Ladder Company Operations

LEXINGTON COUNTY PROFESSIONAL FIREFIGHTER ASSOCIATION

LEXINGTON COUNTY, SC
4529
FIRE FIGHTERS

VERSION 1.2022

PREFACE

This manual was compiled with knowledge and experience by dedicated and committed members of the Lexington County Fire service. Countless hours, discussions, and information was pieced together to continue to build an aggressive Truck Culture for the citizens and firefighters in Lexington County.

This manual should be used as an aid for knowledge and training purposes, as well as, a stepping stone for younger members interested in ladder company operations. It is imperative that any member riding a Ladder Company will understand and be competent on all tools and functions of Ladder Company operations.

Riding a Ladder company is a privilege. With that privilege comes a lot of responsibility. When you earn that position and privilege you become a Truckman. Not everyone assigned to a ladder company becomes a Truckman. This title only is inferred when a firefighter possesses the drive, determination to excel at their craft, and to help others succeed.

This book contains information from training, experiences, and manufacturer manuals to provide the most up to date information on ladder company operations. Successes and equally important, failures, have been used to help construct this book so that you can better understand your role and responsibility on a LCFS Ladder Company.

This book is not the end all, be all. There is still so many important tasks that can not be documented in words, as well as, new ideas and techniques. If you do not understand something, ask. The LCFS Truckmen are the foundation and beginning of an outstanding Ladder Culture.

Pass on what you learned, this is the blood line of the fire service.

The following letter was written by the Chief Engineer of Los Angeles Fire Department on July 18, 1919.

CITY OF LOS ANGELES

FIRE DEPARTMENT

July 18, 1919

TO: Company Commanders

FROM: Ralph J. Scott, Chief Engineer
Los Angeles Fire Department

SUBJECT: L.A.F.D. TRUCK COMPANY SOPS

In past years, the staffing of L.A.F.D. Truck Companies was reserved for firemen who had proven themselves through physical strength, ability and actual firefighting experience. The assignment to a Truck Company was a position that was "earned" within the Engine House and was usually considered a "permanent assignment". Firefighting requires constant vigilance, hard work, a sound mind and the diligent application of basic fundamentals. Only through hard work and dedication to duty could a fireman earn the respect required in the Engine House to be assigned to a permanent position on the Truck Company.

EFFECTIVE IMMEDIATELY:
All Truck Company Officers will be held strictly accountable in applying these standards in assigning positions on L.A.F.D. Truck Companies.

R.J. Scott

Ralph J. Scott

Reference List

This manual would not be possible without the sharing and passing on of fire service tactics and information. The people and organizations on this list (and beyond) are leaders within the fire service today and deserve much more recognition than just a list within this manual. We owe special recognition to the following for providing and using their information, pictures, and passion for the Fire Service in regards to ladder company operations:

1. Arthur Ashley, Lexington KY
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22. Greg Mundy, Irmo Fire District, Irmo, SC
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Clackamas Truck Manual, Clackamas Fire District #1, Clackamas OR

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All contributors of the Firefighter Rescue Survey

