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INTRODUCTION

Ventilation is the "systematic" removal of heat, smoke, and fire gases from a structure, and replacing it with cooler, clean, fresh air.

Ventilation does NOT put out fires. However, effective ventilation DRAMATICALLY assists in the attack, control, and extinguishment of a structure fire.

Effective ventilation will accomplish four main objectives.

1. Save lives.
2. Assist in firefighter access.
3. Control the horizontal spread of fire.
4. Reduce the possibility of flashover and backdraft.

Save Lives

Proper 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. The replacement of heated smoke and fire gases with cooler, fresh air will help the occupants to breathe better. 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.

Firefighter Access

A proper ventilation aids in the removal of super-heated smoke and fire gases from the building, which in turn permits firefighters to locate and extinguish the fire safely and more rapidly. Heat is reduced and visibility is increased. Ventilation will also reduce the chance of steam burns to firefighters from their hose stream. Rapid extinguishment of the fire reduces water, heat, and smoke damage.

Control the Horizontal Spread of Fire

In a structure fire, heat, smoke, and fire gases travel upward to the highest point of the building, usually the roof or ceiling. If the heat, smoke, and fire gases are not released, they will accumulate at the highest point of the structure and begin to bank down and spread laterally. This process is generally known as mushrooming. Proper ventilation will reduce mushrooming, which in turn will reduce the rate that fire can spread over an area. Ventilation provides an escape for the accumulating heat, smoke, and fire gases.

Strip ventilation, when used in conjunction with an offensive ventilation hole (heat hole), can help stop the horizontal spread of fire.

Reduces the Possibility of Flashover and Backdraft

Flashover:

Flashover is a condition where all the contents of a room are heated to their ignition temperature. Once their ignition temperature is reached, the entire room will quickly be involved in flames. Proper ventilation helps eliminate this condition because the heat is removed from the structure before the contents reach their ignition temperatures.

TYPES OF VENTILATION

Horizontal Ventilation

Horizontal ventilation is the systematic removal of heat, smoke, and fire gases through wall openings such as doors and windows. With horizontal ventilation, there are two methods usually performed, which are natural and positive pressure ventilation.

Natural ventilation is easily done by opening doors and windows and allowing the wind to ventilate the building. Natural ventilation is limited, due to the location of the fire in relation to the structure's openings and wind direction. Positive pressure ventilation is a method of forcing clean, fresh, pressurized air into a structure with blowers. By systematically opening doors and windows to channel the pressurized clean air, you can effectively ventilate smoke out of a structure.

Positive Pressure Ventilation

To ventilate the building, the door is opened, and a blower is positioned OUTSIDE the building as in *Figure 1*. This method will force clean, fresh, pressurized air inside the building and create a positive pressure (like blowing up a balloon) inside the building.

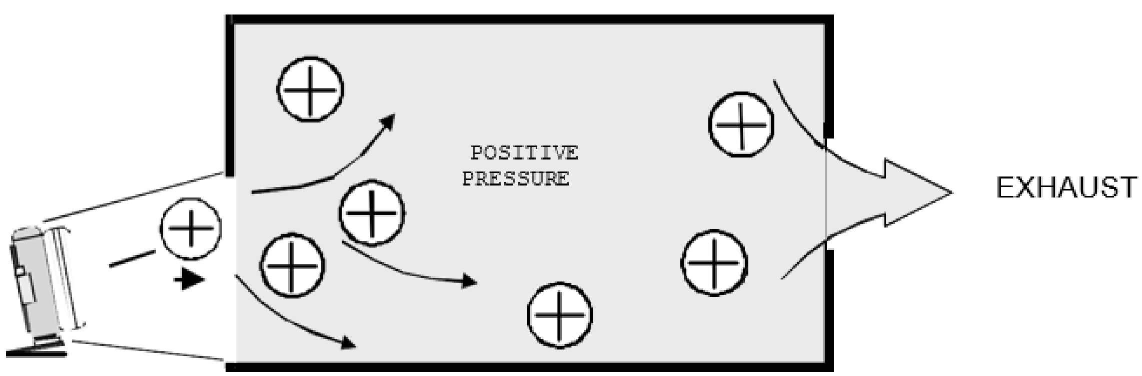

Figure 1 - Positive Pressure Ventilation with a Fan

The positive pressure will be equal at the top, bottom, and corners of the building common to the pressurized air. When the window is opened, the contaminants from ALL parts of the pressurized building will exhaust to the exterior (like piercing a hole in a blown-up balloon).

<u>Implementation of Positive Pressure Ventilation</u>

The effective implementation of positive pressure, as in *Figure 2*, is dependent on the entrance opening, airflow between openings, exhaust opening, weather, training, and communication.

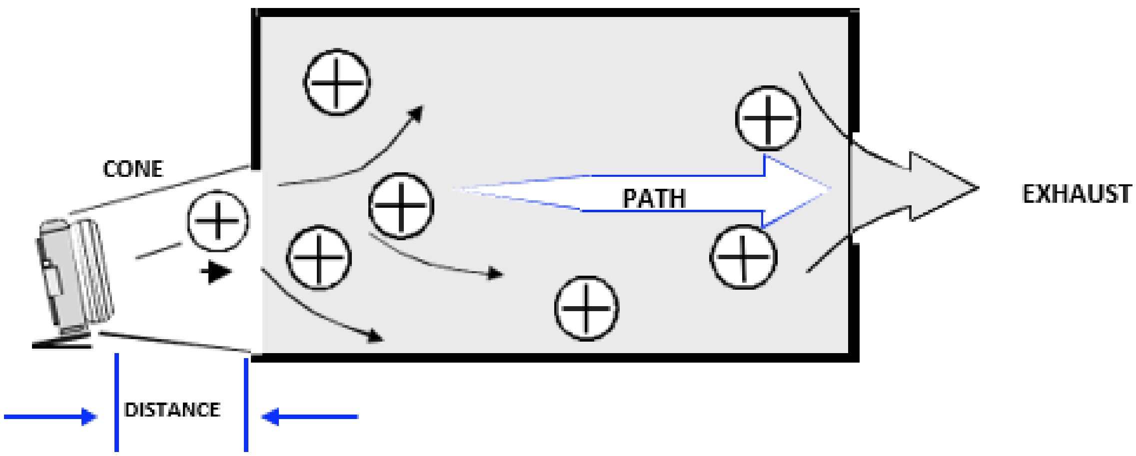

Figure 2 - Distance and flow path of Positive Pressure (Click Video Link)

Entrance Opening

Blowers must be positioned so the cone of air issued from a blower will completely cover the entrance opening to eliminate contaminants being forced back through the "unsealed portions" of the entrance opening and being reintroduced into the pressurized building. This is accomplished by varying the distance from the blower to the entrance opening.

Air Flow between Openings

It is imperative that the path of pressurized air between an entrance and exhaust opening be controlled to achieve maximum ventilation. When pressurized air is directed from an entrance opening to an appropriate exhaust opening -without being diverted to other openings- contaminants will be removed with the pressurized air in a minimal amount of time. Simultaneously opening multiple windows and/or doors will not facilitate a successful positive pressure ventilation operation.

Exhaust Opening

Exhaust openings can be selected to provide horizontal or vertical ventilation of contaminants. The location of the exhaust opening is dependent on the location of heat and smoke, and the prioritization of suppression operations (overhaul, search and rescue, extinguishment, etc.). The size of the exhaust opening is dependent on the size of the entrance opening, and capacity and number of blowers being utilized.

Positive pressure is most efficient when the exhaust opening (heat hole, window, door, etc.) is between three-fourths (3/4) to one and three-fourths (1 3/4) the size of the entrance opening. This variance is due to the number and cubic feet per minute rating (CFM) of blowers that are utilized. A single blower utilizes a smaller exhaust opening than multiple blowers in parallel or series configurations. Optimum efficiency is easily obtained by a combination of training and practical experience.

<u>Weather</u>

Wind can have an adverse effect on positive pressure ventilation, but its effect is dependent on direction and velocity. As in any ventilation operation, maximum efficiency can be obtained by utilizing the prevailing wind direction to an advantage (windward to leeward). It is most advantageous to pressurize the structure on the windward side and exhaust contaminants on the leeward side of the building. If it is not possible to utilize the prevailing wind as an advantage, positive pressure has proven effective against winds (leeward to windward) of up to 25 mph; efficiency will be reduced accordingly. Temperature, humidity, and rain do not have any appreciable effect on positive pressure ventilation. Although cold-damp weather conditions may limit the ability of smoke to rise, these atmospheric conditions will not limit the ability of blowers to move contaminants horizontally, and in most cases, vertically.

<u>Training and Communication</u>

The key to effective positive pressure ventilation is dependent on controlling the entrance opening, the path of the interior air flow, and the exhaust opening. These factors can only be maintained in their proper relationship if all personnel engaged in the ventilation operation have been properly trained and are aware of the goal of the intended operation. If personnel are not assigned specific tasks, they should not arbitrarily move and/or reposition blowers or alter exhaust openings.

Blower Placement

<u>Single Blower</u>

A single blower should be positioned so the cone of pressurized air JUST covers the entrance opening as in Figure *3*. If the blower is too close to the opening, the opening will not be completely covered by pressurized air. If the blower is too far from the opening, pressurized air will strike the area around the opening, reducing the amount of pressurized air being forced inside the building. Optimum placement is dependent on the size of the entrance opening and the CFM of the blower. These two factors will regulate the distance between the blower and the entrance opening. This operation can be enhanced by "tilting" a blower.

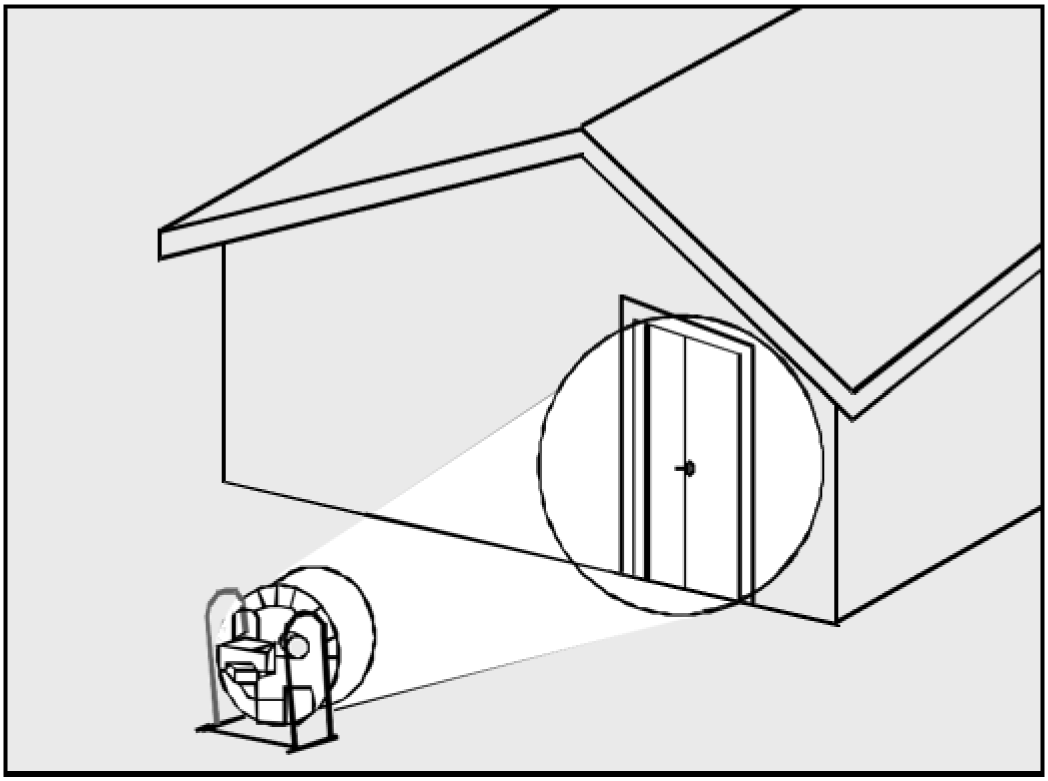

Figure 3 - Single Fan

Multiple Blowers

Multiple blowers can dramatically increase CFM when used in series or provide proper coverage of the opening when used in parallel. Multiple blowers can also reduce the time necessary to complete a ventilation operation.

In Series

For standard entrance openings maximum effectiveness is achieved by placing two blowers in series (in-line) with each other.

In Figure 4, Blower A is positioned about two feet from the entrance opening. This ensures that all the pressurized air from the blower enters the building yet allows sufficient room for ingress/egress of personnel. Blower B is positioned behind Blower A. The proper location for Blower B is determined by the distance necessary to cover the entrance opening with pressurized air.

Blower B is utilized to cover the entrance opening with pressurized air, force pressurized air into the building, and increase the capacity of blower A by approximately 10%.

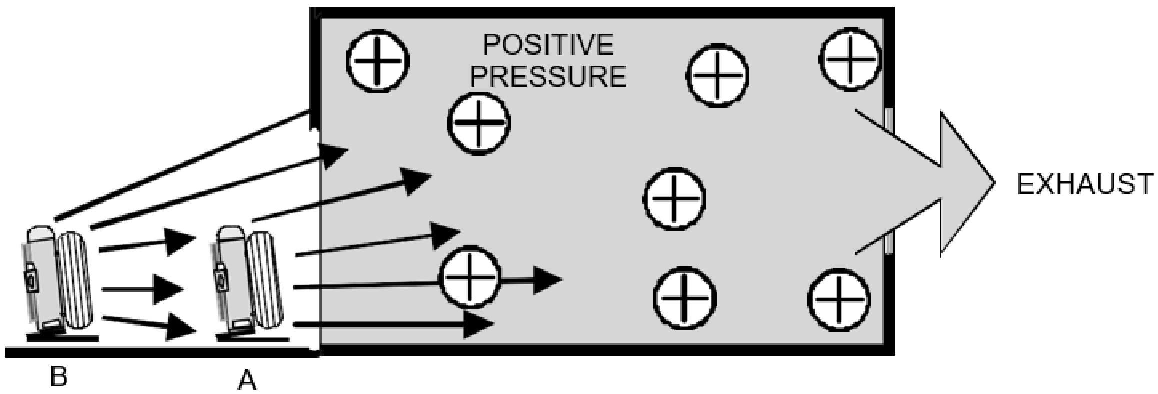

Figure 4 - Two Fans in a Series

If two blowers of unequal CFM are utilized in the series position, place the large blower about two feet back from the entrance opening and utilize the smaller blower behind the larger blower to cover the entrance opening with pressurized air. This configuration will utilize the larger blower to provide most of the pressurized air for the ventilation operation while the small blower covers the entrance opening and increases the efficiency of the larger blower.

If the area in front of an entrance opening is limited to three feet or four feet (i.e., raised porch), place the smaller blower in the entrance opening and the larger blower three to four feet back from the door. Use the larger cone of pressurized air to seal the entrance opening.

Parallel

For standard entrance openings, multiple blowers in a parallel (side-by-side) configuration are less effective than multiple blowers in a series configuration. However, for large entrance openings, multiple blowers in a parallel configuration (Figure 5) should be utilized due to their combined ability to cover the larger opening with pressurized air. The size of the opening will dictate the number of blowers that will be necessary to cover the opening with combined cones of pressurized air. Remember that some openings (i.e., Loading-dock doors) can be reduced in size by partially closing the door which will reduce the size of the entrance opening that must be covered by pressurized air. Depending on the number of blowers that are available, large areas may be effectively ventilated by utilizing a combination of parallel (proper coverage of the opening) and series (increased CFM) blowers.

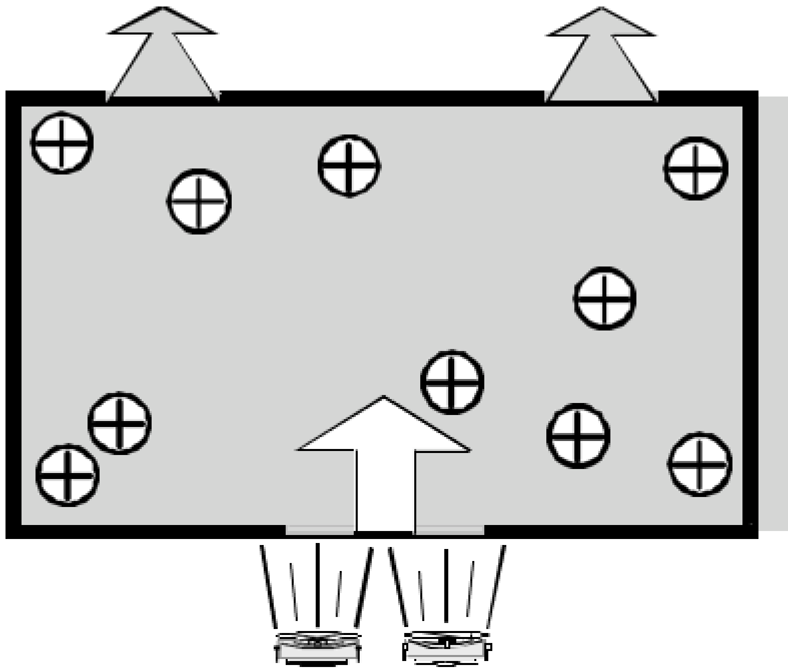

Figure 5 - Two Fans in Parallel

<u>Areas without Exhaust Openings</u>

Areas or locations that do not have an exhaust opening (storage rooms, offices, enclosed work areas, etc.) can be effectively ventilated by using multiple blowers.

