protection Association 704 hazardous materials placard ("diamond") on the exterior, the size of the electrical service, the type of equipment or machinery on the roof, stock type and supplies stored out in the yard, and whether hazardous materials are present.

Tactics

Horizontal ventilation. Horizontal ventilation operations can often be done by ventilating windows, doors, or larger openings, such as loading dock doors and display windows. Pressurized ventilation can enhance or replace the natural ventilation process.

Vertical ventilation. Initial roof operations should take advantage of natural features such as skylights, scuttle covers, and any bulkheads that may be present on the roof. Roof operations are predicated on the size and progress of the fire and the type of roof. Initial operations should be offensive and an opening made over the fire. If necessary, they should be followed by defensive tactics if personnel and conditions allow. Larger buildings require additional or larger ventilation openings than the standard hole made in dwellings. Because additional equipment and personnel are required, emphasize safety.

Institutions

The location of a fire in institutional buildings must be determined to evaluate its potential effect. Prime locations for fires in these types of buildings are in the kitchens, lounges, and storage areas. Hospitals, sanitariums, and rest homes are characterized by non-ambulatory residents who may need assistance or need to be removed. Jails and other detention facilities have occupants who may need to be released by security personnel. If a detention facility is in your district, plan your responsibilities ahead of time for incidents that might involve your services.

Firefighters must consider the height and number of floors in relationship to the location of the fire. A fire on the lower levels of a multistory institution can expose the floors above. Rescuing occupants on the upper floors may prove difficult. A fire on the upper levels may not expose the lower floors and may easily be ventilated with roof or stair shaft techniques.

Tactics

Single story. Ventilation efforts should initially focus on creating a ventilation opening as close to the fire as possible to reduce the extension of fire elements to other portions of the building. Openings should be large enough to ensure rapid and effective ventilation so as to facilitate the removal of occupants and the deployment of suppression personnel. Additional operations should provide ventilation for hallways and other passageways to minimize horizontal extension within. Pressurized ventilation in conjunction with horizontal ventilation can be effective.

Multistory. Begin initial ventilation operations with the vertical passageways such as stairwells and hallways if they are contaminated by fire or smoke. If a fire is on the top floor, always consider ventilating over the fire to reduce horizontal extension. Likewise, always consider the effect of using an uninvolved stair shaft to ventilate the floors below. Remember, it is crucial for all firefighters to be aware of the attack and evacuation stairwells in buildings with multiple levels. Lower floors can be ventilated by using a combination of pressurized ventilation, horizontal openings, or stairwells. When ventilating the lower floors, particularly through a stairwell, always consider its effect on the upper floors. Regardless of the size or height of the structure involved, always try to compartmentalize and restrict the extension of fire and its by-products.

Note that access into the stairwells of many institutions is restricted to prevent people from leaving or entering a floor. Many times it is more advantageous for a firefighter to get a key than to force the doors.

High-rise office buildings

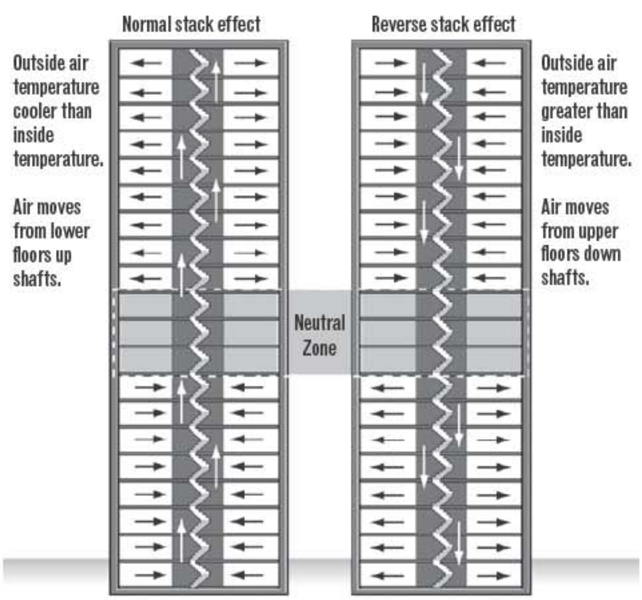
Of the various types of structures encountered by the fire service, high-rises can be the most challenging in which to perform ventilation operations (fig. 14–81). In the older high-rises, there may be windows that open, but in the newer structures there are none. The newer high-rises are built with curtain wall construction and tempered glass windows, which are designed to be broken by firefighters to remove smoke from the floor. These windows are typically identified by a glass etching or reflecting sticker of the firefighter's Maltese cross (tempered windows break into small pieces as opposed to large, dangerous shards of glass from a plate glass window). The air in these buildings is pressurized and moved by HVAC systems located on various floors throughout the structure. Firefighters must realize that although a high-rise building may have windows, it may not be wise to indiscriminately ventilate them. Fires on upper floors can be affected by the wind currents present at upper levels of the atmosphere. In addition, falling glass from these high levels could injure anyone in its path.