In Memoriam Of

Durham Alexander DeLaura, Columbia, SC - 2017

Frank Martinez, Atlanta, GA - 2016

E.J Mascaro, North Charleston, SC - 2017

Dean Ray Jumper, Columbia, SC - 2021

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CHAPTER ONE

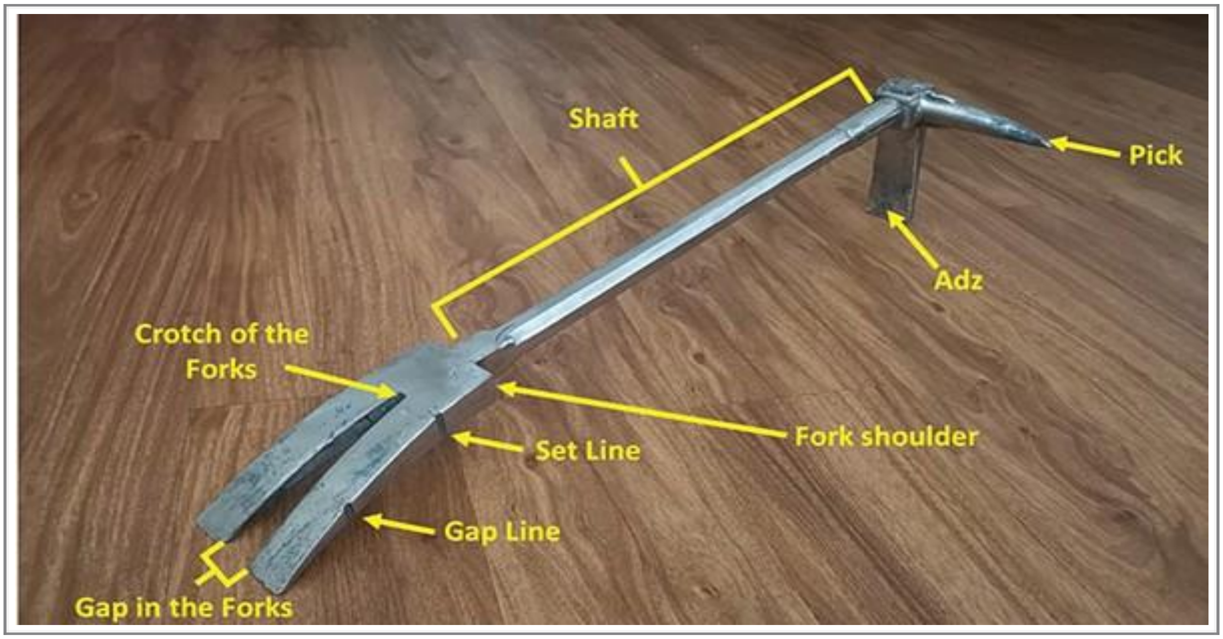
TOOLS
AND
EQUIPMENT

CHAPTER: 1 Hand Tools

Pro-bar Halligan

The Pro Bar Halligan is one of the most versatile tools any fire department member can carry. Every Truckmen should carry one during fireground operations.

The Pro-bar Halligan was invented in the 1940's by Hugh Halligan. It weights 8.5- 10 lbs (depending on version) and is 30 inches in length. The Halligan bar was designed with a focus on maximum efficiency and speed for the purpose of forcible entry. Many companies and manufacturers have attempted to re-produce a Halligan similar to the "pro-bar" version and have failed every time. The only true Halligan is a Pro-Bar Halligan, currently produced by Fire Hooks Unlimited.



Flat Head/Pick Head Axe

The flat head and pick head axe is another tool that should be carried by most Truckmen when headed topside for vertical ventilation. The axe comes in both six pound and eight pound axe versions (will be further discussed in the forcible entry chapter). The flat head axe is a great tool for breaking roof material (with blunt side) and the pick head axe is a great axe for lightweight construction.

Using the pick side of the axe, you can "J Hook" the material and it comes easily off of the roof. The flat head axe is also instrumental in forcible entry.

The Lincoln Bar

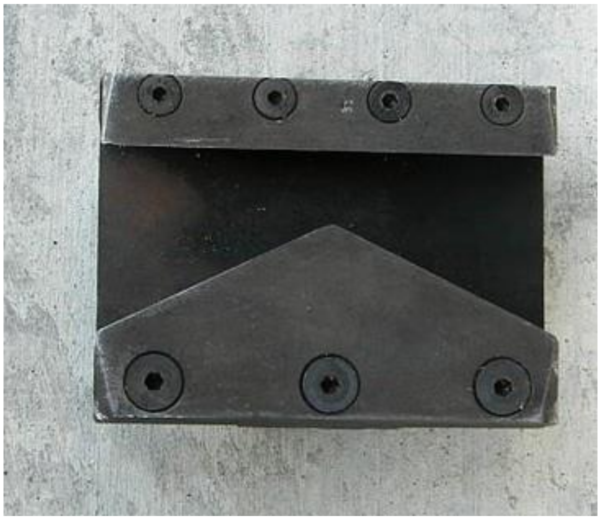
The Lincoln bar is a 54" extended Halligan Pro-Bar. Its name comes from the quarters of FDNY Rescue Company 2 where members “linked” two halligans together in their workshop. The Lincoln bar is absolutely a must have for all outside ladder company members and a must for flat roof operations. Its length enables it to have a almost 40 to 1 mechanical advantage lever ratio. This tool should be primary on any window bar/security devices, but is too long or heavy for inside work. This Lincoln bar in conjunction with a regular halligan is a monstrous combination for outside work and forcible entry.

The Rex Tool is a lock pulling tool that many officers could/should carry. Its designed with a “U” shaped end with sharp tapered blades that will bite into lock cylinders (forcible entry chapter). Its handle provides additional leverage to pull well secured lock cylinders and the opposite chisel end is used to drive rim locks off after a cylinder is removed.

