Pre-Lecture

I. You Are the Fire Fighter

Use this activity to motivate students to learn the knowledge and skills needed to effectively perform ventilation.

Purpose

To allow students an opportunity to explore the significance and concerns associated with ventilation.

Instructor Directions

1. Direct students to read the "You Are the Fire Fighter" scenario found in the beginning of Chapter 14.
2. You may assign students to a partner or a group. Direct them to review the discussion questions at the end of the scenario and prepare a response to each question. Facilitate a class dialogue centered on the discussion questions.
3. You may also assign this as an individual activity and ask students to turn in their comments on a separate piece of paper.

I. Introduction

Slides: 1-6

A. Ventilation

1. The process of removing smoke, heat, and toxic gases from a burning building and replacing them with cooler, cleaner, more oxygen-rich air.

B. A fire gives off products of combustion, which include:

1. Smoke
2. Heat
3. Toxic fire gases

C. Convection is one of the primary mechanisms of fire spread.

1. The gases may be hot enough to ignite combustible materials along their path.
2. The gases may lack enough oxygen to burn, and when mixed with air may explode in a backdraft.
3. Property may be damaged caused by the exposure to smoke and heat.
4. Products of combustion will rise until blocked by the ceiling and then continue to spread horizontally along the ceiling until there is another avenue for vertical spread

D. Upon reaching the highest point, mushrooming will occur, which is the process of the products of combustion spreading out and banking down.

E. Products of combustion that are trapped in a structure present a series of risks and dangers to the occupants and to fire fighters.

1. Several fire gases, most notably carbon monoxide, are toxic.
2. The gases may be so hot they cause fatal respiratory burns

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3. The smoke may obscure vision making it difficult for occupants to find exits and fire fighters to find the trapped occupants.
4. The smoke is irritating to the eyes and mucous membranes of the respiratory system.

II. Benefits of Proper Ventilation

Slides: 7-8

A. Allows fire fighters to locate trapped occupants more rapidly

B. Provides fresh air to occupants overcome by toxic products of combustion

C. Allows fire fighters to advance hose lines more rapidly and safely

D. Allows fire fighters to direct streams directly at the seat of the fire

E. Reduces chance of backdraft and flashover

F. Helps limit fire spread within the structure

G. Complete ventilation clears the atmosphere and reduces property loss caused by smoke damage.

III. Factors Affecting Ventilation

Slides: 9-10

A. Fire fighters must consider how fire behavior dictates the movement of the products of combustion.

B. A plan must be developed of where and when to create openings.

C. Convection (natural ventilation)

1. The transfer of heat through a circulating medium of liquid or gas.
2. As heat rises, the cooler air is drawn toward the seat of the fire bringing oxygen to the fire.
3. Smoke and superheated gases may travel to uninvolved areas within the structure if there is an opening.
4. Heated gases will always follow the path of least resistance.
5. Fire fighters can make openings that offer less resistance.
6. Fire fighters use this basic principle to cause the convection flow to draw heated products out of the building.

D. **Mechanical ventilation** (may be used to direct the flow of combustion gases)

1. Negative-pressure ventilation uses fans to draw or pull smoke through openings.
2. Positive-pressure ventilation uses fans to introduce fresh air which displaces the smoke and other products of combustion
3. Hose streams can be used to create currents to ventilate an area.

E. Wind and atmospheric forces can play a significant role in ventilation.

1. Wind should always be considered when determining where and how to ventilate.
2. Creating an opening on the windward side of a building will push the heat and products of combustion into the structure.
3. Creating an opening on the leeward side of a building will create a negative-pressure zone that pulls the heat and smoke out of the structure.

4. Temperature and humidity also affect ventilation, particularly in tall buildings and large-area buildings.

    a. Strong updrafts are likely on cold days in heated high-rise buildings.

    b. A downdraft is likely on a hot day in an air conditioned building.

    c. Because humidity makes the atmosphere more dense, removing cool smoke from a building could be more difficult on a humid day.

IV. Building Construction

Slides: 11-14

A. The way a building is constructed will affect ventilation operations.

B. **Fire-resistive construction** refers to a building in which all the structural components are made of noncombustible or limited-combustible materials.

    1. Generally divided into compartments, which limit fire spread

    2. Fires are usually the combustible contents of an interior space

    3. Fires in fire-resistive buildings may spread through heating, ventilation, and air conditioning systems (HVAC), stairways, and elevator shafts.

    4. The roof is often steel or concrete, which may make roof access difficult or impossible.

C. **Ordinary construction buildings** have exterior walls of noncombustible or limited-combustible materials

    1. The interior walls and floors are usually of wood construction.

    2. The roof has a wood deck with a wood structural support system.

    3. Often, numerous paths available for fire spread including openings in walls and floors for plumbing and electrical chases, void spaces in walls behind the plaster or drywall, and a cockloft, which is open to large areas of the building or buildings

D. **Wood-frame construction** has many similar features as ordinary construction, however, the exterior walls are not noncombustible.

