Chapter 10.0

Ventilation

Ventilation is a part of structural firefighting tactics, and involves the expulsion of heat and smoke from a burning building, permitting the firefighters to more easily and safely find trapped individuals and attack the fire. Ventilation can also be used to preserve salvageable property(s) and control flow paths and fire spread.

This chapter will be broken down into the following sections:

10.1 Ventilation and Tools
10.2 Vertical Ventilation
10.3 Horizontal Ventilation
10.4 Positive Pressure Ventilation
10.5 Negative Pressure Ventilation (Hydraulic)

Ventilation

Officer will determine the best means of ventilation, if not specified by Command

- Ensure adequate personnel to complete the job swiftly and safely
- Providing sufficient laddering for access and escape
- Determining the structural integrity of the roof and exterior walls
- Ensuring the safe travel pattern of personnel walking the roof
- Determine and coordinate the location of openings with interior crew

BACKDRAFT SIGNALS

- Dense black smoke becoming gray-yellow smoke under pressure exiting from small openings. Little or no visible flame.
- Smoke appears to be breathing in and out of openings.
- Smoke-stained, rattling windows-muffled sounds.

BURN TIME- Direct flame exposure chars to a depth of 1 inch in 45 minutes. Gang nails and stems are normally 3/8"; it takes 17 minutes to char to this depth. **ROOF FAILURE WILL OCCUR MUCH SOONER.**

Tools for Ventilation

Equipment Considerations:

- Trash/rubbish hook
- Pike Pole (D handle)
- Halligan
- TIC
- SCBA
- Axe (Flat head/Pick Head)
- Chain Saw
- Ladders
- Radios
- PPV fan

Section 10.2

Vertical Ventilation

Vertical ventilation is the removal of super-heated air, gases, smoke and pressure inside a closed or vent limited structure by cutting a hole in the roof. When vertical ventilation is coordinated with the attack team and the hole is of the appropriate size, the super-heated air, gases, smoke and pressure move to the path of least resistance and follow their natural path up, allowing the attack team to make a safer, and oftentimes, quicker attack on the seat of the fire.

In the past, the idea of vertical ventilation was to allow the pressurized smoke and heated air to escape before sending in the attack crew, making conditions safer by providing visibility and even preventing a backdraft. This also allowed for a more rapid advance to the seat of the fire.

Research coordinated by both NIST and UL has provided firefighters evidence to guide flow path management decisions. Vertical ventilation is part and parcel to this discussion. The timing for the decision to provide vertical ventilation does need to be carefully coordinated with the engine company. In locales with close-in companies, or where robust engine and truck crews arrive together, early vertical ventilation is a great strategy to improve conditions for the rapidly advancing engine crew, who will immediately apply water.

In locales, such as Pendleton, where staffing is at a premium, early vertical ventilation in the absence of a ready hose line could mean the difference between salvaging part of the building or ending up with a parking lot.

Experience and training along with crew size and crew integrity will be critical to the ventilate/not-ventilate decision and/or the decision on whether to go to the roof.

Considerations:

- Type and construction of the roof
- Fire effect on the structure (time)
- Location of firewalls and parapets
- Location and/or existence of heavy roof equipment (i.e. HVAC, Live Loads)
- Any information determined with the TIC
- Escape plan, evacuation route, and confirmation of a secondary means of egress.
- Flow Path is crucial, coordinate with interior attack crews (The **flow-path** is the route that air/oxygen takes when it heads in to feed the fire and the route that fire, smoke or heat heads for, to leave the building.)

Vertical Ventilation:

- Sounder will sound the roof prior to leaving the ladder.
- Use the TIC, rubbish hook, and coordination with interior attack crew to determine location of opening.
- After opening location is determined, hole size should be considered. In general 4ft x 4ft minimum for residential and 8ft x 8ft for commercial.
- If possible the crew will then retrace its steps and exit the roof asap

Types of Vertical Ventilation:

Ventilation openings can be located to control/redirect the travel of fire in two ways; **Offensive Ventilation** and **Defensive Ventilation**.

Offensive vertical ventilation- Offensive operations are over the seat of the fire (heat holes). This type of ventilation is often used in the residential house fire over the fire area in coordination with fire attack to improve conditions (heat, smoke, fire travel) in order to provide a better environment for an aggressive fire attack.

Defensive vertical ventilation- Defensive operations are placed ahead of horizontal fire spread (aka-trench/strip cuts). This type of ventilation allows fire to be directed with ventilation towards a specific area in order to avoid the fire spreading to areas of egress or salvageable property.

Cutting the vent hole- There are many types of cuts and techniques that can be used for cutting ventilation holes in the vertical ventilation setting. Sometimes cutting a hole is not even necessary if there are easily accessible openings such as bulkhead doors or skylights.

When cutting in the offensive setting, try to as closely as possible be over the seat of the fire. Use a Kerf Cut or Inspection Cut to check conditions below before creating a larger ventilation hole. Be sure to locate and maintain the integrity of the roof by identifying rafter locations and potential soft spots by sounding adequately with a tool or using *inspection cuts*. Use a roof ladder to work off of in safe location, and consider using a tool such as a Halligan or pick-head axe driven into the roof for a foothold off the ladder.

When cutting with a power tool, be aware of those around you on the roof. Venting a roof is not a single man operation, and the team should work together to provide for adequate manpower, safety, and situational awareness of fire/building conditions.

When the hole is cut, use a prying tool to remove the portion of the roof that has been cut out. This may require striking/prying tools. If on a residential structure, be sure to use a tool that can reach the ceiling below to complete the ventilation. In instances where it is possible to do so, a pike pole or rubbish hook may be turned upside down in order to use the handle side to punch through ceiling material below.