Along with the Rex tool is what they call a "little Rex". It is a perfect lock pulling tool for Truckmen to carry in their pockets to match with the pike of a Halligan.

K TOOL

The K Tool is another through the lock tool that is used primarily for lock cylinder in mortise locks. The tool is used in conjunction with a Halligan or axe, placed over the cylinder and hit down to "bite" into the cylinder. The cylinder is then pulled off the door.



The PIG and PIGLET Tool

The Pig and Piglet tools are both tools designed by an Austin, Texas firefighter. These tools combine the weight and strength of a flat head striking axe and a pick-head back for an excellent roof work tool.

The Pig is an eight pound tool, while the Piglet is a smaller six pound tool with a curved pick head. Both tools are excellent for flat roof operations.

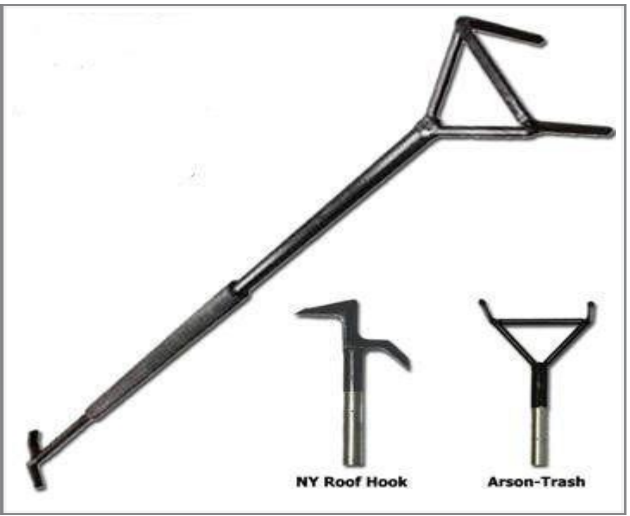
New York Roof Hook

The NY Roof Hook was designed as well by Hugh Halligan in the 1950's. It should be the hook of choice for any ladder company Truckman. It is designed so that every fulcrum can maximize the energy to deliver to your objective. It should be matched up with a Pro-Bar Halligan for optimal use, this set is called the "The OV Tools". It can be used for almost any and all tasks on the fireground. You should carry a minimum of a six foot length for optimal performance and leverage.

L.A Trash/Roof Hook

The LA Trash/Roof Hook is produced by NUPLA and is a solid fiberglass handle (honeycomb design) with a 6" wide triangle hook with two tines. The difference between any other Trash hook design and the NUPLA design is that the NUPLA tines are 3/8" which will not bend/break like other designs. It is also stronger as the fiberglass handle is solid design and the "D" handle is perpendicular to the hook head, which makes sounding a roof more efficient and effective. This hook and a Colorado hook (pictured as well) should be the standard topside vertical ventilation hook choice.

This hook should be used over a NY Roof Hook, as this hook sounds the decking and a Roof Hook may pierce the decking (Ventilation chapter).



STIHL 461R Chainsaw

The Stihl 461 R (rescue) chainsaw with a 20” bar is the saw of choice for the Fire Department. Much research and development has gone into this saw choice.

This was the only saw out of other manufactures that would start in a smoke filled environment and would last longer in heavy, dense smoke conditions. This saw is the saw of choice for any topside ventilation objective

Weight - 14.3 lbs
Bar Length - 20”
Power - 6.0 BHP
Displacement - 4.41 cu. In.
Chain - 3/8” RDR Carbide Chain

STIHL RDR Chain

This chain is the recommended chain for chainsaws.
3/8 pitch - .063 gauge - 72 drive links.
Three teeth in a row or six total, chain is out of service.

The RDR (Rapid Duo Rescue) chain can cut wood to lightweight metal. This chain is a very aggressive carbide tooth chain that will easily cut through most metals we will encounter.

Husqvarna K970

The Husqvarna series are the rotary saws of choice for LCFS. Like the chainsaws, these rotary saws have undergone extreme R & D testing and were scored #1 by the committee due to power, weight, and cutting abilities. These saws also out performed all other saws in heavy, dense smoke conditions.

The rotary saw of choice currently is the K970.

Husqvarna K970 -

Cutting depth - 5inches with a 14” blade
Power - 6.5HP
Displacement - 5.71 cu inch
Weight - 24.3lbs.

