**Chapter 15: Ventilation**

**Chief Concepts**

* Ventilation is the process of removing smoke, heat, and toxic gases from a burning building and replacing them with cooler, cleaner, oxygen-rich air. The ventilation process has two different components. The first is the removal of smoke, toxic gases, and hot air. The second is the addition of cooler, cleaner, and oxygen-rich air.
* The sudden addition of oxygen-rich air to a smoke-filled and fuel-rich atmosphere can result in a sudden flashover or a backdraft.
* Because of modern construction techniques, fires have a large supply of fuel in furnishings and a limited supply of oxygen as a result of tightly shut windows and doors. This can lead to an underventilated fire. An underventilated fire simply needs a supply of oxygen to become a raging fire, a flashover, or a backdraft.
* When ventilation is coordinated with fire attack and the application of water, it can save lives and reduce property damage.
* As a fire grows and develops, the products of combustion—smoke, heat, and toxic gases—spread throughout the structure and present a life-threatening risk to occupants and fire fighters, reduce visibility, and increase property damage. These trapped products of combustion create a potential for explosion. Ventilation removes some of these products from the interior atmosphere and allows them to escape in a controlled manner.
* The principle of convection controls the spread of the products of combustion. Convection is one of the primary mechanisms of fire spread. These gases can be hot enough to ignite combustible materials along their path.
* With convection, when heated gases expand, they become less dense than cooler gases. As a result, the hot gases produced by a fire in a closed room rise to the ceiling and spread outward, displacing cooler air and pushing it toward the floor. As the fire continues to burn, the hot layer of gas banks down closer to the floor. If the heated products of combustion escape from the room, they spread horizontally along the ceiling until they find a path or an outside opening that allows them to reach a higher level. They then flow upward through the vertical opening until they reach another horizontal obstruction, such as a ceiling.
* The benefits of proper ventilation include improved visibility, removal of heat, removal of steam created by the attack lines, reduced risk of backdraft, and limited fire spread.
* To reduce the risk of backdraft, ventilation must release as much heat and unburned products of combustion as possible. Placing a ventilation opening as high as possible within a building can help to eliminate potential backdraft conditions. When it is safe, fire attack crews should extinguish the fire and cool the interior as quickly as possible.
* Both ventilation and cooling are needed to relieve potential flashover conditions. Short bursts of water are applied to the ceiling by the attack crews, and the ventilation openings are placed close to the fire.
* Convection currents can carry smoke and superheated gases to uninvolved areas within the structure. Fire fighters must be able to predict where the fire might travel by convection currents. Fire fighters can also take advantage of convection by making ventilation openings that cause the convective flow to draw the heated products out of the structure.
* The direction and force of the wind should be considered when determining where and how to ventilate a building. Even a slight breeze can have a dramatic influence on the effectiveness of a ventilation opening.
* All of the structural components in fire-resistive construction are made of noncombustible or limited-combustible materials. It generally has spaces divided into compartments, which limit potential fire spread. However, the products of combustion can spread through stairways and HVAC systems. The roof is usually supported by a steel or concrete roof deck that is difficult to impossible to cut vertical ventilation holes in.
* Ordinary-construction buildings have exterior walls made of noncombustible or limited-combustible materials that support the roof and floor assemblies. The walls and floors are usually wood construction. The roof can be cut with power saws or axes to open vertical ventilation holes. These buildings usually have windows and doors that can be used for horizontal ventilation. Vertical openings frequently provide a path for fire to extend into an attic or cockloft.
* Wood-frame buildings often contain many void spaces. Lightweight construction components, found in newer buildings, can fail quickly under fire conditions.
* Ventilation is related to the three major tactical priorities in firefighting operations: life safety, fire containment, and property conservation.
* Fire fighters must be able to recognize when ventilation is needed and where it should be provided, based on the circumstances of each fire situation. They must consider many factors, including the size of the fire, the stage of combustion, the location of the fire within a building, and the available ventilation options.
* Horizontal ventilation takes advantage of the doors, windows, and other openings at the same level as the fire. In some cases, fire fighters make additional openings in a wall to provide horizontal ventilation. Horizontal ventilation is commonly used in residential fires, room-and-contents fires, and fires that can be controlled quickly by the attack team.
