Studies have shown that only 20% of annual fire fatalities are actually burned. The remaining 80% mortality are victims of smoke inhalation. When analyzing the nation’s fire loss, we find that less than one-half the loss is caused by the fire; the rest is a result of heat and smoke.

Fire officials now believe that a considerable portion of the annual loss of life and property is a direct result of the lack of timely, adequate and effective ventilation.
In the science of fighting structure fires, there is no operation more important than that of ventilation. Knowing the basic principles of ventilation will greatly reduce fire deaths and property. Because ventilation is basically a technical operation, today's firefighter, in order to understand and execute strategies and tactics, requires basic knowledge of building construction and the chemical and physical phenomena that occur during a fire.

During his career, the professional firefighter faces a multitude of hazards inherent to the profession, not the least of which is the task of executing vertical ventilation. Operating on the roof of a burning building while the structural integrity of the building degrades moment by moment is an extremely high risk situation. It is the true professional who has the knowledge and expertise to reduce risk with the aggressive application of proper ventilation techniques.

**DEFINITION**
The planned and systematic direction and removal of smoke, heat, and fire gases from a structure

**Physics of Fire**

It is important that each firefighter be able to look at a fire and understand what is occurring inside the burning structure. From this understanding comes the ability to make proper choices when attacking the fire. The result is reduced exposure to hazards for the firefighter, a more rapid control of the fire, enhanced rescue efforts and reduced property damage.

Building fires progress through three basic stages: the incipient or beginning phase; the steady state or free-burning phase; and the hot smoldering phase.

When confronted with any of these three phases, the firefighter must realize that the ventilation hazard and tactic will depend upon the phase encountered.

**The Incipient (Beginning) Phase**

In the incipient phase, the oxygen content in the air has not been depleted and remains about 21%. At this point the fire is producing water vapor, carbon dioxide, and in smaller quantities, sulfur dioxide (SO2) and carbon monoxide (CO). Some heat is being generated and the actual fire flame temperature can be above 1,000 degrees F (537°C). Yet the actual room temperature may be only slightly elevated based on the length of time the fire has been burning. At this point either natural or positive pressure ventilation is usually adequate.

**Steady State (or Free-Burning) Phase**

Simply put, this is the phase where there is adequate oxygen and fuel to sustain free-burning and fire growth to the point of full involvement. Oxygen-rich air is drawn into the fire by the flow of rising convection currents. Heat rises to the uppermost reaches of the confined area and spreads out laterally from the top and then down. Cooler air is forced to lower levels
allowing upper level combustibles to ignite. At this point the temperatures in the upper regions can exceed 1,300 degrees F. The following effects may be observed:

**Mushrooming**

As smoke and gases are heated, they become lighter in weight and tend to rise. If this process is confined to a room or building, smoke and gases will rise to the uppermost level. Cooler air is displaced down towards the fire, providing oxygen and sustaining combustion. As this process of circulation takes place, the heated gases and smoke build internal pressure that continues to rise to the highest point available and to spread laterally. This phenomenon is called “mushrooming.”

A phenomenon called “rollover” takes place during the early stages of the free-burning phase. Rollover occurs when super-heated gases pushed toward and along the ceiling mix with available oxygen and ignite, creating a fire front that rolls across the ceiling. The most direct way to stop the gases from feeding rollover is to extinguish the fire. However, in the interim, vertical ventilation in the proper location will reduce the chances of rollover.

Sometimes confused with rollover is the term “flashover” which is a simultaneous ignition over the surface of the entire room. This occurs when the heat from the fire raises the temperature of the room and its contents to their ignition temperatures. The ignition is quite dramatic, happening in an instant. A flashover can usually be avoided by releasing heat with early and aggressive vertical ventilation and hose streams directed at both ceiling and contents.

**WARNING**

Flashover presents a serious safety hazard to the attack group. Priority execution of ventilation tactics can reduce the hazard to the attack group.

Should the fire vent itself to the outside, the supply of oxygen becomes unlimited and free-burning will occur until the fuel is gone. At this point, a clean burning state exists with high
temperatures and thermal columns. If the room or building remains unvented to the outside, a decrease in the oxygen level occurs and the third hot smoldering phase begins.