In the photo above, Blower A (Figure 6) is positioned to provide a flow of air past the opening. This blower can be located outside the building to provide pressurized air to the interior of the building and past the area to be ventilated. Blower B is positioned in the bottom portion of the opening and will provide pressurized air that will create a positive pressure within the area to be ventilated and force the contaminants out of the upper portion of the entrance opening. The air flowing past the entrance opening will force the exhausting contaminants to follow its direction to the exterior of the building.

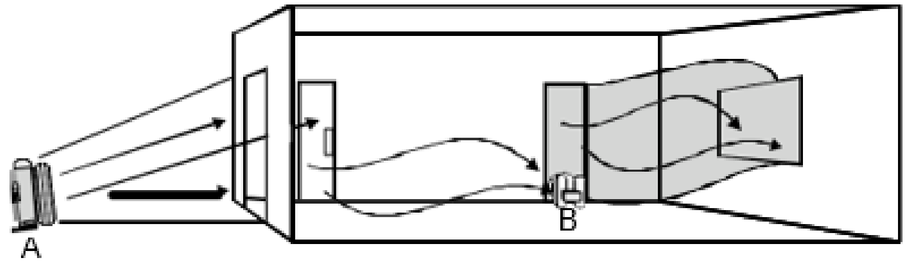

Figure 6 - Pressurizing The Space

If the flow of air past the opening is not sufficient, the exhausting contaminants from the area to be ventilated can circulate back into the blower in the bottom portion of the opening. To alleviate this condition, use an additional blower. Blower C (Figure 7) provides a sufficient flow of air past the exhausting contaminants and Blower B.

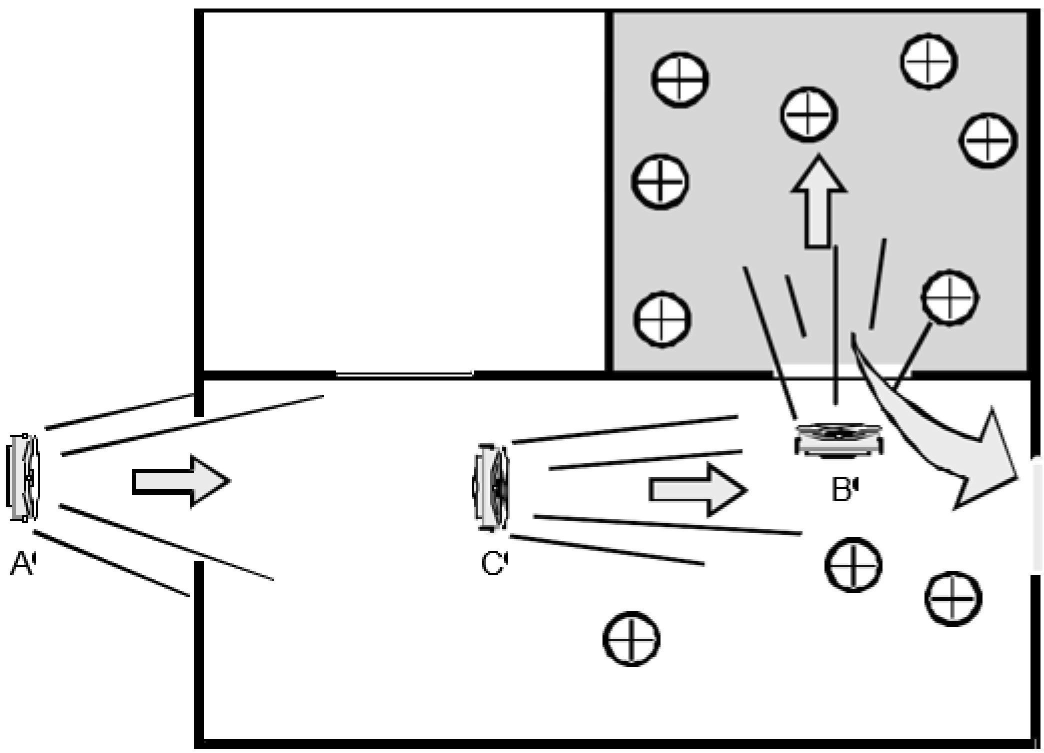

Figure 7 - Multiple Fans in Operation

Structural Considerations

Below ground areas should be treated as any other smoke removal problem with the following added considerations:

- Use of creative methods may be required to channel the smoke i.e., use of salvage covers, additional blowers, etc.

- The smoke that is exhausted from the below ground area in many cases will accumulate in the ground level floor (or higher) and will require evacuation from its new location.

- Removal of the smoke at or above ground level will be accomplished using standard positive pressure ventilation techniques.

Single Story

Effective ventilation requires SYSTEMATIC VENTILATION of contaminated areas within a building. This process will provide the maximum amount of pressurized air from a blower to ventilate each contaminated area within a building. This results in maximum efficiency and minimal time for ventilation. During positive pressure operations, do not "open the structure up". This will reduce the flow of air through each room and increase the time for ventilation.

Additionally, remember that removing screens on windows prior to using these openings for ventilation purposes will increase the efficiency of these openings by at least 50%. Assume that a kitchen fire, (Figure 8) has charged the dwelling with smoke. All doors and windows are closed, a blower has been positioned to cover the front door with pressurized air, and positive pressure would be utilized as follows:

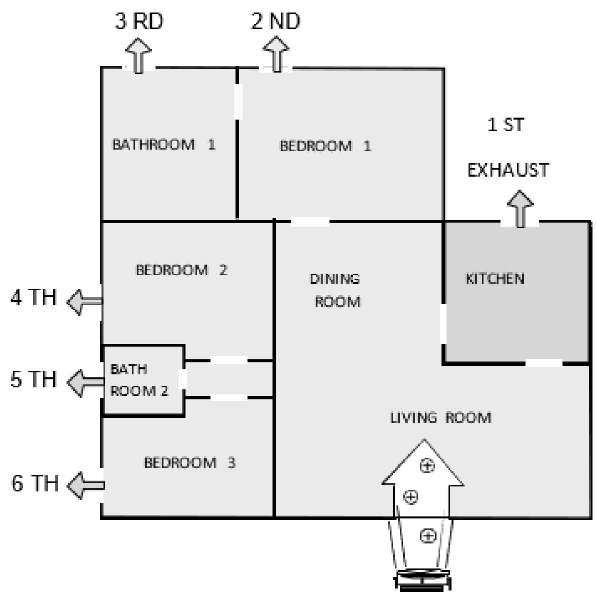

Figure 8 - Pressurizing multiple rooms

- To clear the kitchen, living room, and dining room: Open the exterior door in the kitchen and both interior doors to the kitchen. When these rooms have cleared, close the exterior kitchen door.

- To clear bedroom one: Open the bedroom door and window. When cleared, close the window and door.

- To clear bathroom one: Open the bathroom door and window. When cleared, close the door and window.

- To clear bedroom two: Open the bedroom door and window. When cleared, close the door and window.

- To clear bathroom two: Open the bathroom door and window. When cleared, close the door and window.

- To clear bedroom three: Open the bedroom door and window. When cleared, close the door and window.

Closing a door or window of an area will yield the same results. Additionally, an area that has open walls or ceilings (from a fire), or other large openings, can be isolated from a ventilation operation by closing an appropriate door if applicable. Remember that it is possible to ventilate several rooms at one time with multiple blowers.

Multiple Story

Assume a first-floor fire (Figure 9) has charged a multiple story dwelling with smoke.

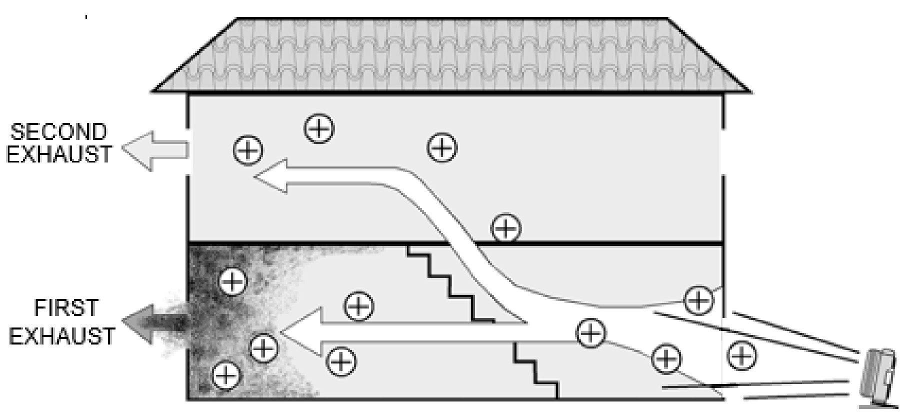

Figure 9 - Pressurizing Multiple Stories

To ventilate the first floor, ensure that all exterior windows on the upper floor are closed, or a stairwell door to the upper floor is closed (whichever is appropriate). Position a blower at an appropriate entrance opening and systematically ventilate the contaminated areas on the first floor of the structure. This will provide maximum pressurized air for ventilation on the first floor, and no flow of air on the second floor due to the lack of an exhaust opening.

To ventilate the second floor, leave the blower in the same position and ensure that all exterior windows and doors are closed on the first floor. If a stairwell door has been closed, open the door, and systematically ventilate the contaminated areas on the second floor.

Due to the lack of an exhaust opening on the first floor, pressurized air from the blower will pressurize the first and second floor but will only create a flow of air on the second floor due to its exhaust openings.

Multi-Family Buildings

These types of buildings generally have multiple floors, and enclosed central hallways that provide access to numerous rooms within the building. The hallways may be of considerable length and may incorporate self-closing doors at various intervals within the hallways. If self-closing doors are present, they may be opened to allow pressurized air to travel to a specific location, or they may be closed to compartmentalize specific sections of a building. This may be useful to keep contaminants from spreading to uncontaminated areas, or to divert pressurized air to a specific area.

Multi-family occupancies can be effectively ventilated with positive pressure by:

First: pressurizing appropriate stairways and hallways.

Second: ventilating contaminated rooms or other areas that are common to a pressurized hallway dependent on the location of the most heat and smoke, and the prioritization of suppression operations (overhaul, search and rescue, extinguishment, etc.).

Assume a third floor, rear apartment fire (Figure 10) has charged the third floor with smoke. The building has an enclosed stairwell that is common to each floor, and self-closing doors separating each floor from the stairwell.

Figure 10 - Pressurizing Multi Story, Multi Family

Position the blowers outside the building, covering the entrance of the stairwell that will be pressurized. Open the third-floor hallway door to the stairwell that is being pressurized with air from the blowers and ensure that the self-closing doors to the first and second floors are closed. By opening the door to the involved apartment, the stairwell, the third-floor hallway, and the involved apartment will be pressurized.

Horizontal and/or vertical exhaust openings can be used in the involved apartment. The hallway and apartment will be cleared of all contaminants. This is most effectively accomplished by opening a patio sliding glass door, large window, or using a room with the greatest number of windows as the initial exhaust opening. When the hallway and that portion of the apartment utilized as an exhaust opening is cleared, systematically ventilate the other portions of the apartment.

Depending on the floor plan of a building and the location of the fire, opposing blowers as illustrated in Figure 11 can be effectively utilized to remove the contaminants in a hallway and an apartment. Blowers of unequal ratings or equal ratings can be effectively utilized for this ventilation operation.

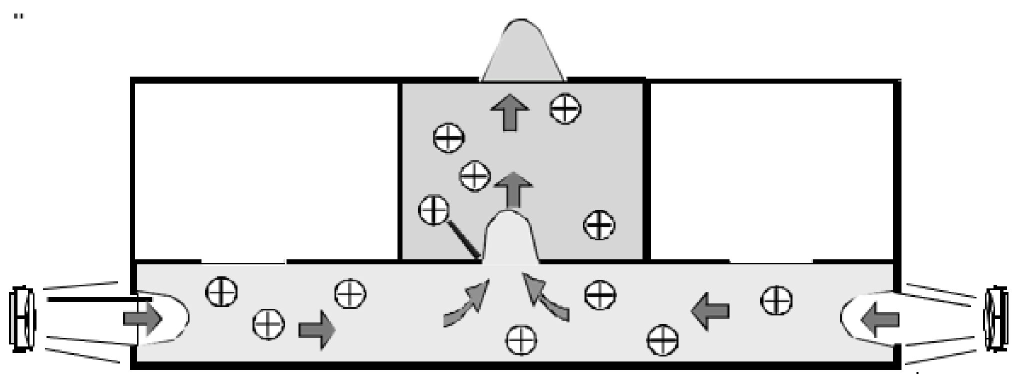

Figure 11 - Pressuring a Center Hall

A multi-family occupancy that may need creative techniques is two story center hallway apartments. These buildings do not utilize self-closing doors which result in vertical openings between the first and second floor hallways. Depending on the location of smoke in the hallways, normal positive pressure operations may cause the smoke to circulate between the first and second floor hallways before exiting the building.

To alleviate this condition, use two blowers as illustrated in Figure 12. This placement of multiple blowers will enhance the pressurization and EQUAL flow of air on each floor. The removal of smoke can be accomplished as follows:

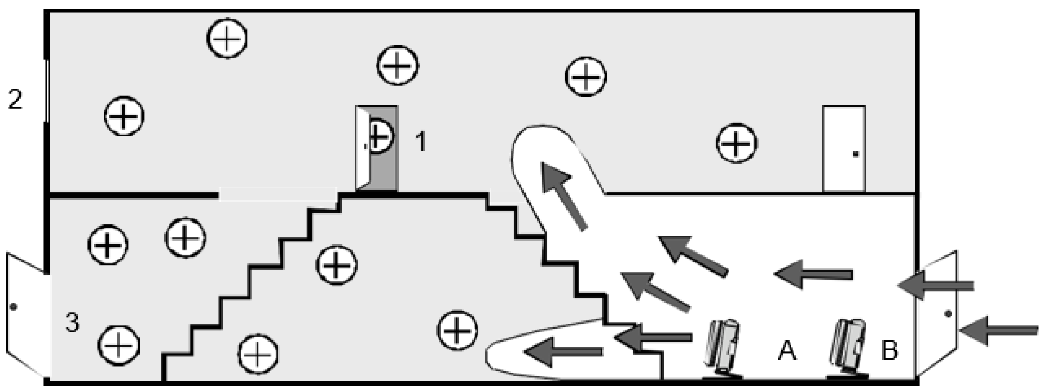

Figure 12 - Multi-Story, Multi-Family Several Fans

NOTE: For this operation Blower B can be placed just inside the door (Figure 12) or outside the door (as per standard practice).

- Involved apartment (Door 1) used as an exhaust opening.
- Second floor window (Window 2) used as an exhaust opening.
- First floor hallway door (Door 3) used as an exhaust opening.

Commercial Buildings

Commercial buildings vary in their size, height, and use. However, the following factors should be applied when considering ventilation operations for these types of buildings.

Depending on the size of the structure, some commercial occupancies such as warehouses and manufacturing occupancies offer large open areas that are normally difficult to ventilate. These occupancies require a combination of blowers that can provide adequate CFM for the area to be ventilated and an understanding of positive pressure principles.

When possible, large areas of a building should be divided into smaller areas by closing partition doors, rolling, or sliding fire doors, etc., and then systematically ventilating each contaminated area. Large structures that are comprised of smaller areas such as stock rooms, workstations, offices, etc., should be ventilated by using systematic ventilation techniques in a pre-planned, coordinated operation.

When large ventilators, removed skylights, or ventilation openings in a roof (heat holes and strips) will negatively affect positive pressure operations, use these openings as vertical exhaust openings. Openings such as doors and windows that are below these exhaust openings must be closed to ensure the flow of pressurized air is maximized and directed to vertical exhaust openings.

Operational Guidelines

Depending on the type of building, determine the effectiveness of removing contaminants horizontally or vertically. Include heat holes and strips when evaluating exhaust openings. Additionally, determine the path that pressurized air must travel to remove contaminants within the building. Consider where the most heat and smoke is in relationship to the location of the exhaust opening.

It may be necessary to pressurize vertical stairwells to horizontally ventilate upper floors of a multi-story building. If possible, reduce large areas into smaller areas and ventilate systematically.

Large structures or large areas within structures require increased CFM to remove large quantities of contaminants. Consider the use of larger blowers for these applications. Multiple blowers in series will also provide additional CFM and enhance the removal of contaminants. Multiple blowers in parallel will provide proper coverage for large entrance openings. Various types of large doors can be partially closed to facilitate the pressurization of an entrance opening. Also consider the Mobile Ventilation Unit (MVU) for large commercial structures.

Multiple Floors

Buildings with multiple floors can be ventilated by systematically ventilating each floor, as in Figure 13. Start where there is the most heat and smoke. This will most likely be the fire floor due to self-closing doors; it could also be the top floor where heat and smoke will have mushroomed because the self-closing doors did not close.

Stairwells can be used to channel pressurized air to each floor, as necessary. Position blowers(s) on the exterior of the building and pressurize the opening to the stairwell that is common to the contaminated floors. Systematically ventilate each floor by opening a door to the pressurized stairwell and an appropriate window as an exhaust opening.