The Husqvarna K1270 is the recommended choice for roof only operations. After much R and D, it is recommended to purchase and use the K1270 as the primary flat roof rotary saw. Although all ladder companies have two K970, it is

the vision of the equipment committee to purchase K1270s in the near future for roof specific operations.

Husqvarna K1270 -

Cutting depth of 5 inches with a 14" blade, up to 5.7" with a 16" blade.
Power - 7.8HP
Displacement - 7.25 cu.inch
Weight - 31.3.lbs

The K1270 with a 14" blade did unbelievable cutting work on built up flat roof operations. This saw, because of its size and weight, should not be used for outside window bar/forcible entry work.

Rotary Saw Blades -

The LCFS Ladder companies have two blades on each of the rotary saws. Rotary saws can be used in an "inboard" or "outboard" operation.

The "inboard" operation is recommended to have the 14" carbide tooth blade on the primary saw for roof operations.

The "outboard" saw is the primary saw for forcible entry, as the blade mounted on the "outside" of the saw enables a closer more efficient cut on forcible entry and egress issues. Both saws can be easily used for rooftop operations and switching out the blades is a simple process as well.

14" CARBIDE TOOTH BLADE

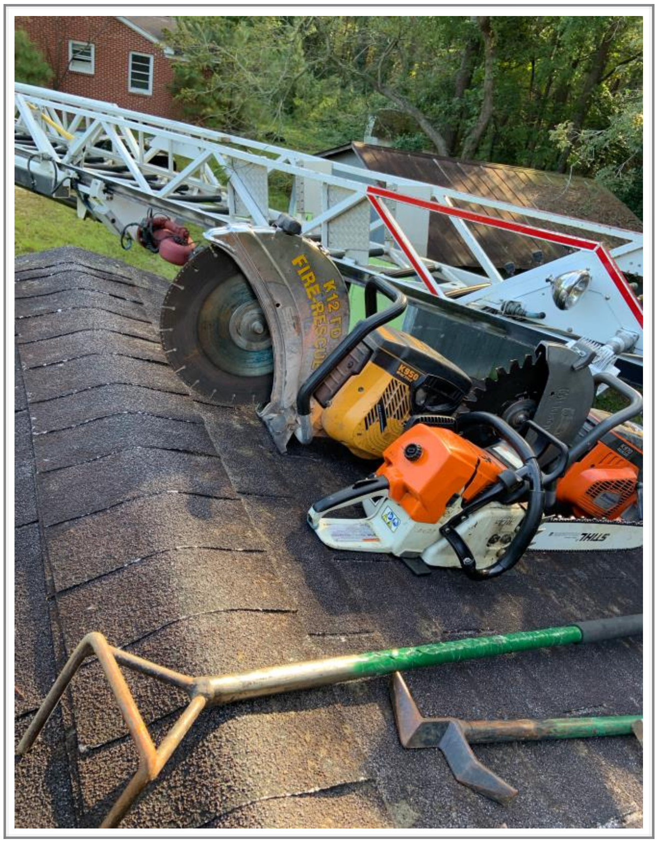
The 14" wide, carbide 30 tooth FHU blade is the carbide blade of choice for our rotary saws. This blade should be used on any roof top material. With more teeth, this blade will outlast its sister blade (12 tooth) which can be more aggressive with wood materials.

It is rated and should be used on flat roof operations, as it runs extremely well on built up and concrete material (ventilation chapter). It does not cut metal well, but it can cut lightweight metal. Expect to lose teeth if it makes contact with metal decking.

14" MULTI-PURPOSE BLADE

The 14" multi-purpose blade, is also referred to as the Diamond blade.

LCFS Ladder company standard diamond blade is the 14" PIRAYA Diamond blade manufactured by Team Equipment. This blade is excellent for forcible entry on metal and concrete. It is not the best choice for flat roof material (unless is it metal/fiberglass). The blade is not designed for wood. Although it will cut through light wood, the design of the blade will actually "burn" slowly through the wood. It is not recommended for any wood use.