### Hot Smoldering Phase

If the free-burning state remains unvented, the fire progresses to the hot smoldering phase with low oxygen levels, little to no flame production and temperatures in excess of 1,000 degrees F. The room now begins to fill with dense black smoke to the extent that the area becomes pressurized and smoke is forced from all cracks. The intense heat continues to vaporize lighter fuels, and these gases greatly increase the chance of a backdraft. At this point, proper vertical ventilation is necessary to allow heat and gases to escape harmlessly to the outside.

### Backdraft

Firefighters responding to a fire that has progressed to the hot smoldering phase must consider the science of the fire before opening the structure or room. The confined area is teeming with pressurized, heated, flammable gases; the introduction of oxygen to this fuel-rich environment will result in an explosion of significant intensity. Proper vertical ventilation will release the heat and smoke and neutralize the hazard. Inappropriate horizontal ventilation, such as through doors or windows, will supply the necessary oxygen for the backdraft explosion to occur with devastating speed.

### 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.
Building Construction

The firefighter’s ability to safely and efficiently ventila"e a building through its roof will depend to some degree on the firefighter’s understanding of roof construction. Construction methods and materials have changed significantly over the last several decades. It is essential that firefighters become familiar with the existing and newly constructed buildings within their response district.

The following descriptions of both conventional and lightweight construction are not to be construed as complete or absolute. Basic characteristics, strengths and weaknesses are given to provide a basic framework of knowledge from which to operate safely.

Conventional Construction

Conventional construction gets its strength from actual size or mass. There is less surface area exposed to air or fire. There is more mass or fuel to consume, creating a longer burn time and a greater window of safety for the firefighter with respect to time.

Roof framing components are continuous lengths of full-sized lumber. Ridge beams are single members with conventional rafters running from ridge to top plate. Rafter size will vary depending on span, pitch, and load.Spacing is usually 16" to 24". Additional members usually can be found in the form of collar ties and knee braces.

Conventional sheathing material is most commonly 1' x 6' laid at 90 degrees to support members and spaced for shingles, or laid at a 45 degree angle for support with no spacing. You will also find plywood used as sheathing in varying thicknesses.

Conventionally constructed commercial buildings built during the 1930's and 1940's commonly used truss construction. Although the conventional truss’s members have the same strength interrelationship, it is much stronger than its lightweight counterpart. This type of construction used 2' x 12' lumber for the top and bottom chord with rafters 2' x 10'. This type of construction is very strong, and early structural collapse is not an immediate concern.

Lightweight construction

In today's world, lightweight construction is predominantly used in the building industry. With high labor and material costs, lightweight construction uses less lumber and smaller, lower cost members. In modern construction, laminated beams, heavy timbers and 1" x 6" sheathing have given way to 2" x 3" and 2" x 4" lumber and 1/2" plywood, regardless of building size.

From a firefighting perspective, the use of less fire resistive materials translates to less time available to ventilate before the roof becomes unstable. This discussion will focus on the four major types of lightweight roof construction: panelized, open web truss, metal gusset plate truss, and wooden “I” beam.
Metal Gusset Plate Trusses

This type of roof system commonly found in residential and commercial buildings is usually 2" x 4" lumber butt jointed and held together by metal gusset plates, commonly known as a gang nail. The gang nail commonly penetrates 3/8".

Trusses are characterized by a top and bottom chord in tension and compression. The strength of the truss lies in the geometric interrelationship. Failure occurs when one component of the truss is consumed by fire or the gang nail pulls loose due to charring. The most common spacing for trusses is 2' on center and the point where the truss crosses the bearing wall is the strongest location.

Wooden “I” Beam

This type of roof and sometimes floor system has a top and bottom chord of 2" x 3" or 2" x 4" lumber. The stem is normally 3/8" plywood or particleboard glued in place. Common spacing is 2' on center, and the area where the roof meets the exterior wall is the strongest location. The stem has very little relative mass and burns to failure quickly.

Open Web Trusses

This type of system has a wooden top and bottom chord that are cross-connected by steel tube web members. The top chord is in compression and the bottom in tension. The steel tubes have the ends pressed flat in a semicircular shape with a hole punched through them. The tubes are placed in slots in the chords with pins driven through them. The top chord usually rests on the bearing wall and the bottom chord is unsupported. Spans of up to 70' are
possible, normal spacing is 2' on center, and the area where the roof meets the exterior wall is the strongest point.

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Panelized Roofs

The panelized roof normally consists of large laminated beams spaced every 12" to 40" spanning the length or width of the building. They are supported by pilasters or steel posts on the ends. Along the span you will find either wooden or steel posts as supports. Beams can span well over 100' and are often bolted together. Normally purlins are installed with metal hangers on 8" centers perpendicular and between the beams.