The chainsaw chains used at PFD are capable of cutting through thin tin/metal (on structure apparatus), but if the need to vent through thicker material arises, consider the rotary saw. The firefighter should also always have a backup tool for ventilation, such as a flat head axe (for residential roofs).

Ventilation on commercial structures should maintain the same basics of safety and operations, but will require more personnel. The techniques used for commercial structures may vary based on building construction and desired outcomes (offensive or defensive ventilation).

Types of ventilation cuts

There are multiple types of ventilation techniques and cuts that can be used on the same style of roof whether in the residential or commercial setting. These styles of cuts should act as a base for ventilation and can be adjusted in size if necessary.

Inspection Cuts/Holes:

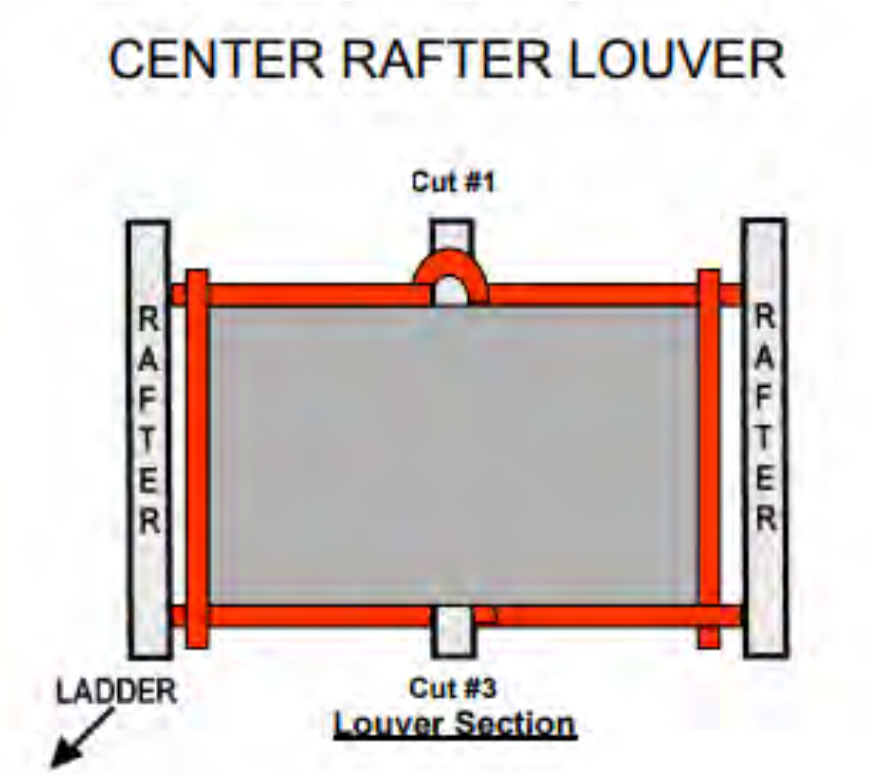
Kerf Cut- This cut, sometimes referred to as a "plunge cut," is a quick and easy inspection hole to use during roof operations. ... The kerf cut is often used when a firefighter is quickly trying to determine the boundaries of the fire's extension.

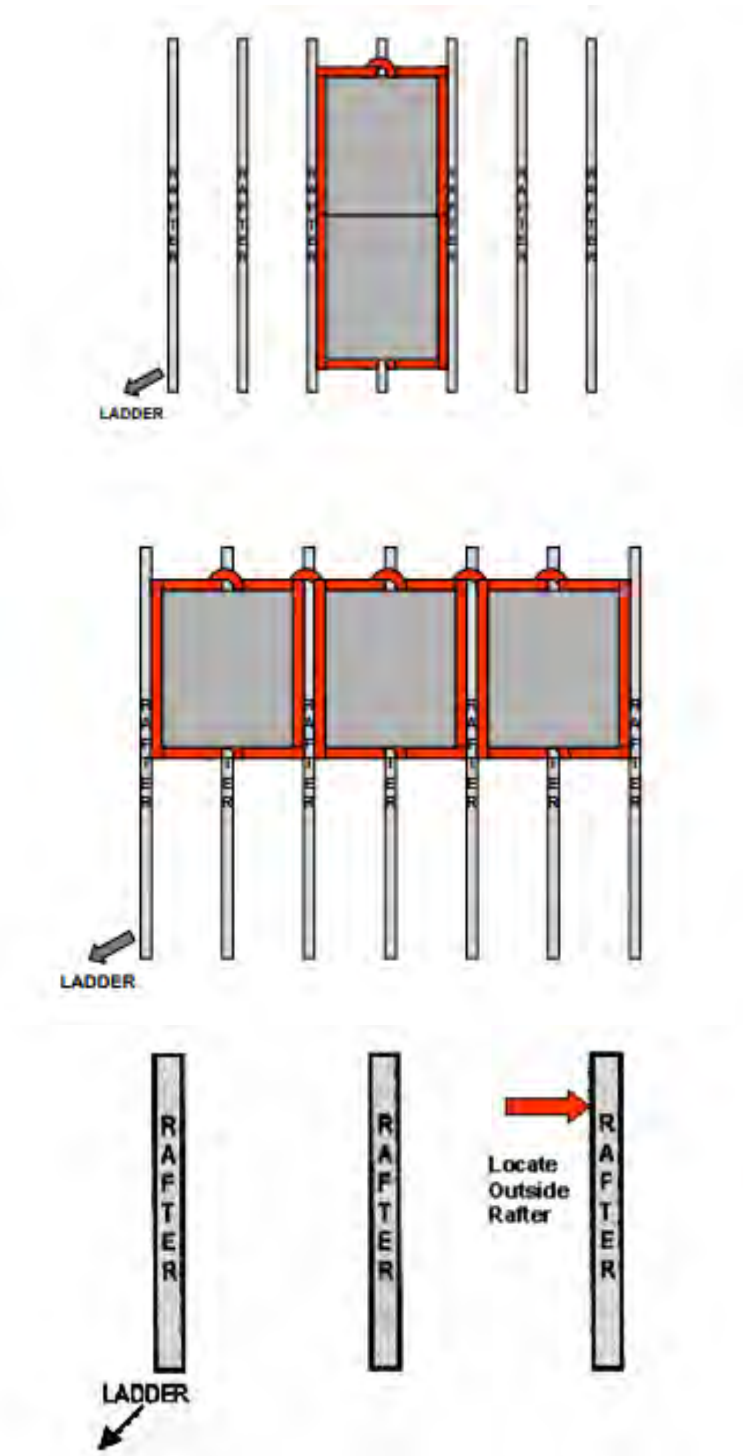
Punch Hole- Drive the sharp end of the pick-head axe, the pry bar end of a hook, or the point on the Halligan tool through the roof covering. Next, pry the tool back out of its hole and read the conditions that come out of the hole.