CHAPTER TWO

RIDING ASSIGNMENTS

CHAPTER: 2 Assignments and Tooling

AUTOMATIC FIRE ALARMS

OFFICER (Inside) - Radio Designation of "LADDER XXX OFFICER"

- Primary Duties:
  - Scene Size-up/360
  - Gain entry to building
  - Communicate interior conditions to crews
  - Locate Fire Alarm panel and relay information
  - Determine the cause for activation
  - Assist in silencing Fire Alarm - Building occupant can reset alarm

- Tools Assigned:
  - Thermal Imaging Camera
  - Halligan
  - Hook
  - 2 Flashlights

IRONS FIREFIGHTER (Inside) - Radio Designation of "LADDER XXX IRONS"

- Primary Duties:
  - Gain entry into building. (locate Knox-Box key)
  - Assist Officer in determining the cause of the alarm
  - Assist with investigation of fire alarm

- Tools Assigned:
  - Irons (Halligan and Axe)
  - Water Can
  - Knox Box Key and Through-the-Lock kit
  - 2 Flashlights

DRIVER (Outside) - Radio Designation of "LADDER XXX DRIVER"

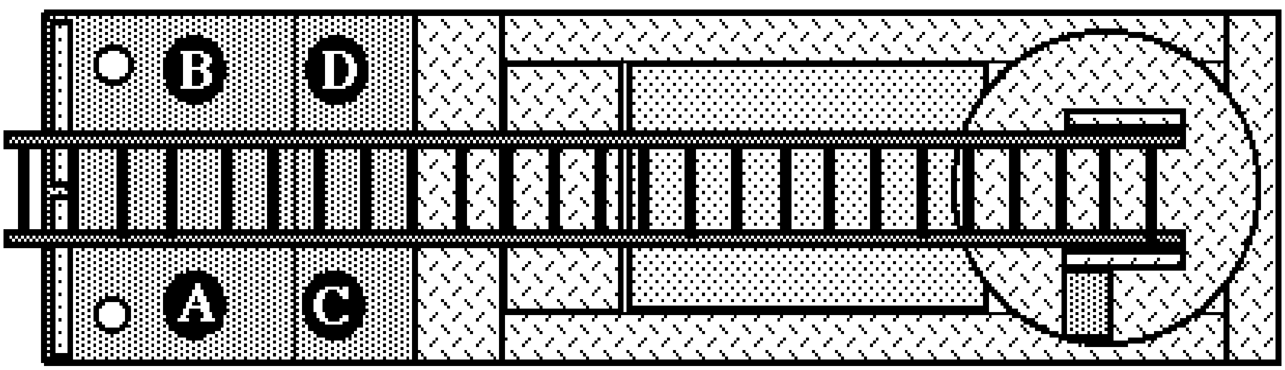
- Primary Duties:
  - Position apparatus for offensive aerial operations
  - 360 of the Building and communicate to Officer
  - Report conditions of upper floors/roof (if needed)
  - Assist in determining cause for fire alarm
  - Collect occupant information
    - Name, DOB, Last four of SSN, phone number, and relation to occupancy

- Tools Assigned:
  - Hook/Halligan combination
  - Striking Tool
  - 2 Flashlights

OUTSIDE VENT-MAN (OVM/Outside) - Radio Designation of "LADDER XXX O.V."

- Primary Duties:
  - Assist with apparatus positioning (if needed)
  - 360 of the building and communicate to Driver
  - Report conditions of upper floors/roof (if needed)

- Tools Assigned:
  - Hook/Halligan combination
  - Striking Tool
  - 2 Flashlights



Outside Team	**Inside Team**
A - Ladder Driver	B - Ladder Officer
C - Outside Vent Man	D - Ladder Irons

RESIDENTIAL STRUCTURE FIRE

Generally, residential structures have smaller, more compartmentalized rooms which will allow our Ladder Companies to "split" crews. The crew will consist of the Inside Team (Officer and Irons) and Outside Team (Driver and OVM).

Although this is the "standard" the Officer can go "All in" or "All Out" if they dictate, as long as it is communicated to the responding units and/or Battalion Chief.

INSIDE TEAM

OFFICER - Radio Designation of "LADDER XXX OFFICER"

- Primary Duties:
  - Size Up/360 (determine best entry location)
  - Forcible Entry
  - Primary Search
  - Locate/confine the fire
  - Interior ventilation as needed
  - Extension Checks (Open wall and ceilings)
  - Ensure hose-lines can meet objectives

- Secondary Duties:
  - Salvage and overhaul

- Tools Assigned:
  - Thermal Imager Camera
  - Halligan
  - Hook
  - 2 Flashlights
  - Other tools deemed appropriate

IRONS FIREFIGHTER - Radio Designation of "LADDER XXX IRONS"

- Primary Duties:
  - Forcible Entry
  - Primary Search
  - Locate/confine fire
  - Extinguish Fire (water can)
  - Extension Checks (Open wall and ceilings)
  - Ensure hose-lines can meet objectives

- Secondary Duties:
  - Salvage and overhaul
  - Air monitor

- Tools Assigned:
  - Irons (Halligan and axe)
  - Water Can
  - Hook
  - 2 Flashlights
  - Other tools deemed appropriate

OUTSIDE TEAM

The outside team of our ladder companies should use the acronym REVUS, as taught in "The Ladder Academy". This acronym is used as a guide to assist in the responsibilities of the outside crews. Every fire is different, every building is different; the outside crews must use their experience and judgement to decide which tasks to complete first.