1. Wood-frame also has many paths available for fire spread, including attics and cocklofts and between the wood truss roofs and between the floors.

2. Many older wood-frame buildings were made with balloon-frame construction.

   a. This type of construction has direct vertical channels within the exterior walls, so fire can spread very quickly from a lower level to the attic or cockloft.

3. Modern wood-frame construction uses platform-frame techniques.

   a. The structural frame in platform construction is built one floor at a time.

   b. A plate at the floor and ceiling helps limit vertical fire spread.

V. Tactical Priorities

Slides: 15-18

A. Ventilation is directly related to the three major tactical priorities in structural firefighting operations:

1. Life safety

2. Fire containment

3. Property conservation

B. Life safety is the primary goal of the fire service.

1. Venting for life safety clears smoke, heat, and toxic gases to give occupants a greater chance to survive.

2. Ventilation increases visibility and reduces heat for faster searches.

3. Ventilation helps limit fire spread and allows fire fighters to advance hose lines more safely and rapidly to attack the fire.

C. A fire fighter's second priority is to contain the fire and gain control of the situation.

1. Venting for confinement prevents fire from spreading throughout the interior of a building or into adjoining spaces.

2. Effective ventilation increases visibility and reduces heat and enables attack lines to be advanced more easily to extinguish the fire.

D. The third priority of the fire service is property conservation.

1. Venting for property conservation plays a significant role in limiting areas damaged by heat, smoke, and water.

2. After a fire is under control, rapid removal of residual smoke will help limit property loss.

VI. Location and Extent of Smoke and Fire Conditions

Slides: 19-21

A. A fire fighter must be able to recognize when ventilation is needed and where it should be provided, based on the circumstances of each fire.

1. There are many factors to consider including:

a. The size of the fire

b. The stage of combustion the fire is in

c. The location of fire within the building

d. The available ventilation options

2. When determining where to vent, consider the following:

a. Ventilate as close to the fire as possible.

i. Ventilate directly over the seat of the fire or through an open door or window that opens to the outside.

b. It may not be possible to ventilate in the immediate area of the fire.

i. If not, the fire fighter should predict how ventilating in a location away from fire will affect the fire

ii. Fire fighters should also anticipate fire spread and then locate hose lines to stop the fire from spreading.

3. The color, location, movement, and amount of smoke can provide clues about the fire's size, intensity, and fuel.

    a. Thin, light-colored smoke, moving lazily indicates a small fire of ordinary combustibles.

    b. Thick, dark gray smoke "pushing" out of a structure, suggests a larger, more intense fire.

    c. Large quantities of black, rolling smoke that rises in a vertical column indicates a petroleum fire.

    d. Smoke movement is a good indicator of the fire's temperature.

        i. The hotter the fire, the faster the smoke will move.

        ii. Cooler smoke moves more slowly and gently.

        iii. Cool, damp days with little wind may cause the smoke to hang low to the ground which is known as smoke inversion.

        iv. When a sprinkler system activates, the smoke may cool and act like fog.

VII. Types of Ventilation

Slide: 22

A. To ventilate, fire fighters use two basic types of ventilation openings.

1. **Horizontal ventilation** utilizes the doors and windows on the same level as the fire, as well as any other horizontal openings that are available.

    a. Fire fighters may make additional openings in a wall to provide horizontal ventilation.

2. **Vertical ventilation** involves openings in roofs or floors so that heat, smoke, and toxic gases escape from the structure in a vertical direction.

    a. Pathways for vertical ventilation can include stairwells, exhaust vents, and roof openings such as skylights, scuttles, or monitors.

    b. Additional openings can be created by cutting a hole in the roof or the floor.

B. When referring to ventilation techniques, fire fighters use the term *contaminated atmosphere* to describe the products of combustion that must be removed from a building.

C. The term fresh air is the term used to refer to the air the replaces the contaminated air within a building.

VIII. Horizontal Ventilation →

Slides: 23-32

A. **Horizontal ventilation** uses horizontal openings in a structure, such as windows and doors and can be employed in many situations, particularly in small fires.

1. Commonly used in residential fires, room-and-contents fires, and fires that can quickly be controlled

2. Generally fast and is an easy way to clear a contaminated atmosphere

3. Can be performed from inside or outside the building

4. Horizontal ventilation is most effective when the opening goes directly to the outside.

5. More difficult when there are no direct openings to the outside or the openings are inaccessible

6. May be used in less urgent situations if the building can be ventilated without additional structural damage

7. Horizontal ventilation tactics may utilize both natural and mechanical methods.

B. **Natural ventilation** depends on convection currents, wind, and other natural air movements to allow a contaminated atmosphere to flow out of a structure.