Triangle Cut- This cut, sometimes referred to as the "A-cut" because of its resemblance to the letter "A," is far superior to the other two cuts because it gives better visibility into the attic/cockloft space and a true size-up of the fire and smoke conditions below. Also, with today's modern lightweight construction, it is very important to identify this type of construction early in the firefight; the triangle cut help us do that quickly.

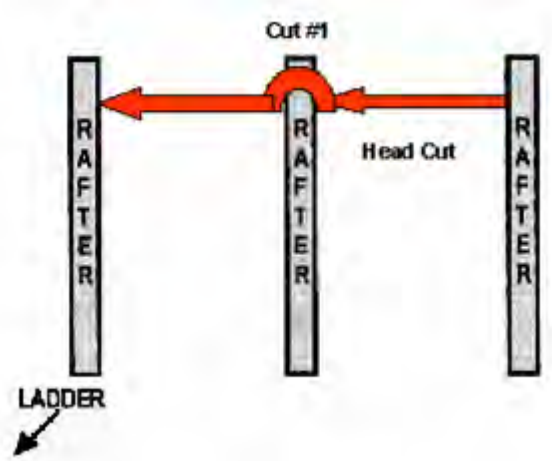
Ventilation Cuts/Holes:

Center Rafter Cut-A technique used when cutting plywood sheathing (4 cuts). Center Rafter provides the largest hole possible with the minimum amount of cuts. Sheathing removal (**louvering**) requires a minimal effort. Louver the cut by pushing/pulling the end(s) of the cut on either side of the center rafter to open up the hole. In order to make a center rafter louver, you must first know rafter type and rafter direction. Next you must determine the location of three rafters. The rafter type and direction is determined by the use of diagnostic tools (inspection hole, sounding etc.) When over your ventilation area make a head cut (top side of the hole on pitched roof) to locate a minimum of three rafters.

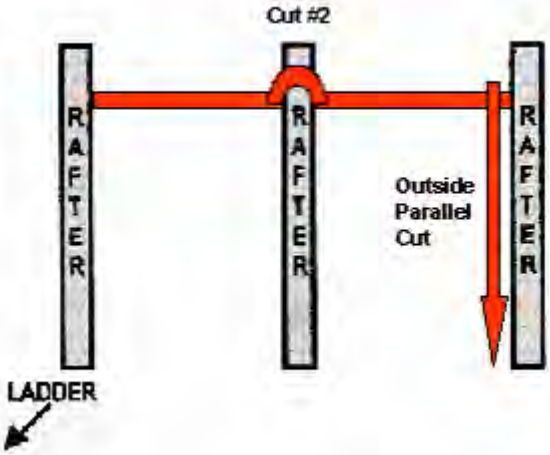




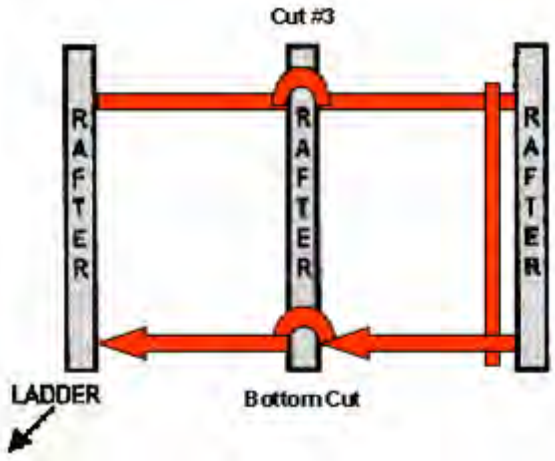
The head cut is started by first cutting away from your ladder to locate your first (outside) rafter.



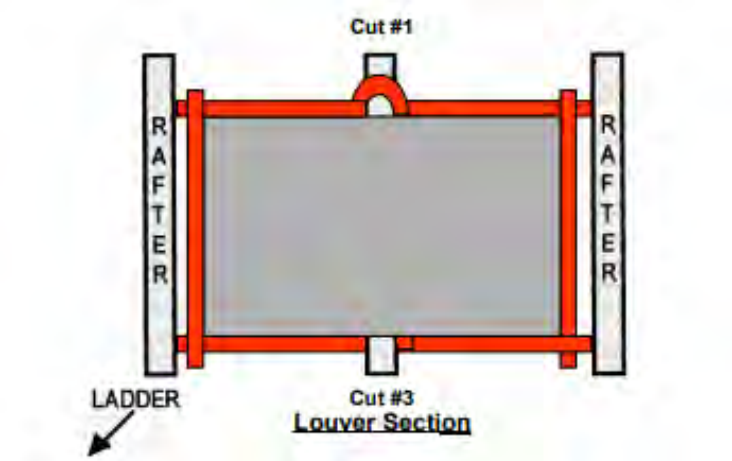
Reverse directions and cut back towards your ladder. Roll the second (center) rafter and stop at the third (inside) rafter.



