Ventilation

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Section III - Truck Company Operations

Vertical Ventilation Theory

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Ventilation

Ventilation is the systematic removal of heat, smoke, and fire gases from a structure, replacing it with fresh air using selected and controlled channels. Effective ventilation allows us to save lives, assist in firefighter access, control the horizontal spread of fire and reduce the possibility of flashover and back draft.

Effective ventilation will save lives by simplifying and expediting rescue operations. The removal of heated smoke and fire gases from a structure will increase the chances of survival to trapped or unconscious occupants. Proper ventilation also makes interior conditions safer for firefighters and improves visibility so that trapped and/or unconscious victims can be located quicker and easier.

When effective ventilation has been performed on the fire ground, it will allow interior crews to gain access to the seat of the fire. Proper ventilation increases visibility and reduces heat. Additionally, it will allow for quicker extinguishment of the fire to reduce property damage.

During the progression of a structure fire, products of combustion (smoke, heat, and toxic gases) rise to the ceiling, bank horizontally to the walls and accumulate from the top downward. This is known as mushrooming. By performing effective ventilation in a structure, we can reduce the horizontal spread of fire.

Flashover and Back Draft

Figure 20-1 Flashover

Flashover is a condition where all the contents of a room are heated to their ignition temperature, Figure 20-1. Once their ignition temperature is reached, the entire room will quickly be involved in flames. Because of improvements with technology and communication systems, firefighters now find themselves arriving earlier to a fire, often before flashover occurs. If not recognized and ventilated early, flashover can kill. Proper ventilation is essential in helping to eliminate this condition because the heat is removed from the structure before the contents reach their ignition temperature.

Back draft is the sudden introduction of oxygen to a confined area that is pressurized with heated flammable gases that are deficient in oxygen that results in an explosive force of significant intensity. It is important to be able to recognize the signs of a back draft. Such indicators are fire in a confined space; heavy, dark, or grayish-yellow smoke; smoke under pressure issuing from all openings; hot doors and windows with heavy smoke staining. If any of these signs are indicated at a fire, vertical ventilation must be performed.

Supports Strategic Goals

Figure 20-2 Vertical Ventilation Needed

If the strategic goal is to stop a structure fire quickly while conceding as little property as possible, it is deemed offensive and requires an interior attack. To support interior operations ventilation must be performed quickly and should be coordinated with the entry of interior crews. Even if entry has been already been made, vertical ventilation will help progress other basic fire fighting objectives more efficiently. If ventilation is not completed soon enough, conditions will deteriorate and interior attack may have to be suspended or abandoned as a result.

If the strategic goal is to cut off the fire, writing off a portion of the property that is in imminent danger of being lost and getting ahead of the fire, then it is a marginal operation. Ventilation is required to both support interior operations and to establish a firebreak at a point of anticipated control. Whether or not the operation goes offensive or defensive depends almost entirely on ventilation.

When the strategic mode is defensive, ventilation operations are directed toward exposures. Structures adjacent to the fire building may require pressurization and other spaces downwind may require closing up to keep heat and smoke out.

Ventilation Size-up

One point that cannot be stressed enough is the importance of taking a quick moment to size up the structure prior to going to the roof. All members of the roof ventilation team must get into the habit of taking an extra 5 to 10 seconds to read the structure prior to climbing the ladders. This size up should include asking yourself the following questions:

- What type of structure is this? (House, Apartment, Business, Industrial)
- What type of roof do you suspect this is? (Conventional, Lightweight, Panelized, Truss) and can you see the size, type, and direction of the rafters from the eaves?
- Where is the location of the fire within the structure?
- Are there any covered exterior walkways or cantilevers to avoid cutting over?
- Where should I place my ladders?

Figure 20-3 The direction and type of rafters can be determined by looking at the exposed eaves

Additionally, company officers should make an effort to ascertain the size, type, and direction of structural members prior to going to the roof. This can be accomplished by a quick glance under the eaves of the roof prior to climbing the ladder on most single and multi-family residential buildings, Figure 20-3. For buildings with no exposed eave, a quick look inside the structure to the open underside of the roof may allow you to identify the type and direction of structural members (panelized, light-weight truss, conventional).

In sizing up a structure in order to select appropriate ventilation tactics, the location and extent of the fire must be determined. This can only be estimated during the initial stages of the size-up and must be better defined as the operations progress. Initial indicators to look for include the amount, location and volume of smoke visible from outside. Another critical factor in the ventilation size-up is proper assessment of structural integrity in relationship to building type, construction, approximate age and amount of time that the building has been burning. Lastly, determine what is burning. Is this a contents fire confined to a room or is it a true structural fire where the structural members of the building are burning?

The first priority of ventilation is improving the interior environment to aid the occupants in their escape and to enhance firefighters' efforts to locate and evacuate them. The next priority is to improve conditions to aid in confining and extinguishing the fire. In many cases the stairs and hallways begin to clear of smoke and heat most dramatically once vertical ventilation through the roof is accomplished. However, keeping these paths of egress survivable must be maintained through additional supportive actions, such as positive pressure ventilation to bring fresh air in from the outside.

Conventional Construction

Lightweight Construction

Vertical Ventilation

Any structure fire that creates enough heat and smoke to be a life hazard or impedes location and extinguishment of the fire must be ventilated through the quickest and most efficient means. Vertical ventilation through the roof is by far the method of choice.

Vertical ventilation is the opening of the roof or existing roof openings (skylights, hatch covers, etc.) for the purpose of allowing heat, smoke, and fire gases to escape from the structure into the atmosphere. In order to properly and safely open a roof, we must have a good working knowledge of building construction (Drill Manual Chapter 8), be able to perform a personal size-up, and have a plan in place with the truck company prior to arriving on scene.

Link 20-1 Refer to Appendix A to read more on the term “Tactically Advantageous”page 20-48

The ventilation hole must be placed in the most tactically advantageous location determined by the type of building construction. We must remember to allow enough space for the time required to cut the hole and enlarge the hole if the smoke is under pressure or conditions for interior crews are not improving. Good communication and coordination with interior crews is essential during vertical ventilation operations.

There are two basic types of heat holes used in roof ventilation: offensive and defensive.

Heat Hole (Offensive)

Depending on the type of roof construction (lightweight vs. conventional), heat holes should be placed in the most tactically advantageous location and as close to the fire as safety will allow, Figure 20-4. A properly placed heat hole will save lives and allow firefighters access by reducing heat, smoke, and fire gases inside the structure. A heat hole will reduce the possibility of back draft/flashover, and will slow down the horizontal spread of fire. When operating on any lightweight roof, or suspected lightweight roof (panelized or lightweight truss), the crew performing operations shall never conduct ventilation holes directly over the fire. Ventilation should occur at the most tactically advantageous spot on a roof. Members should employ the practice of “trading space for time” so that they will complete their roof-cutting operation prior to the fire impinging on a given ventilation hole.

Figure 20-4 Heat Hole - Offensive Operation

Trench/Strip Ventilation (Defensive)

A strip ventilation hole should be placed well ahead of the fire and should extend the entire width of the building, creating a firebreak, Figure 20-5. Strip ventilation helps to stop the horizontal spread of fire. Strip ventilation must be done in conjunction with a heat hole. The heat hole must be accomplished first, which will slow down the horizontal spread of fire and allow the entire strip to be completed before the fire reaches the strip ventilation hole.

Figure 20-5 Trench (Strip) Cut - Defensive Tactic

Ladder Placement

When operating on a roof it is important to have at least two escape routes away from the fire. Ladders should be placed on the uninvolved side of the building, preferably at the corners, and away from windows if possible. The ladder should be extended well above the roof line (2 rungs minimum, 3-5 rungs above the roof line preferred). The further the ladder extends over the roof's edge the easier it is to see, plus this added length gives more support when getting on or off the ladder. Prior to climbing the ladder, look for clues to the building's construction features to be certain you have the necessary tools to properly cut the roofing material and punch through the underlying ceiling. Most importantly, know the location of the fire and have an escape route in place in case conditions on the roof deteriorate and become unsafe.

Protective Hose Line

A charged hose line at the point of ventilation can be used to cover exposures, to cool hot tar paper, prevent jamming the chain saw, protect the ventilation team, or to extinguish any hot spots on the roof caused by embers issuing from the vent opening. This hose line should never be directed down the vent hole; this action will prevent heat and smoke from escaping and it will also push superheated steam down onto interior attack crews and occupants. To expedite getting this line into operation, coordinate with an engine company to stretch the line to a position where the nozzle can be tied off and pulled onto the roof utilizing a rope bag.

Figure 20-6 Sagging Roof (above 2 images)

Reading Roof Structure and Integrity

There are some visual indications of an unstable roof that must be watched for and recognized in order to maintain a safe operation. Prior to climbing up the ladder look at the

walls to see if they are bowed out. Bowed walls are caused by an outward thrust from a sagging roof, indicating a weak roof that may fail early., Figure 20-6. Before stepping onto the roof observe the duct work protruding through the roof. Each has a metal flashing that is normally at or below the surface of the roof covering. If this flashing is set above the roof covering or if the black cement-sealing bead is exposed, it is probably due to roof sag. Look for any smoke issuing from attachment points between the roof and walls. Sometimes you can actually see the roof sagging.

Figure 20-7 A fire in the attic space can compromise roof integrity

Before stepping onto the roof always sound it with your foot or an appropriate tool to determine its integrity. Once on the roof, determine the location of the structural members and use them as your path to and from the vent hole location. Never traverse "cross country." Excursions must be parallel to an exterior wall, usually the shortest wall as this is generally the direction of structural members. The ridge of a pitched roof is also a strong and safer route. The roof can appear in tact but actually may have no supporting members beneath the covering material. Plywood sheeting burns from the bottom layer up, delaminating to the point that it may not support even one person.

If conditions appear satisfactory and you proceed along the roof, look for signs of heat such as bubbling or smoking tar. As you move away from the edge on a flat roof out over a structural member, it is normal to feel sponginess in the roof. The lighter the construction or longer the span, the more spring you will feel. To assess what is normal for a given roof, check the feel of a structural member in a known safe area, such as where you placed your ladder, to get a baseline.

If the Sounder is unsure of the fire location or the structural layout, the Cutter should perform a diagnostic cut. These roles of Sounder, Cutter, and the diagnostic cuts are explained in detail below.

Responsibilities of The Sounder

Figure 20-8 The "Sounder" is responsible for backing up the "Cutter."

The Sounder should be the most experienced firefighter on the ventilation crew. They are assigned to the roof hook or pike pole and should be the first person off the ladder onto the roof. The primary responsibilities of the Sounder are to observe roof for hazards, sagging, and active fire, locate the optimal location for a ventilation hole and guide the crew on and off the roof safely. Sound the roof or any surface you contact when stepping off a ladder with an appropriate tool. Use your roof hook, axe head, or foot to stomp or slam it against the roof. Sound out an area large enough to accommodate all crew members. Once you sound the roof and determine it is safe for personnel to get onto it, call out "Roof Safe."

Always sound an area 3 feet in front of where you are walking. Use the Thermal Imager to identify hazards, structural members and fire location. Identify the need for a diagnostic cut (kerf cut, smoke indicator hole, inspection hole). Progress towards the most tactfully advantageous area to cut the heat hole. Move along structural members such as walls and ridge lines when possible. Utilize existing openings such as skylights, vents, and penthouse doors for ventilation. Thoroughly and aggressively sound the area to be cut for structural members and roof integrity, as well as its surrounding areas.

Back up your partner while cutting is in progress. This can be done by sounding behind your partner as they move along their cut and by providing a second set of eyes for hazards. On pitched roofs or when working near an edge or other hazards, the sounder may also assist the cutter by placing one hand on the back of their jacket, axe handle, or SCBA to support and guide them, Figure 20-8 . Ensure solid footing at all times and continuously scan the entire area for changing conditions and hazards. Complete the heat hole by punching through the ceiling, communicate with partner, evaluate effectiveness of the hole with interior crews and lead the crew off the roof to the exit point, following structural members along the way.

Responsibilities of The Cutter

The Cutter is the member of the ventilation crew that is assigned to the saw. The Cutter should first ensure the area has been aggressively sounded prior to stepping off of the ladder. After the entry point onto the roof has been deemed safe, follow in the path of the Sounder to the area where you will make your diagnostic cuts (kerf cut, smoke indicator hole, inspection hole), if they are needed. This is typically in the opposite direction of the fire so that upon exiting the roof you will not be cut off by any worsening conditions from your diagnostic cuts or fall in the hole when returning to the ladder. Make additional appropriate diagnostic cuts as necessary as you progress towards the fire.

Go to highest, hottest, safest and most advantageous point on roof, clear area of hazards and unnecessary personnel, ensure you have enough space and time to complete the operation, and maintain firm footing and balance. Disengage the chain brake and execute the cut at full throttle to help prevent the saw choking out from smoke entering the air intake.

There are two different methods for manipulating the saw through the cuts:

Chain Saw Position – 45 Degree Angle

Holding the bar at a 45-degree angle, keep the bar at a shallow depth no deeper than the 6 rivets at the tip of the bar. Bury the bar only as deep as necessary keeping in mind the thickness of the roofing material. Avoid cutting into structural supports and rafters.

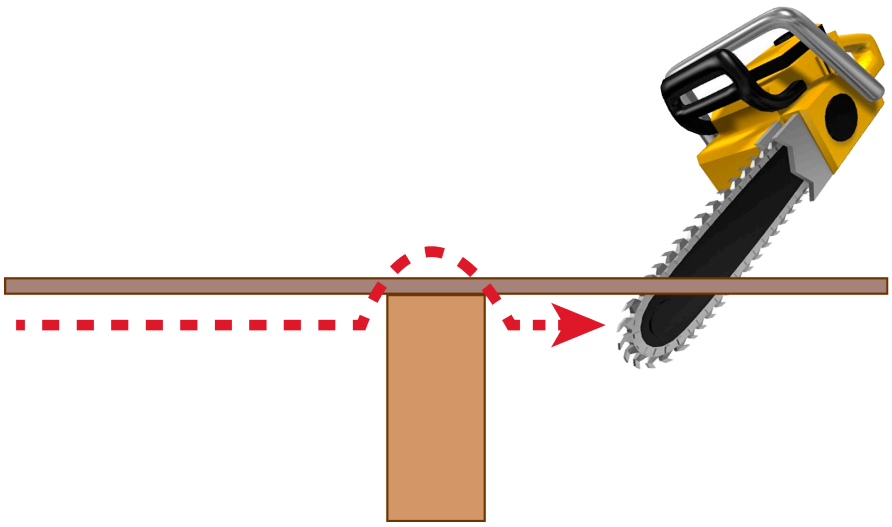
Chain Saw Position – 90 Degree Angle

Holding the bar at a 90-degree angle move the saw briskly through the roofing material until you impact or "feel" the saw contact the rafters. Roll the rafter by pulling the saw upwards and back at a 45-degree angle so that only the tip of the chain and bar penetrate the roofing material.

Rolling A Rafter

When you encounter a structural member of the roof such as a rafter when cutting with a chain saw, it is important to lift the saw up and over or "roll it" to avoid cutting through it. Thick roofing material can make it difficult to recognize structural members when cutting with the saw. Recognizing structural members when using a chain saw requires experience, training and the ability to use your senses, Figure 20-9

- Look - Look for visible indicators of a rafter's location (sky lights, raised ridges etc.)
- Listen - Listen for the sound of the saw working harder to indicate it has contacted a rafter.
- Feel - Feel for a change in effort or force needed to move the saw. Generally, the steeper the angle of the saw to the roof, the more noticeable the change in force that is needed to move the saw when contacting a rafter..



General Saw/Cutting Guidelines

- Avoid cutting into structural supports and rafters.
- Look at side of guide bar; avoid looking at top of chain while in motion.
- Make your cuts working from the fire towards your direction of egress

or ladder.

- Avoid lugging or binding chain and guide-bar.
- An effort shall be made to keep your feet on a structural member or rafter.
- If you need to move or adjust your feet during the cutting operation, have your Sounder back you up and guiding your direction. Make small secure steps and ensure solid footing before proceeding.
- When changing hands with the saw or in between cuts you must ensure the chain has come to a complete stop. This can be accomplished by letting the chain naturally decelerate to a complete stop, by tapping the chain on the roofing material to bring it to a stop (if on appropriate roofing material), or by setting the chain brake.
- When traveling any distance across the roof you will be required to set the chain brake.
- Communicate with partner, evaluate effectiveness of hole, notify Interior Division or I.C. and exit the roof following your Sounder's lead.

Additional Considerations

- To cut the ventilation hole, work from the top down, from the fire toward your escape route, and with the wind at your back when possible.
- Do not use any power saw in line with your body.
- Spend a minimum amount of time on the roof and limit the amount of personnel to what is needed to do the job.
- When cutting on a tile roof, the location of your heat hole should be determined by the type and integrity of the roof construction (lightweight vs conventional).
- In many cases the fire will remain compartmentalized in the fire room until the Sounder breaks through the ceiling with a roof hook or a pike pole creating an open path up to the vent hole.
- If it is an attic fire, or has extended into the attic from below, ceilings must be pulled from below as quickly as possible in order to begin extinguishment. This should be done in close coordination with the vent hole.