1. Natural ventilation can only be used when air currents are adequate.

2. Natural ventilation is often used when ventilation is needed quickly.

3. Wind speed and direction play an important role in natural ventilation.

   a. If possible, open leeward side of building first to allow the contaminated atmosphere to flow out.

   b. The windward side can then be opened to bring in fresh air.

   c. Opening a window on the windward side first could push the fire into uninvolved areas of the structure.

C. Breaking glass may be needed if the window cannot be opened and the need for ventilation is urgent.

1. Before breaking a window, always try to open it first.

2. Always wear full protective clothing, including eye protection when breaking a window.

3. When breaking glass, the fire fighter should always use a hand tool and keep hands above or to the side of the falling glass.

4. A tool should be used to clear the remaining glass to prevent injuries.

5. When breaking glass, look out to ensure that no one will be struck by the falling glass.

6. Fire fighters may need to break glass from the ground level, from a ladder, with a ladder, or from above.

D. Door openings also can be used for natural ventilation operations.

1. Doors provide a large opening, often twice the size of an average window.

2. When using a door for ventilation, it may compromise entry and exits for fire fighters.

3. It is usually better suited for using doors as fresh air entry points.

4. Doorways are also good places for mechanical ventilation devices.

E. **Mechanical ventilation** uses mechanical means to augment natural ventilation.

1. There are three different methods of mechanical ventilation.

a. Negative-pressure ventilation

b. Positive-pressure ventilation

c. Hydraulic ventilation

2. When using negative-pressure ventilation, the fan draws the heat, smoke, and fire gases out by creating a slightly negative pressure inside the building. Fresh air is drawn into the structure, replacing the contaminated air.

a. Smoke ejectors are usually 16” to 24” in diameter and can be powered by electricity, gasoline, or water.

b. Negative-pressure ventilation can be used to clear smoke out of a structure after a fire, particularly if natural ventilation would be too slow.

c. Negative-pressure ventilation has several limitations, including positioning, power source, maintenance, and air flow control.

d. Smoke ejectors usually have explosion proof motors which makes them excellent choices for venting flammable or combustible gases and other hazardous environments.

3. Positive-pressure ventilation uses large, powerful fans to force fresh air into a structure.

   a. The fans create a positive pressure inside the structure, displace the contaminated atmosphere and push the heat and products of combustion out.

   b. Fans are usually set up at exterior doorways, often the same opening used by the attack team.

      i. To work effectively, ventilation openings must be kept to a minimum.

      ii. There must also be an opening near the seat of the fire for an exhaust opening.

      iii. The entry and exit openings should be approximately the same size.

      iv. To increase efficiency, close off unaffected areas.

      v. Large areas can be ventilated by using multiple fans side-by-side or one behind the other.

   c. Positive-pressure ventilation has many advantages over negative-pressure ventilation.

      i. It can be set up by one fire fighter very quickly.

      ii. The fire fighter does not have to enter the hazardous atmosphere.

      iii. Positive-pressure is both quick and efficient.

      iv. It can confine the fire to a smaller area.

      v. It increases safety to fire fighters and building occupants by reducing interior temperatures.

      vi. Positive-pressure fans do not get as dirty because the products of combustion do not move through the fan.

   d. Positive-pressure ventilation does have its disadvantages as well.

      i. Most importantly, it may spread the fire.

      ii. It is also very noisy.

iii. It may also increase the carbon monoxide levels inside the structure.

iv. Since the motors get hot, they are unsafe to use if flammable or combustible vapors are present.

4. Hydraulic ventilation uses the water stream from the hose line to exhaust smoke and heated gases from a structure.

   a. The fire fighter directs a narrow fog or broken stream out the building through an opening such as a window or doorway making certain that it hits an officer in the ear

   b. The contaminated atmosphere is drawn into the low pressure area behind the nozzle.

   c. The draft created by the nozzle pulls the smoke out through the opening.

5. Hydraulic ventilation is most useful for clearing a room after the fire is out.

   a. To perform, a fire fighter enters the room, places a nozzle through the opening, and opens the nozzle to a narrow fog or broken spray pattern.

   b. The fire fighter keeps directing the stream outside and backs into the room until the pattern almost fills the opening. The nozzle is usually 2’ to 4’ inside the opening.

   c. The fire fighter must stay low, out of the heat and smoke, or to one side to keep from partially obstructing the opening.

6. Advantages of hydraulic ventilation:

   a. It can move several thousand cubic feet of air per minute.

   b. It does not require any specialized equipment.

7. Hydraulic ventilation does have it disadvantages.

   a. Fire fighters must enter smoke-filled environment to use.

   b. It may deplete needed water supplies that are needed for fire attack.

   c. It may cause excessive water damage if used improperly or for long periods of time.

   d. In cold weather, it may cause a safety hazard due to ice build-up.