Move back to the first (outside) rafter and cut a parallel cut approximately 2 to 3 inches inside the rafter.



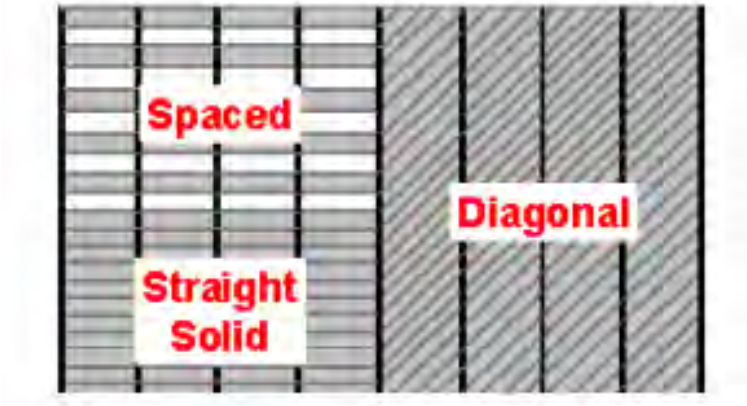
Make the bottom cut, cutting towards the ladder. Start at the first (outside) rafter, roll over the second (center) rafter and stop at the third (inside) rafter.



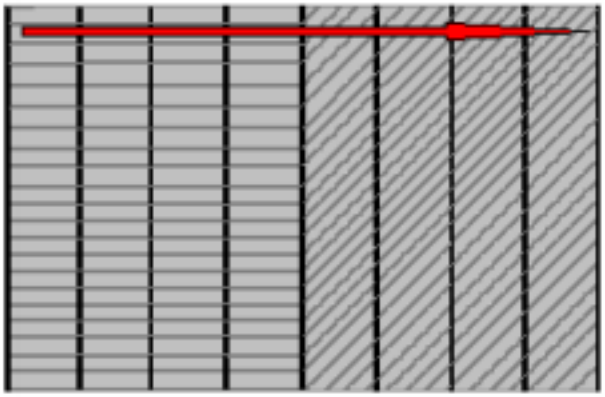
Make a parallel cut approximately 2 to 3 inches inside the third (inside) rafter. Louver the cut section.

Two “Louvers”

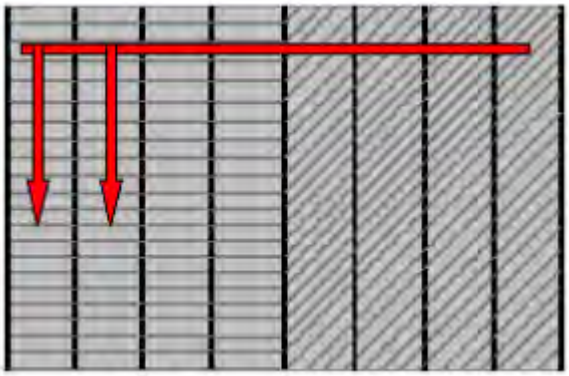
DICING- This technique is used for cutting 1” x 4” or 1” x 6” solid, spaced or diagonal sheathed roofs. Dicing has many advantages, first, it is directional. The roof team will always be working back toward their ladder. The roof team can work simultaneously, after the chain saw operator makes the third cut, the puller can start pulling boards and the chain saw operator can continue cutting the roof. This type of cut may be necessary with older legacy construction homes in Pendleton with Tongue and Groove roof decking.



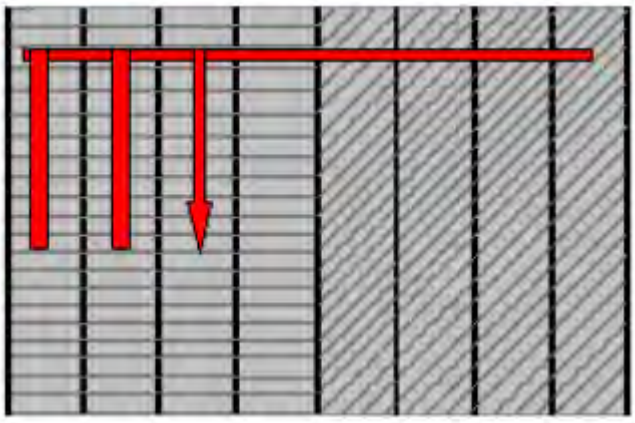
Dicing does not require the cutter to know the exact location of the rafters. Rafter type and rafter direction is all that has to be known. Rafter type and direction has already been determined with diagnostic tools (inspection hole, sounding, etc.)



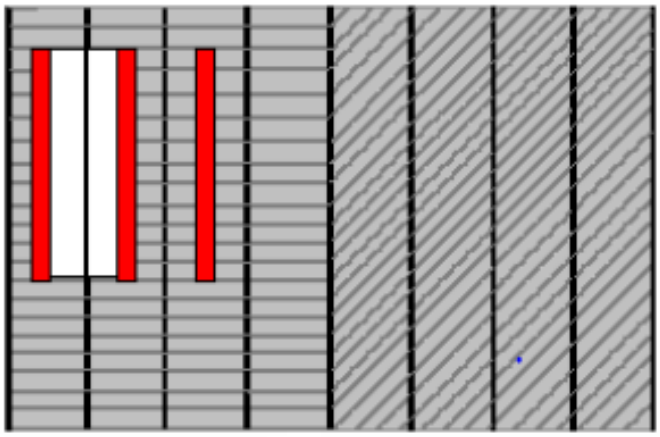
If needed, the first cut performed in this operation is a score cut or a head cut. This cut is perpendicular to rafter direction and should be cut along the intended ventilation hole.