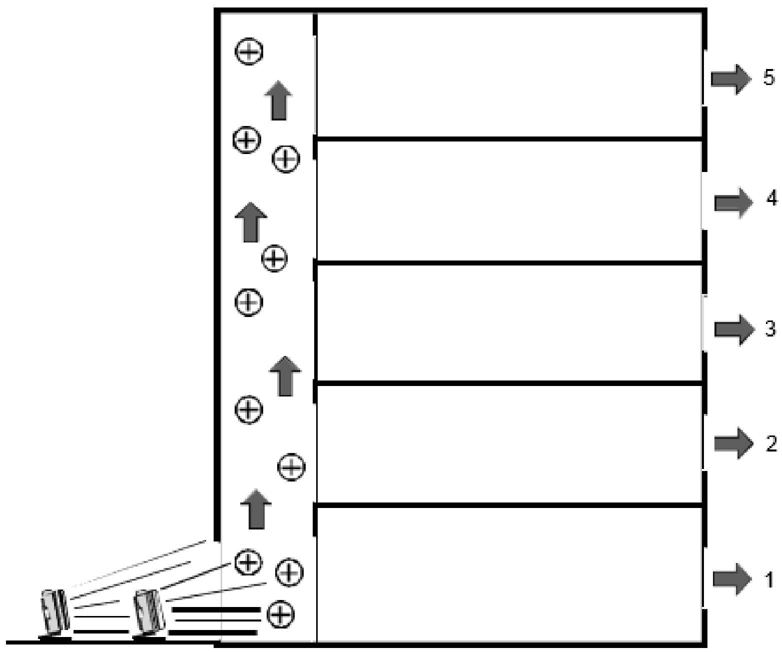

Figure 13 - Multi Story, Pressurizing the stairwell

Mobile Ventilation Unit

The MVU will produce considerably more CFM and should be considered for tunnels, high rise buildings, large underground parking structures, and very large commercial buildings.

NOTE: Positive pressure ventilation should never be utilized in place of a Self-Contained Breathing Apparatus (SCBA). SCBA should ALWAYS be used when personnel encounter hazardous atmospheres.

Vertical Ventilation

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. To open a roof properly and safely, you must have a good working knowledge of building construction.

The key to safe and effective roof ventilation is the knowledge of rafter type and rafter direction.

Rafter Type and Direction

- To cut a roof safely and effectively, you must know how it is built. Rafter type is very important to know. With older conventional construction, rafters are made from solid pieces of lumber. Roofs built with conventional construction will usually withstand fire for a much greater length of time than lightweight truss construction, resulting in a safer roof to operate on. With conventional construction, if time and safety permits, the roof team "WILL" cut the heat hole directly over the fire.

- When exposed to fire, roofs built with lightweight truss construction will fail at a very fast rate, resulting in a significantly reduced time for the roof team to operate.

- When operating on a lightweight truss roof (or suspected lightweight truss), the ventilation team shall never conduct ventilation operations directly over the fire.

- Members should employ the practice of "trading space for time" so that they may complete their roof-cutting operation prior to the fire impinging on a given ventilation hole.

- Rafter direction is important to know because we usually cut 1" x 4" and 1" x 6" sheathing parallel to rafters. On roofs sheathed with plywood, the "Head Cut" is made perpendicular to rafters. You need to know rafter direction to accomplish any Heat Hole or Strip Ventilation Hole.

- There are basically only TWO (2) types of ventilation holes:
    - Heat Hole (Offensive)
    - Strip Ventilation (Defensive).

Heat Hole (Offensive)

A heat hole is a hole placed directly over the fire or as close to the fire as safety will allow. A properly placed heat hole saves lives and will allow firefighter access by reducing heat, smoke, and fire gases inside the structure. A heat hole will also reduce the possibility of backdraft and flashover and will slow down the horizontal spread of fire.

Trench Cut Ventilation (Strip Cut 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. Strip ventilation helps to stop the horizontal spread of fire. Strip ventilation must be done in conjunction with a heat hole and hose lines in advance of the fire front. 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.

CUTTING TECHNIQUES

The following techniques are meant to be the foundation for roof operations. Ventilation crews should be ready to change techniques "on the fly". The roof's construction may be different than expected or the situation may become more complex. The ventilation team leader should be monitoring the team's progress and be prepared to abandon the task based on his team's experience, the roof's complexity, changing fire behavior, and time.

The following techniques can be adopted by crews to perform the task safely and efficiently. It is highly recommended that crews train on the different techniques and adapt them to their experience levels.

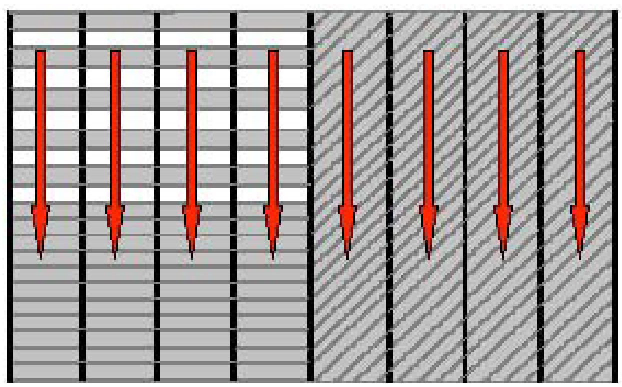

Figure 14 - Dicing

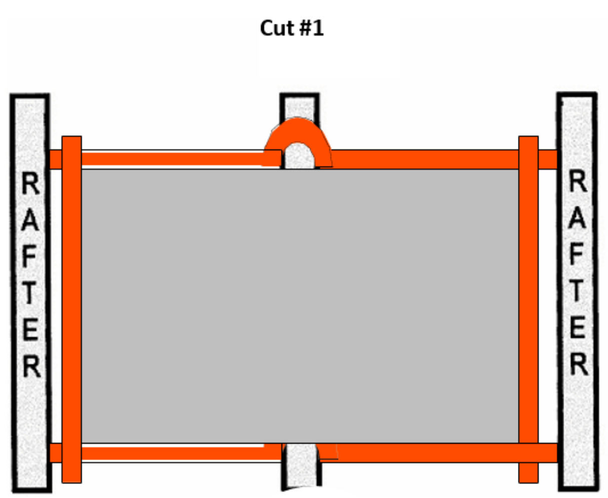

Figure 15 - Center Rafter Louver "5-Cut"

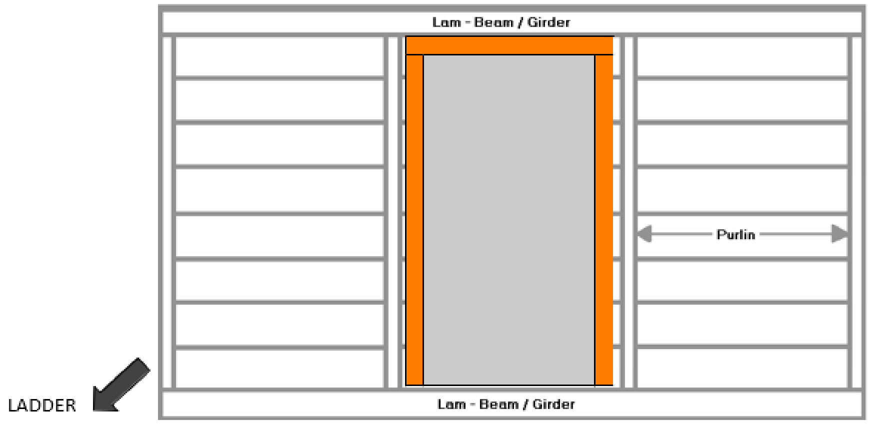

Figure 16 - Panelized

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.

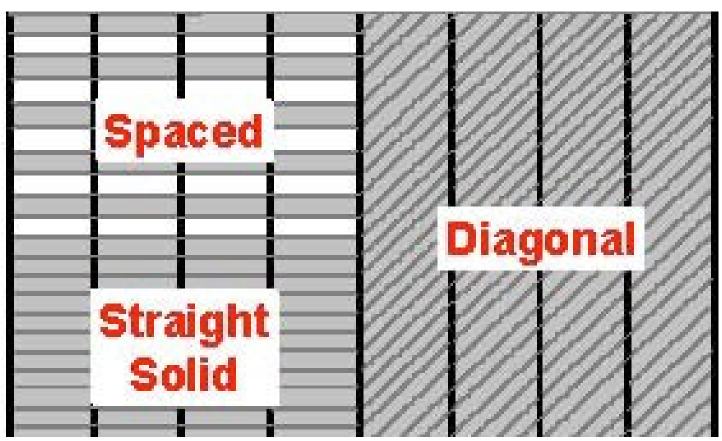

Figure 17 - Roof Sheathing Consisting of 1x4 or 1x6 slats

Dicing does not require the cutter to know the exact location of the rafters. Rafter type and direction are all that is required to be known. Rafter type and direction has already been determined with diagnostic tools (plug cut, 45-degree inspection cut, sounding, etc.).

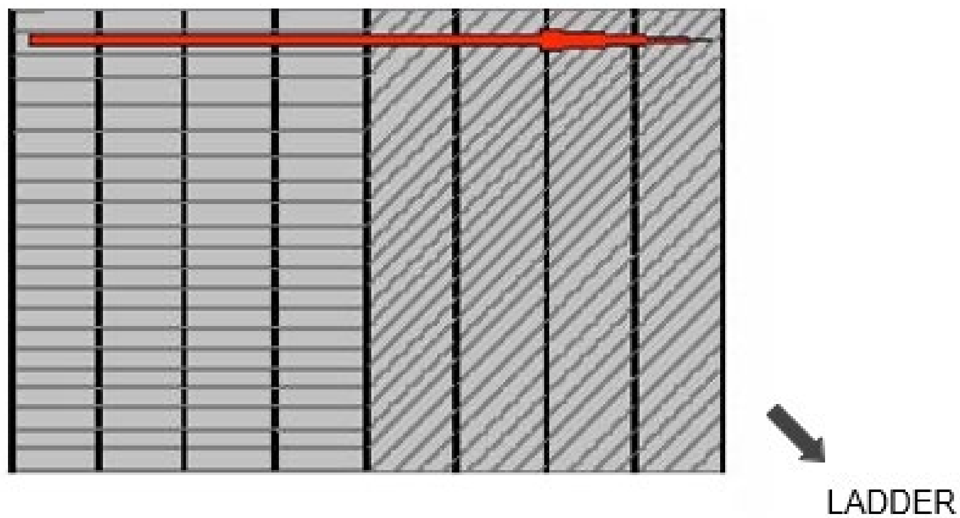

Figure 18 - Head Cut for Dicing

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 if the intended ventilation hole.

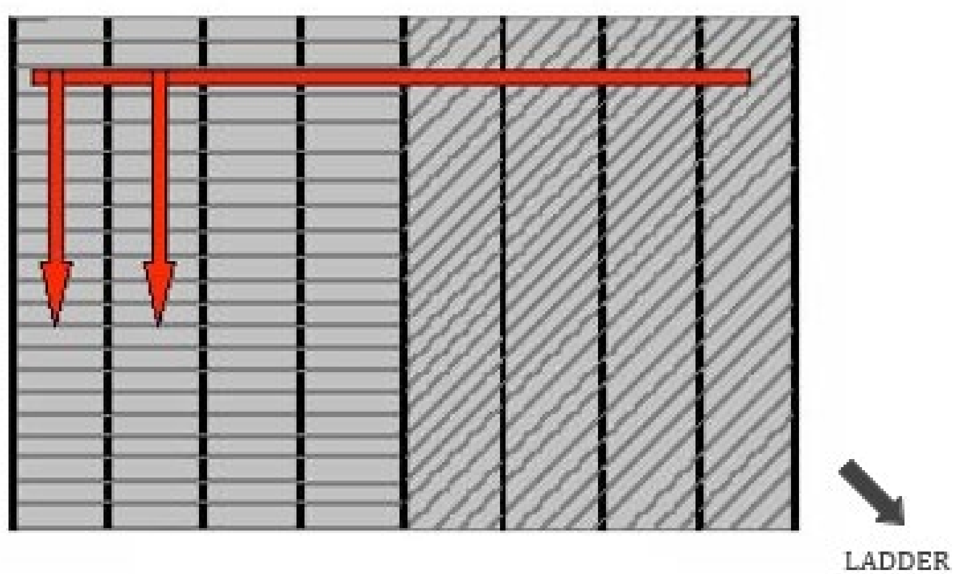

Figure 19 - Vertical Cuts

If needed, make a score cut or head cut first. 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; “Do Not” 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 too 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).

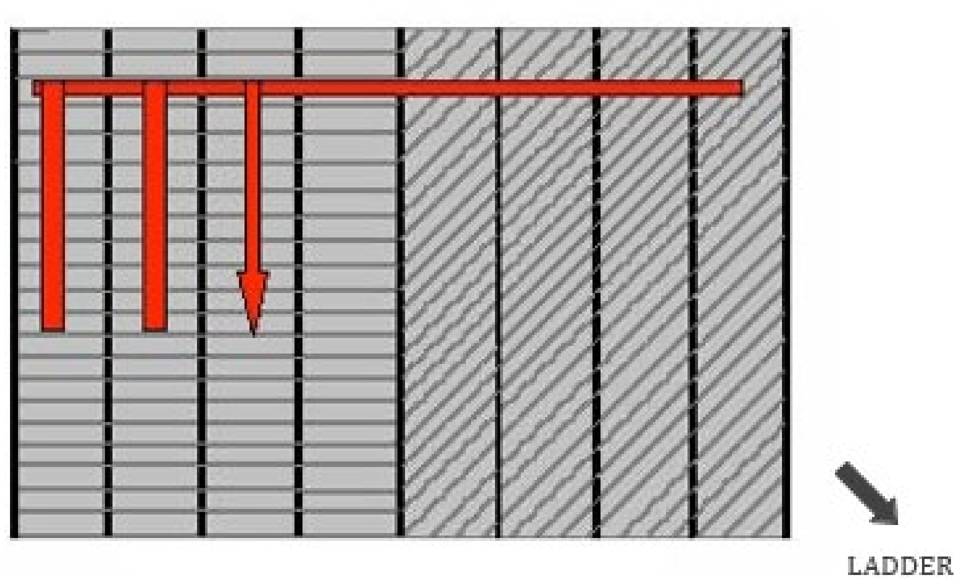

Figure 20 - Second Set of Vertical Cuts

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

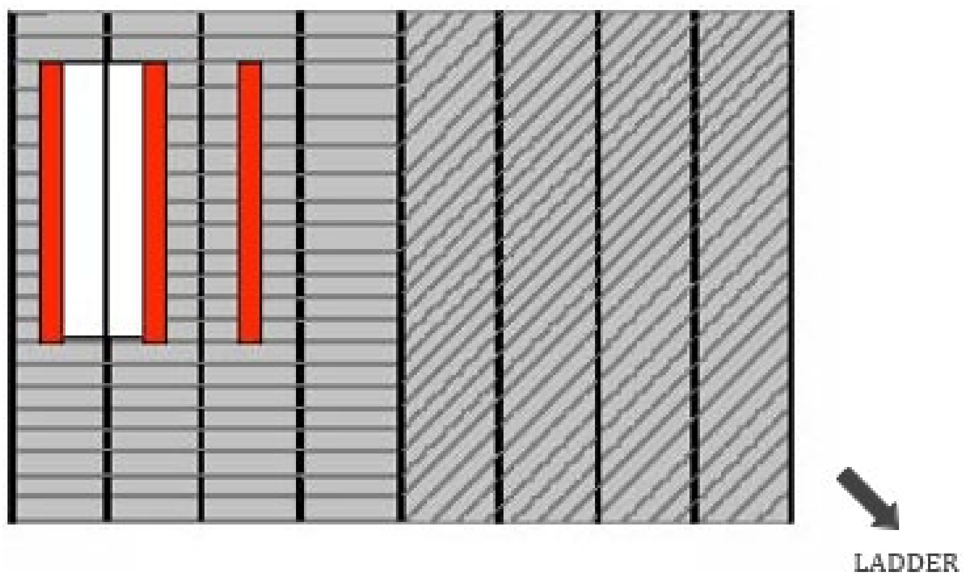

Figure 21 - Pull Cut slat from Cut #1

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

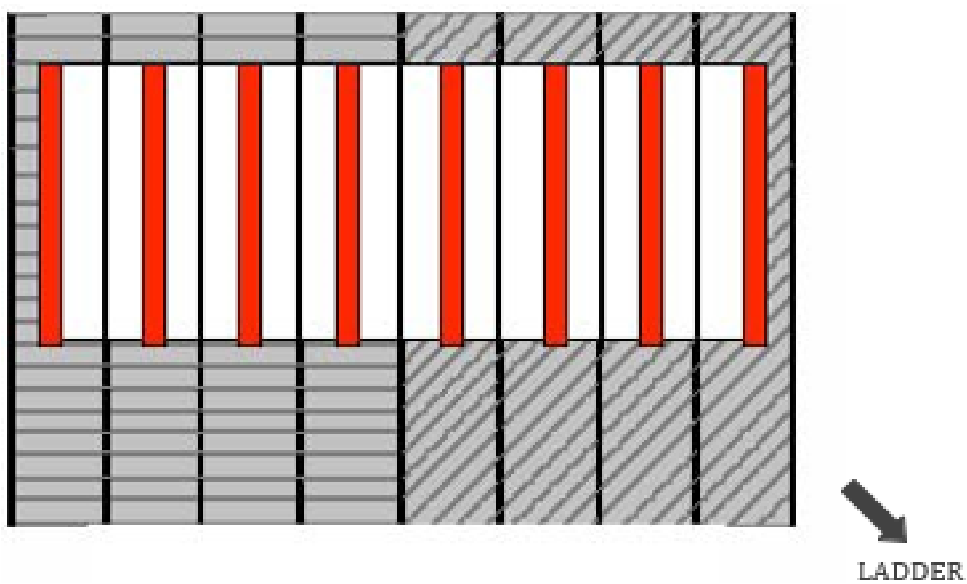

Figure 22 - Completed Dicing Operation

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.