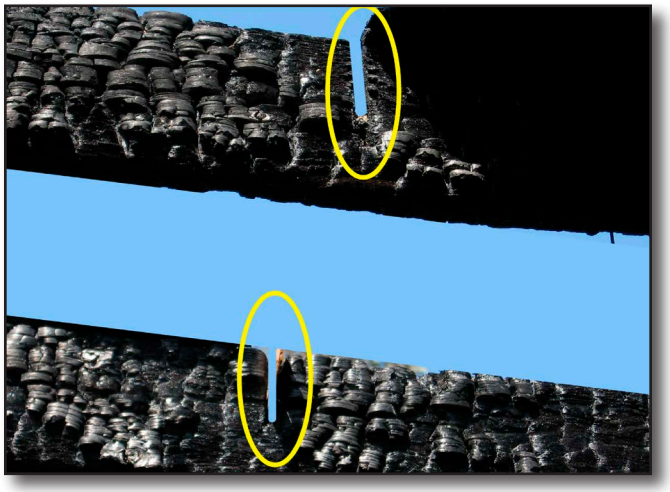


Figure 20-9 Failure to "roll the rafters" when cutting will significantly compromise the integrity of the roof

Diagnostic Cuts

Figure 20-10 Kerf Cut

Kerf Cut

A Kerf cut is a single cut the width of the chain saw guide-bar made through the roof decking used to identify conditions below and the roof integrity, Figure 20-10 .

Figure 20-11 Smoke Indicator Hole

Smoke Indicator Hole

This is a small, triangular hole cut through the roof decking used to identify fire conditions below and roof integrity. To do this, cut a triangle with each side the width of the chain bar, or approximately 3 inches wide, Figure 20-11. Place smoke indicator holes every 10 feet or so along your path between the fire and your escape route to monitor changing conditions. If any of the holes between you and your egress begin to show more smoke or pressure, this is an indicator that conditions have worsened and you may need to find an alternate point of egress.

Plug Cut

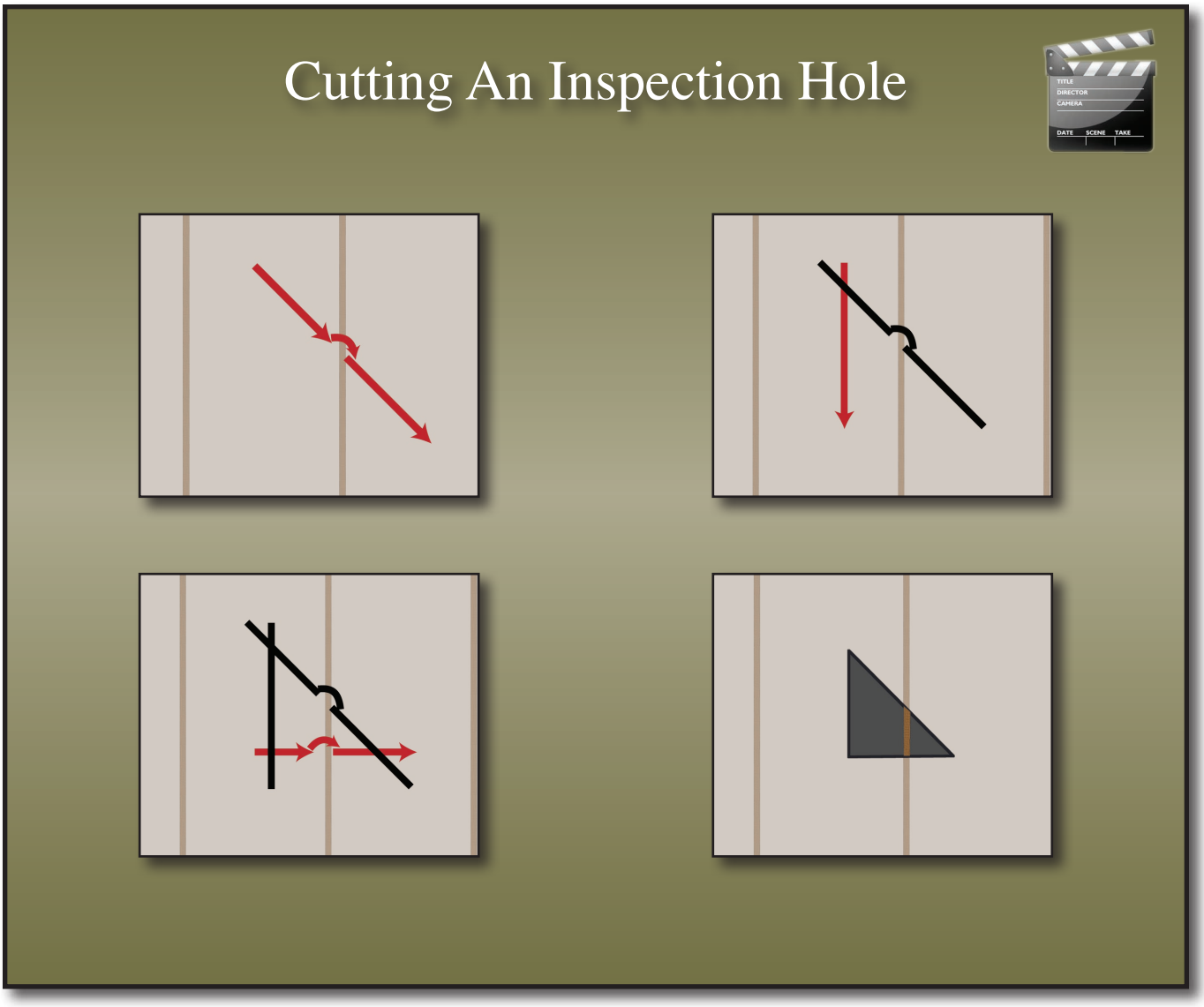
A plug cut is a small triangular cut that only removes the roof covering and exposes the roof sheathing, Figure 20-12. This cut is used to identify the sheathing type (wood sheathing = conventional construction) and roof composition thickness.

Figure 20-12 Plug Cut

Inspection Hole

This is a larger triangular hole measuring 2’x2’x2’ used to determine rafter type, rafter direction, sheathing type, thickness of the roof composition, Figure 20-13. The inspection hole should be cut in a safe area away from the fire in the structure. As a general rule, the inspection hole should be cut in an area opposite the direction of travel from the ladder. This allows firefighters to cut in a safe place and well as prevent firefighters from falling into the hole when returning to the ladder from the fire location. When complete this can also act as a smoke indicator hole.

- The first cut shall be made at a 45-degree angle to any exterior wall. Roll the first rafter you come into contact with and continue to cut a few more inches.
- The second cut shall be made parallel to any exterior wall so that it intersects with your first diagonal cut.



- The third cut will complete the triangle. Remember to roll the rafters when you come into contact with them.

Remove the roofing material. This cross section will determine the type of roof (lightweight vs conventional), rafter direction, smoke or fire condition, roof composition thickness and structural integrity of the rafters. Punch through the underlying ceiling if necessary.

Figure 20-13 Inspection Hole

Residential Roof Ventilation

Center Rafter Louver

This cut is generally considered the foundation for all offensive ventilation heat hole operations. A center rafter louver offers the flexibility to expand the size of the heat hole in any direction using the same basic technique and principles.

In order to make a center rafter louver, you must first know rafter type and rafter direction. Next, you must determine the location of the three rafters. The rafter type and direction is determined by the use of diagnostic tools (plug cut, inspection cut, etc.)

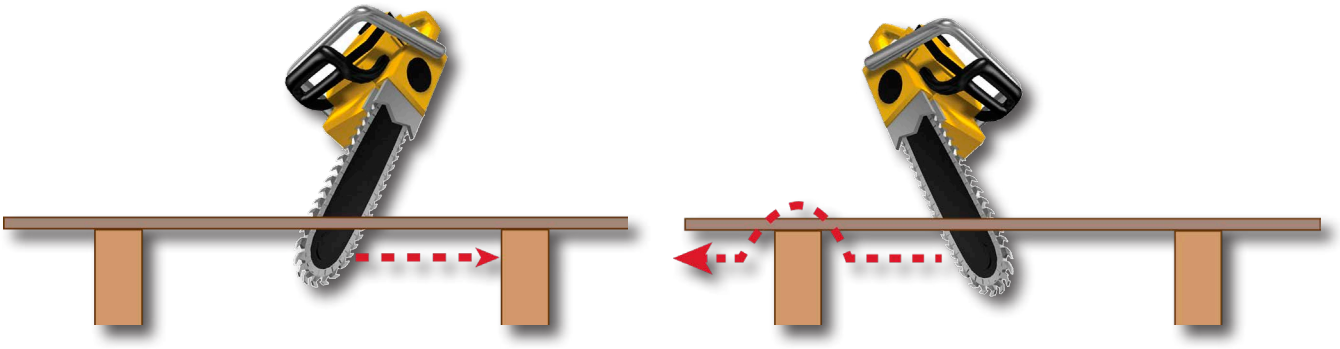
The SDFD endorses the use of the Center Rafter Louver utilizing the 5-step cut method.

*** Note – The SDFD Training Division recognizes that there are numerous methods to perform the center rafter louver that are equally as fast, effective, and safe as the 5-step cut. The 5-step cut has been chosen as the method of choice due its simplicity and to help standardize roof operations department wide. Other similar cutting techniques may be used as long they are in concurrence with department policy, are safe, effective, and have been approved by the company officer.*

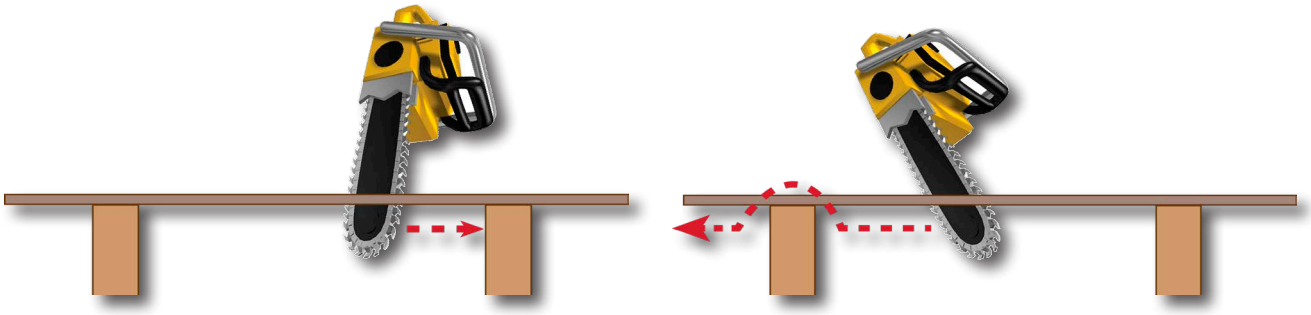
5-Step Cut

The 5- step cut is a fast, safe and effective method for cutting a 4' x 4' heat hole. The "5" refers to the number of individual cuts required to make the hole.

- First Cut - This establishes the head cut and outside rafter by cutting away from the ladder toward the fire. There are two approved methods for completing this first cut:
    - Flip and Pull Method – This method requires the ability to cut with either hand on the saw. Hold the saw and cut away from you until you contact an outside rafter nearest the fire. Remove the saw from the cut, change hands and position yourself for the second cut in the opposite direction.



- Push Back Method – Insert the saw into the roofing material and push the cut away from you, cutting with the topside of the chain until you hit the outside rafter. Once completed, you are in the correct position to make your second cut by simply pulling back toward you.



- Second Cut – This finishes the head cut by continuing cutting toward the ladder, rolling the next or center rafter, then continue until you hit the inside (ladder-side) rafter.
- Third Cut – This cut is parallel to the outside (fire-side) rafter. This cut should be approximately 4' long.
- Fourth Cut - This cut is made across the bottom of the hole working towards your ladder, rolling the center rafter, then stop cutting at the ladder-side rafter.
- Fifth Cut - This last cut is made parallel to the inside (ladder-side) rafter and completes the hole.

The 5-step cut should result in a 4'x4' hole on most structures (depending on the rafter spacing) and will satisfy the minimum size expectations on a residential structure fire that requires vertical ventilation.

The Louver

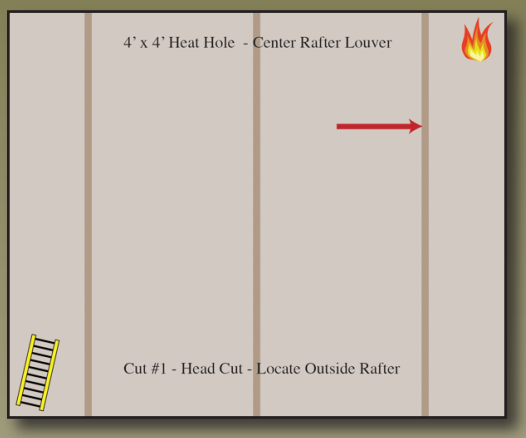
The Louver method can be utilized on roof decking comprised of sheathing, plywood and corrugated metal. Once a 5-step cut has been completed, one side of the cut can be pushed down by the Sounders roof hook(preferably the windward side of the louver) allowing the other side to be raised utilizing the center rafter as a fulcrum. The louver will prevent the section of roofing from falling down onto interior crews and when done in coordination with wind direction it will actually increase the amount of smoke and heat removed from the building. After the louver is completed it is vital to punch through the underlying ceiling to create a clear path for smoke and heat to exit the building.

Communicate with your partner that the operation is complete, evaluate the effectiveness of the heat hole, notify your officer, Interior Division or I.C. and exit the roof following the Sounder's lead.

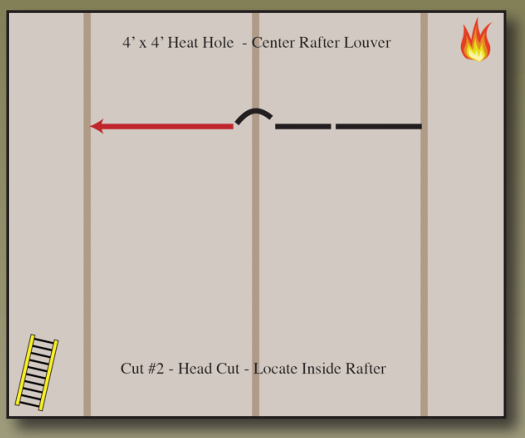
Center Rafter Louver Challenges

There are two common problems that may arise when performing the center rafter louver. The first issue is a result of cutting a hole that spans over two

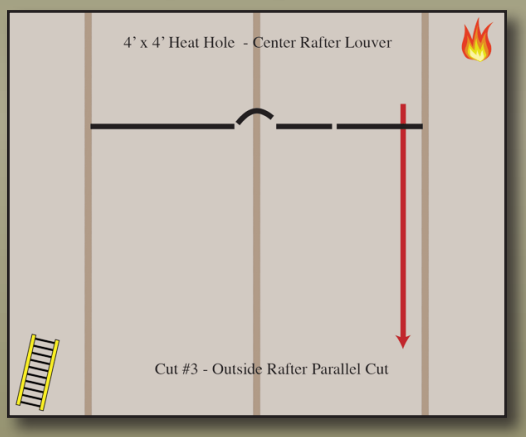
Center Rafter Louver
(Utilizing the 5 Step Cut)



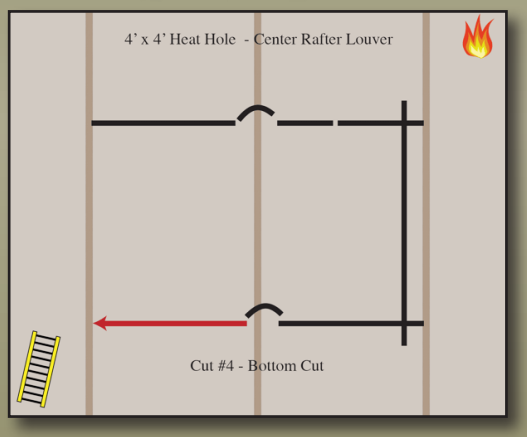
Cut #1 - Head Cut - Locate Outside (Fire-Side) Rafter



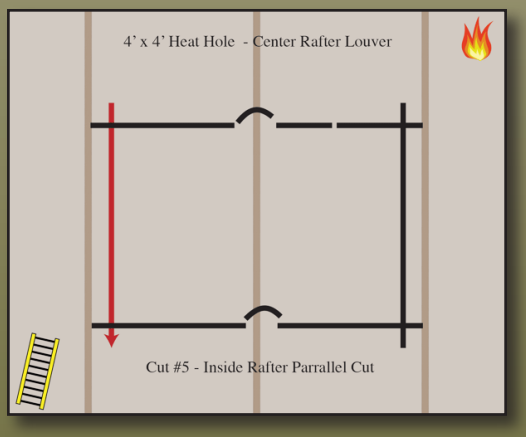
Cut #2 - Finish Head Cut - Locate Inside (Ladder-Side) Rafter



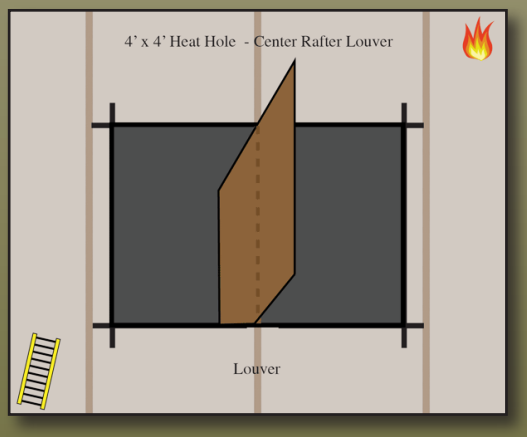
Cut #3 - Outside Rafter Parallel Cut



Cut #4 - Bottom Cut



Cut #5 - Inside Rafter Parallel Cut



Louver & Punch Through Ceiling

rafters instead of just one. When this occurs, it will make it very difficult or impossible for the sounder to louver the cut because it has two fulcrum points instead of one.