Wooden 2" x 4" rafters are installed with metal hangers on 2' centers, perpendicular to and between the purlins. Decking is usually 1⁄2" plywood. The safest and strongest locations are the beams, purlins and perimeter of the building. The inherent weakness is the lightweight construction between the major framing members.

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WARNING

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
Roof Styles:

There are three basic categories of roof design: pitched roofs, arched roofs and flat roofs. The following discussion identifies them by category and evaluates some of the more common styles with respect to strengths and weaknesses.

Pitched Roof Styles

Gable, hip, shed, bridge truss, mansard, lantern, sawtooth, gambrel and butterfly.

- **Gable**: Basic A-frame design with the roof pitched in two opposing planes. If constructed in a conventional manner, the continuous ridge, exterior and bearing walls are normally safest locations. In the lightweight version, the ceiling joists are the bottom chords of the truss, often not tied to the interior walls.

- **Hip**: Two sets of opposing pitches where the roof slopes down to meet every outside wall. Strengths lie at the ridges, valley rafters and at the point where the rafters cross the outside walls. Weaknesses are the same as a gable when in the lightweight version.

- **Shed**: Basically this style is half a gable. The weakness here is the mono-pitched truss with a single web member subject to early collapse.

- **Bridge Truss**: This is heavy duty trussing with sloping ends. The two parallel chords are in constant tension and compression and can fail during heavy fire exposure. However, the likelihood of failure is dependent on the dimensions of the materials and the span of the trusses. This roof usually fails in sections and may have a large open attic space.

- **Mansard**: The mansard roof has a double slope on each of its four sides. The lower slope is steeper than the upper slope. The four sides meet in the middle in a hipped peak/ridge. If it is a more modern version, the sides form a central flat area. This type of roof is usually bridge truss construction and creates large dead spaces and a potential for early collapse.
Arched Roof Styles:

Ribbed truss, bowstring truss and lamella styles.

- **Bowstring**: The arched chords are usually 2”x 12” lumber with 2” x 10” rafters. Tie rods with turnbuckles are used for lateral support and to regulate tension. The roof is quite strong but sudden collapse can occur if the tie rods are heated to failure.

- **Ribbed Arch**: Construction is similar to the bridge truss except that the top chord is arched. The heavy timber is very fire resistant but is often open with no attic to protect the framing.

- **Lamella Roof**: A geometric egg crate or diamond pattern frame with sheathing laid over it. The 2" x 12" members are bolted together with gusset plates. The roof is supported by exterior buttresses or internal tie rods.

The common hazard inherent in all arched roofs is their tendency towards sudden and complete collapse. Hazard should be estimated by the size of lumber and the span involved. If there is heavy fire involvement in the truss area, personnel should withdraw from the roof and the interior to avoid sudden collapse.

The Flat Roof:

Conventional flat roofs are constructed with rafters 2” x 6” or larger depending upon the span. Rafters are covered with 1” x 6” sheathing often laid at 45 degrees to the outside walls. The perimeter of the building where the rafters rest on the exterior wall is considered a strength. Due to mass, rafters are also considered safe locations.

Several lightweight roof systems are used to produce flat roofs. The wooden "I" beam, metal gusset plate truss, and open web types are all previously mentioned possibilities. Identification of building construction type is most difficult in flat roof buildings. The single best way of being certain about building construction type is having previous knowledge of the building.
Strategic Considerations

With knowledge and experience to assist him, the modern-day fireground commander realizes his decision is not, “should we ventilate,” but rather, “what type of ventilation should we use, how aggressive should we be - and to what level are resources to be allocated.”

Ventilation is the first step in gaining positive control of a fire building. It is one of the first steps in the action plan allowing all subsequent operations such as search, rescue and fire attack to be much more safe and efficient.

The ventilation size-up process always starts with the assessment of life hazard and the potential search and rescue. Next determine the location, extent and probable path of the fire. Then identify and consider the strengths and weaknesses of the building's construction.

If the life safety of occupants is at stake and the need for rescue becomes evident, the need for immediate ventilation becomes essential. To allow the occupants a chance at survival and to facilitate a quick search and rescue by firefighters, commitment to restoring a viable atmosphere to the building must be a priority.