* Vertical ventilation involves making openings in roofs or floors so that heat, smoke, and toxic gases can escape from the structure in a vertical direction. Pathways for vertical ventilation can include ceilings, stairwells, exhaust vents, and roof openings, such as skylights, scuttles, or monitors. Additional openings can be created by cutting holes in the roof or the floor and making sure that the opening extends through every layer of the roof or floor.
* Horizontal ventilation tactics include natural and mechanical methods. Natural ventilation includes opening or breaking a window or opening a door and allowing convection currents, wind, and other natural air movements to help flow contaminated atmosphere out of a structure. Mechanical ventilation uses large high-powered fans to augment natural ventilation.
  + Mechanical ventilation includes negative- pressure ventilation, positive-pressure ventilation, and hydraulic ventilation.
  + Negative-pressure ventilation uses smoke ejectors to exhaust smoke and heat from a structure. It can be used to move smoke out of a structure after a fire.
  + Positive-pressure ventilation uses fans to introduce clean air into a structure and push the contaminated atmosphere out. It can be used to reduce interior temperatures and smoke conditions in coordination with a fire attack or to clear a contaminated atmosphere after a fire has been extinguished.
  + Hydraulic ventilation moves air using fog or brokenpattern fire streams to create a pressure differential behind and in front of the nozzle. It is most useful in clearing smoke and heat out of a room after the fire is under control.
* Vertical ventilation refers to any opening that allows the products of combustion to travel up and out. This term is most often applied to describe operations on the roof of a structure. The roof openings can be existing features, such as skylights or bulkheads, or holes created by fire fighters who cut through the roof covering. The choice of roof openings depends primarily on the building’s roof construction.
* Before performing vertical ventilation, fire fighters must evaluate all pertinent safety issues and avoid unnecessary risks. The biggest risk is roof collapse. Assess the roof for roof scuttles, heat vents, plumbing vents, louvre ventilation, and fan shafts to prevent tripping or falling from the roof.
* When working on a roof, have two safe exit routes. A second ground ladder or aerial device should be positioned to provide a quick escape route. The ventilation opening should never be located between the exit route and the ventilation crew.
* Fire fighters who are assigned to vertical ventilation tasks should always be aware of the condition of the roof. They should immediately retreat from the roof if they notice any of the following signs:
  + Any visible indication of sagging roof supports
  + Any indication that the roof assembly is separating from the walls, such as the appearance of fire or smoke near the roof edges
  + Any structural failure of any portion of the building, even if it is some distance from the ventilation operation
  + Any sudden increase in the intensity of the fire from the roof opening
  + High heat indicators on a thermal imaging camera
* The two major components of roof construction are roof support structures and roof coverings. The roof support system provides the structural strength to hold the roof in place. The structural system is either solid-beam or truss construction. The roof covering is the weather-resistant surface and may consist of many layers.
* Roof designs include flat roofs, pitched roofs, and arched roofs.
  + Flat roof construction is similar to floor construction. It can be supported by solid components or by trusses. Flat roofs often have vents, skylights, scuttles, or other features that penetrate the roof deck. Removing the covers from these openings provides vertical ventilation without the need to make cuts through the roof deck.
  + Pitched roofs have a visible slope. They can be supported by trusses or a system of rafters and beams. Many of these roofs have a layer of solid sheeting covered by a weather-resistant membrane and outer covering. The roof construction material dictates how to ventilate the roof.
  + Arched roofs create large open spans without the use of columns. They are often supported with bowstring trusses. The collapse of a bowstring truss is usually very sudden.
* The types of vertical ventilation openings include the following:
  + Built-in roof openings
  + Inspection openings
  + Primary (expandable) openings
  + Secondary (defensive) openings
* Some commercial or industrial structures have concrete roofs. There are few options for ventilating these structures. Use alternative ventilation openings such as vents or skylights.
* Metal roofs conduct heat and are often supported by lightweight steel metal joists.
* Both horizontal and vertical ventilation can be required to vent a basement.
* HVAC systems may be used to ventilate high-rise buildings.
* To ensure successful ventilation operations, all equipment and tools must be in a ready state and properly maintained.