The second issues can be encountered when ventilating roofs with conventional construction. Wooden blocks are commonly placed in between rafters to give them added strength and stability. When a hole is cut over these rafter blocks, they will prevent the cut from being able to louver, Figure 20-14. When performing your cuts parallel to the rafters be aware of any resistance or change in cutting force required, as this may indicate you have run into one of these blocks.

Dicing & Removal Method

Once you have determined the type of roof construction, the dicing method may be used as an alternative to the center rafter louver for conventional roofs using 1" x 4" or 1" x 6" solid, spaced or diagonal sheathing Because 1" x 4" or 1" x 6" boards are short and usually only nailed once, it is not imperative to know the exact location of the rafter, only the rafter type and direction. There is no need to outline the opening with all five cuts. Two parallel cuts on either side of a single rafter may suffice if the roof covering is light. If necessary, make a head cut and use a roof hook or axe to pull the first plank of sheathing. Now the sheathing can be removed by pulling a plank at a time, "dicing" them off the rafter. Keep the length of the center rafter cuts less than the length of the roof hook to allow personnel to stand in the uncut, safe portions of the roof.

Figure 20-14 Rafter blocking can prevent the roofing material from being louvered and may require the dicing and removal method.

The dicing method may also be utilized on roofs sheathed with 4x8 sheets of plywood or OSB if the firefighters are having difficulty performing the center rafter louver. In some cases, firefighters may be unaware they are trying to louver over a rafter or truss that is spanned by wood blocking, thus preventing the cut from louvering.

Another common situation where the center rafter louver may not work well is a conventional residential roof where the ceiling is attached directly to the under-side of the rafters. These roofs do not have an attic space below them and are filled with insulation, thereby prevent the roofing material from easily being louvered downward.

If you find yourself in a similar scenario, dicing they roof can be a good alternative to help the sounder remove the roofing material. It must also be noted that if you are going to dice a roof with 4x8 decking, you must make cuts on all four sides of the hole.

Commercial Roof Ventilation

To ventilate commercial roofs the cutting strategy is dictated by several factors; building construction, the fires location, and the truck company's objective to ventilate for fire fighting efforts or life saving efforts. For most roofs, including conventional flat, pitched, and lightweight construction, the Center Rafter Louver method is generally the most effective. The only difference in performing this cut on a commercial structure versus the residential cut is that the end result should produce two 4'x4' holes in series to equal 4'x8' as a minimum standard.

4' x 8' Center Rafter Louver

The 4'x 8' center rafter louver can be accomplished in two ways:

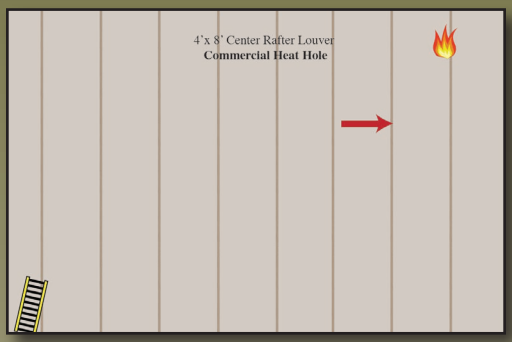
Method 1- Perform two separate 4'x4' center rafter louvers next to each other as described in the residential section

Method 2- In anticipation of a large commercial hole:

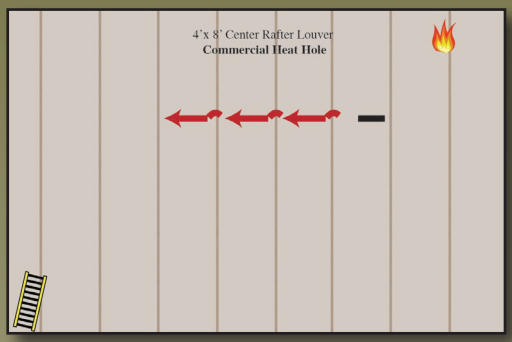
- Place a long head cut moving away from the fire rolling multiple rafters.
- Insert a downward, or vertical cut, along the inside of the outside (fire-side) rafter (#1).
- Working back towards your ladder make a bottom cut, rolling the next rafter (#2) and stop when you contact rafter #3.
- Make another downward or vertical cut on the fire-side of rafter #3, completing a 4x4 Center Rafter Louver.
- Since you made on long head cut to start, simply repeat the previous three cuts to add a second 4x4 Center Rafter Louver.
- Have the sounder louver the two holes when safe starting with fire-side and working back towards the ladder.

With commercial ventilation the 4'x 8' dimension is a minimum size. Additional holes or expansion of the initial heat hole may be necessary if the pressurized smoke exhausting from the heat hole increases or builds. If a larger size heat hole is deemed necessary, it may quickly be expanded on by cutting additional holes "with" or "against" the construction.

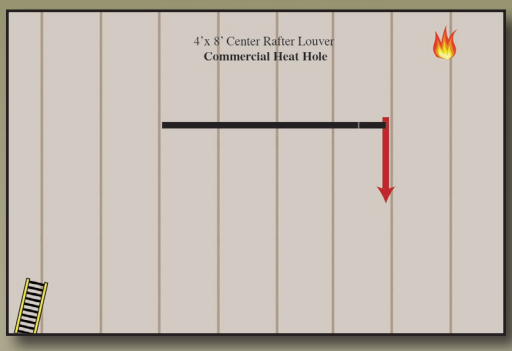
4’ x 8’ Center Rafter Louver



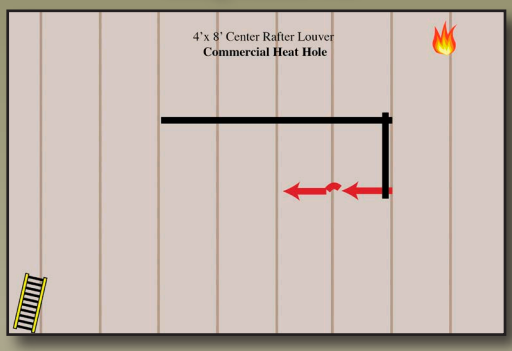
Find Outside Rafter



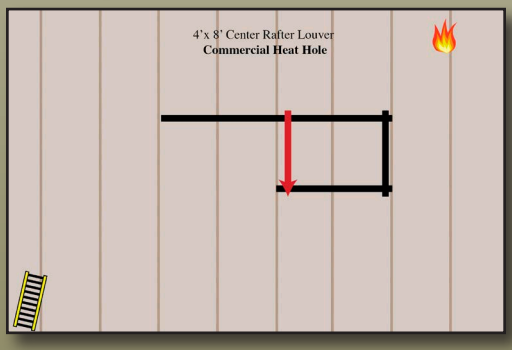
Long Head Cut



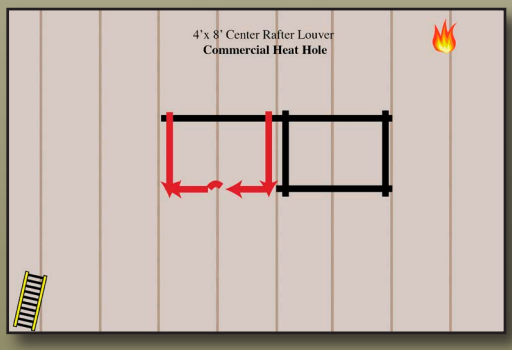
Outside Vertical End Cut



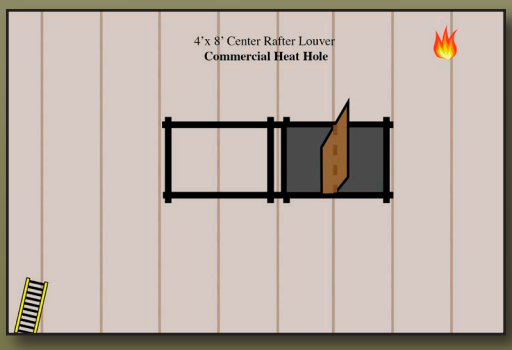
Bottom Cut



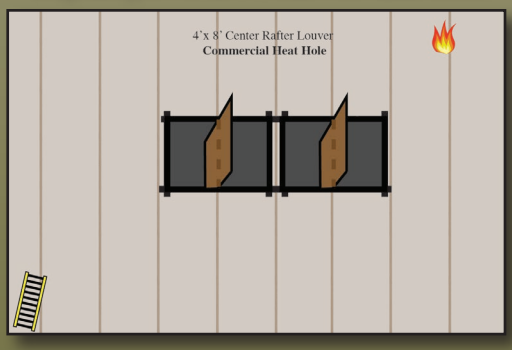
Inside Vertical Cuts



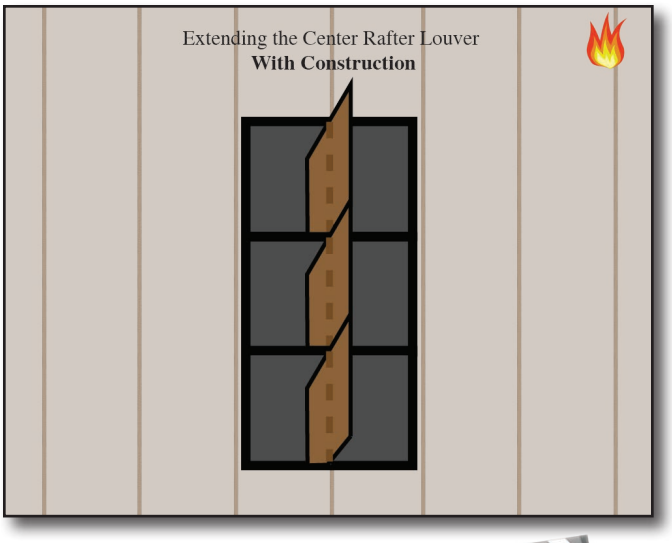
Repeat previous 3 cuts for 2nd Hole



Louver & Punch Ceiling



Louver & Punch Ceiling



Media 20-1 Expanding the Center Rafter Louver WITH the Construction

Expansion With the Construction

To expand a hole with the construction:

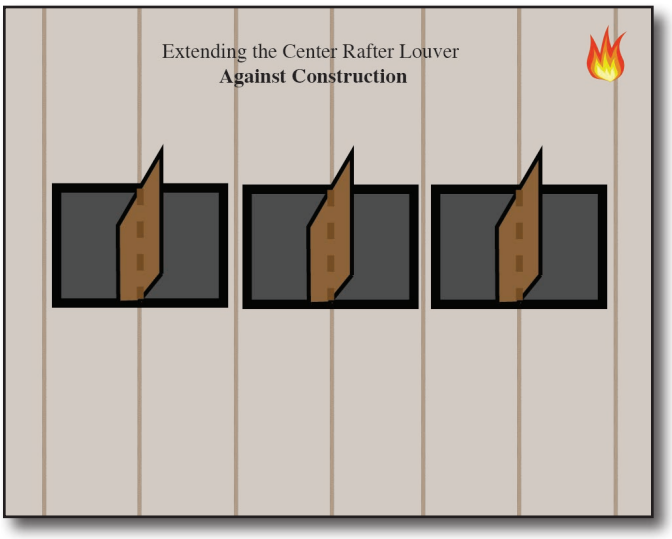
- Start at the far side of the hole and continue the already established downward cut along the outside (fire-side) rafter until the desired length is reached.
- Working back towards the ladder, add another bottom cut using caution to roll the center rafter.
- Complete the expansion by adding onto the existing downward cut inside the inside (ladder-side) rafter and connect it to the new bottom cut.

The end result will be an additional hole that has been center rafter louvered over the same rafter as the previous hole. Repeat these steps as necessary until the desired size heat hole has been created. Expanding a heat hole "with" the construction is the preferred method because it only requires three additional cuts and only requires one center rafter to be rolled (during the bottom cut).

Expansion Against the Construction

If expanding your hole "with" the construction does not meet your objective, you may alternatively expand your hole "against" the construction. This is accomplished by making additional center rafter louvers working outward from the side of your original heat hole towards your ladder.

When expanding your heat hole "against" construction, you simply make additional 4'x 4' center rafter louvers working away from the fire towards your ladder. This method is slower and requires more saw work due to the number of rafters you must roll when compared to expanding "with" the construction. However, expanding your hole "against" the construction may be the best tactical option.



Media 20-2 Expanding the Center Rafter Louver AGAINST the Construction

These two methods of expansion can be used with both residential and commercial roof ventilation operations.

Expanding The Center Rafter Louver

Expanded WITH Construction

Expanded AGAINST Construction

Trench (Strip) Ventilation

Trench ventilation is a defensive, coordinated effort to save a structure while writing off a portion between what is currently involved and where a firebreak (the trench cut) is made. This tactic is very effective in buildings of large horizontal extent (such as strip malls) where a common attic is shared by several interior spaces.

After a heat hole is cut as close to the fire as possible, a location ahead of the fire must be selected by the roof team. Because this is a defensive cut, you should not initially expect to see fire through your cuts. If fire is licking through your cuts, this is an indicator that you have not given yourself enough spacing or time to safely complete your trenching operation. Also, communicate with the interior crews to have them pull ceilings to confirm how far the fire has travelled.

It is important that the hole be opened on the fire-side of the fire wall which is evident by its vertical extension above the roof level. The trench or strip cut is 2' to 3' wide, running the entire width of the roof, perpendicular to the fire's path. A trench (strip) cut will either be accomplished with the construction or against the construction.

Note – There are several methods to use when performing a trench cut. The order and length in which you decide to make your head cuts, side or dicing cuts, and bottom cuts will vary upon the number of personnel available, the number of saws working together, roof construction, and the company officers plan. In

general, a trench (strip) cut is nothing more than multiple center rafter louvers expanded upon from wall to wall either "with" or "against" the construction.

The following two techniques are a general guideline for performing a trenching operation "with" and "against" the construction.

Trenching With the Construction (Center Rafter Louver)

- Make a head cut on one side of a single rafter and transverse to the opposing wall.
- Make your vertical end cut approximately 2' to 3' in length rolling the center rafter.
- Make your bottom cut working back approximately 4' to 6.'
- Make another vertical/relief cut to make louvering the roof manageable.
- Repeat the above steps to make multiple 4' to 6' wide center rafter louvers working back toward the wall where you began your head cut.
- Once all cuts have been completed, louver and exit the roof.

Once again, this method is the preferred and quicker of the two because it does not require rafters to be rolled when making the head and bottom cuts.

Trenching Against the Construction (Center Rafter Louver)

This may be encountered on an arched roof, a bridge truss roof, or a panelized roof with purlins set between beams.

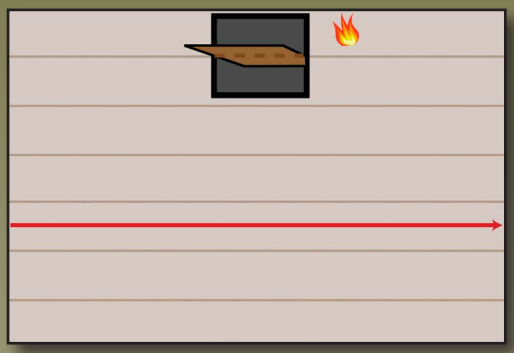
- Make a head cut and transverse to the opposing wall, rolling each rafter you come in contact with.
- Make a vertical end cut 2' to 3' in length perpendicular to the head cut.
- Begin your bottom cut working back towards your ladder, rolling the center rafter and stopping at the third rafter. (Same as making a basic center rafter louver)
- Make your inside vertical cut to create a center rafter louver.
- Repeat the above steps creating multiple center rafter louvers until you have worked your way back across the entire roof.

Trench ventilation prevents the horizontal spread of fire through large buildings. Trench Ventilation = Manpower. Be sure to allow sufficient time to complete the cut before fire reaches the strip/trench. Multiple saws and support personnel are required to work within a well, coordinated plan to effectively complete a trenching operation.

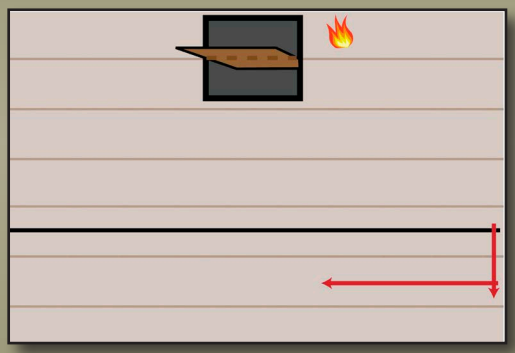
Do not open (louver or J-hook) the trench (strip) until cutting is complete and all personnel are on the ladder (safe) side of the trench. Failure to do so will draw the fire towards the trench prematurely. This may result in the fire extending past your trench. NEVER direct hose lines into the trench. Remember, the entire portion of building preceding the location of the trench is a write off.