In the absence of civilian life hazard, the focus of the ventilation objective becomes the support and facilitation of the fire attack operation. The fireground commander should carefully consider that heat, smoke and flame will follow the route chosen by the specific type of ventilation.

Oftentimes, the act of ventilation will intensify the fire due to the introduction of fresh air. If a search and rescue operation is in progress, consideration should be given to routing heat and smoke away from such efforts. Additionally, due to this increased fire intensity, coordination with the fire attack group’s water delivery is essential.

Normally the most effective vertical ventilation is a heat hole cut directly over the area of fire involvement. However, attempts to do so when dealing with lightweight construction can have catastrophic results. It may be prudent to allow burnthrough while augmenting ventilation from a position of greater strength and safety.

Circumstances sometimes require a relatively defensive ventilation posture. The use of directional openings (i.e., strip cuts) should be considered. These types of openings are cut ahead of the fire and are designed to channel and limit the horizontal spread. The size and configuration of the directional opening should be commensurate with the intensity of the fire and requires a corresponding commitment of resources.

When the decision is made to use directional openings, we are usually attempting to limit horizontal fire travel. Consideration should be given to both or opposing sides of the problem and ventilation groups assigned to each.
Consideration should also be given to the amount of structural fire containment during the formulation of the action plan. When the fire is contained within the room or area of origin and has not yet spread to the overhead or attic spaces, use of vertical ventilation causes needless damage. It also allows the fire access to previously undamaged areas. The use of positive pressure methods will provide optimum results.

Vertical ventilation of large arched roofs requires the commitment of one or more aerial ladder companies. Forethought and accurate placement of the turntable are required to allow operations to take place from the aerial, ensuring safety and an escape route if roof failure becomes imminent.

Ventilation of the multi-story building presents a number of problems. The use of horizontal methods are often most appropriate despite the immediate concerns of lapping and falling glass. Vertical ventilation can prevent lapping and mushrooming but exposes the vertical route to heat, smoke, and fire spread.

Vertical ventilation with occupants above the fire floor could easily block their exit and endanger them inappropriately. Extreme caution should be exercised when utilizing vertical shafts and stairways.

When developing action plans, incident commanders should make every effort to both maximize and assign adequate resources to the ventilation task. At routine residential structure fires, the competent truck company can handle multiple tasks by dividing into two-man task teams. Normal pitched residential roof work can easily be accomplished using two men, freeing the other truck company members for other tasks.

More complex incidents, such as what a strip mall or multi-story building will present, require a greater commitment of manpower and equipment. A strip mall with a horizontally spreading fire has a potential need for strip cuts on opposing sides of the fire. This is a slower operation requiring two task teams, one for each side, commanded by a single vent group leader.

When dealing with high-rise ventilation, be prepared to allocate four to six times the manpower normally assigned to ventilation work. The need for simultaneous work on several floors requires one group leader to coordinate the operation of a number of task teams each handling individual floors.

### Tactical Considerations and Methods: Vertical Ventilation

The following tactical methods and considerations are designed to offer methods and techniques with which to operate safely. At no time are these methods to be construed as absolute. Company commanders and group leaders shall retain flexibility to meet individual needs.

When given the task of ventilation, the group leader is faced with a number of key considerations. The tactical method chosen should be the one that accomplishes the strategic goal as quickly and safely as possible. The group leader must have a clear understanding of priorities: are we offensive or defensive; do we need to protect a critical search and rescue attempt; or are we trying to get control of the building and access the fire. The group leader must stay informed. Communication with the incident commander and attack groups will keep the operation coordinated and effective.
Diagnostic Methods: Indicator Hole

When the ventilation group first arrives on the roof, fire and building construction information is at a premium. One of the first diagnostic methods is the indicator hole. This can be a saw’s kerf cut, the hole from the blade or pickhead of the axe, or a small triangular hole made with an axe or saw to provide a first look at fire intensity and construction. It is a prudent commander who leaves a trail of these holes when traveling long distances across roofs. They are immediate indicators of increased fire activity that can be monitored during roof operations.

The Inspection Cut

In the approximate area being considered for ventilation, the ventilation group should initiate an inspection cut. Even when you are positive of rafter direction, you still have to determine the type of construction and have a firm understanding of the fire’s intensity in the rafter or truss area. Even in dense smoke, identifying the rafter size by feel will give you an idea of time constraints and relative safety.