IX. Vertical Ventilation ↑

Slides: 33-51

A. Vertical ventilation is the release of smoke, heat, and other products of combustion into the atmosphere in a vertical direction.

1. It will occur naturally, due to convection currents, if there is an opening.
2. It may be assisted by mechanical means such as fans or hose streams.
3. It usually involves making openings in the roof of a structure.
4. Roof openings can be existing features, such as skylights or bulkheads, or created by fire fighters who cut through the roof.
5. Vertical openings should be made as close to the seat of the fire as possible.
6. Smoke issuing from the roof area, melted asphalt shingles, or steam coming from the roof surfaces are all signs used to identify the hottest point.

B. Safety Considerations in Vertical Ventilation

1. Vertical ventilation should be performed only when it is necessary and can be done safely.
2. The most obvious risk is the possibility that the roof will collapse.
3. Falling from the roof—either off the building or through a ventilation opening, open shaft, or skylight into the building—is another possibility.
    a. Smoke can cause poor visibility and disorientation.
    b. Factors such as darkness, snow, ice, or rain can create hazardous situations.
4. Effective vertical ventilation often results in rapid fire control and reduces risks to fire fighters inside the building.
5. Vertical ventilation should always be performed as quickly and efficiently as possible.
6. Fire fighters working on a roof should always have two safe exit routes that are separate from each other, preferably by 90 degrees
7. The ventilation opening should never be between the fire fighter and their escape route.

8. Have a charged hose line ready to protect fire fighters and exposures, but do not direct a hose stream into the ventilation opening.

9. Once the ventilation opening has been made, the fire fighters should withdraw to a safe location.

10. "Sounding" is a way to test the stability of a roof with a tool.

    a. Simply strike the surface of the roof with the blunt end of the tool

    b. If the roof is in good condition, the impact should produce a firm rebound and a reassuring sound.

    c. If the impact does not produce this sound, or the tool penetrates the roof, the structure is not safe.

    d. Continue to sound the area around you periodically to monitor conditions.

    e. Modern lightweight construction frequently uses thin plywood for roof decking, which may delaminate from a relatively minor fire.

    f. Sounding is not a foolproof method to test the condition of a roof and may give fire fighters a false sense of security.

11. A fire fighter's path to a proposed vent hole site should follow the areas of greatest support.

    a. This includes the roof edges, which are supported by bearing walls, and the hips and valleys.

12. The order of the cuts in making a ventilation opening should be carefully planned.

13. Fire fighters should be upwind, have a clear exit path, and be standing on a firm section of roof.

C. Basic Indicators of Roof Collapse

1. Roof collapse is the greatest risk to fire fighters performing vertical ventilation.

2. Fire fighters should immediately retreat from the roof if they notice any of the following signs.

    a. Any spongy feeling or indication that the roof is not solid

    b. Any visible sagging of the roof supports

    c. Any indications that the roof is separating from the walls

    d. Any structural failure in another portion of the building

    e. Any sudden increase in fire intensity from the opening

D. Roof Construction

1. All roofs have two major components—a support structure and a roof covering.

2. Support system provides the structural strength to hold the roof in place.

    a. It must also be able to bear the weight of any rain or snow accumulation, any rooftop machinery or equipment, and other loads placed on the roof.

    b. The system may be constructed of solid beams of wood, steel, or concrete or a system of trusses made of wood, steel, or combination wood and steel.

3. The roof covering is the weather-resistant surface of the roof and may have several layers.

    a. Roof covering materials include shingles and composite materials, tar and gravel, rubber, foam plastics, and metal panels.

4. The roof decking is the rigid layer made of wooden boards, plywood sheets, or metal panels.

5. The selection of tools, the technique used, the time required to make an opening, and the manpower requirements all depend on the roofing materials and the layering configurations.

6. Roofs may fail in two manners.

    a. First, the support system may fail causing sudden and total collapse.

    b. Alternatively, the roof covering may fail by "burning through" close to the seat of the fire and then spreading out causing roof failure.

7. In areas with winter snow loads, roofs are usually more substantial allowing for large fires without burn through.

8. In areas with no winter snow loads, roofs function more like an umbrella. Fires may quickly burn through.

9. The two major structural support systems for roofs use either solid beam or truss construction.

    a. It may not be possible to determine by looking at the roof from the exterior.

    b. Solid-beam construction uses solid components, such as girders, beams, and rafters.

    c. Trusses are assembled from smaller, individual components.

        i. Trusses can collapse quickly and suddenly when exposed to fire.

        ii. Trusses are constructed from lightweight components in a series of triangles

iii. Some trusses are very strong and assembled with substantial components that can resist fire as well as solid beams.

iv. Trusses can be used with almost any type of roof or floor.

v. The individual components of a lightweight truss used for roof supports are often wood 2" x 4" sections or a combination of wood and lightweight steel bars or tubes.

vi. Even more critical are the points where the individual components join together.