The migration of smoke and toxic by-products throughout a high-rise building can often present a greater hazard to life than the spread of fire itself. During fires, the migration of air throughout a high-rise, frequently by its HVAC system or natural channels, results in the spread of smoke and toxic gases to areas far removed from the actual fire. This can render vertical and horizontal escape routes impassable and hamper fire-suppression efforts. Because smoke normally travels upward, the floors above become prime exposures for stratification, mushrooming, and possible fire extension. Thus it is important to have some type of guidelines for ventilation operations.

Smoke movement is also affected by a phenomenon known as "stack effect." In essence, smoke will be aided in its movement up through a building when temperatures inside the building are warm and the temperature outside the building is cool. Conversely, reverse stack effect will tend to drive smoke down through a high-rise building when temperatures are warm outside and cool inside the building (fig. 14–82).

Consider that some buildings will be equipped with smoke management systems. These may protect parts of a building (such as pressurization of an elevator shaft to keep smoke out) or may be installed throughout a high-rise building to exhaust the floor that is involved in the fire and pressurize the floor above and below to keep smoke from migrating to those areas. Most modern high-rise buildings have stairwell pressurization systems that inject air into a stair shaft during a fire to keep smoke out. It is important to identify all smoke management systems and how they work during preplanning operations.

Fig. 14–81. A high-rise office building. Of the various types of structures encountered by the fire service, high-rises can be the most challenging for firefighters to perform ventilation operations.



Effects of normal and reverse stack.

Fig. 14–82. The effect of normal and reverse stack effect in a building

HVAC operating guidelines. The following measures should be taken in regard to the HVAC system when units arrive at a fire in a high-rise:

- Determine the location of a building representative (fire safety director or maintenance worker).
- Determine the status of *all* HVAC systems. Manually shut down any system that has not automatically shut down (including supply and return fans).
- Determine the fire floor or floors.

Once the fire floor(s) have been determined, activate the supply fan in *all* HVAC zones that do not include the fire area. Activating these fans provides fresh air and pressurizes the zones, limiting the spread of smoke and gases. All units operating in the building should report any adverse conditions to the incident commander.

PPV used in high-rise operations. Opening the bottom and top doors of a stair shaft quickly develops a natural upward flow of air. Placing blowers at the bottom of the shaft can augment this flow, regardless of the height of the building. Such currents can be used to keep contaminants from accumulating in a stair shaft (if the roof opening is kept closed) or to remove accumulated contaminants and keep the shaft clear (roof opening kept open). Emphasis is placed on stair shafts that may be used by attack personnel. This creates better visibility in the stairwell, allowing the engine company to hook up to the standpipe system and the truck company to search the floors above and the stairwell. Note that such operations can be affected by the presence of a stairwell pressurization system.

High-rise fires present unique and varied ventilation problems. Firefighters should never attempt a haphazard approach to ventilation without specific plans for the effective use of personnel and equipment. Additionally, when ventilation operations are necessary, it is essential to have a clear understanding of the parameters imposed by high-rise buildings.

High-rise multiple dwellings

In many cities across the country, large high-rises have numerous apartments per floor. These buildings may have windows that open or not and outdoor balconies in some instances. Another common type of these buildings is referred to as *projects* and are prevalent in lower-income areas. These buildings come in various shapes, heights, and sizes and also have ventilation issues to handle. Recently, many major cities and outside agencies have been studying on the effects of wind-driven fires at these occupancies. Unfortunately, numerous firefighters have been killed in fires in such dwellings over the course of the years.

When fires occur in these buildings, firefighters begin with their normal ventilation efforts: ventilating the fire apartment windows from the floor above in coordination with the hoseline's fire attack. The first firefighter who reaches the apartment on the floor above should relay the wind conditions to the incident commander and follow their directions. Ventilation of an upper-floor fire in these dwellings is usually performed by a firefighter reaching downward with a 6-ft (2-m) hook, a Halligan tool attached to the hook, or a Halligan attached to a utility rope to break the fire apartment's windows. The roof's bulkhead is normally opened to clear the stair shaft of contaminants. Opening the door at the base of the shaft also allows a draft to be pulled up the stairs to help clear the stairwell of contaminants.