Trench (Strip) Cut
(With Construction)

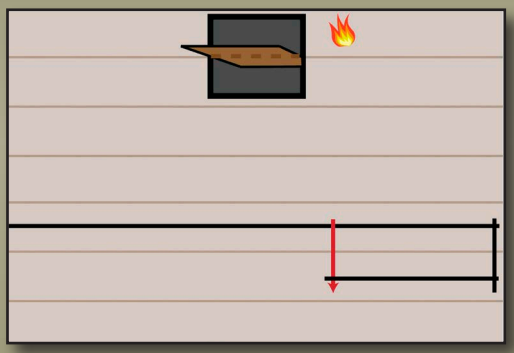
Cut a heat hole ahead of the trench to provide enough time for crews to complete the trench cut



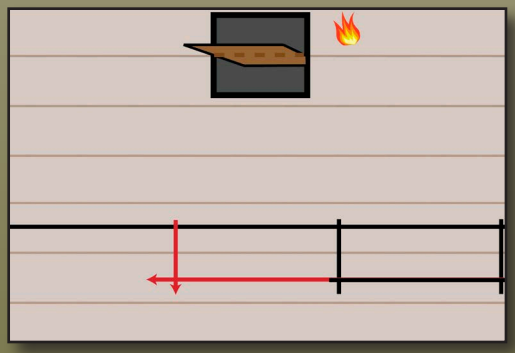
Make a head cut on one side of a single rafter and transverse to the opposing wall



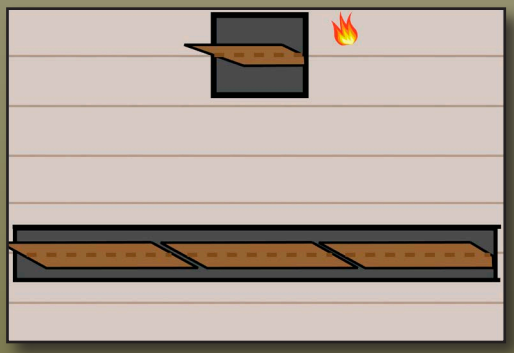
Make your end cut 2' to 3' in length perpendicular to the head cut and your bottom cut approximately 4' to 6' in length



Make a dice cut to create manageable center rafter louvers

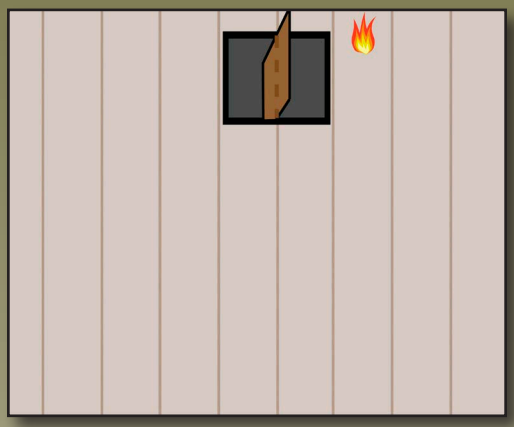


Repeat the previous steps until you have worked your way across the entire roof

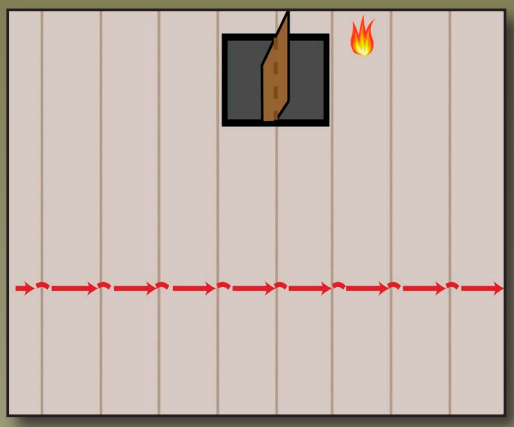


When all cuts have been completed, louver the multiple center rafter louvers you created to form a trench.

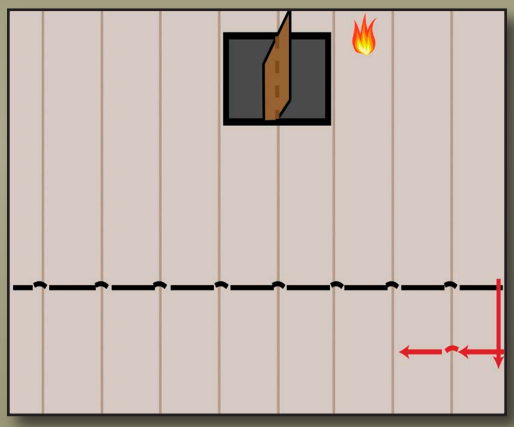
Trench (Strip) Cut
(Against Construction - Center Rafter Louver Method)



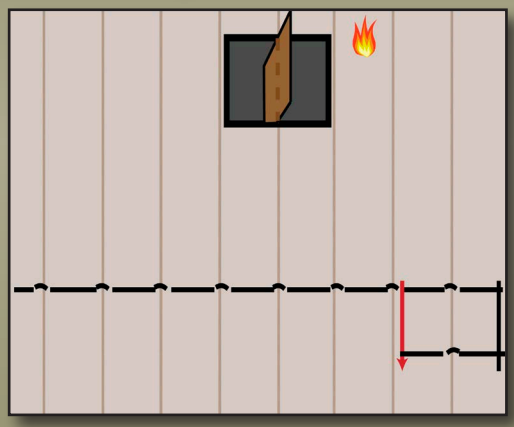
Cut a heat hole ahead of the anticipated trench location



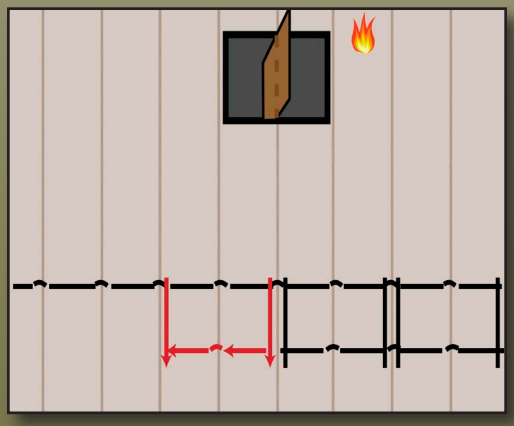
Make head cut from wall to wall, rolling each rafter you come in contact with



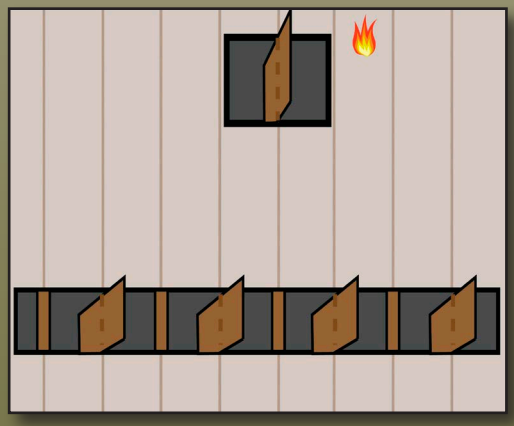
Make end cut 2' to 3' in length and your bottom cut, rolling the center rafter



Make your next end cut to complete the center rafter louver



Repeat the previous steps creating multiple center rafter louvers to form a trench



Once all cuts have been completed, louver the roofing material to open the trench

Trenching Against the Construction (Dicing Method)

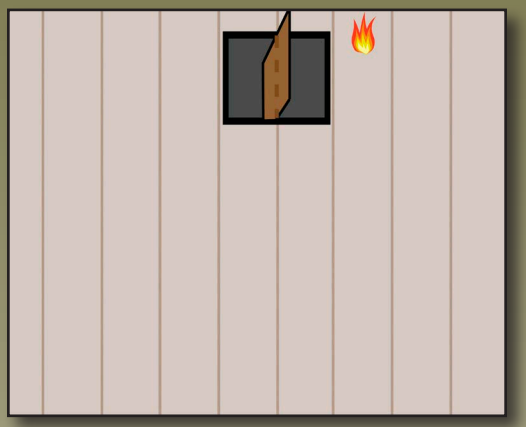
An alternative to trenching against the construction using the center rafter louver method is to use the dicing method. This method requires the same number of vertical cuts be made as the center rafter louver but results in smaller and twice as many individual pieces. This method may be preferred when the ventilation team is having difficulty in louvering the roofing material or when removal of the material is desired. This method also works well when multiple saws are working together at the same time. For example, while the head cut is being made by one saw, the second saw can begin making the vertical dice cuts between each rafter. The long bottom cut should be the last cut to be made when using the dicing method.

The disadvantages to this method is that unless you can see the rafters through your head cut or you marked their location with your saw, you are essentially guessing where to place your dice cuts in between the rafters. Another disadvantage to this method is that you create twice as many pieces which must be louvered or removed when compared to the center rafter louver method.

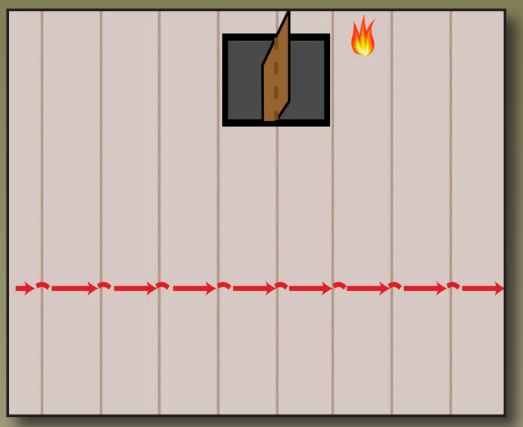
To trench against the construction using the dicing method:

- Make a head cut and transverse to the opposing wall, rolling each rafter you come in contact with.
- Next, make dicing/relief cuts between each rafter 2’ to 3’ in length perpendicular to the head cut. The dicing/relief cuts must be spaced every 16” to 24” depending on the distance between each rafter resulting in smaller manageable sections that can be easily louvered or removed.
- Finally the bottom cut should be made and run the length of the trench, wall to wall intersecting all the dicing/relief cuts.

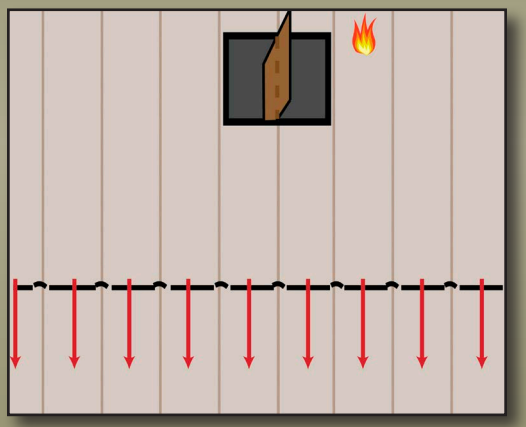
Trench (Strip) Cut
(Against Construction - Dicing Method)



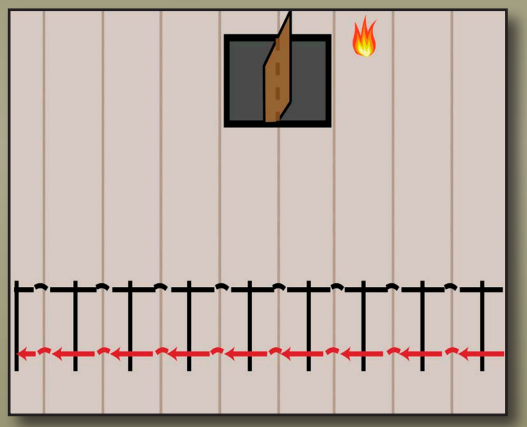
Cut a heat hole ahead of the anticipated trench location



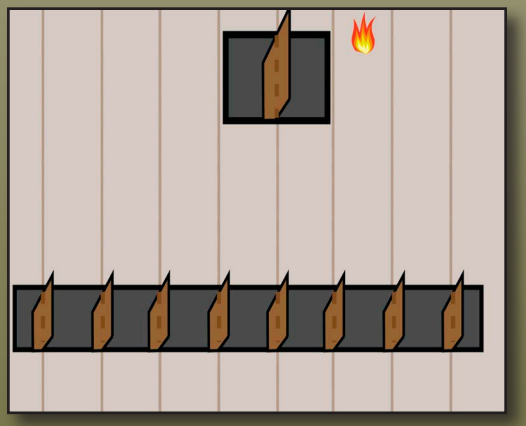
Make head cut from wall to wall, rolling each rafter you come in contact with



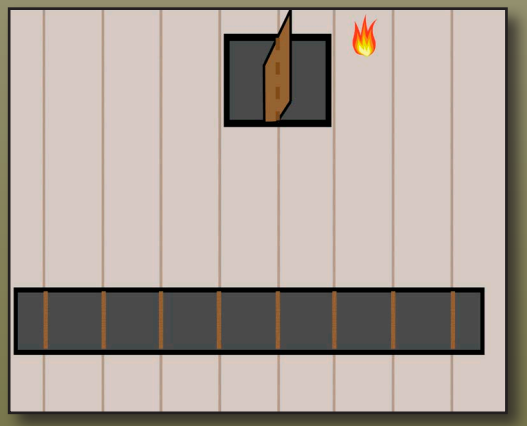
Make dicing/relief cuts 2' to 3' in length between each rafter



Make bottom cut from wall to wall intersecting dice cuts while rolling the rafters



Louver the diced section and punch through the ceiling as necessary



If time permits, remove louvered roofing material completely

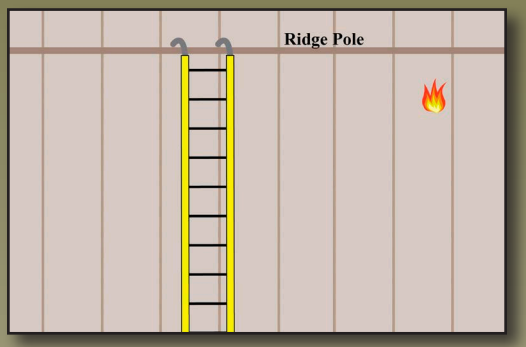
Pitched Roofs – Ventilating Off A Roof Ladder

For roofs with a pitch greater than 30 degree (but less than 45 degrees), or a roof that proves to be slippery, a roof ladder is recommended. To vertically ventilate from a roof ladder:

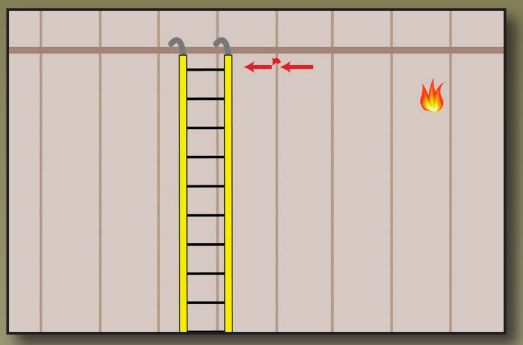
- Place a ground ladder to the roof on the windward side of the anticipated heat hole location.
- Deploy the hooks of a roof ladder and take the roof ladder aloft, placing it securely over the peak of the roof.
- Two firefighters should then place themselves in position on the roof ladder for ventilation. The lead FF should have roof hook to sound the area to be cut while the second FF should have the saw. Once sounded, exchange the hook for the saw from FF#2 to perform the cutting. The second FF performs the safety/support role.
- The second FF should then strike the pick head of their axe or roof hook into the roofing material approximately 2' to 3' perpendicular from the roof ladder to create a foot hold for the lead FF cutting.
- Once in position, the lead FF should begin cutting their heat hole. All cuts should be made from one stance.
    - Make a head cut near the ridge pole to locate the rafters.
    - Make a cut parallel on the outside of the center rafter moving downward.
    - Third should be the bottom cut, working towards the ladder
    - Lastly, make a second parallel cut on the inside of the center rafter moving downward.
    - When working from a roof ladder, it is preferential to make several small or narrow heat holes expanding with the construction than attempting to make one large hole.
- Louver
    - The lead FF should pass the saw back to their partner on one side of their body (right) and accept the axe or roof hook from their partner on the other side of their body (left) to louver the roofing material and punch through the ceiling.
- Evaluate effectiveness, communicate to IC or Interior and exit.

Note: Do not try to walk or climb on the ladder while cutting. These holes will be more narrow and shorter in length due to the restricted movement while working from the ladder. The Firefighter can reposition and then extend their hole as necessary to make the heat hole larger.