(a) These connection points are often the weakest portion of the truss.

(b) The connections are often made with heavy-duty staples or by gusset plates.

(c) When one connection fails, the truss loses its ability to support a load.

vii. If only one truss fails, other trusses may be able to absorb the additional load, however, the overall strength of the system will be compromised.

viii. Trusses also can be made of metal.

(a) Lightweight steel trusses often support roofs on commercial or industrial buildings.

(b) When exposed to the heat of a fire, they tend to expand and lose strength.

E. Roof Design

1. Fire fighters must be able to identify the types of roofs and the material used in their construction.

2. Flat roofs can be constructed with many different support systems, roof decking systems, and material.

a. Although classified as flat, they usually have a slight slope.

b. The roof structure may be solid components such as beams and rafters or trusses.

c. Beams or trusses usually run from an exterior bearing wall to another bearing wall.

d. The decking is usually constructed of multiple layers.

i. The first layer is usually made of wooden boards, plywood sheets, or metal decking.

ii. The second and subsequent layers are of roofing paper, insulation, tar and gravel, rubber, gypsum, lightweight concrete, or foam plastics.

e. Some roofs have only one layer, such as metal sheets or precast concrete sections.

f. Flat roofs often have vents, skylights, scuttles, or other features penetrating the roof deck.

g. Flat roofs may also have a parapet wall that extends above the normal roofline.

3. Pitched roofs have a visible slope for rain, ice, and snow runoff.

   a. Pitched roofs can be supported by trusses or a series of rafters and beams.

   b. Rafters usually run from one bearing wall to a center ridge pole and back to another bearing wall.

   c. Most pitched roofs have a layer of solid sheeting (metal or plywood) or wooden boards (some may use laths), then covered with weather resistant membrane and outer covering such as shingles, slate, or tiles.

   d. Type of construction will dictate ventilation method.

   e. Tile and slate roofs require breaking tiles and pushing through the laths.

   f. Metal roofs can be cut and peeled back.

   g. Wood roofs are usually cut, chopped, or sawed.

   h. May use a ground or aerial ladder to access the roof and then place a roof ladder's hooks over the ridge to work on the slope.

4. Arched roofs are generally found in commercial structures to create large spans without columns.

   a. They are common in warehouses, supermarkets, bowling alleys, and similar buildings.

   b. Arched roofs may use truss or beams made of wood, steel, or concrete arches.

   c. Arched roofs are often supported by bowstring trusses, which give the roof its distinctive curved shape.

   d. Bowstring trusses are usually constructed of wood and spaced 6' to 20' apart.

   e. The trusses support a roof deck of wooden boards or plywood sheeting and a waterproof membrane.

   f. A ceiling is often attached below bottom chords concealing them and creating large, open attic spaces, which are often used for storage ; hidden fires can quickly weaken the trusses causing collapse

   g. Collapse of a bowstring truss roof is often sudden and covers a large area.

F. Vertical Ventilation Techniques

1. Roof openings that can provide vertical ventilation are built-in roof openings, inspection openings to locate the optimal place to vent, primary expandable openings directly over the fire, and defensive secondary openings to prevent fire spread.

2. The objective of any roof ventilation operation is simple: to provide the largest opening in the appropriate location, using the least amount of time and the safest technique.

    a. Before starting any vertical ventilation operations, fire fighters must make an initial assessment.

        i. Construction features and indications of fire damage should be noted, safety zones and exit paths established, and built-in roof openings that can be used should be identified.

        ii. Ventilation operations should not be conducted in unsafe locations.

        iii. Vertical ventilation is most effective when the opening is at the highest point and over the seat of fire.

        iv. Examination holes may need to be made to evaluate conditions under the roof and to identify the proper location for a ventilation opening.

        v. A power saw can be used to make a kerf cut.

        vi. Once the spot over the fire is located, the ventilation team should determine the most appropriate type of opening to make.

        vii. If the roof must be cut to provide a ventilation opening, cutting one large hole is better than several small ones.

        viii. The original hole should be a minimum size 4' long by 4' wide.

        ix. Once the roof opening is made, a hole the same size should be made in the ceiling material below to allow heat and smoke to escape.

3. Tools used in vertical ventilation

    a. Several types of tools can be used in roof ventilation.

    b. Power saws are commonly used to cut the vent openings, but many hand tools can also be used.

    c. Axes, Halligan tools, pry bars, tin cutters, pike poles, and other types of hooks, can be used to remove coverings of existing openings, cut through the roof decking, remove sections of the roof, and punch holes in the interior ceiling.

    d. A utility rope should also be carried for hauling additional equipment if needed.

e. All personnel involved in roof operations should use breathing apparatus and full protective clothing.