Center Rafter Louver Cutting Techniques

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 are determined using diagnostic tools (plug cut, 45-degree inspection cut, sounding, etc.). When you are over the ventilation area, make a head cut to locate a minimum of three rafters.

FRESNO FIVE CUT (Louver Against Construction)

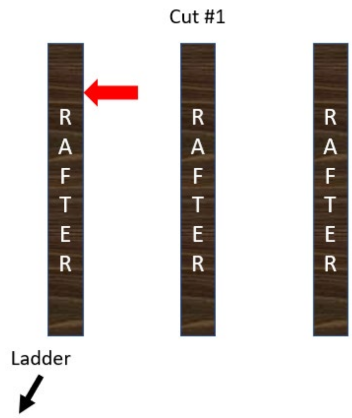

Figure 23 - Cut #1 Identification Cut

The head cut is started by first identifying your "inside" rafter. Do this with either a left-handed back cut or with the top of the bar. (**Click Video Link**)

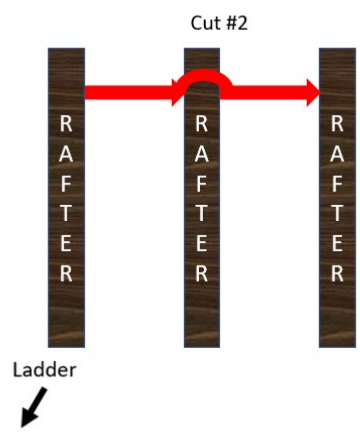

Figure 24 - Cut #2 Head Cut

Reverse directions and cut away towards the outside rafter. Roll the second "center" rafter and stop at the third "outside" rafter.

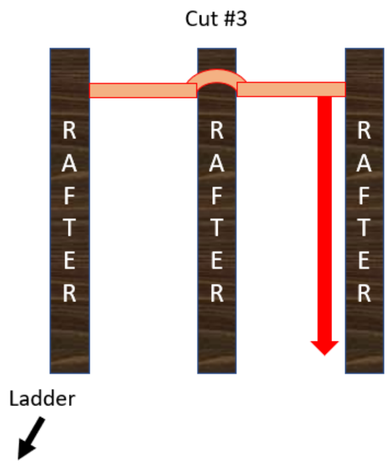

Figure 25 – Cut #3 First Vertical Cut

At 2" inside of the outside rafter, make a 4ft vertical cut down from the top cut.

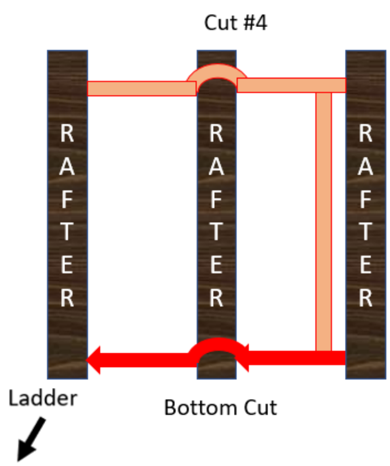

Figure 26 - Cut #4 Bottom Cut

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.

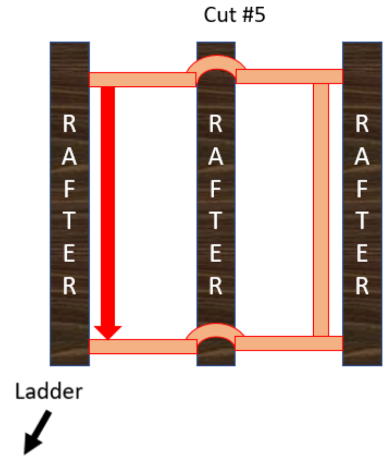

Figure 27 - Cut #5 Vertical Cut to complete Hole

Make a parallel cut approximately 2 inches inside the "inside" rafter and then louver section.

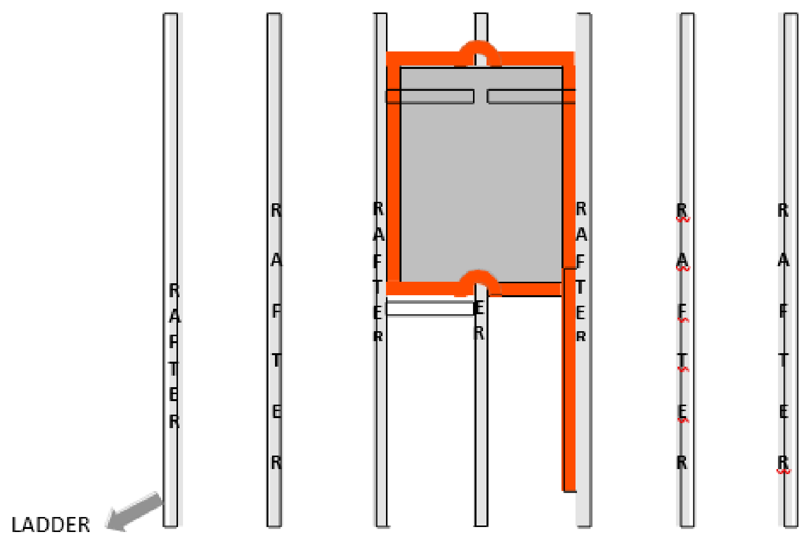

Figure 28 - Center Louver Extended with Construction. Cut #1 Extend Vertical Cut

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

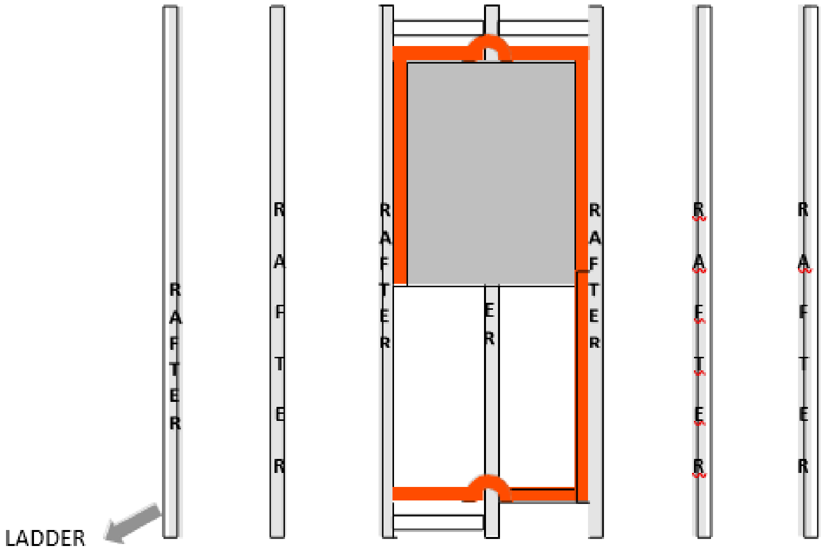

Figure 29 - Cut #2 Bottom Cut

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

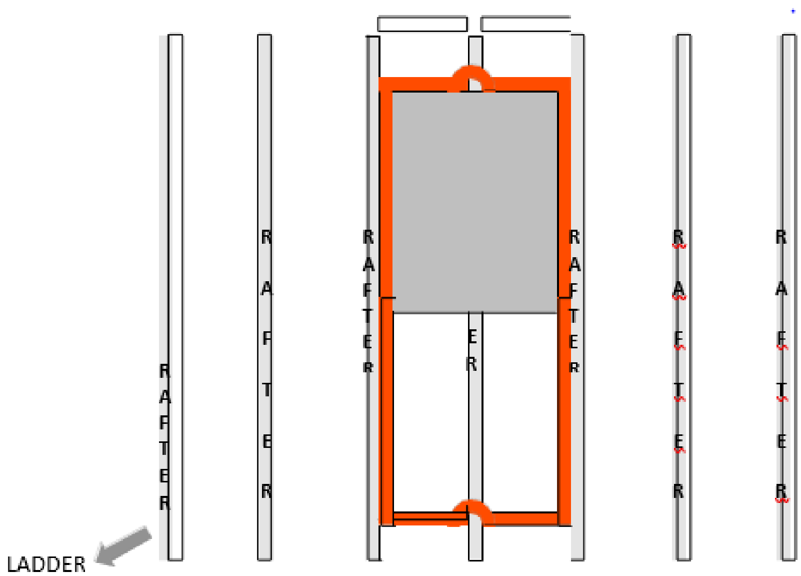

Figure 30 - Cut #3 Last Vertical Cut to Connect the Second Hole

Make a parallel cut approximately 2 to 3 inches inside the third "inside" rafter.

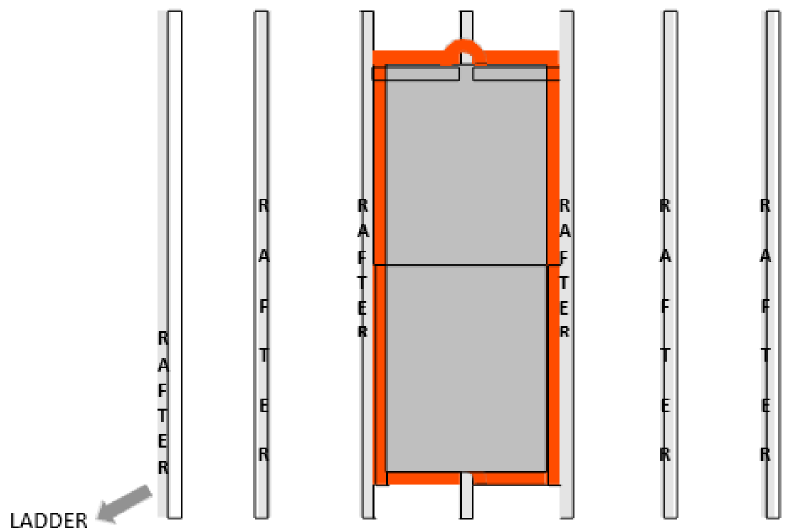

Figure 31 - Center Louver Extended with Construction

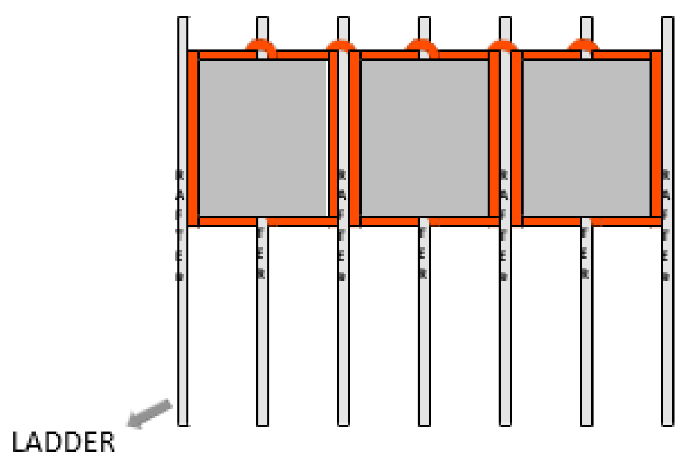

Figure 32 - Center Louver Extended Against Construction

Panelized Roof Cutting Techniques

<u>Pull Back Method (Offensive)</u>

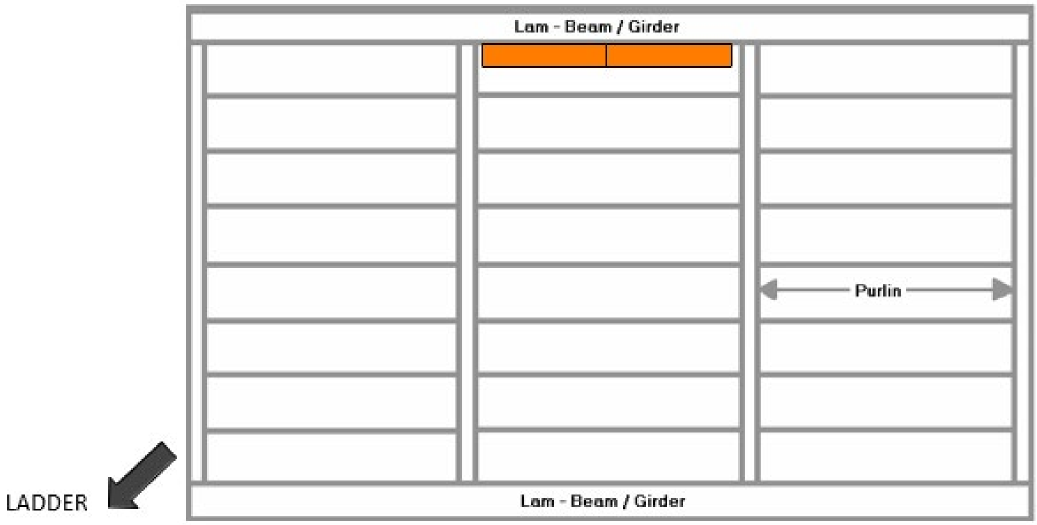

Figure 33 - Pull Back Method, Head Cut

Standing on purlins, the first cut is made parallel to lam-beam, stopping at purlins.

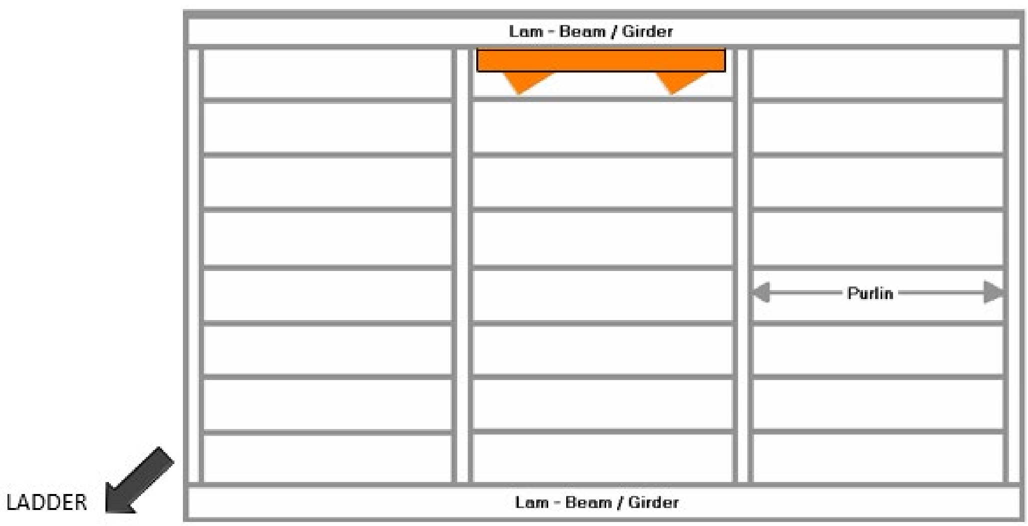

Figure 34 - Use Hooks Prior to Continuing Cut to Prevent Panel from Falling In

Cut small triangles through roof decking. Insert rubbish hooks into triangles. Rubbish hooks are used to pull back roofing and decking materials.

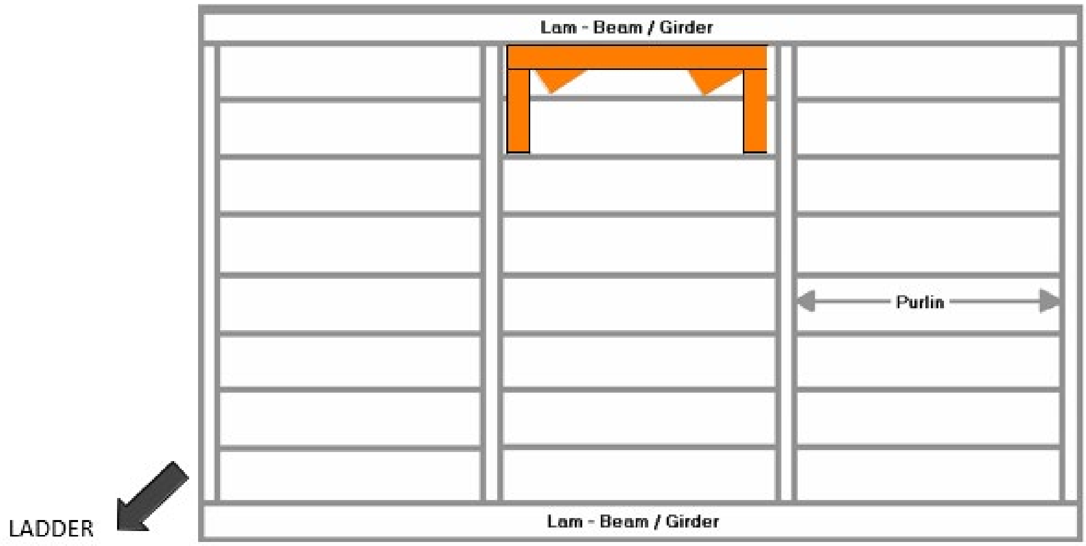

Figure 35 - Panelized Pull Back

Cut completely through the first rafter and stop at the second rafter.