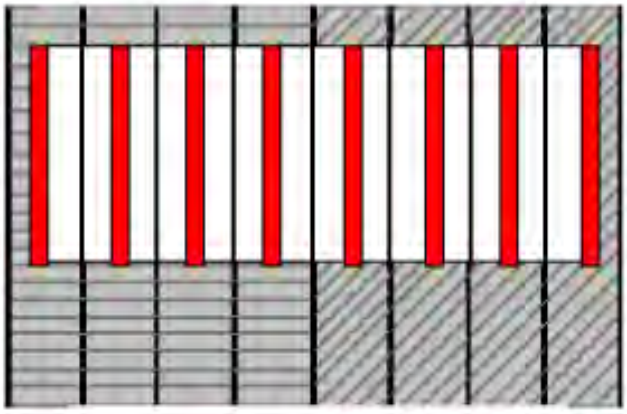
If a score cut or head cut is needed, the ventilation team moves back to the starting point of the cut and begins making parallel cuts (parallel to rafters) between rafters without concern as to the location of the rafters. The length of the dice cut is determined by the reach of the tool being used to pull the sheathing, (pick head axe, rubbish hook). The chain saw operator should be aware of rafter spacing, **"DON'T" span two rafters**. If the rafter spacing has not been previously determined, spacing should be apparent after the first few dice cuts have been removed. If two cuts are made between rafters, the cut material will fall through and possibly cause injury to interior firefighting crews. If the cuts are spaced to far apart and span two rafters, the cut sheathing may be difficult to pull and impossible to louver. The ventilation team should always work and cut toward the path of safety (towards ladder).



The chain saw operator should cut a minimum of three dice cuts before the puller starts removing sheathing.



After the third dice cut is complete, puller removes roof sheathing. Always leave a minimum of one un-pulled section between the cutter and the puller.



Always work back towards your ladder. On a roof constructed with multiple layers of roof composition or diagonal roof sheathing, an additional score cut or bottom cut may be necessary.

***Technique Tip**: Another option for tongue and groove style roof decking is to cut strips out between rafters, eliminating the need for pulling nails and individual boards.

Strip Ventilation "Defensive Ventilation"- A large section of roofing material that has been removed well ahead of the fire. The strip acts as a firebreak. Strip ventilation can help prevent fire spread in multifamily dwellings such as an apartment building or other large occupancy (nursing home, hotel, etc.). The peaked roof will have a strip of roof/decking material cut out from the peak downwards. The further we get from the ridge when venting attic spaces the more time and energy is being wasted. The peak of the roof is where the buildup of heat and smoke will be greatest. When encountering fire in the attic of a peaked roof occupancy and fire spread is the main concern the most appropriate tactic and efficient use of resources is a strip vent (If resources and abilities allow). A large hole or strip should be cut at the point fire is desired to stop spreading. This point should be far enough from current fire location that the tactic can be completed but not at a point that you will draw fire to a location you are trying to salvage. Open up along the ridge with an appropriate sized hole for the volume of the attic space.

Trench Cut/Ventilation "Defensive Ventilation" -This type of cut requires excessive manpower and tools and is often performed on a commercial/large structure. The main focus of this defensive tactic is to cut off fire extension to an area of the building that has not been involved in fire; this means that a portion of the building will be "written off," so to speak. Keep in mind that many buildings will not possess the necessary attributes to employ a trench cut. For example, H-shaped buildings would benefit from the use of the trench cut during operations, as the building will have a choke-off point in the center of the structure, which can act as a pinch point for smoke and heat. Older, narrow Type III (ordinary) constructed taxpayers would benefit from this tactic, as the construction method used in the roof area may provide crews with an increased operational time frame to complete the trench. Adversely, newer lightweight strip malls would not be a positive candidate for this tactic. The main reason is the safety concerns when dealing with lightweight construction.

Approach the roof from a safe area, and start off by making a large vent opening directly over the fire to allow smoke and heat to exit the structure. This will also buy some time for the companies to complete the trench cut.