4. Power saws will effectively cut through most roof coverings.

   a. A rotary saw with a wood- or metal-cutting blade or a chain saw can be used.

   b. Special carbide-tipped saw blades can cut through typical roof construction materials.

5. Roof construction is a major consideration in determining the type of roof cut to use.

6. A 4' x 4' rectangular cut is the most common type of vertical ventilation opening.

   a. The rectangular cut requires four cuts completely through the roof decking.

   b. When using a power saw, the fire fighter must carefully avoid cutting through the structural supports.

   c. The fire fighter should stand upwind of the opening with an unobstructed exit path.

   d. A triangular cut in one corner can be used as a starting point for prying up the deck.

   e. If there are several layers of roofing material, fire fighters may have to peel them off in layers.

7. The louver cut is used for flat or sloping roofs with plywood decking.

   a. Power saws or axes may be used to make the cuts.

   b. Louvered cuts can quickly create a large opening.

8. The triangle cut is used for metal decking roofs to prevent the decking from rolling away as it is cut.

   a. A saw or axe may be used to cut the triangle-shaped section of decking.

   b. Because triangle cuts are generally smaller, several may be needed to create an adequately sized vent.

9. Peak cuts are used for peaked roofs sheeted with plywood.

   a. A tool is used to reveal the roof covering along the peak.

   b. A power saw or axe may be used to make a series of vertical cuts between the support from the top to the bottom of the plywood sheet.

10. Trench cut is used as a defensive tactic to stop the progress of a large fire in long narrow buildings.

a. The trench cut creates a large opening ahead of the fire, by removing a section of fuel and letting heated smoke and gases flow out of the building.

b. The incident commander (IC) who chooses to use this tactic is "writing off" part of the building and identifying a point where crews will be able to stop the fire.

c. A trench cut is a primary cut used to limit fire spread. A primary vent should be made before crews start working on the trench cut.

d. Although effective, trench cuts require both time and manpower so they must be made far in advance of the fire.

X. Special Considerations

Slides: 52-60

A. Many obstacles can be encountered during ventilation operations.

1. Poor access or obstructions such as trees, fences, or tight exposures can prevent fire fighters from getting close enough to place ladders.

2. Many residential and commercial structures have multiple roofs and roof layers.

3. Abandoned buildings may have the window openings boarded or sealed.

4. Security measures such as steel bars and shutters can hamper ventilation efforts.

B. Ventilating a Concrete Roof

1. Some commercial or industrial structures have concrete roofs.

2. Concrete roofs are generally flat and difficult to breach.

3. The roof decking is generally stable, but fire conditions underneath could weaken the supporting structural components or bearing walls, leading to failure and collapse.

4. There are few options for ventilating concrete roofs.

5. Fire fighters should use alternative openings such as vents, skylights, and other roof penetrations or horizontal ventilation.

C. Ventilating a Metal Roof

1. Metal roofs and metal roof decks present many challenges.

2. Discoloration and warping on a metal roof may indicate the seat of the fire.

3. Metal roof decking is often supported by lightweight steel bar joists, which can sag or collapse when exposed to fire.

4. As the fire heats the metal deck, the tar roof covering can melt and leak through the joints into the building, where it can release flammable vapors.

   a. This can quickly spread the fire over a wide area under the roof decking.

   b. Fire fighters should look for indications of dripping or melting tar, and begin rapid ventilation to dissipate the flammable vapors before they can ignite.

   c. Hose streams should be used to cool the roof decking from below to stop the tar from melting and producing vapors.

   d. When a metal roof deck is cut, the metal can roll down and create a dangerous slide directly into the opening.

D. Venting a Basement

1. Basement fires are especially difficult to ventilate.

2. If a basement fire occurs, windows or exterior doorways into the basement should be opened or broken to provide as much ventilation as possible.

3. A combination of vertical and horizontal ventilation can sometimes be used in attacking a basement fire.

4. Smoke and hot gases moving up the stairway as the fire fighters descend can make entry difficult or impossible.

5. The preferred method of attacking a basement fire is to make as many ventilation openings on one side of the basement as possible allowing fire fighters to enter from the opposite side, along with fresh air.

6. Fire fighters may need to cut holes in the first floor, by open windows, to allow the smoke and heat to rise out of the basement and vent out the window.

E. High-Rise Buildings

1. Venting a high-rise building can be challenging.

2. Many high-rise buildings have sealed windows that are difficult to break.

3. High-rise buildings have unique patterns of smoke movement.

   a. Smoke can be trapped on individual floors or it may move up or down within the vertical shafts.

b. Newer buildings may have smoke management capabilities in the HVAC.

4. The stack effect may occur in high-rise structures.

   a. The stack effect is a response to the differences in temperature inside and outside a building.

   b. A cold outer atmosphere and a heated interior will cause smoke to rise quickly through vertical openings, filling the upper levels of the building.

   c. A hot outer atmosphere and a cooled interior will cause smoke to push down the vertical openings, toward a lower level exit.