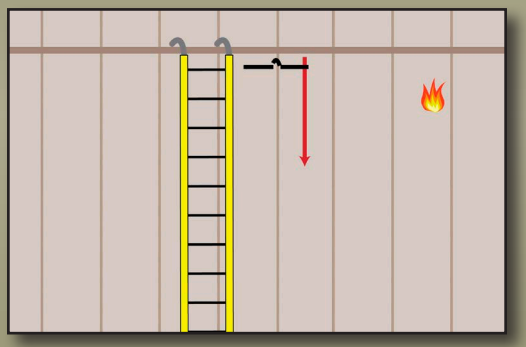
Ventilating From A Roof Ladder
(Pitched Roofs 30° to 45°)



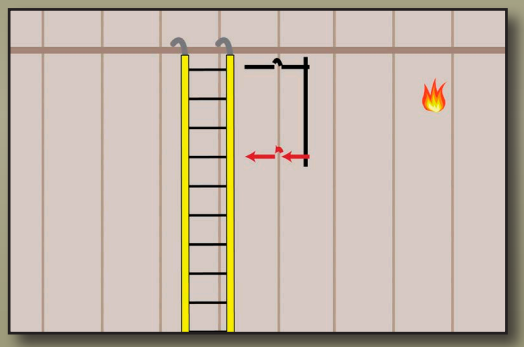
Place roof ladder over the ridge pole and upwind of the anticipated hole. FF#2 should create a foot hold for FF#1



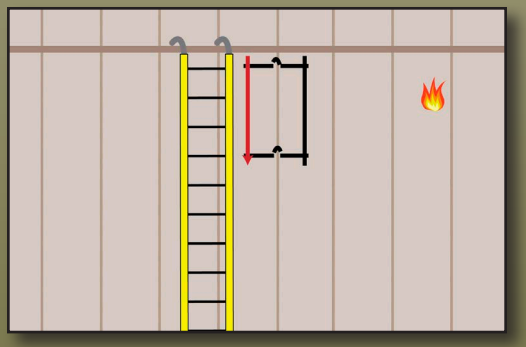
Cut #1 - Make a head cut near ridge pole to locate the rafters



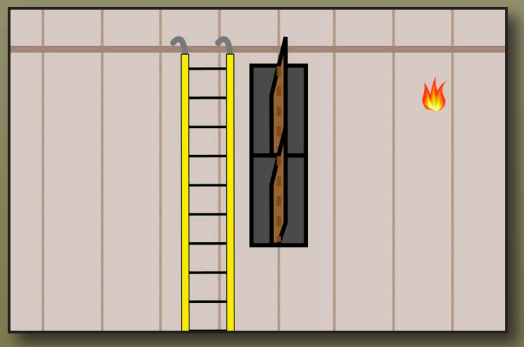
Cut #2 - Make a parallel cut to outside of center rafter moving downward



Cut #3 - Make a parallel cut to inside of center rafter moving downward



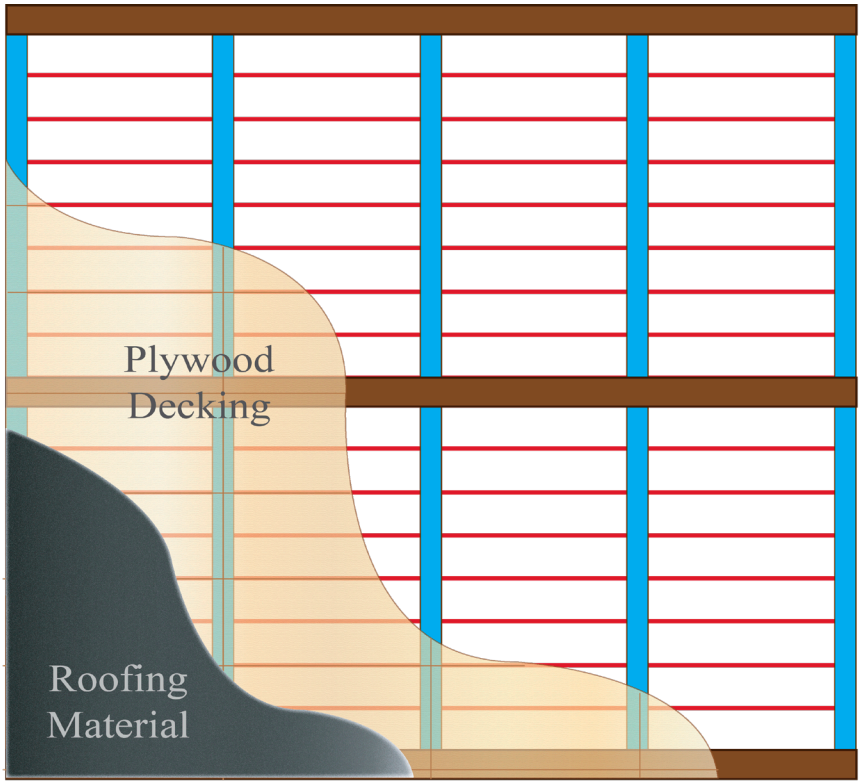
Cut #4 -Reposition on ladder and make bottom cut



Repeat cuts 2, 3, & 4 to extend downward if desired then louver & punch through ceiling

Panelized Roof Ventilation

To understand the different methods of cutting a lightweight panelized roof, you must have a basic understanding of the construction of these roofs as outlined in Chapter 8, Building Construction, of the Drill Manual.



Brown = Beams - Spaced from 12′ to 40′
Blue = Purlins - Spaced 8′ On Center Perpendicular to the Beam
Red = Rafters (Sub-Purlins) - Spaced 24″ On Center Perpendicular to the Purlins

Panelized Roof Safety Considerations

Additional safety considerations must be made when cutting a lightweight panelized roof. The first step is to identify the type of roof. An inspection hole is the fastest way to accurately determine what type of roof you are working off of. If you encounter a single 2”x 4” structural member on a commercial flat roof, you are most likely dealing with a panelized roof.

Unlike conventional roofs, firefighters must restrict their path of travel and working area to the buildings perimeter, the beams, and the purlins when ventilating a panelized roof. Locating the beams and purlins can be a challenging task when looking at a roof the size of a football field, however, it must be done successfully. The following are some tips for locating beams and purlins:

- Locating a 2”x 4” rafter will tell you which way the beams and purlins run in the building. The rafters attach perpendicularly to the purlins and

run parallel to the beams.

- Look for visual indicators on the roof itself. Often beams and purlins will be slightly raised and give a "ribbed" appearance.
- Skylights in a panelized roof are typically 4' x 8' in size and are placed in between purlins and run parallel to the rafters and beams. (The short ends of the skylights typically butt up next to the purlins)

Figure 20-15 Panelized roof system with steel beams and steel truss purlins

- Aggressive sounding with the roof hook will reveal a hollow sound and slight rebounding of the tool when over the 2" x 4" panels and a thud sound with little rebound when over the structural members (beams and purlins).
- Be aware of your footsteps, if there is a bounce in the roof when you are stepping you may be over the 2" x 4" panel section. It should also be noted that a roof with a slight bounce is typically still structurally sound. A structurally compromised roof will generally have a "dead" feel and may sag under weight.
- The use of the thermal imager may also be a useful tool for locating structural members. If there is fire below, the hotter spots will indicate the more lightweight members of the roof, while the cooler spots will indicate larger structural members.

On a panelized roof, never cut directly over the fire, as there is potential for catastrophic failure. Remember that fire spreads very fast in open truss construction and can easily compromise the structural integrity of the lightweight panelized roof you are working on. Smoke indicator holes should be placed approximately every 10' of travel when working on a panelized roof.

There are three methods to cut a lightweight panelized roof: louver off the main beam, louver off the purlin and offensive louver.

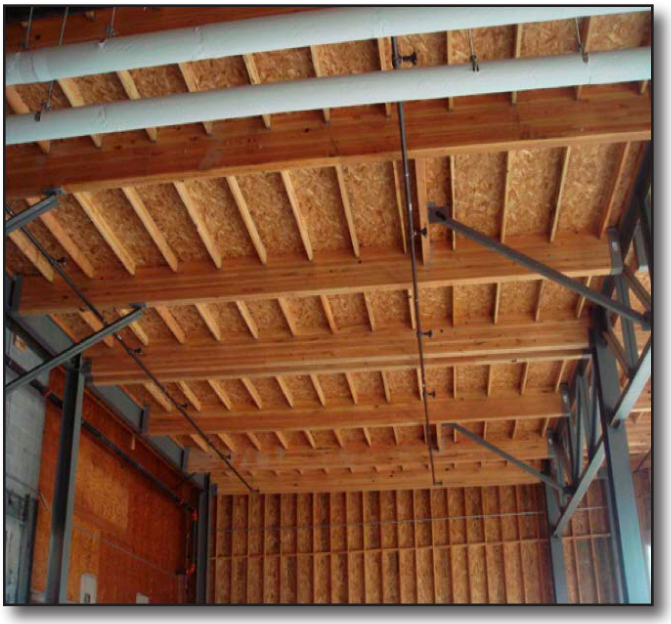


Figure 20-16 Panelized roof system with steel truss beams and laminated wood purlins

Louver Off The Main Beam

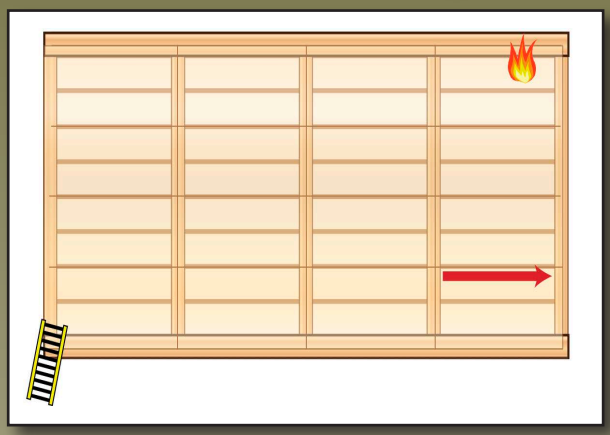
The most structurally sound ventilation method for lightweight panelized roof ventilation is louvering off of the main beam. The main beam is the strongest structural member. These beams generally span the short side of the building and run parallel with the rafters (sub-purlins). To complete this operation, the Cutter should be positioned on a beam. Reach out with the saw about 3-1/2', far enough to clear the first rafter, locate the inside of a purlin.

- Make a head cut approximately 8'parallel with rafters from purlin to purlin.
- Next cut perpendicular to the beam, parallel to outside purlin, roll the center rafter and stop at the beam.
- The next cut is the bottom cut, cut along the beam from purlin to purlin.
- The final cut is parallel to the inside purlin and connects the head and bottom cuts. This cut will involve rolling the rafter between the head cut and the beam you are working from.

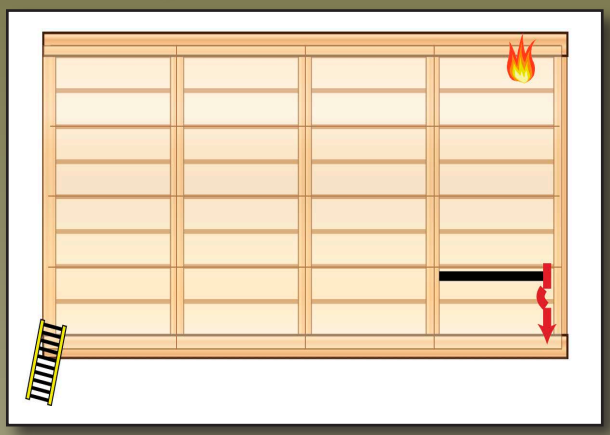
Because of work area limitations (standing on a beam), the Cutter and Sounder exchange tools. The Cutter will ensure all crew members are on the ladder-side of the ventilation hole, verify all cuts are completed, then louver the hole and punch through the underlying ceiling material as necessary.

Louvering off of the main beam is the preferred method for ventilating a panelized roof because the beam is the most stable member of the roof and the cut only requires one rafter to be rolled (the center louver rafter). This hole is similar to expanding the center rafter louver "with" construction. As previously discussed, depending on the tactical objectives, cutting "with" the construction is not always an option.

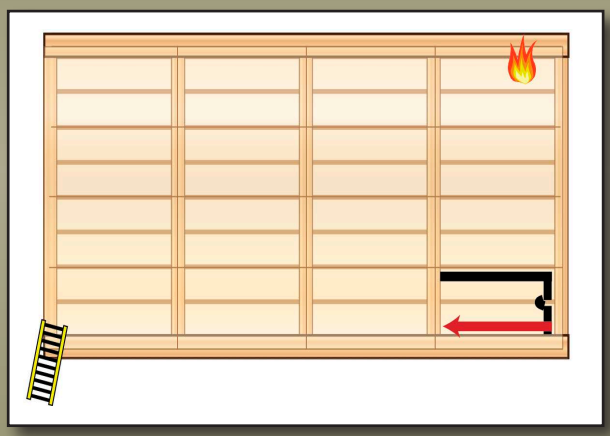
Louver Off The Main Beam
(With Construction)



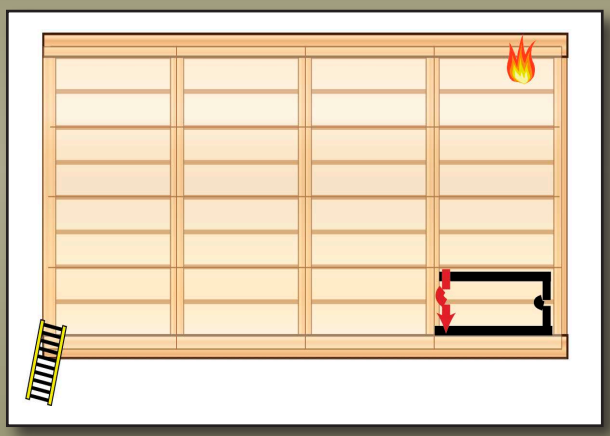
Standing on main beam, reach out and cut parallel to rafter, extending the cut from purlin to purlin



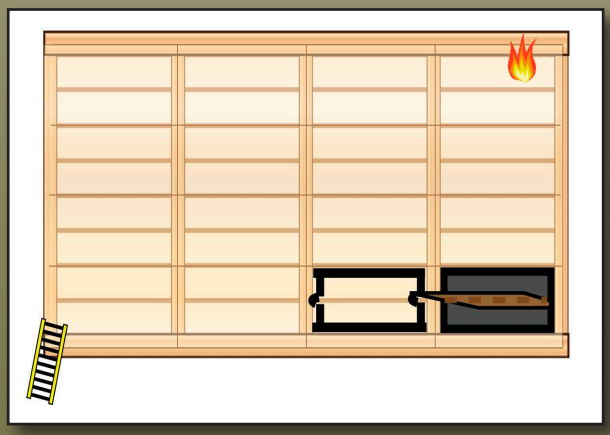
Second cut should be made parallel to the purlins, rolling the rafter and stopping at the main beam



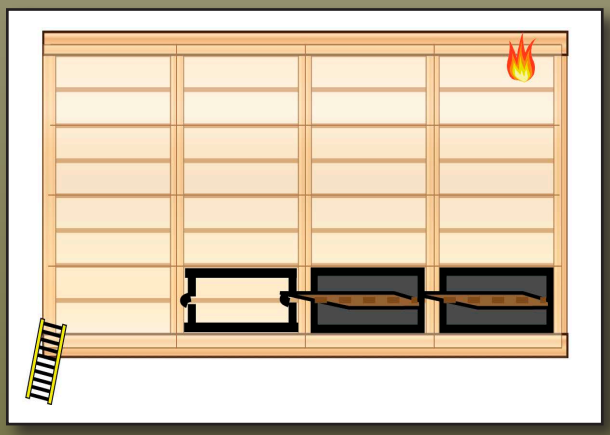
Bottom cut is made parallel to main beam, extending from purlin to purlin



Fourth cut is made parallel to the purlins, rolling the rafter and stopping at the main beam



Begin cutting the next section if conditions indicate and louver the first hole



Continue to cut and louver sections as conditions indicate

Louver Off The Purlin

The purlin is less structurally sound than the beam, however, it does provide a relative amount of safety. This can be used as an offensive or defensive cut and is slightly more difficult than working off of a beam because we are cutting against construction. To complete this operation, position the Cutter on a purlin. Utilize the basic 5 step cut to complete a ventilation hole against the construction utilizing three rafters (sub-purlins), then move over one rafter and repeat the same operation.

The end result will be several center rafter louvers side by side similar to the steps described when expanding the heat hole "against" construction. The only difference between the two is that the cutter must make their best attempt to remain standing over the purlin. This results in side cuts with a 2' to 3' length, versus the desired 4' length, due to the limited reach of the firefighter from the purlin.

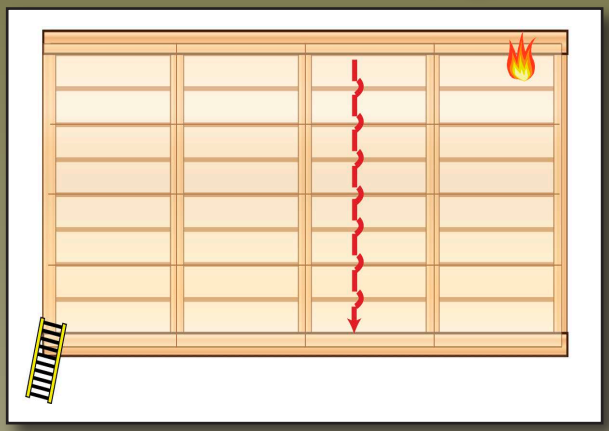
Be sure to allow ample time and space, as this operation can be lengthy. Ensure the Sounder does not louver ANY of the holes until ALL of them have been cut completely and all crew members are on the ladder-side of the fire.