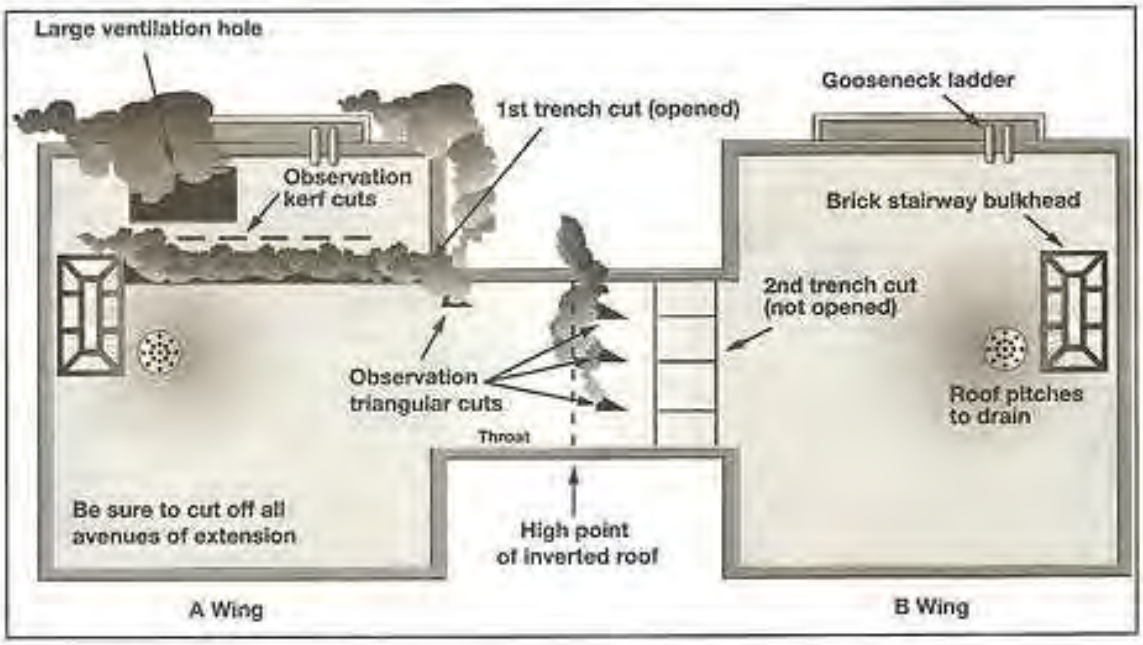
Once that opening has been completed, look for a suitable spot to cut the trench, at least 20 feet from the original ventilation opening. Look for some existing roof openings that can assist in making the trench cut (vent chases, scuttle hatches, bulkhead doors, etc.) and cut from these openings; the existing openings will lessen the amount of area the crews will have to open up. Look for a pinch point or "throat" area of the building that will facilitate cutting the trench. Optimally, limiting the length of the cut from side to side will decrease the time needed to make the cut and it will get the crews off the roof faster.

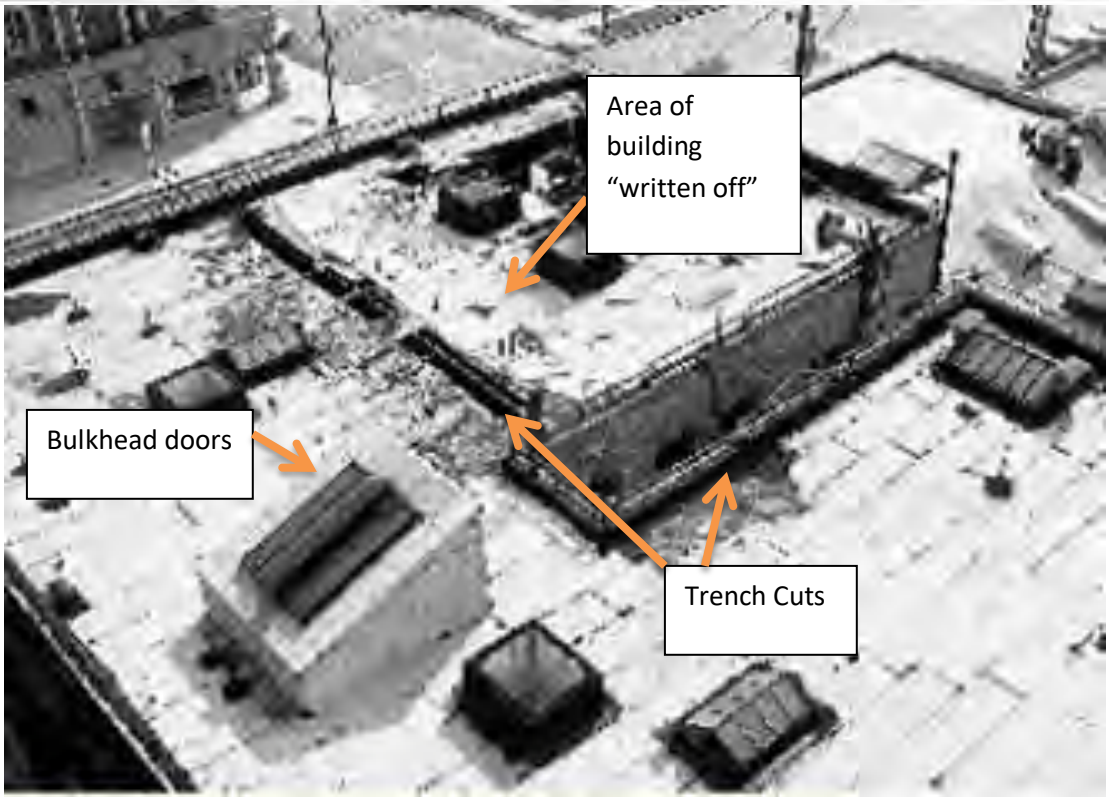
Prior to cutting the trench, the crews should make a few inspection holes between the existing vent opening and the area for the trench to be cut. An inspection hole is a series of three Kerf Cuts (a cut in the roof material the same width of the blade in use) in the shape of a triangle. These inspection holes will serve as early warning as the fire progresses in the direction of the trench. A few inspection holes should also be cut beyond the trench area as well; if the fire has jumped the trench area, it may be necessary to move the trench cut further down the roof.

Once a spot is chosen for the trench, check the direction of the roof rafters. Cutting the trench in the same direction as the roof rafters are running can save the roof crew valuable time. For example, if the trench is cut with only one rafter within the trench sides, the trench panels can be pivoted open on only one nailed rafter. If the roof rafters are wide enough apart, the trench may be able to be cut completely within the rafters, and the sections can be lifted out entirely. If the trench is made perpendicular to the direction of the rafters, many more relief cuts will be required to open up the trench panels.