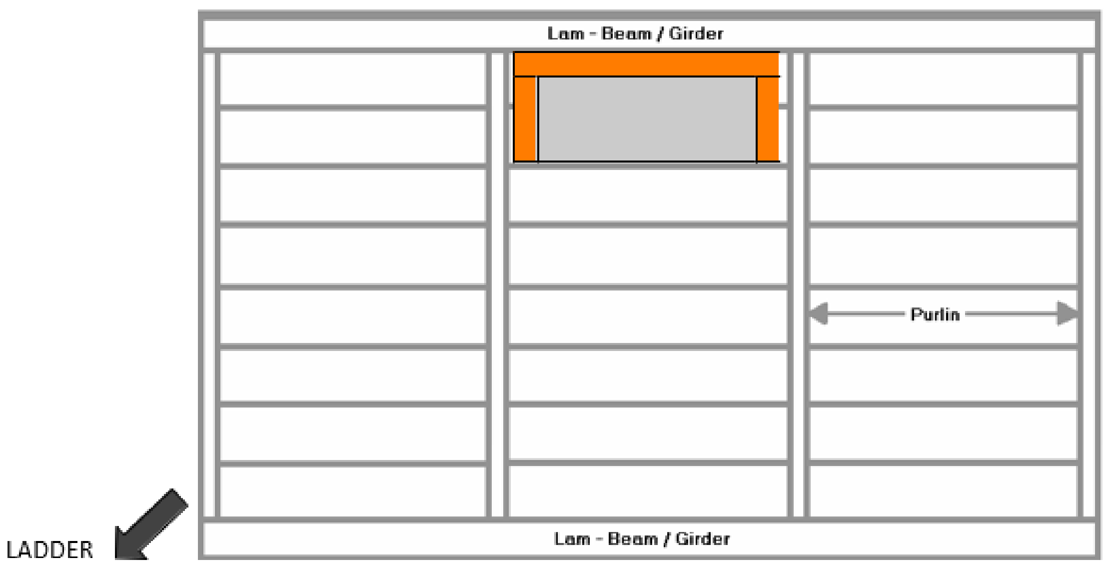

Figure 36 - Panelized Roof Cut

Pullers pull back 4' x 8' panel with rubbish hooks. Panel will break at plywood seam.

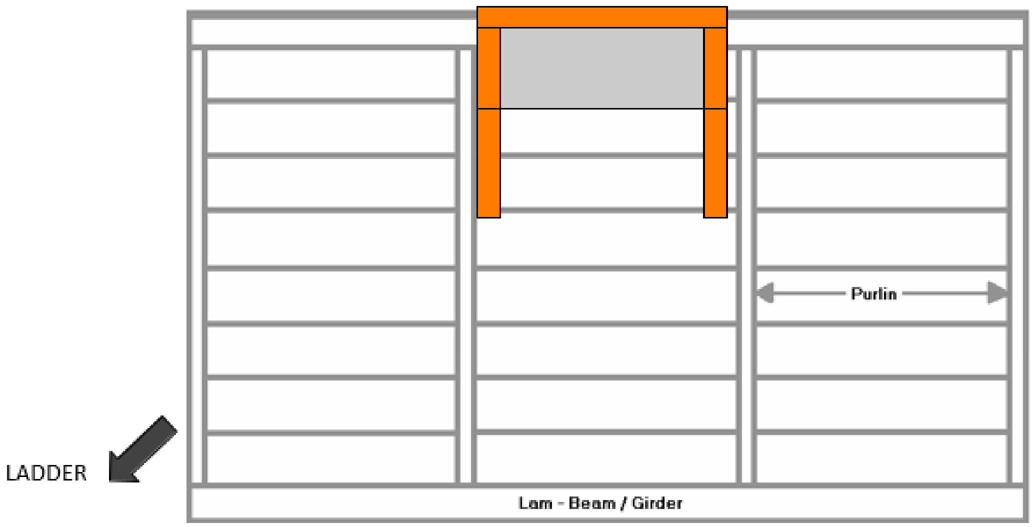

Figure 37 - Panelized Roof Extended with Construction

Pullers insert rubbish hooks over exposed rafter. Cutters cut completely through two rafters. Stop at third rafter.

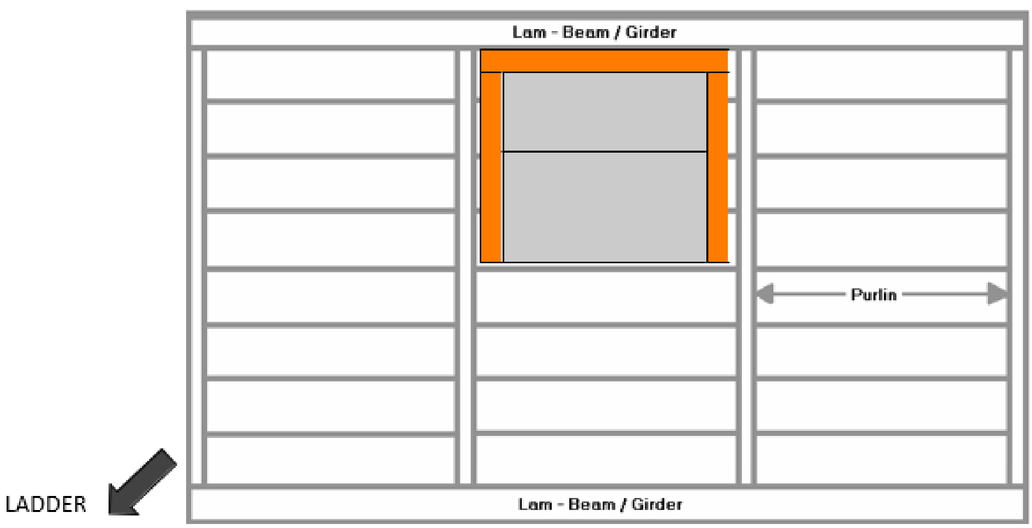

Figure 38 - Panelized Extended with Construction

Pullers pull back 4' x 8' panel with rubbish hooks. Panel will break at plywood seam.

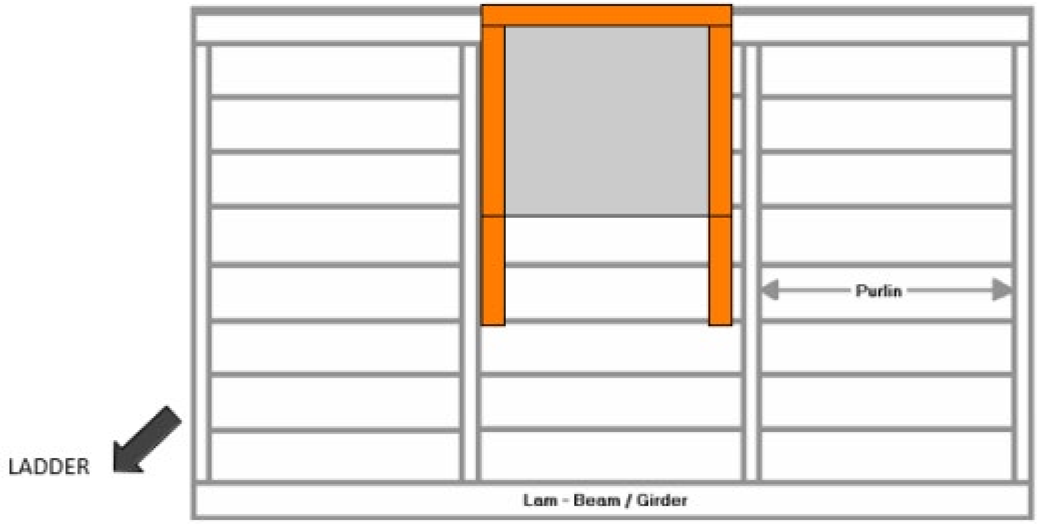

Figure 39 - Panelized Extended with Construction

Pullers insert rubbish hooks over exposed rafter. Cutters cut completely through two rafters. Stop at third rafter.

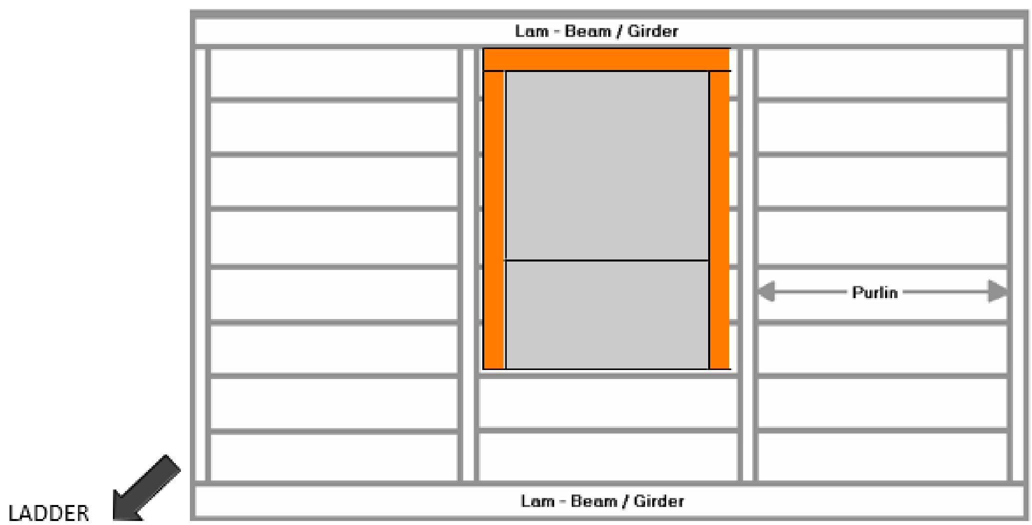

Figure 40 - Panelized Extended with Construction

Pullers pull back 4’ x 8’ panel with rubbish hooks. Panel will break at plywood seam.

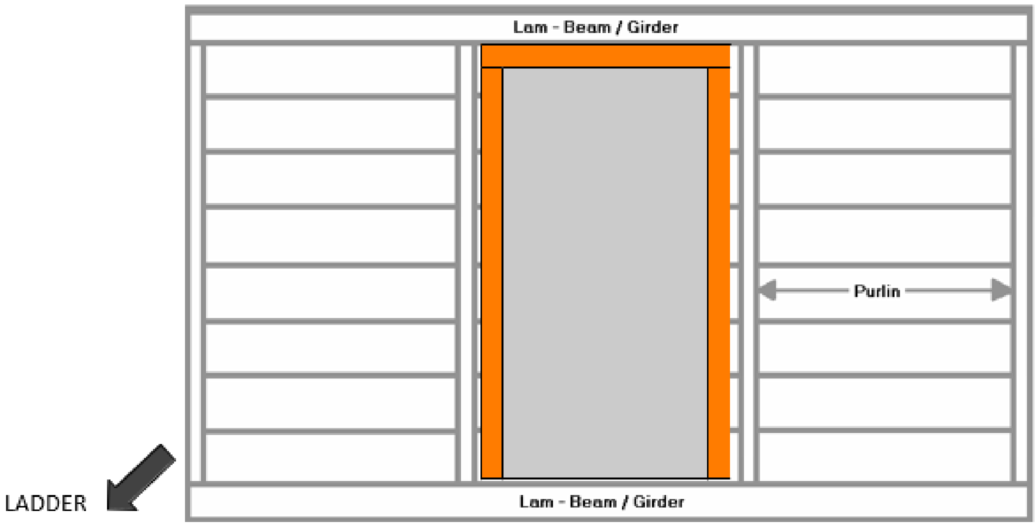

Figure 41 - Panelized Extended with Construction

Complete pull back from lam-beam to lam-beam.

<u>Offensive Louver</u>

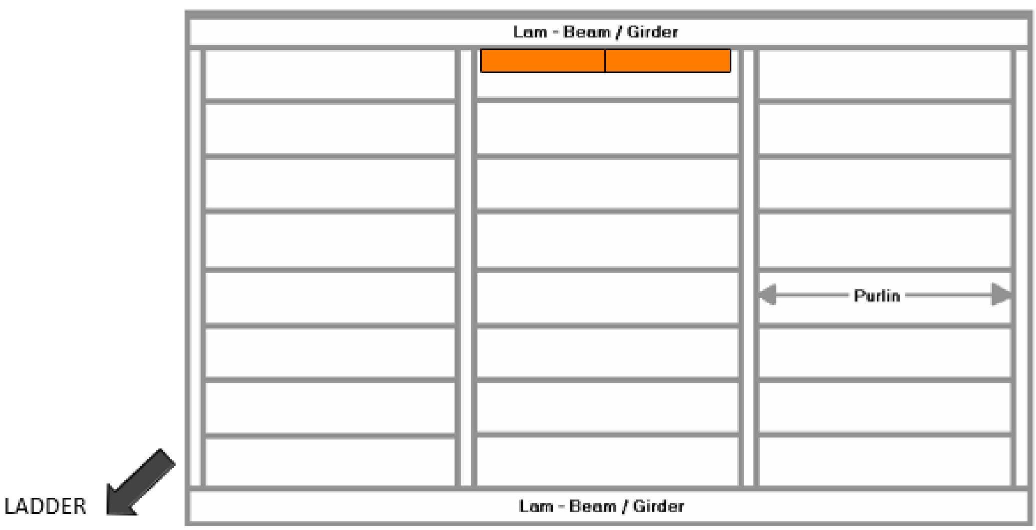

Figure 42 - Offensive Louver from Purlins

While standing on purlins, the first cut is made parallel to lam-beam, stopping at purlins.

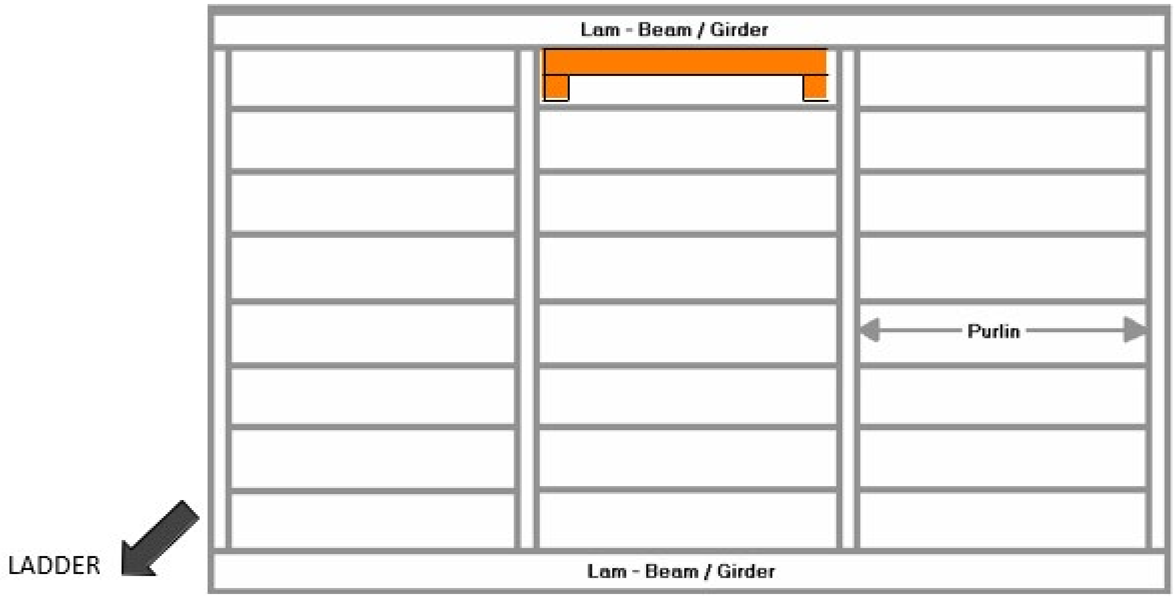

Figure 43 - Offensive Louver from Purlins

Cut parallel to purlins; locate center rafter.

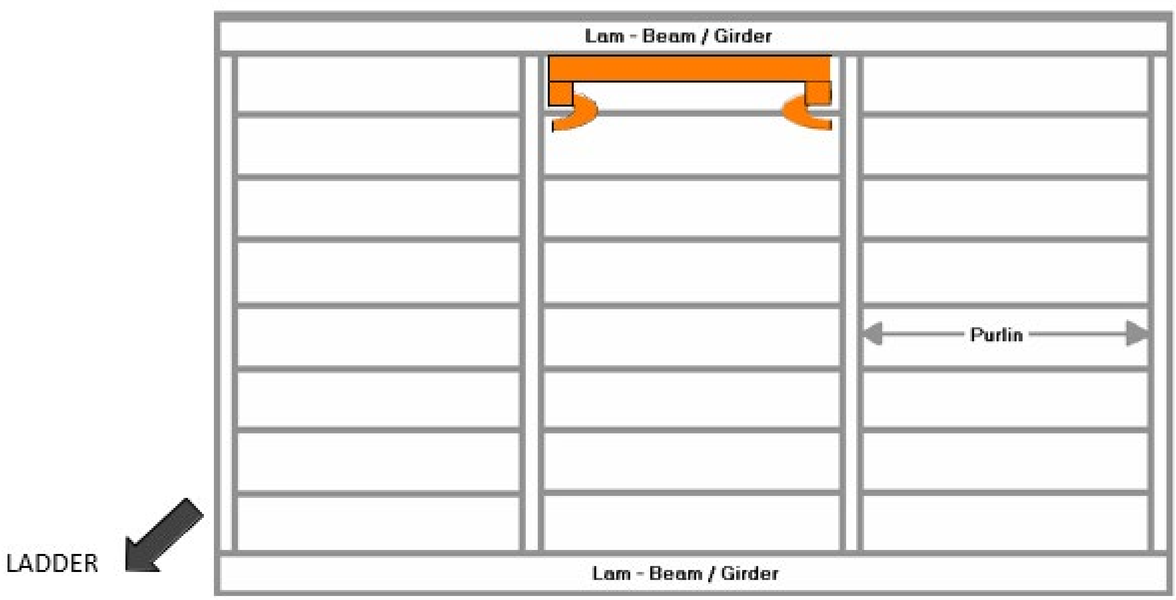

Figure 44 - Offensive Louver from Purlins

Roll center rafter.