The inspection cut is made through the roof decking and not the framing members. The initial cut is made at 45 degrees to the outside walls, continuing until the cut intersects a framing member, and then continues at least one more foot. Complete the legs of a triangle so the piece over the rafter can be removed. We now have a clear look at the roofing, decking, rafter size, type and spacing, as well as smoke and fire intensity. The optimum size inspection hole would have cuts about two feet long.

The information gained from these diagnostic methods, allows us to address the critical question: Can ventilation be accomplished safely? If so, the type and location of the hole is selected and the most expedient technique is employed to cut the hole.

The normal progression for cutting the roof starts with some sort of indicator hole or holes. Next comes the inspection cut optimally in a location suitable for the final hole. The procedure is completed by expanding the inspection cut to create the hole and safely ventilate the structure.
Cutting Methods: The Heat Hole

Generally speaking, the heat hole would optimally be placed as close to the seat of the fire as possible. In doing so we provide the most direct path for the heat and smoke to exit the structure with as little collateral damage and building exposure as possible. This procedure can be very dangerous and the ventilation group must be sure of the structural integrity. Selection of the correct type of cutting method will expedite the procedure and limit the necessary time the team must be at risk.

There are several ways to approach cutting the heat hole. One of the fastest ways is the dicing technique. Dicing is recommended for use on conventional pitched roofs with 1" x 6" sheathing. The normal procedure would be to determine the location of the hole, make a head cut (roll rafters) and scoremark the rafter location. Next make a number of cuts parallel to the rafters. After making the cuts the approximate size of the planned opening (one cut between each rafter), we can use an appropriate tool in a “J” hooking motion to pull and rake the roof and sheathing from the opening. This is a very quick and efficient method requiring a minimum of manpower. Unlike other methods, the dicing technique can produce a hole that is just as easy to widen as it is to lengthen. Remember to never dice or make cuts any longer than you can reach with the tool available.

Another commonly used method of quickly executing a heat hole is the use of the louvering technique. Louvering is effectively used on sheathing and is virtually mandatory on plywood decking when the decision has been made to use vertical ventilation.

Louvering starts with a head cut — rolling three rafters. Next, two cuts are made parallel to and just inside the outer two rafters. These cuts will be to the desired size of the hole. A base cut is made parallel to the head cut. Where the cuts intersect, the saw should continue past a few inches. At this point you have a cut section in a rectangular shape attached only to the center rafter. Push down on one side and pull up on the other to relieve smoke and heat.

WARNING
Ventilation directly over a fire in lightweight construction is extremely dangerous and is not recommended.
Another quick method of ventilating a pitched roof with sheathing commonly found on dwellings is the **PULL-BACK METHOD**. This method is limited to sheathing and is accomplished by making three cuts — the first a head cut perpendicular to the rafters rolling three. Next, two cuts parallel with the rafters are made to the approximate size of the hole. The top board is loosened and the hole is opened top to bottom with a "J" hooking motion.

When dealing with a panelized roof which is basically a mix of conventional and lightweight construction, consider the use of the **DROP PANEL METHOD**. If executed correctly, the hole can be cut from positions always over a beam or purlin with greater relative safety. The concept is to make three cuts creating a rectangular hole with the cut piece breaking or falling into the building.

First, using two saws, make a cut parallel to the beam. Next, while standing on consecutive purlins, make parallel cuts alongside the purlins starting from your first cut. These cuts must be about six inches from the purlin to miss metal hangers and deep enough to cut through the 2" x 4" joists and plywood decking. The cut panel will fold in and drop through as you cut. Sometimes the piece will break off if you reach a seam in the decking. This method creates a large heat hole with relative safety to the team. It is mandatory that this operation be coordinated with the fire attack and search groups to avoid exposure to the falling panel.

The panelized roof also lends itself to the use of the louvering technique. The previously described cutting method remains the same with the following additional considerations: If possible, locate the hole next to a beam; for safety, three of the cuts can be made while on either the beam or the purlins; and the hole size will necessarily be 4 feet wide and up to 12 feet long.

It should be noted that the panelized roof is inherently weak and unsafe. Burnthrough and panel failure can occur within a few minutes of direct flame contact. If the need for ventilation is great, this type of roof usually has a number of skylights that can be easily opened or removed rather than risking the vent group in an attempt to be directly over the involved area.

There are times when the risk of placing a heat hole directly over the fire is too great and the fire's progress horizontally needs to be controlled. In this situation, the use of the **STRIP OR TRENCH VENTILATION METHOD** is recommended. This cut can be made "with" or "against" the construction and is much more time-consuming than the common heat hole.