Starting from the upwind side, with the crews located between the trench and the means of egress make two straight cuts approximately three feet wide, from one wall completely to the opposite wall of the building. Remember: do not cut the trench between you and your egress! It will be necessary to put perpendicular relief cuts throughout the length of the trench cut. Make the relief cuts at approximately every five feet down the length of the trench cut; this will keep the sections of the trench cut manageable for crews to manipulate open.

The trench cut is just one part of the overall strategy on the fire ground; a major portion of the operation involves a second part, the actual opening of the trench. Therefore, it is imperative that strict coordination between the suppression teams and the roof teams be adhered to. Command should have large hose streams placed underneath the area of the trench cut, to suppress any fire that may come towards the opening. When ready, the roof team shall open up the trench, and punch out the ceiling below the cut area. Once opened, do not stand by and admire your work; get off the roof immediately. The introduction of products of combustion with the fresh air above the roof may result in vent-point ignition, so it is critical that a protective hose line be in place to assure the safety of the roof teams as they exit the roof.


Large ventilation hole
Gooseneck ladder
1st trench cut (opened)
Observation kerf cuts
Brick stairway bulkhead
2nd trench cut (not opened)
Observation triangular cuts
Roof pitches to drain
Throat
Be sure to cut off all avenues of extension
High point of inverted roof
A Wing
B Wing


Area of building "written off"
Bulkhead doors
Trench Cuts

Section 10.3

Horizontal Ventilation

Due to a lack of initial on scene resources in many instances, horizontal ventilation is often the preferred method of ventilation at Pendleton Fire. The reasons for this are that horizontal ventilation requires less manpower, quicker accessibility, and often lower risk levels than that of vertical ventilation. This however does not mean that horizontal ventilation is always preferred over vertical ventilation, but due to low staffing levels may be the most advantageous method for ventilation of a structure during fire ground operations.

Horizontal ventilation may be used in many different styles and options. Windows, gable end vent openings, doors, horizontal cuts, etc. may all be used to perform horizontal ventilation. Regardless of the method used, the opening should always be monitored for changing fire conditions and the respective flow path created should be understood and managed appropriately. Indiscriminate opening/breaking of windows and other openings is never advised. This outdated idea creates an unmanageable flow path of oxygen within the structure and can lead to intensely increased fire conditions and a decrease in survivability.

Horizontal ventilation is generally fast and easy to use and can be done from either inside or outside of the building.

Horizontal ventilation can often be used in conjunction with Positive Pressure Ventilation, but must be done so in coordinated manner.

Horizontal ventilation may be useful in setting where:

- **Fire is not in the attic**
- **Daylight basements**
- **Multistory building with fire below the top floor**
- **Weakened building where vertical ventilation is unsafe**
- **Building where vertical ventilation is ineffective**

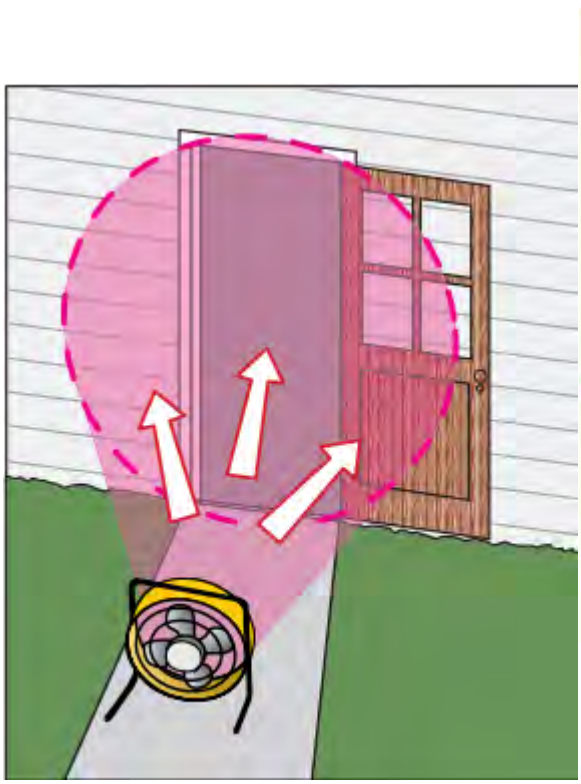
Section 10.4

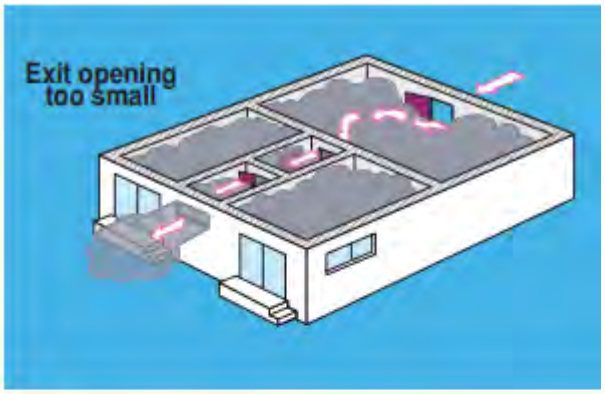
Positive Pressure Ventilation

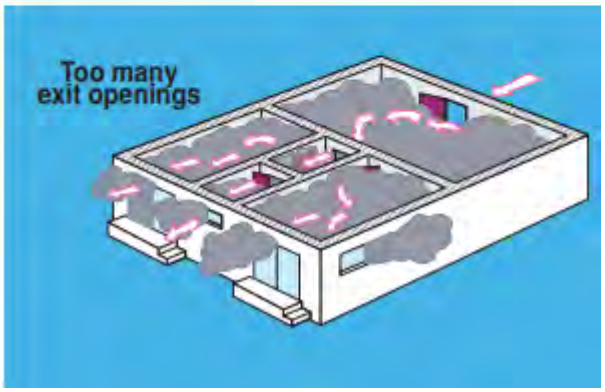
Probably the most effective method of forced ventilation is now most often called positive pressure ventilation, or PPV. It is basically the introduction of fresh air into a building at a rate faster than it can exit. This creates a higher pressure within the confined area overcoming the pressures created by the fire. When compared to other forms of ventilation such as negative pressure ejection and natural, PPV is a much more efficient, predictable and safer method of accomplishing the ventilation goal. The exact path or route the air currents take is preselected by the ventilation group and constitutes positive control of the building**. Indiscriminate opening and closing of doors and windows can cause poor efficiency and unnecessary fire spread and damage.**