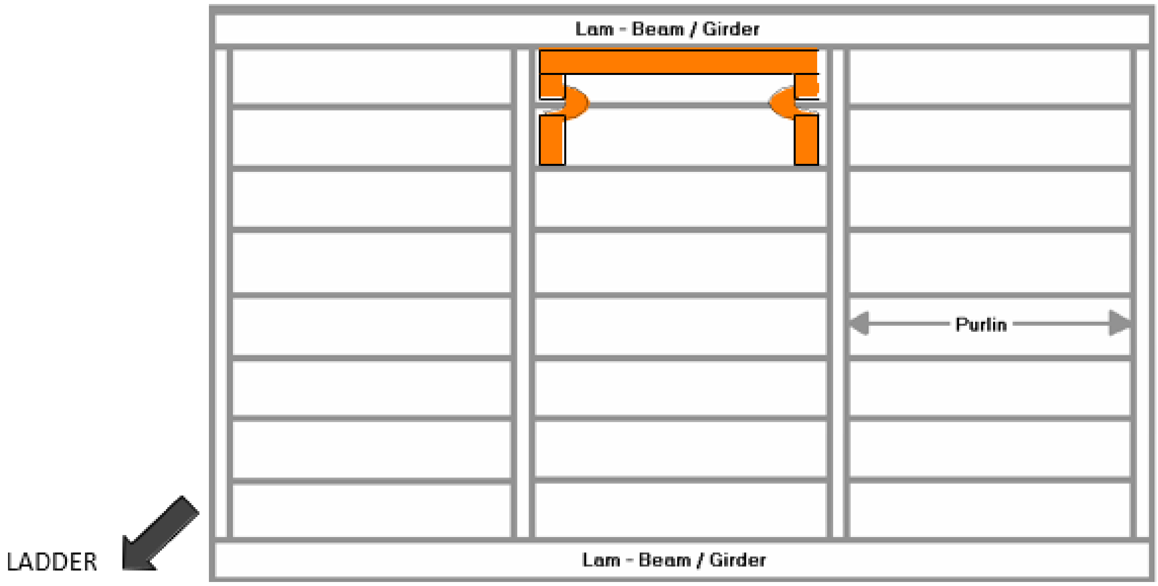

Figure 45 - Offensive Louver from Purlins

Stop at third rafter.

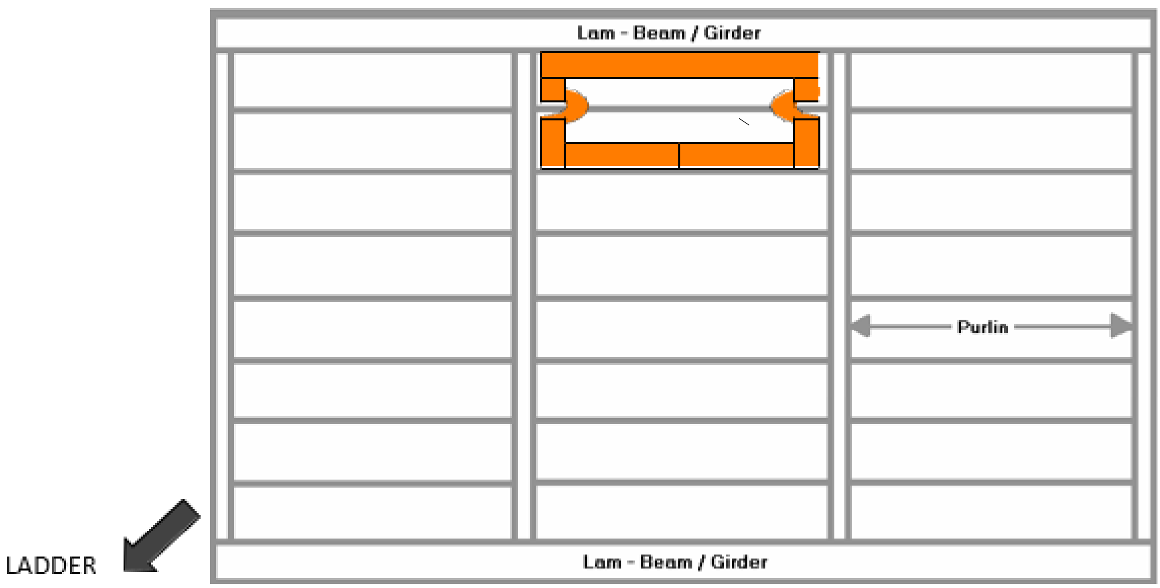

Figure 46 - Offensive Louver from Purlins

Cut inside of third rafter.

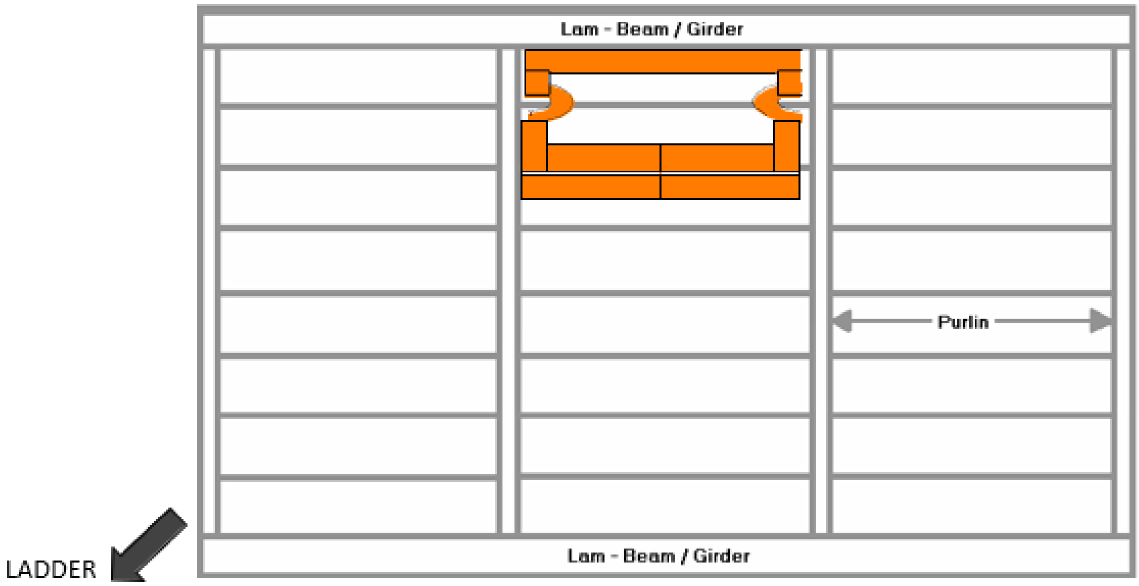

Figure 47 - Offensive Louver from Purlins

Cut outside of third rafter.

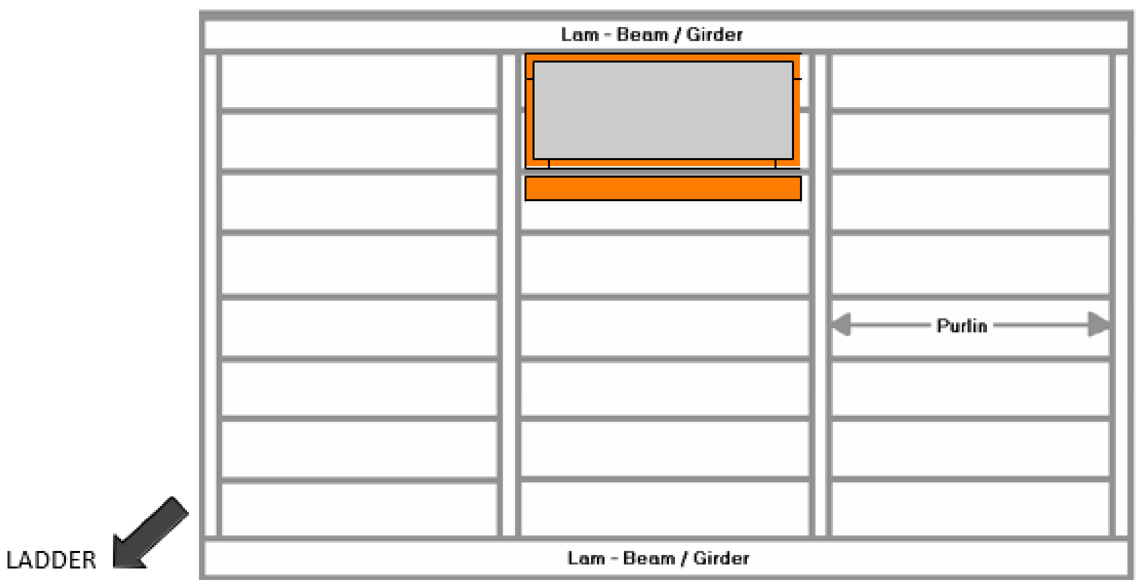

Figure 48 - Offensive Louver from Purlins

Louver section.

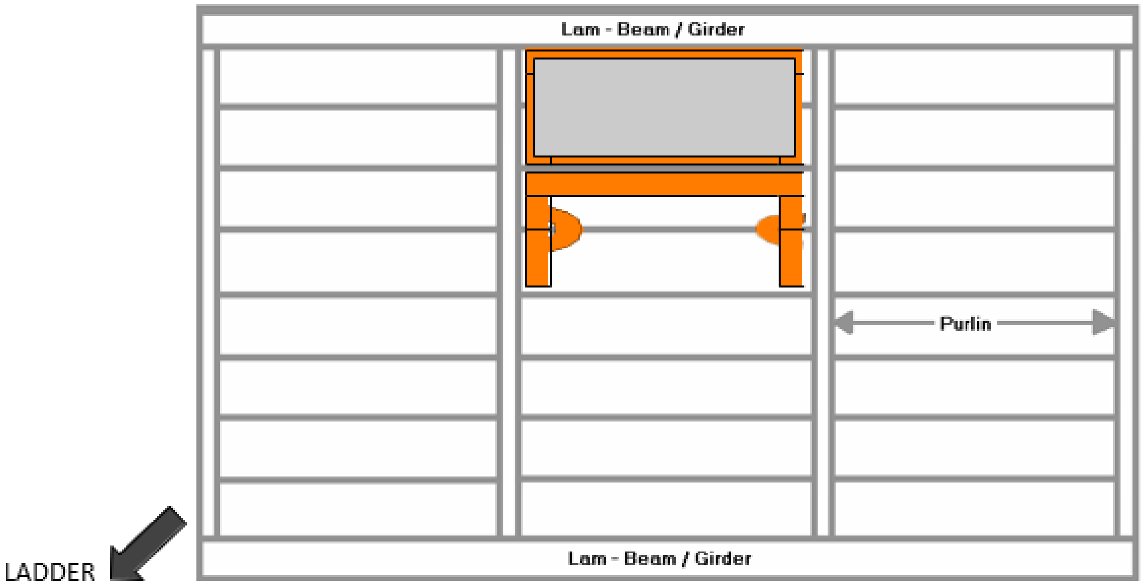

Figure 49 - Offensive Louver from Purlins

Cut parallel to purlins, roll center rafter, and stop at third rafter.

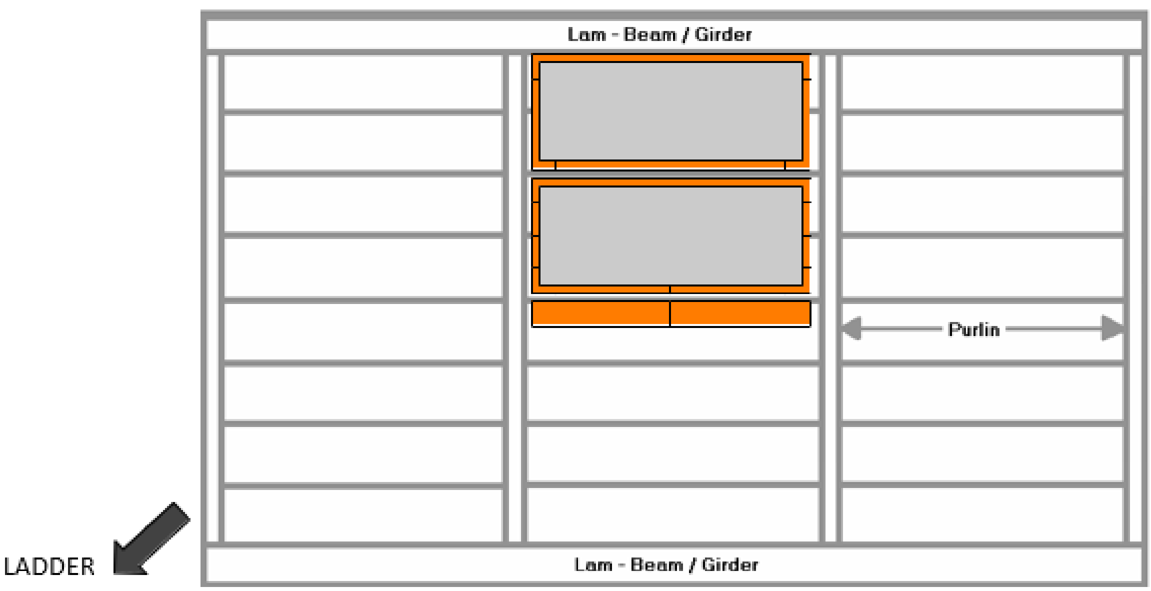

Figure 50 - Offensive Louver from Purlins

Cut on both sides of third rafter (fourth and fifth cuts). Then louver section.

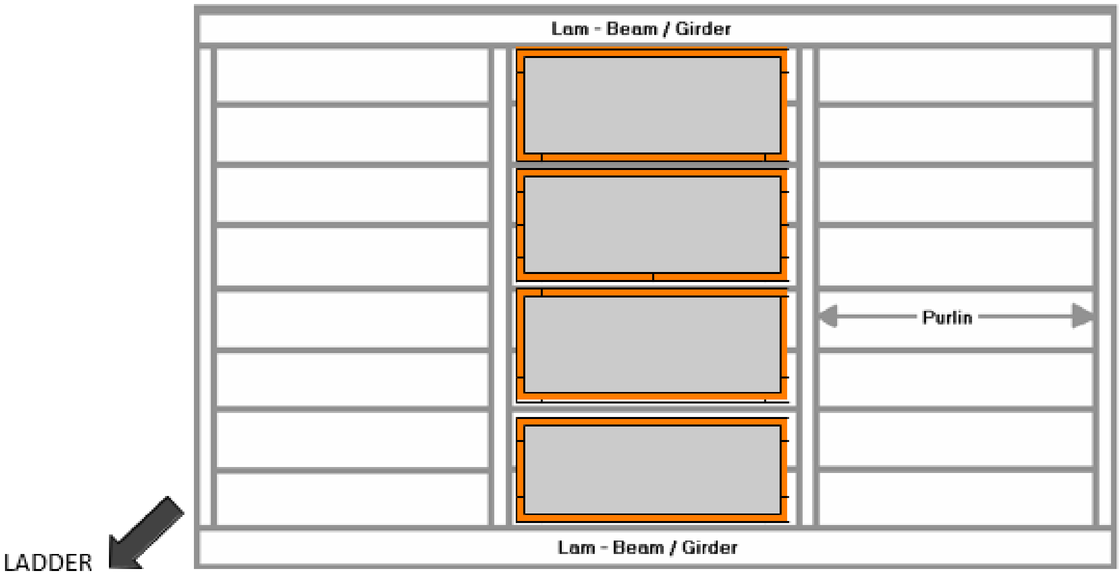

Figure 51 - Offensive Louver from Purlins

Continue offensive louver from lam-beam to lam-beam.

<u>Louver off a Lam-Beam / Main Beam (Defensive)</u>

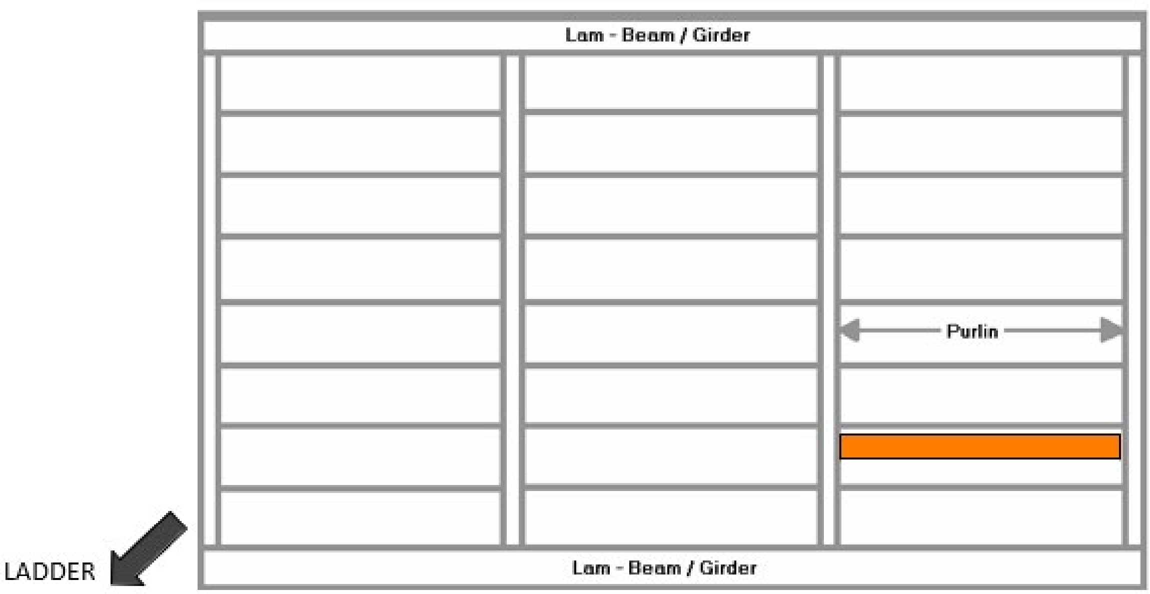

Figure 52 - Louver off a Lam-Beam or Main Beam (Defensive)

While standing on a lam-beam, reach out approximately 3 feet, and make first cut parallel to rafters from purlin to purlin.