The fastest **STRIP CUT** utilizes the **BETWEEN THE RAFTERS TECHNIQUE** when operating with the construction. Next to the perimeter of the building a head cut is made across two rafters. Two more cuts are made across the roof, each inside and between the two rafters. Two saws should be used to expedite the technique. The saw operators should be staggered about six feet apart. The cut strip of decking will fall into the attic.
Another method of producing a STRIP CUT when operating with the construction is by the use of the CENTER RAFTER TECHNIQUE. This will allow the vent group to either louver the cut sections or pull them back and remove them. A head cut is made next to an exterior wall and across three rafters. Next, two parallel cuts are made on either side of the center rafter across to the opposite side of the building. The strip will have to be cut into sections every four to six feet and either louvered or removed. It is recommended that two saws be used—one in the lead position and the other following. The following saw should make the perpendicular cuts to section the strip.

The strip cut made against the construction requires additional cuts and more time to execute. Again, the use of two saws is recommended as two parallel cuts are made across the roof from exterior wall to exterior wall, about three feet apart. Next, make a single cut between each rafter and louver or remove the cut sections.

A commonly asked question concerns the size of the hole. The rough rule of thumb is: In square feet, make the hole no less than ten percent of the building area involved. Consider that your enemy is time and that the integrity of the structure is deteriorating as you stand on it. Cutting too small a hole will be ineffective and force the ventilation group to either enlarge the freshly cut hole or to cut an additional hole.

After cutting the desired hole, you should evaluate effectiveness. The initial release of heat and smoke is usually quite intense. If after fifteen to thirty seconds the intensity and pressure do not subside, consideration should be given to enlarging the hole or strategically cutting another. If the vent group leader is not sure of the relative effectiveness of the hole, a simple communication with an interior attack group will give an immediate ventilation status.

Occasionally the ventilation group will be asked to transition to fire attack. Normally, attempts to extinguish attic fires from the roof are considered poor tactics causing unnecessary damage and fire spread. If the need arises and the interior fire attack group cannot access the fire, the ventilation group can act. Another hole needs to be cut in the roof for the sole purpose of accessing the fire with an appropriate hose stream. The original hole allows heat, smoke and steam to be relieved vertically rather than being pushed down into the structure, which is what happens when the attack is made through the vent hole.

Selection of the vent site has a specific relationship to the fire and none to the pitch of the roof.
On complex pitched roofs with multiple hips, gables and dormers, every effort should be made to approach the ventilation site by moving uphill utilizing exterior wall lines, bearing walls, division walls, valleys and ridge lines. Be aware of the possibility of fire in concealed spaces and use kerf cuts, indicator holes, inspection cuts and aggressive sounding to verify and update the safety of your position on the roof.

When operating on pitched roofs, the previous standard was: Always cut the hole at the highest location. Ventilation group leaders should not fall into this trap. Each incident is unique and requires a specific solution to its ventilation scenario. Remember, when you open the roof you will be moving heat, smoke and fire from their present location along a path to the vent hole. If we are going to open an attic that is not involved, we should place the hole precisely over the involved area and push out the ceiling, minimizing the exposure to the building and attic.

**Tactical Considerations and Methods—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.
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.

When setting up for PPV, the exhaust openings are most efficient when they are 75 to 150 percent of the entrance openings for standard three to five horsepower blowers. As the blower horsepower increases, or you are using multiple blowers in line, the exit openings increase to a range of 100 to 175 percent of the entrance opening.

When positioning blowers, the cone of pressurized air should be placed so the cone just covers the entrance opening. The blower will normally be tilted 20 to 30 degrees with smaller blowers necessarily closer to the opening.

When using multiple blowers, place the largest capacity unit closest to the opening, about two feet away. The smaller capacity blower is placed behind the larger unit and is positioned so that its cone of air will seal the opening. This will increase the effectiveness about ten percent.

When dealing with a building that is compartmentalized, a sequential approach to PPV is needed. Regardless of the type of occupancy, the ventilation group must progress systematically, starting with the closest room, by pressurizing one room after another until complete. Blowers can also be placed inside to assist in the direction of flow within the structure.

Multiple-story ventilation problems are normally solved by starting at the lowest level and ventilating towards the top. Basically, a sequential approach should be taken floor by floor. Pre-selection of the route the heat and smoke will take is critical; exposure of occupants and unaffected building areas should be avoided.