Either of the above methods can be used as defensive operations by repeating the given technique and expanding the holes until a large enough strip/trench is completed in the appropriate location.

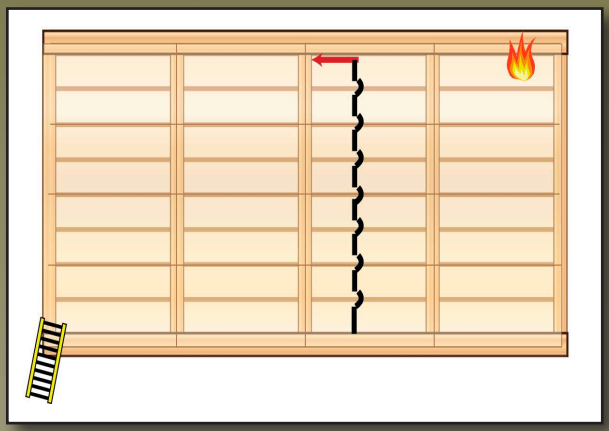
Two Saw Louver Off The Purlin (Offensive Louver)

This method requires two truck crews working in coordination with each other. Have both Cutters with chain saws work from opposing purlins in conjunction with each other to complete a large hole approximately 4'x 8.' The two Cutters will each essentially complete a "louver off the purlin" as previously described, except they will be performing this simultaneously across from each other and the two sections will join to form one large hole. Proper coordination must be utilized to ensure a safe, effective operation.

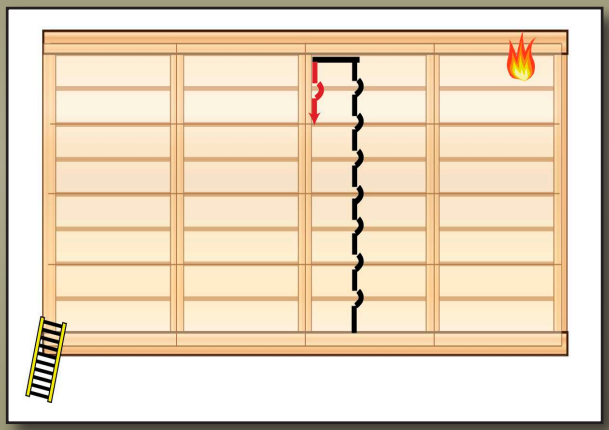
Louver Off The Purlin
(Against Construction)



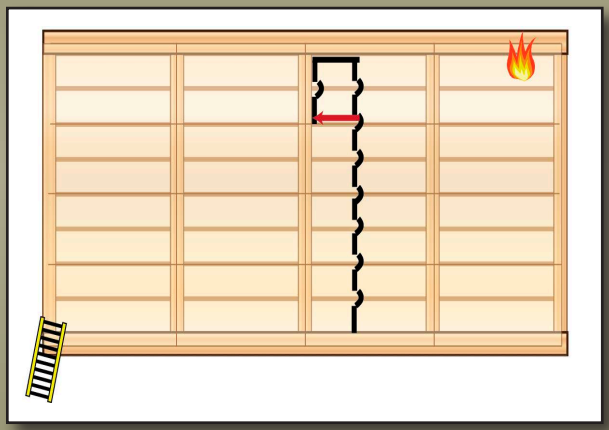
Standing on a purlin, reach out and cut parallel to the purlin, extending the cut from beam to beam



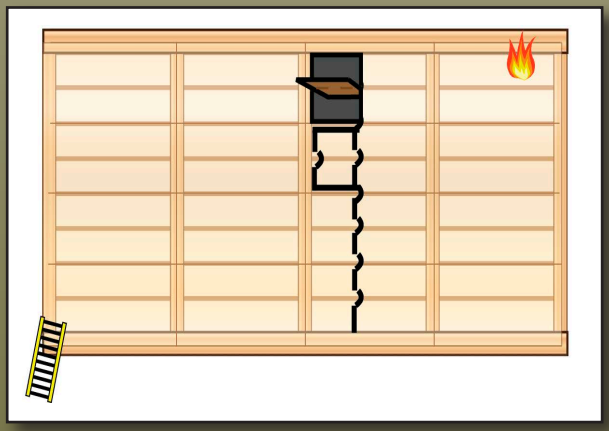
Second cut should be made parallel to the beam, from the first cut, stopping at the purlin



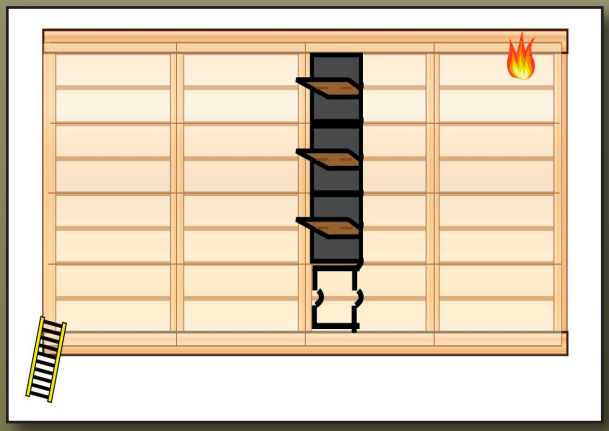
Third cut is made parallel to the purlins, rolling the 1st rafter and stopping at the 2nd rafter



Fourth cut is made parallel to the 2nd rafter, and stopping at the purlin



Repeat cuts 2 through 4 on the next section if conditions indicate and louver the first hole

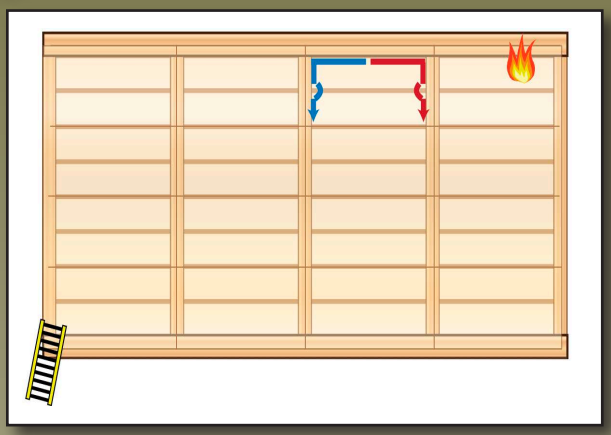


Continue to cut and louver sections as conditions indicate

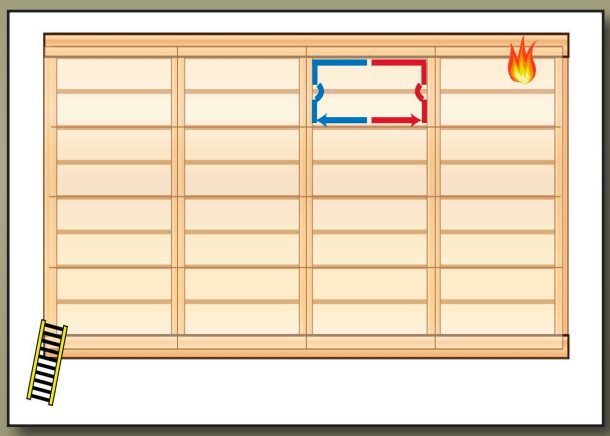
Purlin Two Saw Louver

"Opposing Saws"

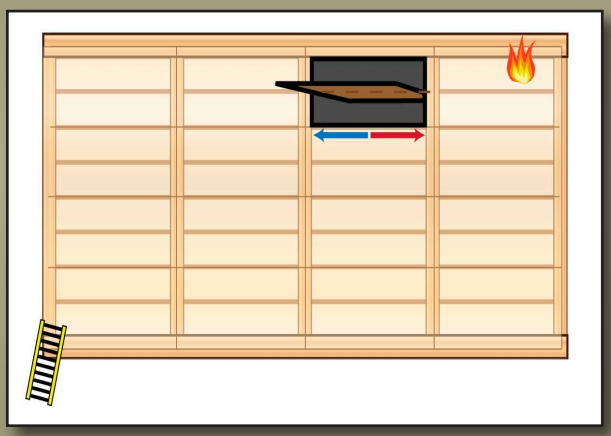
Using two saws, stand on purlins and make first cut parallel to beam, stopping at purlins



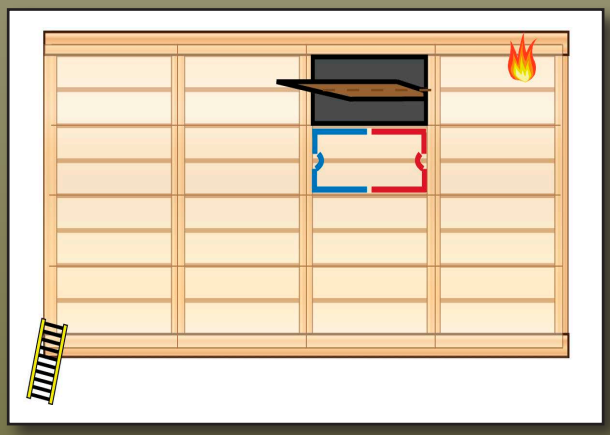
Second cut should be made parallel to the purlins, rolling the 1st rafter and stopping at the 2nd rafter



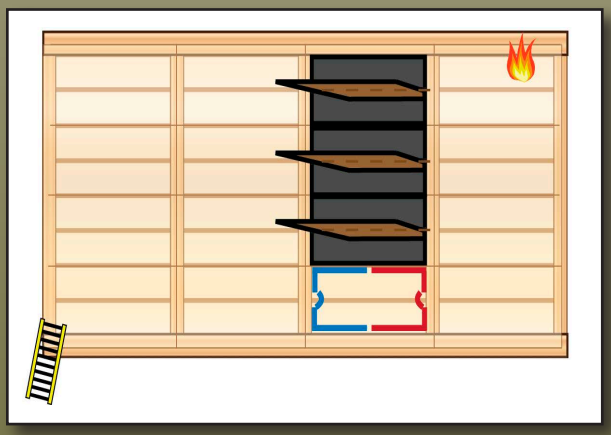
Third cut is made parallel to the 2nd rafter, and stopping at the purlins



Repeat first cut on the next section if conditions indicate and louver the first hole



Repeat second and third cuts to finish the second hole



Continue to cut and louver sections as conditions indicate

Vertical Ventilation in Multiple-Story Buildings

When dealing with multiple-story buildings it may be necessary to open the roof even if the fire is not near the top floor. A major fire several stories below the roof will most certainly produce life-threatening smoke rising up to the highest point.

If it is an older multi-unit residential building, it may be configured with a "center hallway" opening, ideal for the placement of a vent hole above. Locate the center hallway from outside, characterized by exterior fire escapes, a row of windows different from the rest, or a row of skylights on the roof. Place the hole close to the involved unit to draw the smoke and heat of the building and clear out the path of egress.

Horizontal Ventilation

Horizontal ventilation is the systematic removal of heat, smoke, and fire gases through wall openings such as doors and windows. Horizontal extension can occur inside a structure from direct flame contact, through wall openings, through corridors and hallways, and through ducts and piping. Horizontal ventilation is used to supplement vertical ventilation and it can also be used independently when vertical ventilation is not safe or not indicated in the given circumstance.

With horizontal ventilation, there are two methods commonly performed, *natural and positive pressure ventilation.*

Natural Ventilation

Natural ventilation is appropriate when smoke conditions are light to moderate and the speed of heat and smoke removal is not a significant consideration. Generally, the fire or source of contamination is already controlled but ventilation is still needed to clear the remaining smoke or toxin from the structure.

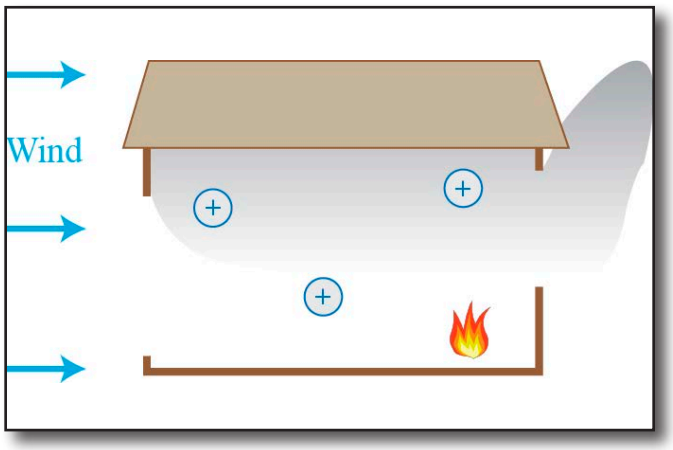


Figure 20-17 Natural Horizontal Ventilation

When removing smoke and gases from a fire, heat causes these products to accumulate from the ceiling down. Therefore, open windows from the top down, removing screens and drawing curtains back to maximize airflow. Look for skylights and other openings that can be removed with little damage. Roof ventilators should be left alone if they are working properly, although they may only serve to ventilate an attic space or some appliance.

For natural ventilation to be effective, openings must be selected in a manner that takes full advantage of wind direction. The entry opening must be made on the windward side of the building and the exit opening on the leeward side. If the windward (upwind) opening is larger than the leeward (downwind) opening, the wind may serve to slightly pressurize the space, Figure 20-17.

First, select and open the leeward opening by identifying the level where the contaminated atmosphere is most concentrated (high or low). Provide windward opening(s) to push in fresh air and expel the contaminated air. This sequence preserves any stratification and minimizes mixing. When utilizing natural openings such as doors and windows during active fire conditions, you must know where the heat and smoke are going. Avoid pulling the fire through the uninvolved areas and creating further damage to exposures inside the structure.

Positive Pressure Ventilation (PPV)

Figure 20-18 Checking the cone of air with an ungloved hand

PPV is a technique that forces fresh air into a structure with high-volume fans to create a higher pressure inside the building than that outside. By systematically opening doors and windows to channel the pressurized clean air, you can effectively ventilate smoke, heat and gasses out of a structure, Figure 20-19.

The effective implementation of positive pressure ventilation is dependent on the following considerations:

- Intake Opening: Proper blower placement (about 6-8' from an open entry point) requires that the cone of air issued must completely cover the entry point to the building in order to build up pressure. This can be determined by removing a glove from one hand and feeling for the limits of the pressure cone, Figure 20-18.
- Exhaust Opening: It is important to regulate the size of the exhaust opening to between ¾ and 1¾ the size of the intake opening. One indicator that the exhaust opening is not large enough is a noticeable engine exhaust odor inside, which should dissipate by increasing the total exhaust opening (opening another window or door).
- Internal Flow: The path of pressurized air must be controlled and directed to the selected exhaust opening. Effective ventilation requires sequential opening of contaminated areas. Diversion to other openings should be coordinated with the closure of the previous openings.