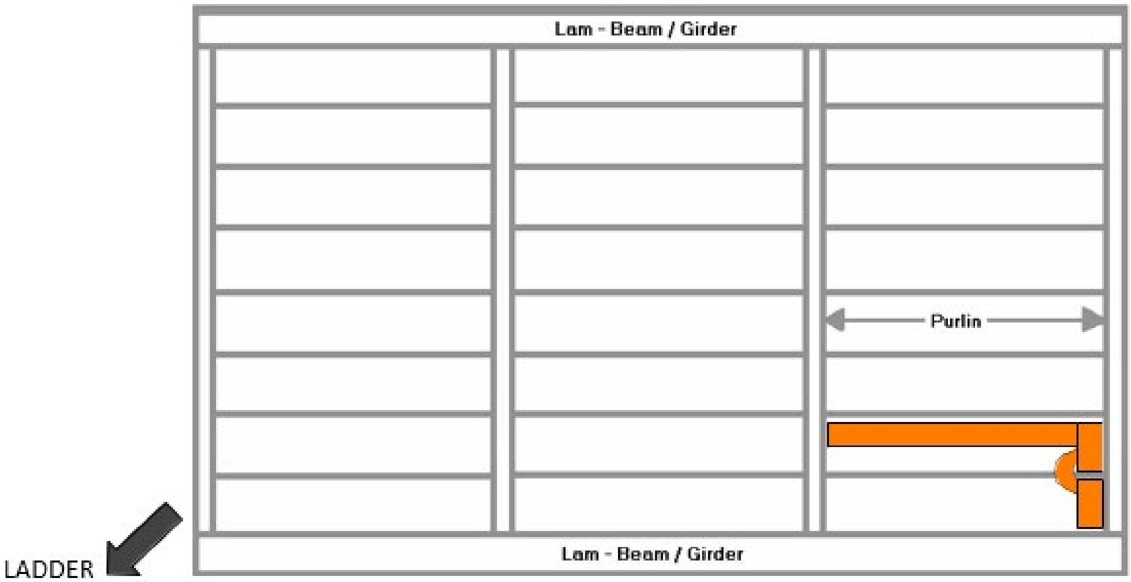

Figure 53 - Louver off a Lam-Beam or Main Beam (Defensive)

Cut parallel to outside purlin, roll center rafter, and stop at lam-beam.

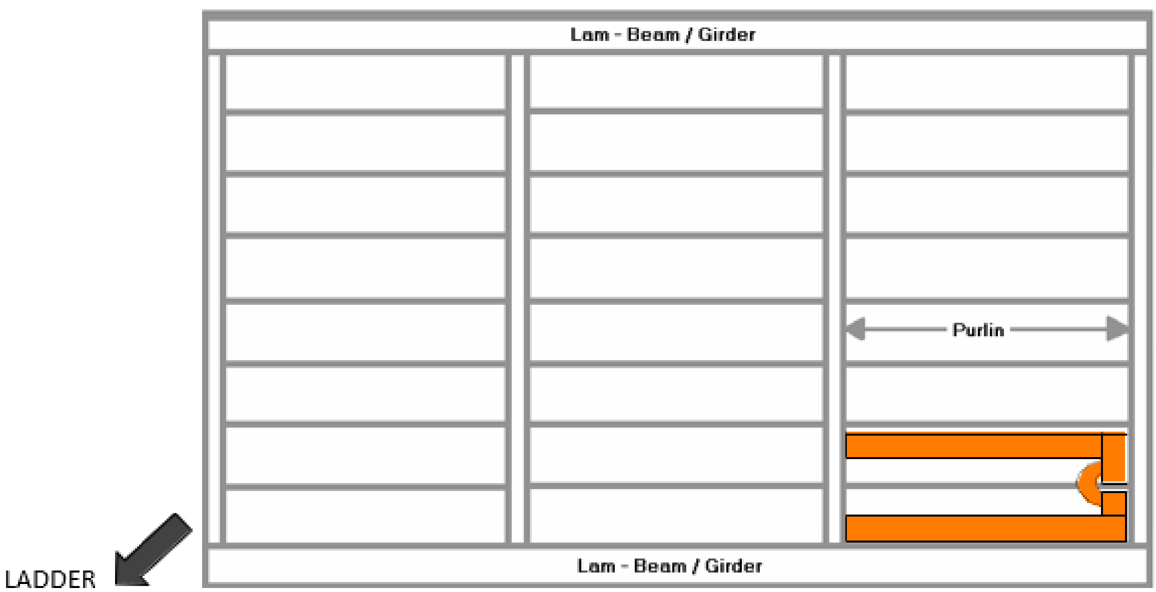

Figure 54 - Louver off a Lam-Beam or Main Beam (Defensive)

Because of work area limitations (standing on a lam-beam), cutter and puller exchange tools. Before louvering section, make outside cut. Cut from purlin to purlin.

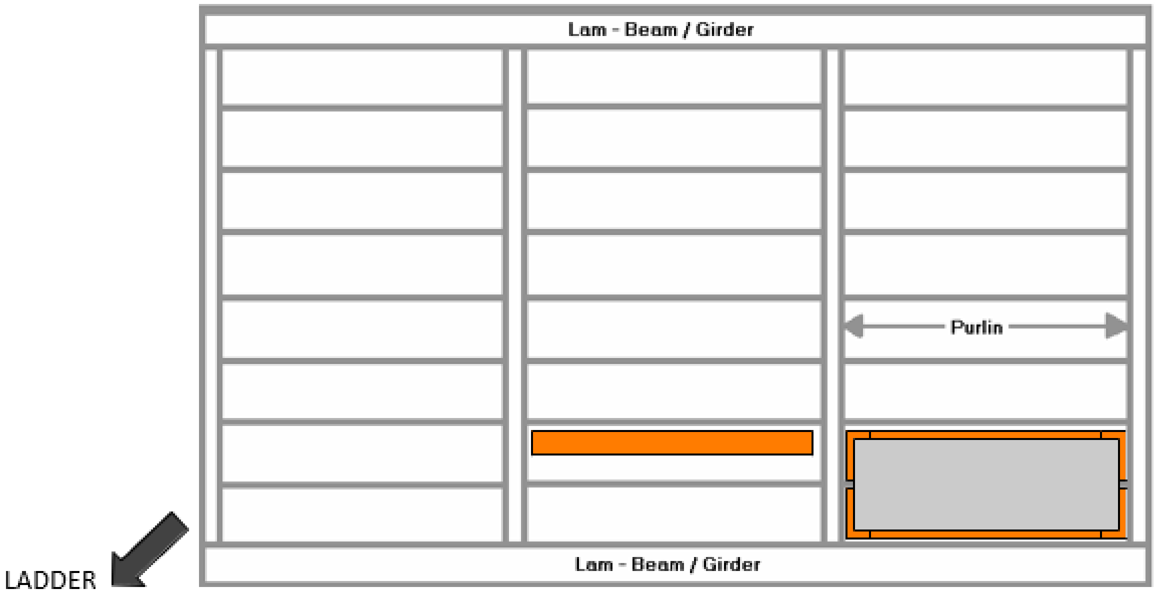

Figure 55 - Louver off a Lam-Beam or Main Beam (Defensive)

Louver section.

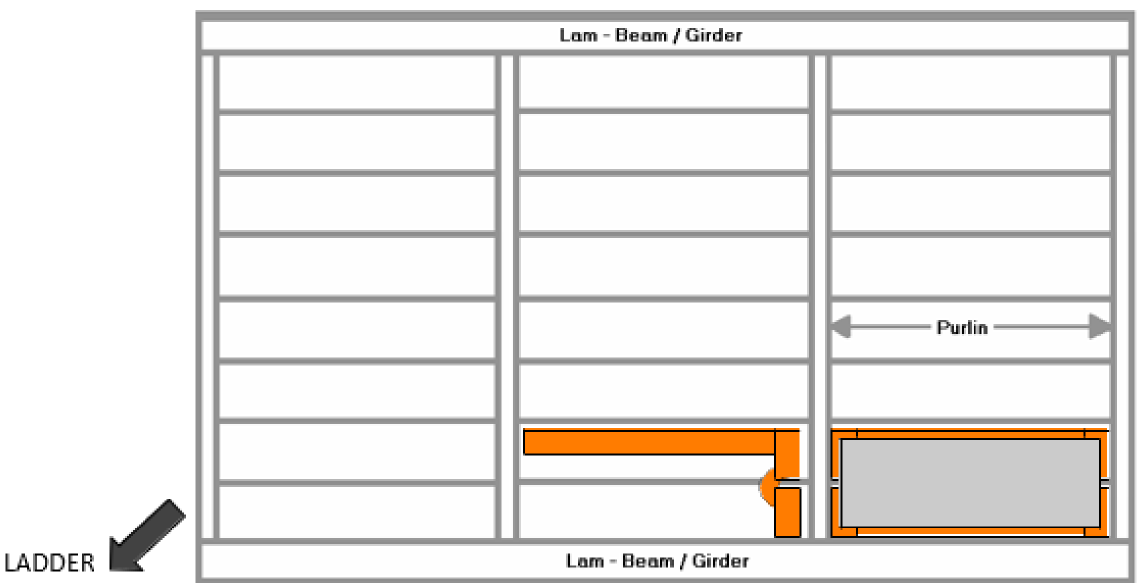

Figure 56 - Louver off a Lam-Beam or Main Beam (Defensive)

Exchange tools, make second cut parallel to outside purlin, roll center rafter, and stop at lam-beam.

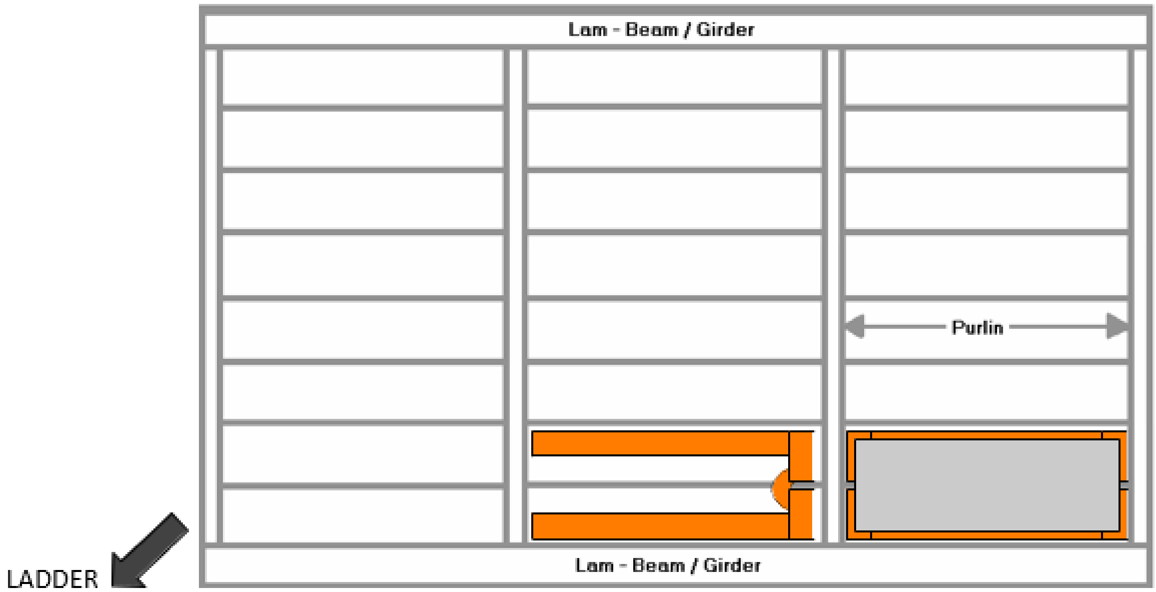

Figure 57 - Louver off a Lam-Beam or Main Beam (Defensive)

Cut parallel to lam-beam from purlin to purlin.

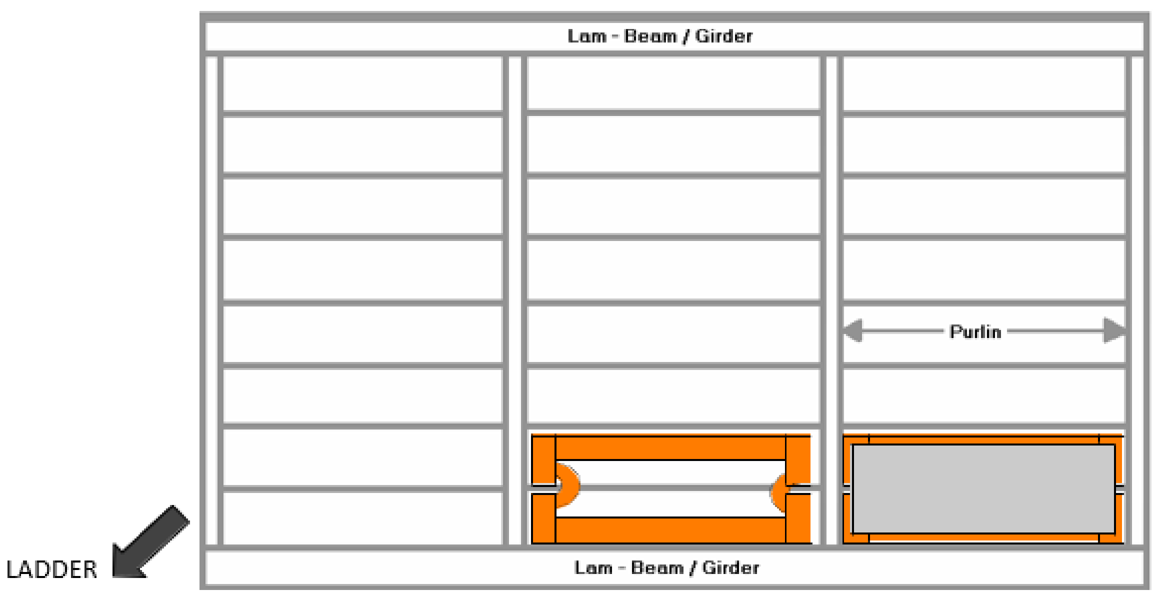

Figure 58 - Louver off a Lam-Beam or Main Beam (Defensive)

Make fourth cut, roll center rafter, and stop at lam-beam.

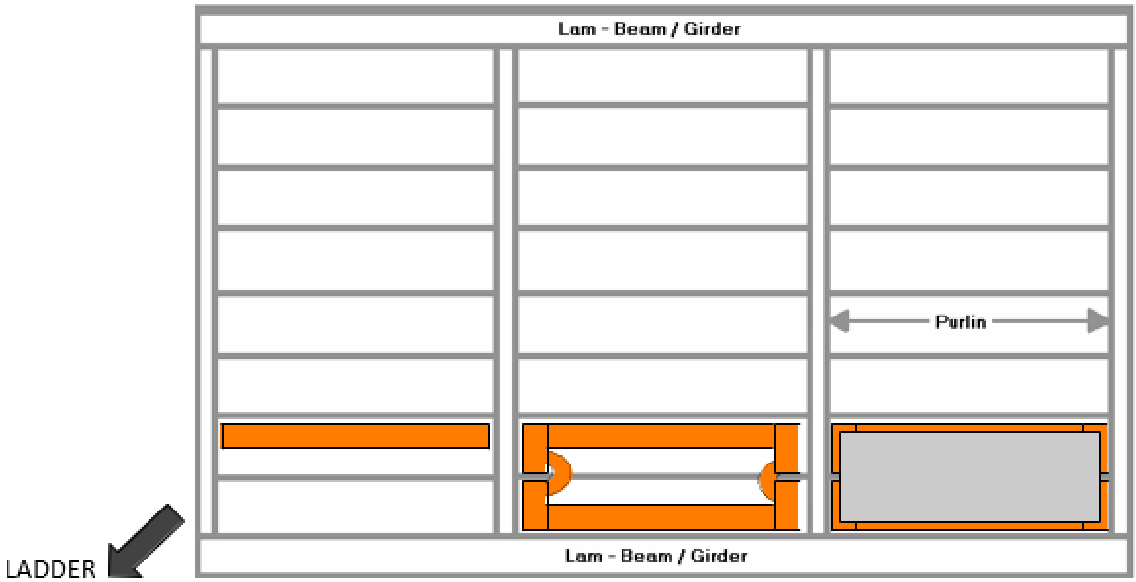

Figure 59 - Louver off a Lam-Beam or Main Beam (Defensive)

Cutter and puller exchange tools. Make outside cut. Cut from purlin to purlin.