Unfortunately, the pressure of the wind causes significant problems for firefighters. As they commence their initial fire attack into the fire apartment or public hallway leading to the fire apartment, windows fail and wind currents blow fire and heat back on top of the operating crews. The heat levels become unbearable, because the apartment's fire load burns at a furious pace from the wind, and chase firefighters out of the apartment or hallway. Firefighters have reported that the conditions changed so rapidly that they did not know what happened.

Recent studies have shown that by pressurizing the attack stairwell with large PPV fans, firefighters can lower the hallway temperatures and diminish the effects of the wind-driven fire back onto the fire attack teams. Also, by pressurizing the stairwell at wind-driven fires, the fire attack team can attempt to proceed into the public hallway or fire apartment to extinguish the fire. Another method of controlling the wind at these fires is to prevent the influx of wind into the fire apartment by dropping a **fire blanket** out the window from the floor above (fig. 14–83). The fire-resistive blanket blocks the window channel from the wind, allowing interior crews to attempt an aggressive fire attack on the fire. This tactic will require additional personnel and time for implementation, and the height and location of the fire will be a major consideration.

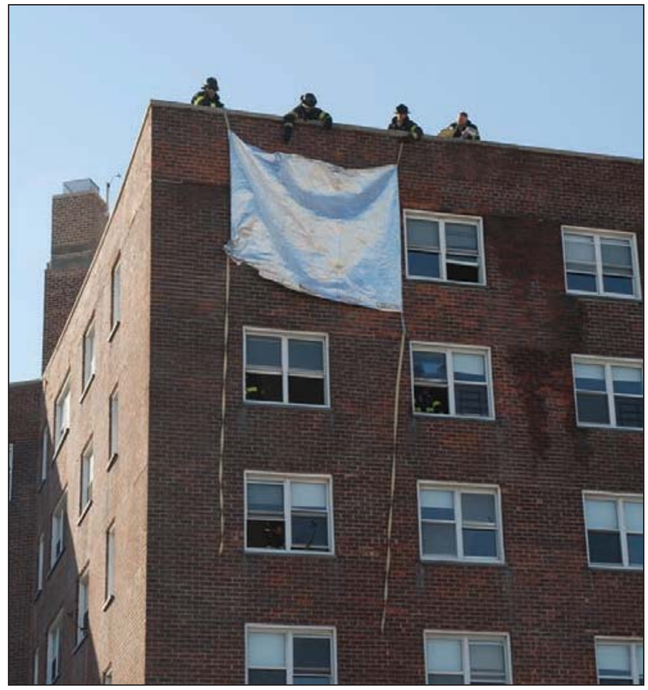


Fig. 14–83. A fire blanket or wind control device being placed over the window of an apartment to block wind from entering. (Courtesy of NIST)

QUESTIONS

1. What are the differences in the two basic principles of ventilation?
2. Smoke contains many different gases that are toxic to civilians as well as firefighters. Among those listed in the text, which are the two most common gases firefighters should be concerned about?
3. When performing ventilation size-up of a structure, what are some of the considerations firefighters must ask?
4. Both negative pressure and positive pressure ventilation may use mechanical methods to ventilate a structure. What is the theory behind how each displaces the smoke and by-products?
5. The improper use of PPV during fire attack can have deadly results for firefighters as well as the civilian occupants of a structure. List three conditions that would prevent PPV from being utilized during fire attack.
6. Regardless of type of ventilation used on a fire scene, what is the goal of effective ventilation principles?
7. In relation to ease and safety of firefighters, what is the most popular method of quickly ventilating a compartment of a structure?
8. After removal of skylights to provide ventilation, what must the ventilation crew check to ensure full access of the opening?
9. How do roof scuttles and bulkhead doors differ in the overall effect of ventilation?
10. If presented with multiple panes when ventilating a window, what are the correct steps to open the window?
11. When ventilating windows that are covered with security grating or steel mesh, what are the different methods that may be employed?
12. Lexan windows can present a unique problem to firefighters attempting horizontal ventilation. What steps can be taken when forced to ventilate these types of windows?
13. VES techniques are generally used when accessing the alleged location of victims when not accessible by other means. This is known as venting for ____________?
14. What are the proper steps of performing VES?
15. Why is closing the door early in the VES technique so critical?
16. List some of the typical tools needed for roof ventilation.
17. The Kerf or plunge cut is commonly used to accomplish what task?
18. When using the "pullback" method of roof ventilation, what are some of the advantages?
19. An effective ventilation technique that can be accomplished more quickly than the coffin cut is?
20. When ventilating pitched roofs, what is the primary purpose of the setting a roof ladder?
21. Caution must be used when ventilating open web steel bar joist supported roofs. What are some of the hazards associated with these types of roofs?
22. Identify the most dangerous type of roof and list the reasons why.