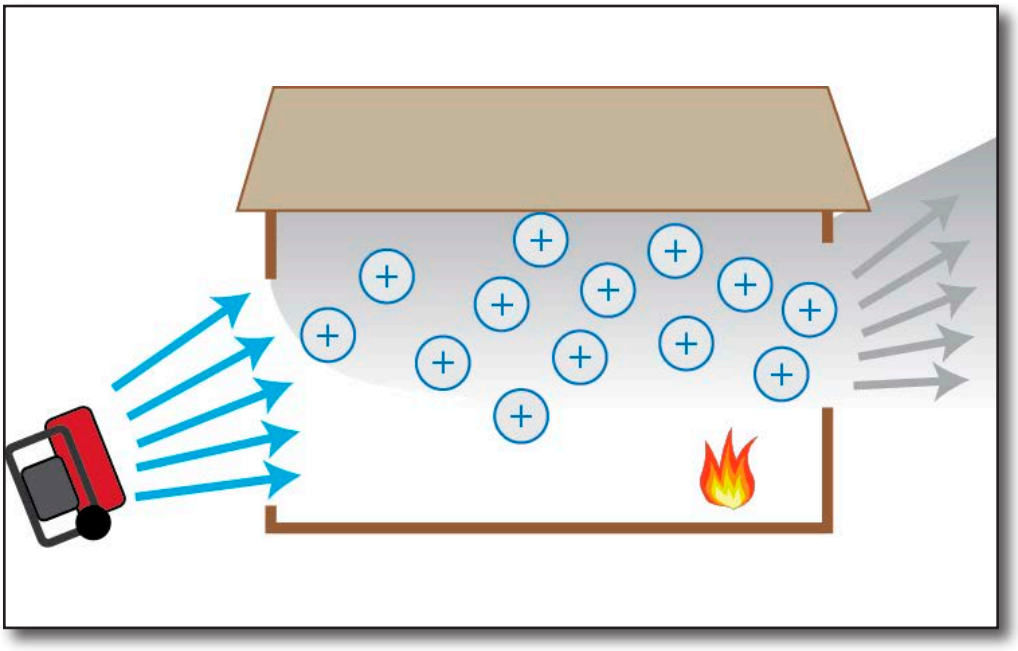
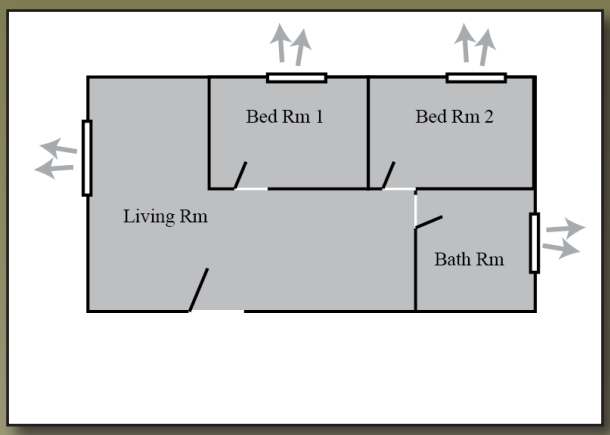
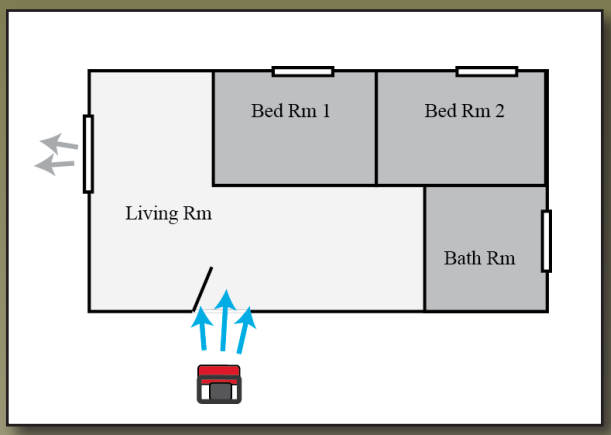


Figure 20-19 Positive Pressure Ventilation

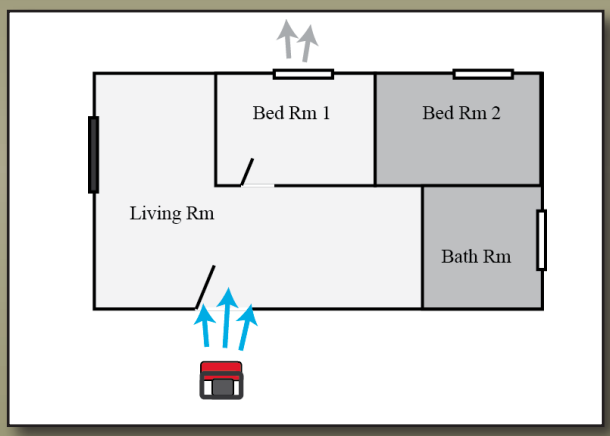
Coordinated & Systematic PPV



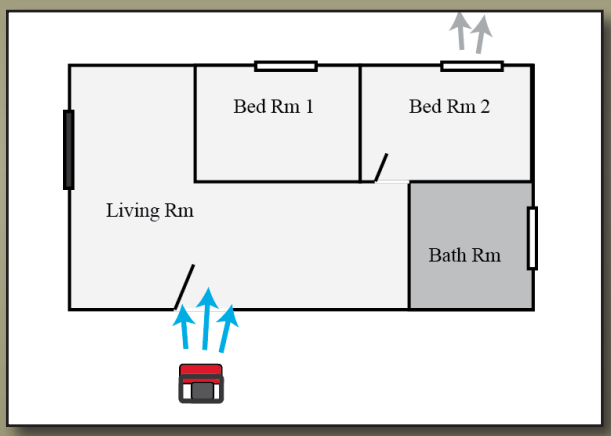
If a blower is not yet available, open all doors and windows to begin natural ventilation



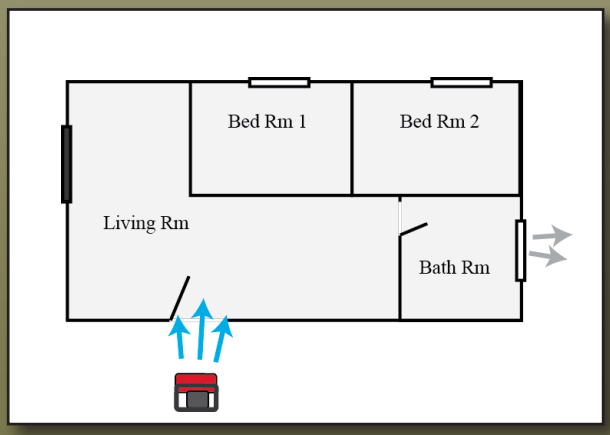
To begin PPV, close all doors except entry door and open a window for an exhaust hole



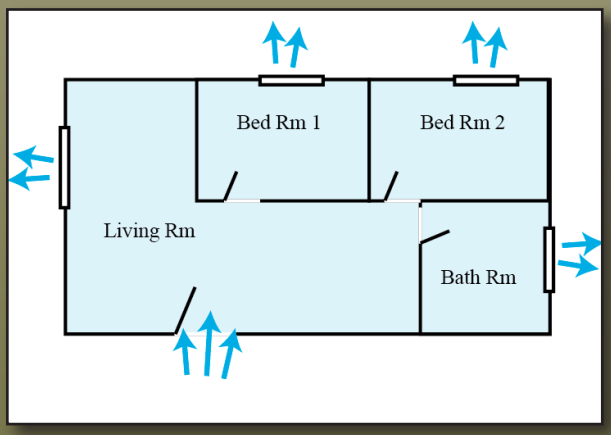
Close living room window to help pressurize house and open bed room #1 door & window



Close bed room #1 door, and open bed room #2 door and window



Close bed room #2 door, and open bath room door and window



When PPV is complete, open all doors & windows to naturally ventilate any residual smoke

Multiple Blowers

Multiple blowers can dramatically increase airflow and reduce the time necessary to complete ventilation operations. Underwriters Laboratories (UL) has recently found that two blowers placed side by side in a converging "v" pattern works more effectively than blowers placed in series, front and back of each other. Place two blowers, side by side, 6-8' from the intake opening. Utilizing blowers for ventilation must be coordinated with fire attack and/or the crews on the roof. Starting a blower in a fire setting without the appropriate exhaust opening can cause serious injury and/or death to firefighters by disturbing the fire behavior inside the structure.

Opposing Blowers

Depending on the floor plan of a given building and the location of the fire, opposing blowers can be used to remove contaminants in the hallway or an individual apartment unit. Place two blowers of equal ratings in openings at opposite ends of the building, then open the door to the unit involved and a window to exhaust the contaminants, Figure 20-20.

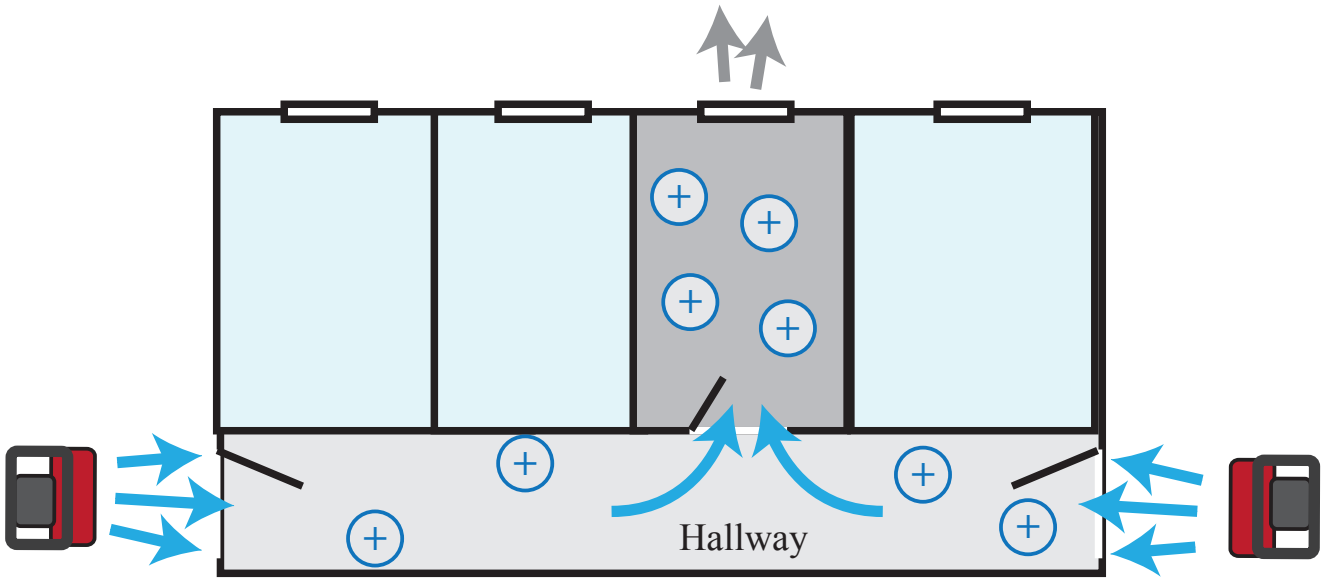


Figure 20-20 Opposing Blowers

Positive Pressure in Large/Multi-Story Buildings

Always start at the lowest level and systematically work your way toward the top when conducting PPV in a multi-story building. To ventilate the first floor, ensure that all of 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, then systematically ventilate the contaminated areas on the first floor as previously described. Once the first floor has been cleared, close the windows or doors on the first floor and then begin ventilating the second floor in the same manner as the first. The use of an electric blower is recommended to assist with air movement on the upper floors, however, the gas powered blower should always remain on the first floor and outside the structure.

Figure 20-21 Positive Pressure Ventilation in multistory buildings must be a well coordinated and planned event.

For large apartment buildings and other multiple occupancy dwellings, two or more blowers can be used in tandem or opposed to increase the air flow through the structure.

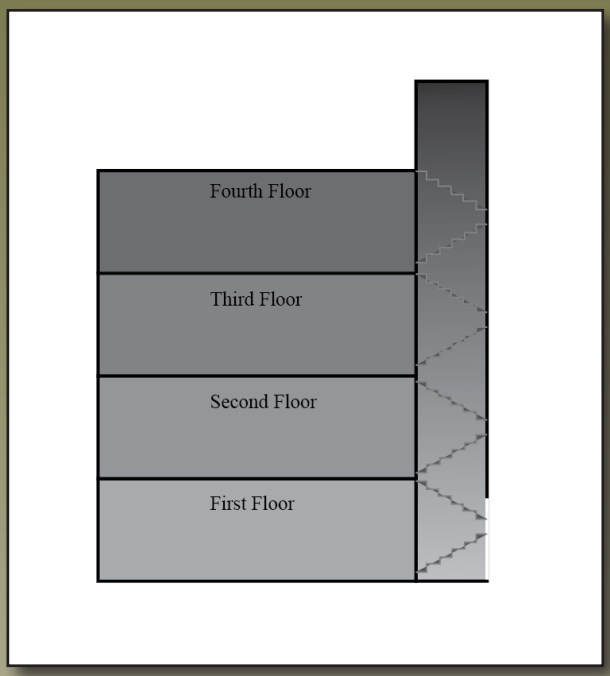
One of the biggest challenges when ventilating large commercial and multiple-story buildings is the coordination and implementation of the ventilation plan. It is important for the Truck Company Officer or Ventilation Group Supervisor to establish and communicate a clear plan for positive pressure ventilation. Independent actions carried out by firefighters who are not briefed on the ventilation plan can make the task of PPV on a large building next to impossible.

Unless you are assigned to the initial fire attack and a ventilation group has not been established, or you are faced with an emergency situation, only the ventilation group should open/close windows and doors for ventilation purposes.

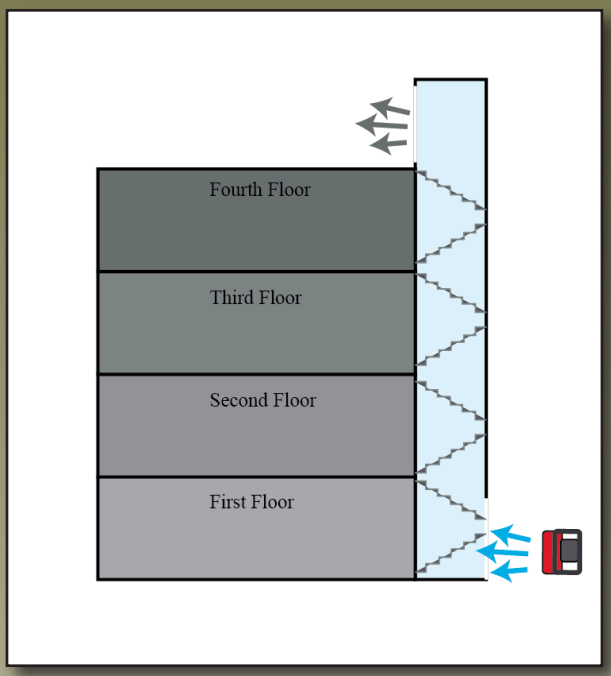
* Resource Note - Water Powered Turbo Blower

Rescue 4 and USAR 41 carry a water powered PPV turbo blower. This blower is operated by connecting an 1 3/4" hoseline to the intake and pumping at 150 psi (max of 250 psi). The blower produces 13,000 CFM of air and is highly effective for ventilating large buildings and stairwells.

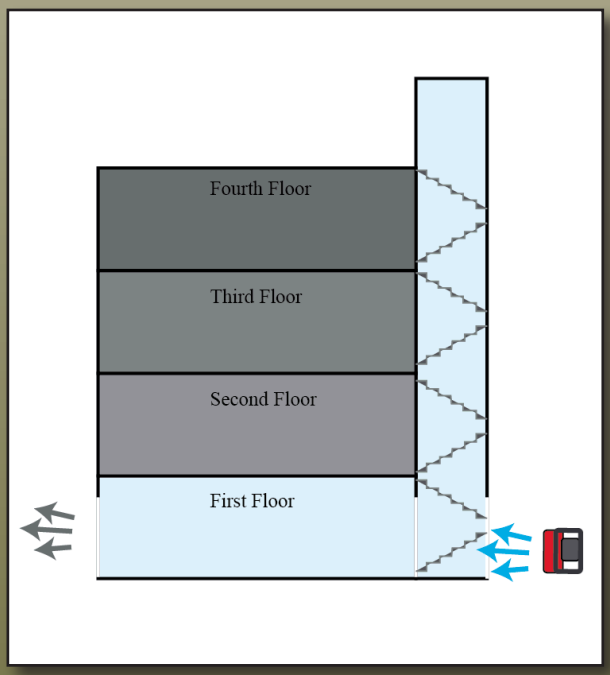
PPV in Multi-Story Buildings



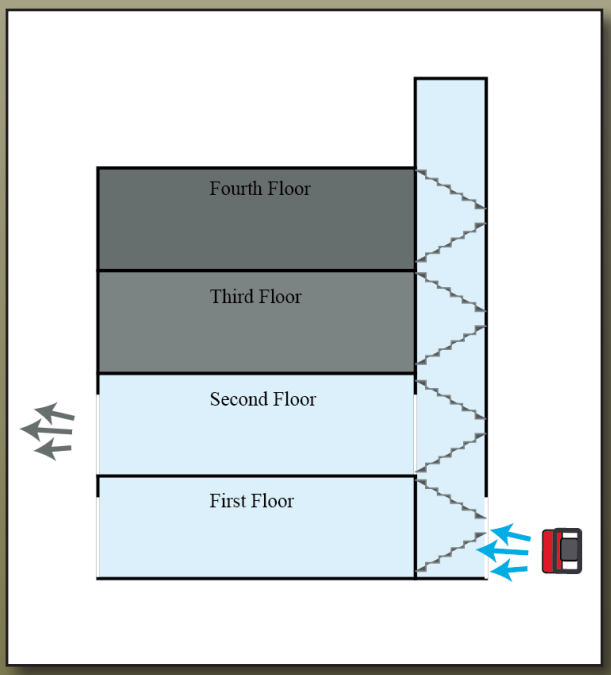
Ventilating multiple-story buildings requires a well coordinated and disciplined plan



The priority is to ventilate the stairwells to provide fresh air for any victims descending the building

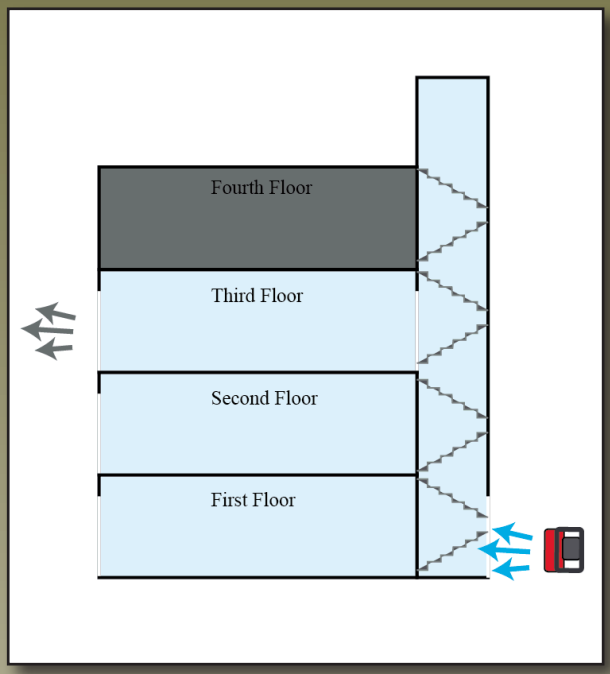


Then begin systematically working from the bottom to the top. Be sure to close top stairwell door to achieve positive pressure