5. The situation can change as the fire produces enough heat to alter the temperature profile within the building.

6. After smoke mixes with fresh air or is hit by water from sprinklers or hose streams, it cools and can "sit" in one location.

7. A key objective in ventilating a high-rise building is to manage the air movement in stairways and elevator shafts.

8. At least one stairwell should be designated as an occupant and rescue route.

9. Positive-pressure fans may be used to keep smoke out of the stairwells.

10. A pressurized stairway also can be used to clear smoke from a floor.

F. Windowless buildings

1. Many structures do not have windows.

2. These buildings pose two significant risks to fire fighters: heat and products of combustion are trapped and fire fighters have no secondary exit route.

3. Windowless buildings are similar to basement fires.

4. Any ventilation will need to be as high as possible and probably require mechanical assistance.

5. Using existing rooftop openings, cutting openings in the roof, reopening boarded-up windows and doors and making new openings in the exterior walls are all possible ways to ventilate windowless structures.

G. Large Buildings

1. Providing adequate ventilation is more difficult in large buildings than smaller ones.

2. Smoke will cool as it travels into unaffected areas.

3. A sprinkler suppression system will also cool the smoke, causing it to stratify.
4. As cold smoke fills the area, it becomes more difficult to clear.
5. When possible, fire fighters should use interior walls and doors to create several smaller compartments in the building.

XI. Backdraft and Flashover Conditions

Slides: 61-62

A. Ventilation is a major consideration in two significant fireground phenomena: backdraft and flashover.

B. Both can be deadly situations and fire fighters should exercise great caution when conditions indicate that either is possible.

C. **Backdraf**t can occur when a building is charged with hot gases and most of the available oxygen has been consumed.

1. If fresh air is introduced to the mixture, the fuel can ignite and explode.

2. To help reduce the danger, fire fighters must release the heat and unburned products of combustion if possible without allowing fresh air to enter.

3. A ventilation opening as high as possible within the building or area can help to eliminate potential backdraft conditions.

4. Once fire fighters see flaming combustion inside the structure, they may open their hose streams to cool the interior atmosphere as quickly as possible.

D. Flashover

1. Both ventilation and cooling are needed to relieve potential flashover conditions.

2. Flashover can occur when the air in the room is very hot, and all combustibles in the space are near their ignition point.

3. Applying water cools the atmosphere, while ventilation draws heat and flames away from the hose crew.

XII. Summary

Slides: 63 - 64

A. Ventilation provides many benefits to occupants and fire fighters.

B. Factors that affect ventilation include: convection, wind, and atmospheric conditions, building construction features, the tactical priorities of the incident and the location and extent of smoke and fire.

C. The way a building is constructed will affect ventilation operations.

D. Ventilation is directly related to the three major tactical priorities in structural firefighting operations: life safety, fire containment, and property conservation.

E. A fire fighter must be able to recognize when ventilation is needed and where it should be provided, based on the circumstances of each fire situation.

F. To remove the products of combustion and other airborne contaminants from a structure, fire fighters must use two basic types of ventilation openings: horizontal openings and vertical openings.

G. Horizontal ventilation uses horizontal openings in a structure, such as windows and doors and can be employed in many situations.

H. Vertical ventilation refers to the release of smoke, heat, and other products of combustion into the atmosphere in a vertical direction.

I. Many obstacles may be encountered during ventilation operations.

J. Ventilation is a major consideration in backdraft and flashover.

XIII. Skill Drills

Time: 180 Minutes
Demonstration/Group Activity

Remember to maintain an adequate instructor to student ratio.

Purpose
Following instructor-facilitated demonstrations, this activity allows students to observe and demonstrate competency in ventilation techniques.

Materials Needed
1. Fire fighter tools including an axe, Halligan tool, pike pole, trash hook, a short utility rope, and power saw
2. An electric fan and/or a gas powered fan
3. A straight or extension ladder sufficient to reach the roof
4. A roof ladder
5. A structure for actual or simulated ventilation
6. Smoke generator, smoke bombs, or a smoke building
7. Balloons and streamers for demonstrating air flow (optional)

Instructor Directions
1. Demonstrate each skill, placing emphasis on describing to the students any critical points or procedures.
2. On the basis of the specific skill, assign each student to a partner or team. Provide each partner/team with equipment or materials as needed.
3. Direct students to practice each skill. Closely monitor the practice sessions and provide constructive comments and redirecting.
4. As individual students achieve success, track their skills and conduct skill proficiency exams using the Skill Drill Evaluation Sheets located on the Instructor's ToolKit CD-ROM. Students failing the exam should be given redirection and an opportunity to practice before being retested.