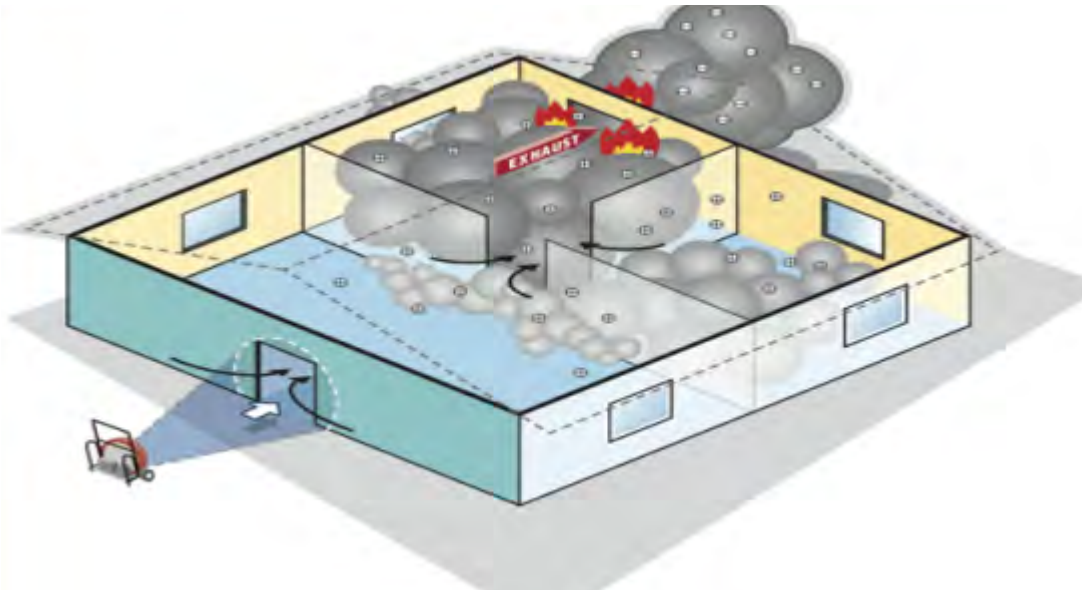
The search group should close doors and windows, taking the first steps in the selection of the PPV routing through the building (FLOW PATH).

Because of the strong influence PPV exerts on fire behavior, incident commanders may elect to use PPV as part of their initial fire attack. With few exceptions, the PPV process can be started as soon as attack lines are charged and ready to advance. The blower should be placed just outside the entry point so that fresh air is at the back of the attack group. **This technique requires absolute knowledge of fire location.**



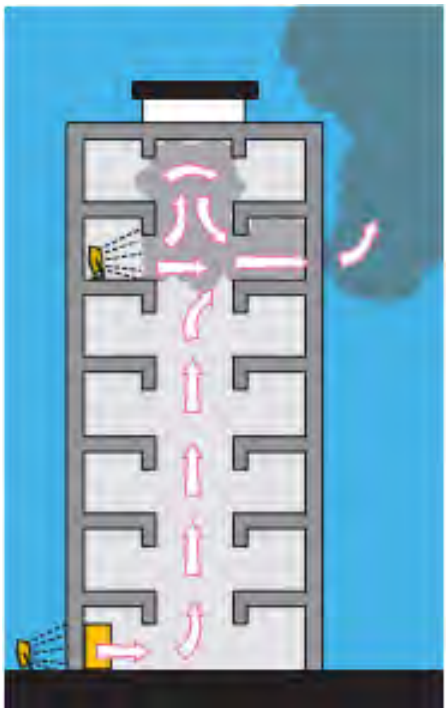






If there is uncertainty about location of the fire, **DO NOT START PPV**. Those that are part of the initial attack group shall locate the fire while at the same time conducting a primary search. Once the fire has been located and an appropriate flow path has been created and managed (interior and exterior), PPV can greatly benefit the progress and working conditions for fire attack, rescue, and later salvage and overhaul.

PPV in structures that are larger than residential homes may require a combination of PPV and NPV (Negative Pressure Ventilation) as shown below.



Negative Pressure Ventilation

Negative pressure ventilation- is another method of ventilation sometimes used in firefighting efforts. The method of negative pressure ventilation is a process of using smoke ejectors to remove the smoke from a building. Negative pressure ventilation is not used as much as positive pressure ventilation for the reason that positive pressure can move more air throughout the structure and clear out more smoke in a timely manner.

Hydraulic ventilation- is another method of ventilation that is very useful if vertical ventilation or positive pressure ventilation is either unsafe or not a feasible strategy. Hydraulic ventilation is done by setting up a hose line on a fog stream and directing it out a window. The air that a fog stream draws in also draws out the smoke and ejects it outside. This method can be useful during overhaul operations as long as there is another hose line in place in the immediate area. The air entrained by the fog stream can change and direct fire conditions by making them more intense or creating a flow path that is not desired.