Many multi-story buildings have sophisticated heating, ventilating and air conditioning systems. The search group should close doors and windows, taking the first steps in the selection of the PPV routing through the building.
systems, commonly called HVAC. This system can form natural channels for the distribution of smoke selectively supplying or exhausting air from specific areas.

In many high-rise buildings, stairwell enclosures are protected with fans tied to the automatic alarm system. These fans pressurize the stairshaft and create an area of safe egress and refuge. The integrity of these areas should not be compromised.

When faced with a rapidly spreading high-rise fire, it is sometimes appropriate to use horizontal ventilation on the fire floor or those floors immediately above the fire. Communication with the fire attack group and incident commander are mandatory to reduce the possibility of fire lapping and injury due to falling glass.

When using the horizontal approach, windows should be opened on the lee side of the high-rise structure. There is a slight reduction of air pressure on the lee side caused by the prevailing wind. Opening the windward side might work against the ventilation group, overpower the attack group and spread the fire to uninvolved areas.

When ventilating vertically, the ventilation group will generally be more efficient when channeling smoke by beginning the routing process at the top, working down to provide a clear path for heat and smoke to exit when the fire floor is finally opened and either natural air flow or pressure is applied. If the route selection is reversed, there is unnecessary exposure of the route and personnel during the process.

**Safety**

**Considerations**

The singlemost dangerous task the average firefighter performs on a routine basis is that of
topside ventilation. With the fire degrading the integrity of the structure at an unknown rate beneath our feet, we attempt to quickly and efficiently relieve heat and smoke within the structure.

What the ventilation group needs the most and almost never has available is the commodity of time.

The vent group must consider: how long has the structure been directly subjected to the impact of flame; what type of roof construction is exposed; and how much longer the roof will be safe to operate on.

The type of building construction, specifically the roof construction involved, must be identified as soon as possible. Remember that the best source of knowledge is gathered from inspections and pre-plans prior to the incident.

Once the decision has been made to attempt topside ventilation, the ventilation group must exercise caution, yet expedite their operation once they step off the ladder. The group must read the roof, taking advantage of positions of strength. Normally exterior walls, ridge lines, valleys, beams, and purlins afford greater security.

Ventilation groups should vigorously sound the roof as they proceed. Members should maintain spacing to avoid possible overload. No direct or cross-country travel. The group should exit the roof by the route established as safest, vigorously sounding as they exit.

Lightweight roofs with significant attic involvement are extremely hazardous. Allowing the roof to burn through while monitoring horizontal spread can often be an effective decision.

If the fire has vented itself prior to our arrival, the deployment of a topside ventilation group for heat hole purposes would be an inappropriate risk of personnel. Burnthrough heat holes are normally precisely over the fire and should be evaluated from below to ensure adequate relief of heat, smoke, and horizontal spread.

Saw operation teams on the roof always require a minimum of two men. As a safety precaution, the backup man to the saw operator can use a hose strap secured to the saw operator's SCBA harness as an added measure of security.

Use of roof ladders should be considered whenever the roof appears to be too steep. Consideration with respect to footing should also be given to the type of roof
covering and characteristics when exposed to water or Class "A" foam.

Serious attention should be given to saw penetration on lightweight roofs using several truss systems. Often the top chord of the truss which has the sheathing nailed to it presents the 2" thickness to the saw operator. This thickness, which is actually 1-1/2", can easily be cut through causing failure of the truss or may contribute to roof failure, depending upon adjacent roof conditions. Often, lightweight trusses can be located by sounding the area and avoiding the member completely with the saw. By executing a center rafter technique you can avoid compromising the roof.

If a lightweight roof has been evaluated as unsafe with potential for collapse, consider that the bottom chord which also functions as the ceiling joist will collapse at the same time. So if it is unsafe to be on the roof, it will also be unsafe to operate underneath large, unsupported open areas.

Often the question is posed: How many ladders should the vent group place before commencing operations? Because we are always very concerned with burn time and limiting the exposure of the vent group, the vent group leader shall place one ladder while considering fire intensity and possible fire pathways.

If the need for a second ladder arises, its position shall be marked with a dropbag and an additional company requested through the command structure to complete the task.

Again, considering time as the priority factor, the vent group should not be required to take a hose line. If the need presents itself, an additional company should be assigned the task of supplying one to the vent group.