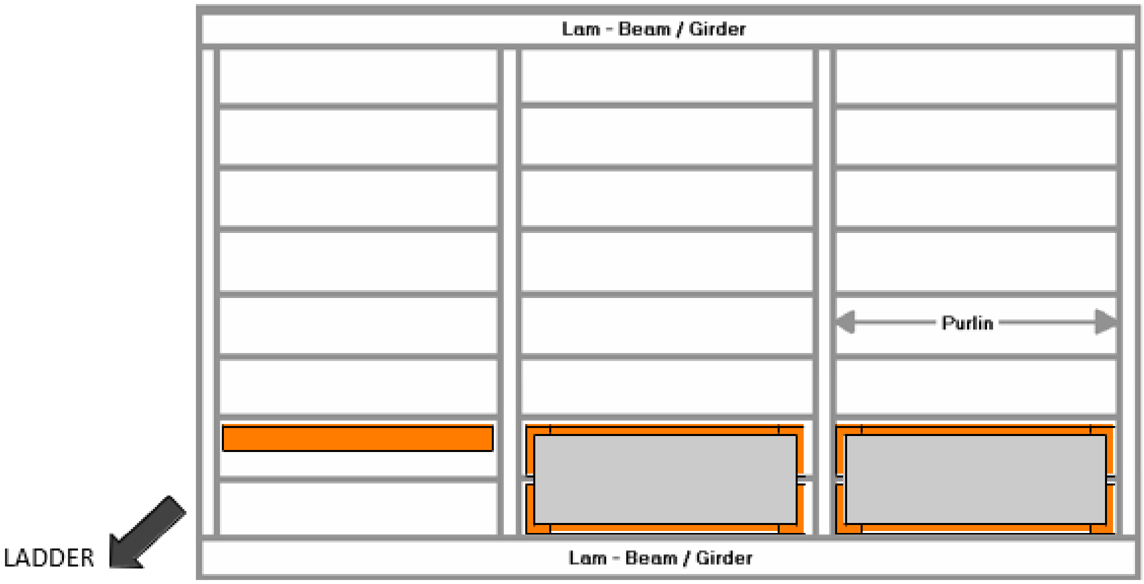

Figure 60 - Louver off a Lam-Beam or Main Beam (Defensive)

Louver section.

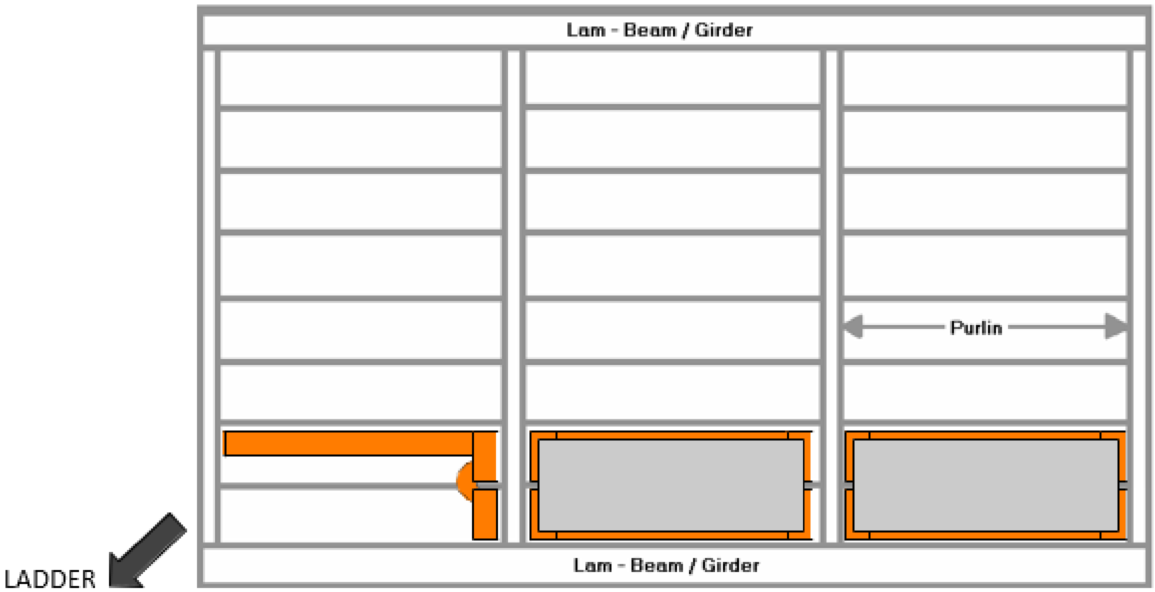

Figure 61 - Louver off a Lam-Beam or Main Beam (Defensive)

Exchange tools, make second cut parallel to outside purlin, roll center rafter, and stop at lam-beam.

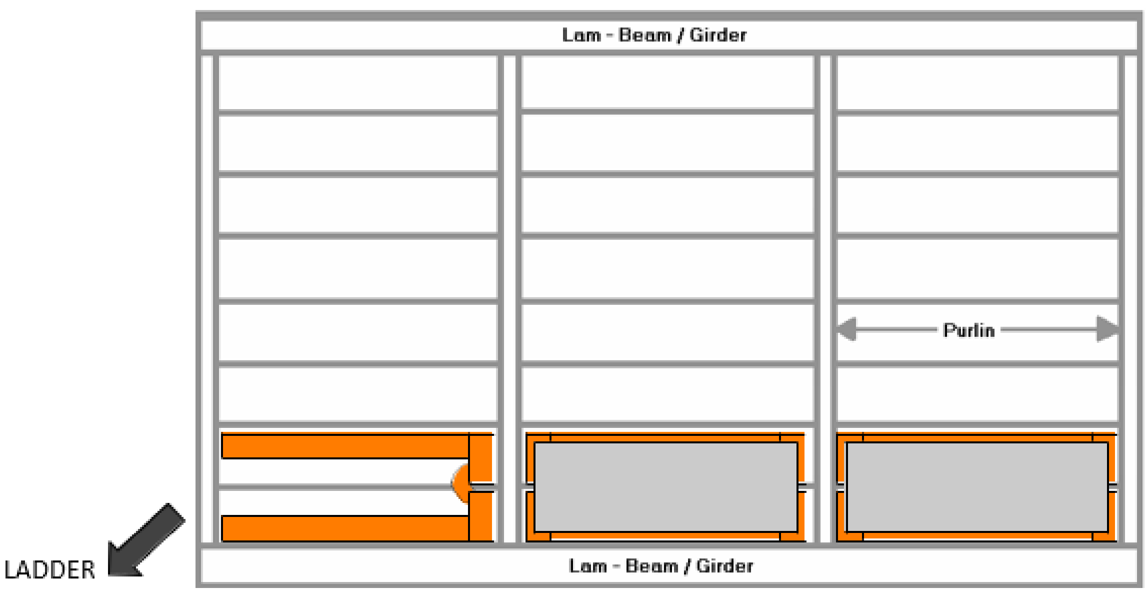

Figure 62 - Louver off a Lam-Beam or Main Beam (Defensive)

Cut parallel to lam-beam, from purlin to purlin.

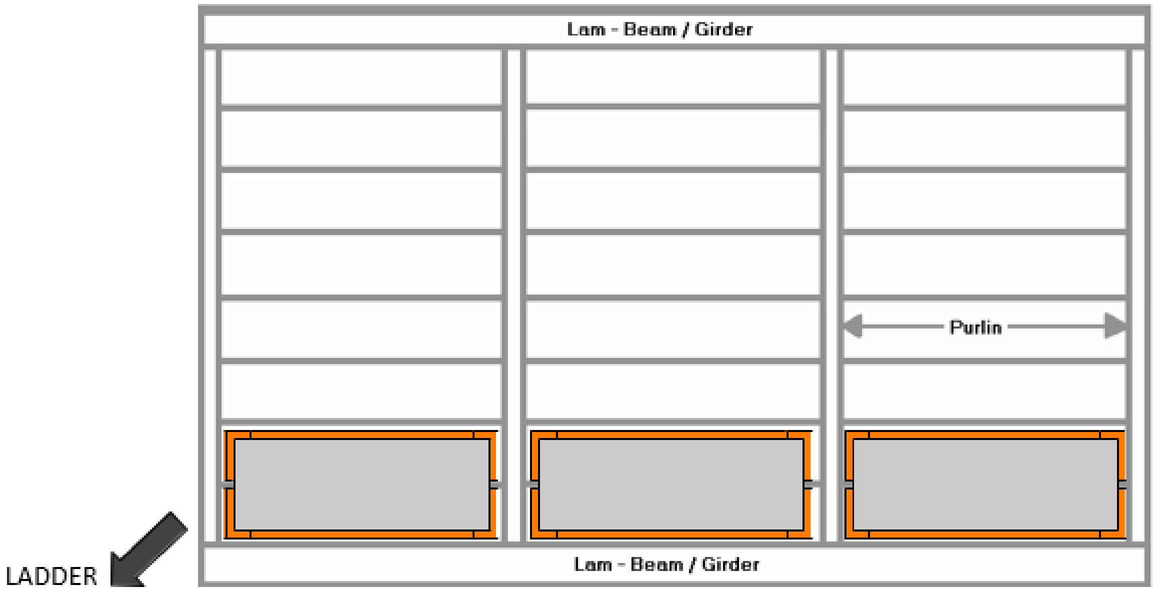

Figure 63 - Louver off a Lam-Beam or Main Beam (Defensive)

Make fourth cut, roll center rafter, and stop at lam-beam. Then louver section. Cut strip from parapet to parapet.

DEFINITIONS

Center Rafter Louver:

Center rafter louver is a technique used when cutting plywood sheathing (5 cut). Center rafter provides the largest hole possible with the minimum number of cuts. Sheathing removal (louver) requires a minimal effort. Center rafters can also be used for cutting strip ventilation on 1” x 4” or 1” x 6” sheathed roofs.

Decking:

Decking is the material used to comprise the base and exterior covering for the roof. The base is the material attached to the roof rafters. The base material can consist of solid wood sheathing, plywood-type materials, corrugated metal, and other materials.

Diaphragm Nailing:

Plywood sheathing is installed so that the 8’ dimension of the plywood crosses the rafters or joists and the 4’ dimension parallels the rafters or joists. The sheets of plywood are then staggered much like a brick or block wall.

Dicing:

Dicing is a technique used to cut 1” x 4” or 1” x 6” solid, spaced, or diagonally sheathed roofs. Dice cuts are made parallel to rafters with no concern to locating rafters.

Head Cut:

A head cut is a cut made through the roof decking that is made perpendicular to rafters. A head cut is used to locate rafters. This cut involves rolling rafters. A head cut must be done on roofs covered with plywood and diagonal sheathing. A head cut is usually the first cut made on a center rafter cut.

Heat Hole “Offensive Ventilation”:

A heat hole is a hole placed directly over the fire or as close to the fire as safety will allow. A properly placed heat hole saves lives and will allow firefighter access by reducing heat, smoke, and fire gases inside the structure. A heat hole will also reduce the possibility of backdraft and 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 ventilation team shall never conduct ventilation operations directly over the fire.

Members should employ the practice of "trading space for time" so that they may complete their roof-cutting operation prior to the fire impinging on a given ventilation hole. Constantly evaluate the effectiveness of the roof-cutting operation and weigh RISK vs. GAIN allowing for a timely and safe exit from the roof.

"J" Hook:

The removal of sheathing is enhanced by a "J" hook motion with an appropriate tool (pick head axe). The "J" hook motion brings the pulling tool under and up to the decking in a smooth, forceful motion that will separate the decking materials from the rafters. This is more efficient if the pulling tool is used near the rafters.

Kerf Cut:

A kerf cut is a single cut made through the roof decking, the same width as the chain saw blade. Although not as effective, the kerf cut can be used as an alternative to using the smoke indicator hole.

Laddering:

Ground ladders should be thrown to the uninvolved corners of the structure. The exception to the rule is when using a roof ladder. Your ground ladder must be thrown to the base of the roof ladder. It is preferable to have the wind to your back. For roof ventilation, a "MINIMUM" of two ladders should be thrown to the involved structure.

Louver:

It is not practical in most cases to remove cut plywood from a roof due to the method in which the plywood is nailed to the roof rafters. The best alternative is to louver the plywood. Once all 4 cuts are complete, use a rubbish hook and push down on the near side (the side closest to your ladder) and pull on the far side. This method is used with the center rafter louver technique.

Nailing Blocks:

Nailing blocks are usually made from a 2" x 4" laid flat between rafters to provide a nailing surface for the edge of the plywood sheathing. Since the plywood normally used is 4' x 8' in size, a nailing block will usually be found every 4 feet.

Parallel Cut:

A cut through the roof decking made parallel to the roof rafters.

Penthouse Door:

Penthouse door is a door leading from the interior stairwell to the roof. Opening the penthouse door can be a quick way to clear smoke out of the stairwell and any hallway that is open to the stairwell.

Plug Cut:

A plug cut is a small triangular piece of roof covering (composition), which is removed from the roof to expose the roof sheathing. A plug cut is used to determine sheathing type and roof composition thickness similar to an inspection cut.

Plywood Type Sheathing:

Plywood, chip board, and oriented strand board (OSB) are all materials used for floor and roof decking. The normal and most common size for plywood is 4' x 8'. Under fire conditions, plywood burns at a quicker rate than solid wood sheathing and plywood delaminates.

Rolling Rafters:

Rolling rafters are used to make a head cut. When a rafter is felt with the chain saw, the saw is backed off and lifted or rolled over the rafter and then re-inserted into the sheathing, and the cut is resumed.

Skim Cut:

A skim cut is a light cut made with the chain saw, cutting through the roof covering and plywood sheathing. The saw is not inserted deep enough to cut through the rafters. You "skim" over the top of the rafters. The skim cut is used on a panelized roof when you are performing the cutting technique known as "louver off a purlin."

Skylights:

Skylights are usually constructed from glass or plastic. On apartment buildings, skylights will be placed over hallways and stairwells. On commercial buildings, they will be placed over manufacturing areas. When using skylights in conjunction with roof ventilation, it is imperative that you systemically remove skylights. Remove skylights in the same direction and order as you would cut ventilation holes.

Smoke Indicator Hole:

A smoke indicator hole is a small triangular hole cut through the roof decking (sheathing and roofing material) made with the chain saw or an axe. A smoke indicator hole is used to indicate smoke and fire conditions directly below the indicator hole. Smoke indicator holes should be placed along the path of access or egress every few yards. Smoke indicator holes should be continually monitored to ensure all routes of travel and escape are safe throughout the roof operation. When placed directly in an area where a roof crew is working, they give a good indication of changing conditions, which may be vital for the safety of the roof ventilation team. Placing smoke indicator holes in the path of the fire can monitor fire spread. Smoke indicator holes can be placed on roofs of buildings attached to fire buildings to indicate interior exposure.

Sounding:

Sounding is a technique used to assist the roof team to safely walk on a roof. Sounding utilizes a long-handled tool (rubbish hook/pike pole) used to hit the roof. Because of its weight and reach, a long-handled rubbish hook is superior to and recommended over, a pick-head axe as a sounding tool. Sounding the roof will allow you to determine the condition of the roof. On some roofs (panelized), sounding can be used to locate main beams, i.e., lam-beams or purlins.

Trench Cut "Defensive Ventilation":

Strip ventilation is a long, narrow section of roofing material that has been removed well ahead of the fire. The strip acts as a firebreak. Strip ventilation is usually performed across the width of the roof, from parapet to parapet.

Ventilators:

Ventilators are placed on roofs to ventilate attics and building interiors. Ventilators can be used to assess the progression of a fire. If ventilators are working correctly, leave them alone. A turbine-style ventilator is about 30% more effective when the turbine is spinning. Ventilators are designed to ventilate; let them do their job.

Vent Pipes:

Vent pipes are plumbing pipes that extend from inside the structure through the roofline. Vent pipes can be constructed from ABS plastic, cast iron, or steel pipe.

Vent pipes travel vertically through a structure (pipe alleys) and can become an avenue for fire to travel. If vent pipes appear to be growing out of the roof, this should be an indication that the roof has sagged or dropped. This condition is known as “growing vent pipes.”

45-Degree Cut:

A 45-degree cut is a series of two cuts used to identify rafter direction “ONLY”. The first 45-degree angle cut is made toward or away from any exterior wall. A 45-degree cut will ensure the saw will intersect a structural member. "STOP" when you hit a rafter. Make a second cut parallel or perpendicular to the exterior wall.

45-Degree “Inspection” Cut:

It is imperative for the roof team to know rafter type, and rafter direction. If rafter type and rafter direction are unknown, a 45-degree inspection cut will tell you rafter type and rafter direction, the sheathing type, the thickness of roof composition and when complete, it can act as a smoke indicator hole. A 45-degree inspection cut is accomplished by cutting through the roof decking at a 45-degree angle toward or away from any exterior wall. A 45-degree cut will ensure the saw will intersect a structural member. When the saw contacts a rafter, roll over the rafter and continue the cut for approximately 6 to 10 inches. Complete the cut by removing a small triangle of decking directly over the structural member.

REFERENCES

Standard Operating Procedures

Section 201.005, Risk Management Policy

Section 202.002b, Residential Structure Fires, Garage

Section 202.003, Commercial/Big Box Fires

Section 202.023a, Center Hall Construction

Training and Equipment Manual

Section 308.008 Forced Air Ventilation Equipment

Section 309.001, Chainsaws

Section 309.002, Stihl TS 400 Cutting Saw

Company Performance Evolutions

Section 315.010, Truck Company Operations, Setting Up an Aerial Ladder

Section 315.102, Truck Company Operations 35' Ladder

Section 315.106, Truck Company Operations, Vertical Ventilation

Individual Performance Evaluations

Section 316.011 Carry and Raise a Straight Ladder

Section 316.013 Carry and Raise a 24' Ladder

Section 316.015 Carry and Raise a 35' Ladder

Section 316.016 Carry a Roof Ladder Aloft

Section 316.021 Ventilate a Roof with a Chain Saw

Section 316.022 Ventilation with a Forced Air Blower

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