Skills
A. Breaking Glass from the Ground Floor (Skill Drill 14-1)
B. Breaking Glass with a Ladder (Skill Drill 14-2)
C. Breaking a Window from Above (Skill Drill 14-3)
D. Negative-pressure Ventilation (Skill Drill 14-4)
E. Positive-pressure Ventilation (Skill Drill 14-5)
F. "Sounding" a roof (Skill Drill 14-6)
G. Power Saw Operation (Skill Drill 14-7)
H. Rectangular Cut (Skill Drill 14-8)
I. Louver Cut (Skill Drill 14-9)
J. Triangle Cut (Skill Drill (14-10)
K. Peak Cut (Skill Drill (14-11)
L. Trench Cut (Skill Drill 14-12)

Post-Lecture

I. Wrap-Up Activities

Time: 40 Minutes

Small Group Activity/Individual Activity/Discussion

A. Fire Fighter in Action

student in gaining a further understanding of ventilation. The activity incorporates both critical thinking and the application of fire fighter knowledge.

Purpose

This activity allows students an opportunity to analyze a firefighting scenario and develop responses to critical thinking questions.

Instructor Directions

1. Direct students to read the "Fire Fighter in Action" scenario located in the Wrap-Up section at the end of Chapter 14.
2. Direct students to read and individually answer the quiz questions at the end of the scenario. Allow approximately 10 minutes for this part of the activity. Facilitate a class review and dialogue of the answers, allowing students to correct responses as needed. Use the answers noted below to assist in building this review. Allow approximately 10 minutes for this part of the activity.
3. You may also assign these as individual activities and ask students to turn in their comments on a separate piece of paper.

Answers to Multiple Choice Questions

1. Answer D: All of the above are true.
2. Answer C: If the saw is not operating properly, it is easier to correct the problem on the ground than on the roof. After testing, it should be shut down and then restarted on the roof. (Restarting should be easier because the motor is already warmed-up.)
3. Answer B: The positive pressure fan should be started when the exhaust opening is ready so that the smoke and heat can be pushed out ahead of the attack crew.
4. Answer C: This situation calls for vertical ventilation directly above the fire as quickly as possible to relieve interior conditions. This will allow the interior crews to find and attack the fire.
5. Answer B: Horizontal ventilation should be provided to release heat and smoke from the apartment while the engine company attacks the fire.
6. Answer A: The fastest way to clear smoke from the stairway is to open an existing opening at the top of the stairs.
7. Answer D: The conditions indicate a high potential for backdraft. The fire conditions call for vertical ventilation, however the roof structure is unsafe for operations above a working fire. This will be a defensive situation to confine the fire to the auto parts store.

B. Technology Resources

This activity requires students to have access to the Internet. This may be accomplished through personal access, employer access, or through a local educational institution. Some community colleges, universities, or adult education centers may have classrooms with Internet capability that will allow for this activity to be completed in class. Check out local access points and encourage students to complete this activity as part of their ongoing reinforcement of firefighting knowledge and skills.

Purpose

To provide students an opportunity to reinforce chapter material through use of online Internet activities.

Instructor Directions

1. Use the Internet and go to www.FireFighter.jbpub.com. Follow the directions on the web site to access the exercises for Chapter 14.

2. Review the chapter activities and take note of desired or correct student responses.
3. As time allows, conduct an in-class review of the Internet activities and provide feedback to students as needed.
4. Be sure to check the web site before assigning these activities, as specific chapter-related activities may change from time to time.

II. Lesson Review

Time: 15 Minutes

Discussion

Note: Facilitate the review of this lesson's major topics using the review questions as direct questions or overhead transparencies. Answers are found throughout this lesson plan.

A. Why is ventilation important?
B. What effects does ventilation have on fire suppression activities?
C. How does fire-resistive construction affect ventilation?
D. How is ventilation used to support tactical priorities?
E. Why would you use horizontal ventilation?
F. What are the advantages of natural ventilation?
G. Why is mechanical ventilation used?
H. What is the difference between positive-pressure ventilation and negative-pressure ventilation?
I. How is hydraulic ventilation used?
J. What safety considerations are important when using vertical ventilation?
K. How do you sound a roof?
L. What is the difference between the roof covering and roof decking?
M. Why is truss construction important to fire fighters?
N. What are the types of roof designs?
O. What tools are needed for vertical ventilation?
P. How do you make a rectangular cut?
Q. How does a trench cut differ from other ventilation cuts?
R. Why are high-rise buildings difficult to ventilate?
S. How can ventilation efforts be assisted in large buildings?
T. How does ventilation help prevent backdraft and flashover?

III. Assignments

Time: 5 Minutes

Lecture

A. Advise students to review materials for a quiz (determine date/time)
B. Direct students to read the next chapter in *Fundamentals of Fire Fighter Skills* as listed in your syllabus (or reading assignment sheet) to prepare for the next class session.