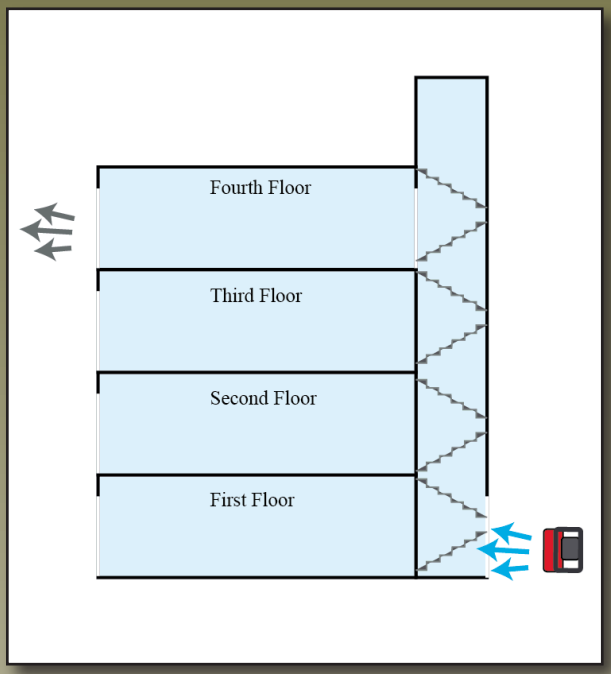


Close the stairwell door to the first floor and then open the second floor stairwell and exhaust window or door

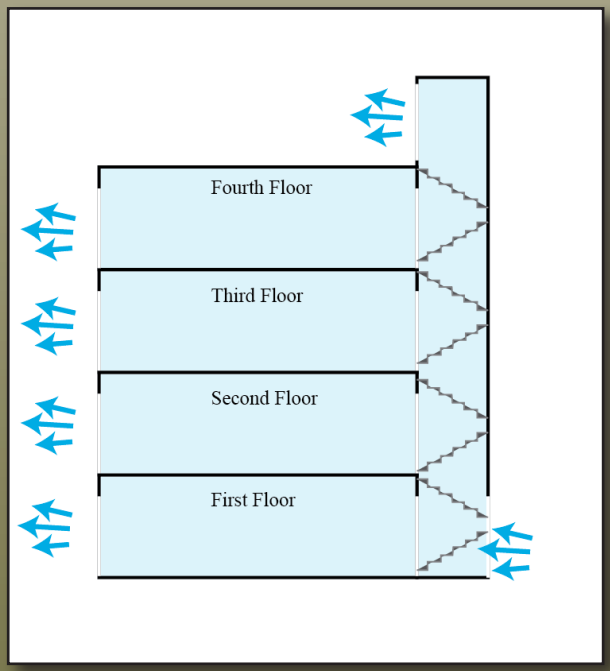
PPV in Multi-Story Buildings cont.



Close the stairwell door to the second floor and then open the third floor stairwell and exhaust window or door



Close the stairwell door to the third floor and then open the fourth floor stairwell and exhaust window or door



When PPV has been completed, open all windows and doors to naturally ventilate any residual smoke or gases

Drafts of 3 to 6 mph can be expected by opening the upper and lower stair shaft doors of a multi-story buildings. Due to atmospheric pressure differentials, natural vertical air currents that flow upward in stair shafts can be created simply by opening the doors at the ground and roof levels. The resulting natural air currents can be used effectively to remove the contaminants within.

NOTE

Positive Pressure in High-Rise Buildings

High-rise buildings (over 75' in height) can be the most difficult type of structure to ventilate. The traveling of smoke and toxic gases through upper floors and stairwells of a high-rise building often present a greater life hazard to the occupants than the fire itself, Figure 20-22. For this reason, pressurization of the stairwells should be made a priority during a high-rise fire and must be a coordinated and well planned effort.

Figure 20-22 High-rise ventilation presents significant challenges

The following high-rise features present unique challenges for conducting a successful ventilation operation.

High-Rise Construction

High-rise buildings will leak smoke and gases between floors and from floors into the stairwell and elevator shafts. Pressurized smoke can travel up through pipe alleys, electrical passageways, trash chutes and other unsealed voids between the floors with relative ease and speed.

Doors

Passageways created by open doors allow smoke to travel to additional areas within a building. It is important to control the status of doors that may affect ventilation airflow, especially stairwell doors. Stairwell doors left propped open will allow smoke to and heat to be drawn into the stairwell, creating an IDLH atmosphere to occupants and firefighters in the stairwell on upper levels.

Windows & Sealed Buildings

Many modern high-rise buildings can be classified as sealed because their external glass panels aren't openable. These buildings environments are controlled by HVAC systems and are therefore likely to retain the smoke, heat and gases until manually ventilated. If it is determined that the windows need to be broken for ventilation purposes, the plan must be clearly communicated with the IC and ensure that no personnel are below on the exterior of the building.

HVAC Systems

Heating, ventilation, and air-conditioning systems control the internal environments of high-rise buildings. Many high-rise HVAC systems incorporate automatic dampers which control the intake and exhaust ducts on each floor depending on the temperature desired. These HVAC systems also create a natural channel for smoke to travel throughout the building. Modern HVAC systems equipped with remote controlled dampers can also serve as a smoke control system. The HVAC smoke control systems vary widely in type and design and may be manually or automatically activated by an alarm system. Unless personnel are well trained on a particular HVAC smoke control system, they should not shut down or attempt to override it.

Stairwells

Stairwells provide natural vertical channels for smoke and toxic gases within a high-rise. Because of atmospheric pressure differentials between the bottom and top floors, stairwells which exit to the exterior of the building will have naturally occurring updrafts of up to 6 mph. Firefighters may take advantage of these natural updrafts and supplement them with blowers on the ground floor to help exhaust the smoke from the stairwells and out through the roof access door, Figure 20-23. Additionally, HVAC smoke control systems are designed to pressurize the stairwell shaft with large fans and exhaust the smoke through the top of the stairwell.

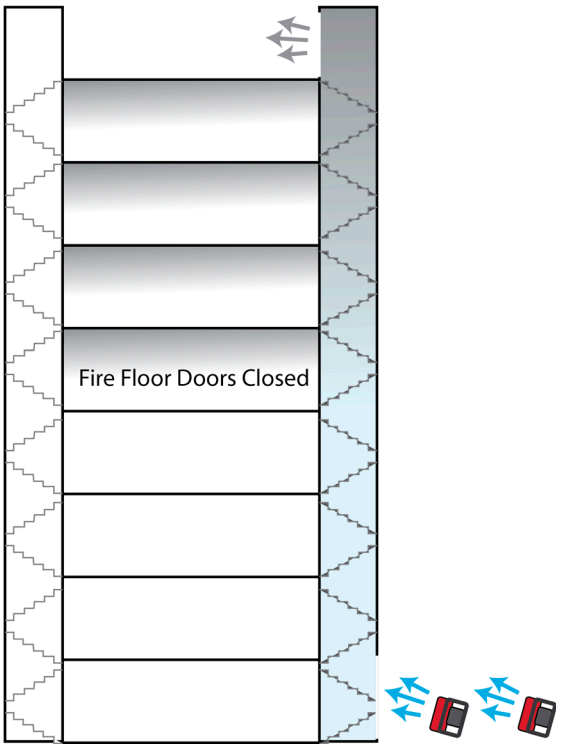


Figure 20-23 PPV in Stairwell

The pressurization of the stairwells must be a priority of the first alarm truck companies. By simply placing two blowers at the stairwell entrance you will pressurize the stairwell and keep smoke and toxic gases from entering from the fire floor. Once in place, vertical ventilation can be achieved by assigning firefighters the task of ascending the stairwells to open the roof access door. This vertical ventilation should only occur if the fire floor door can be controlled or closed. If the fire floor door cannot be controlled, an adverse result of opening the roof top door in the stairwell may occur. This action may draw smoke and heat towards the stairwell if the door to the fire floor is not controlled or kept shut during the fire attack placing occupants evacuating down the stairwell at risk.

If the fire floor door can not be controlled, it may be best to keep the roof top door closed and a cross ventilation operation may be used. Cross ventilation involves pressurizing the stairwell and directing the airflow across the fire floor, exhausting the smoke out through a broken window or to the stairwell on the opposite side of the building, Figure 20-24. This is a prime example of the complexity of ventilating high-rise structures and illustrates the importance that ventilation must be a well coordinated and clearly communicated event.

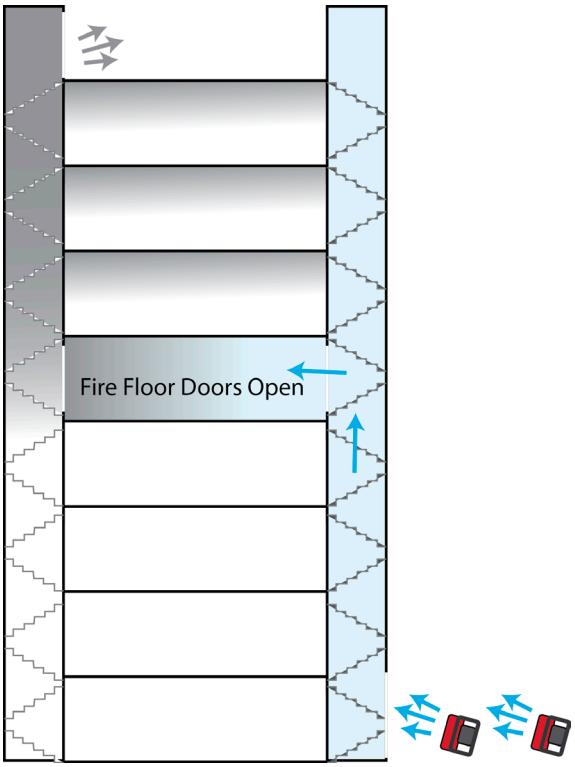


Figure 20-24 Cross Ventilation

Elevators

Elevator shafts can be at the core of the building or they may be randomly located throughout. Some high-rises use banked elevators, which do not extend all the way to the top floors. These elevator shafts act like stairwells and can push smoke to upper levels of the building. Unlike stairwells, elevator shafts are more difficult to ventilate due to the restrictive access.

Additional Ventilation Techniques

The following are some less common, but important ventilation techniques that can be used to clear a structure of heat, smoke and gasses.

Negative Pressure Ventilation

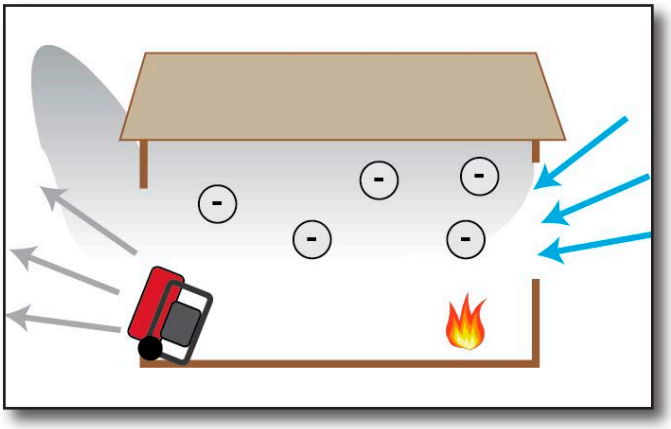


Figure 20-25 Negative Pressure Ventilation

Negative Pressure Ventilation describes the oldest type of mechanical ventilation that uses fans to create artificial circulation to expel smoke from a building. This method places fans in windows, doors and/or roof openings facing outward and creates an exhaust by pulling the smoke through the fan and to the outside, Figure 20-25. This method can be used to supplement natural ventilation and needs to be coordinated with wind direction.

Negative pressure ventilation is the least desired method for ventilating a structure because it draws contaminants through the blower, creating a need for additional equipment cleanup and maintenance. This method also requires that the blower be placed inside the doorway, hampering ingress an egress from the structure. Lastly, negative pressure ventilation tends to clear the low lying areas of a structure instead of the hotter, smokier, and more toxic levels of gases found towards the ceiling.

Hydraulic Ventilation

Hydraulic ventilation may be used when other types of forced ventilation are unavailable or impractical. The method involves flowing a fog stream from a hose line out an opening to draw the products of combustion out of the structure. Use a wide stream pattern to cover the majority of a door or window and it will create enough pressure to draw heat and smoke out. Caution must be used not to create additional water damage.

One hazard associated with using hydraulic ventilation is that it requires the firefighter to position themselves in the exhaust window when flowing the hose line. The heated gases in the upper levels of the room are then drawn down by the hydraulic ventilation and out the window past the firefighter's head. If using this method of ventilation, the firefighter must remain low and be sure to have full PPE, flash hood, and SCBA donned.

Summary

Ventilation is an important skill that allows heat, smoke and gasses to escape an IDLH and create a safe environment for both victims and firefighter alike. It allows cool, fresh air to be drawn into a building and helps to eliminate potential hazards. Proper ventilation requires knowledge of building construction, situational awareness and adequate training on the various techniques. While this practice will provide for life safety, it can also be extremely dangerous and should be treated as such. Take care to understand the different methods, and most importantly, how to carry them out both safely and effectively.

Appendix A - "Tactically Advantageous"

Tactically Advantageous Location: Performing vertical ventilation in an area of the structure that will support the tactical objective..

Most frequently the tactical objective is an offensive hole cut to halt the fires lateral spread and improve interior conditions for the benefit of trapped occupants and firefighters operating inside. This is called ***venting for fire*** and is performed in close proximity to the main body of fire; building construction will be one of the essential factors to consider when placing this hole. If the fire is in a bedroom the most tactically advantageous location will be as close as safely possible to that bedroom. If it's in the kitchen put the hole over the kitchen and so on. Conventional construction with a contents fire will afford you the opportunity to cut directly above the fire whereas lightweight construction would preclude you from doing this as you would have to employ the "space for time concept".

The defensive hole is cut when it is determined that the fire is of large enough magnitude that operating crews will have to sacrifice part of the building in order to save the entire structure. The most common defensive cut is a strip cut. This is conceptually similar to a fuel break that's used in wildland fire fighting; the fuel is removed well in advance of the fire. When the fire reaches the fuel break it has nothing to burn and forward progress is halted.

Now imagine your local strip mall, long and narrow with a common attic; the ideal scenario for a strip cut. The most tactically advantageous location to make this cut will be far enough in advance of the fire that you can complete the cut from wall to wall prior to the fire reaching you. Once complete, when the fire does arrive, it will vent out this long wall to wall strip cut and its forward spread will be halted (like the fuel break). By placing this hole remote from the fire in its anticipated path of travel indicates that you have found the most tactically advantageous location and have achieved your objective.

Lastly, the concept of ***venting for life*** means you will be cutting ventilation holes to improve interior conditions for escaping occupants. Your most tactically advantageous location may be over a hallway or a stairwell to facilitate occupant egress.

Crews operating on the roof may be tasked with cutting both offensive and defensive holes and the tactically advantageous location will be different for both. The key is to understand your objectives and how your actions will affect interior crews.

Media & Link Index

- SDFD Ventilation Training *(be patient - longer download)*
- Vertical Ventilation - Diagnostic Cuts
- Vertical Ventilation - Academy Evolution Part 1 of 3
- Vertical Ventilation - Academy Evolution Part 2 of 3
- Vertical Ventilation - Academy Evolution Part 3 of 3
- Room Ventilation - Academy Evolution
- Animation - Inspection Hole
- Animation - 4 X 4 Center Rafter Louver (5 Step Cut)
- Animation - Expanding the Center Rafter Louver **WITH** Construction
- Animation - Expanding the Center Rafter Louver **AGAINST** Construction

- Vertical Ventilation - Truck Company SOG - Academy
- Vertical Ventilation - Drill Sheet - Post Academy
- Mechanical Ventilation - Truck Company SOG - Academy
- Mechanical Ventilation - Drill Sheet - Post Academy

References

1. Truck Company Operations, second edition, John Mittendorf
2. SDFD Truck Company SOG - 72nd Basic Fire Academy
3. SDFD Ventilation IST Power Point - Kurtis Bennett, 2009
4. IFSTA Essentials, 5th Edition
5. Truck Company Operations, Rio Hondo Community College & Foothill Training Officer's Assn.

Credits

Writers:

Jeffrey Williams, Kevin Pendleton, Kurtis Bennett

Layout & Editing:

John Brubaker, Kurtis Bennett

Media:

John Brubaker

Grammatical Editing:

Kevin Pendleton

NOTE: If you have any additional information or content that you feel would be appropriate to contribute to this Chapter or would like to report any errors or misrepresentations, please contact the SDFD Training Division or email the Drill Manual Revision Staff at

SDFDDrillManualTeam@SanDiego.gov

Revisions/Updates

Date	*Revision/Update Description*
June 2020	All references to the number of rungs a ladder must be above the roofline have been changed to be more consistent with IFSTA. New language now states: "A ladder must be a minimum of 2 rungs above a roofline, 3 - 5 preferred."