R - Rescue: Vent, Enter, Search, Ladders, Aerial Device.
E - Egress: Aerial and portable ladders, window bars/security devices, fortified doors, etc.
V - Ventilation: Vertical and horizontal ventilation options.
U - Utilities: Electric, gas, and/or water.
S - Salvage: Salvage and overhaul operations, air monitor.

OUTSIDE VENT MAN - Radio Designation of "LADDER XXX O.V"

- Primary Duties:
    - Size-up/360 to ensure appropriate actions (Bring Portable ladder with you for Charlie (C side).
    - Roof Operations/Ventilation
    - VES
    - Portable Ladders
    - Egress issues/security devices
    - Utilities
- Secondary Duties:
    - Secondary search
    - Salvage and overhaul
    - Air monitoring
- Tools Assigned:
    - Hook/Halligan combination
    - Saws (Chain and/or Rotary)
    - Portable ladders
    - Fan
    - Salvage Tarps
    - 2 Flashlights

DRIVER- Radio Designation of "LADDER XXX Driver"

- Primary Duties:
    - Position Aerial for maximum versatility
    - Roof operations/Ventilation
    - Portable ladders

- VES
- Egress issues/security devices
- Utilities

- Secondary Duties:
  - Scene lighting
  - Secondary searches
  - Salvage and overhaul
  - Air monitoring

- Tools Assigned:
  - Hook/Halligan combination
  - Saws (Chain and/or Rotary)
  - Portable ladders
  - Fan
  - Salvage Tarps
  - 2 Flashlights

COMMERCIAL STRUCTURE FIRE

Commercial buildings require different tactical objectives due to the occupancy load, size, and space. While splitting crews (inside/outside) will be normal operations for residential structures, most commercial structure fires will require Ladder Companies to stay together as a crew. This will be defined as “All In” or “All Out”. The crew will stay together under most circumstances. However, like most incidents, it will be up to the decision of the officer and/or Battalion Chief to communicate “All In/All Out” or “Split”. Staying together as a company will be the “standard” in ladder company responses to commercial building fires.

ALL IN - Radio Designation of “LADDER XXX”

- Primary Duties:
  - Forcible Entry (Consider fortified doors and Through-The-Lock)
  - Locate and confine fire - use of Search Rope Bag
  - Primary Search - use of Search Rope Bag
  - Extension checks
  - Ensure hose-lines can meet objectives

- Tools Assigned:
  - Halligan
  - Hooks
  - Lincoln Bar
  - Search Rope Bag
  - Thermal Imager Camera
  - Through the Lock Kit
  - Other tools deemed appropriate

ALL OUT - Radio Designation of "LADDER XXX"

- Primary Duties:
  - Roof Ventilation
  - Forcible entry/Security bars
  - Portable ladders
  - Additional assignments as needed

- Tools Assigned:
  - Chainsaw(s)
  - Rotary(s)
  - Roof bag
  - Hand tools
  - Portable ladders
  - Through the lock kit
  - Other tools deemed appropriate

When responding to commercial building fires, both ladder companies need to communicate on the positioning and tactical decisions of the other company. Generally, Tower Ladders should position for storefront attack (front or bay doors) and Aerial Ladders should position for optimal roof positioning. It is highly recommended that the ladder companies continuously train and discuss all options to ensure tactical and operational proficiency. For additional information refer to Chapter 10: Aerial Operations.

It is also imperative that ladder companies continue to train and understand fires that have taken place in the past years. For example, the Stratford Arms fire on November 16, 1973 in Los Angeles, CA. The fire started on the first floor in the lobby of a three story apartment building (center hallway) and rapidly advanced up the open stairways and hallways. Once the fire made the third floor and unchecked, it rapidly advanced and killed 25. The question from incidents like this pose the question, is it quicker to ventilate and prevent lateral fire spread and control the conditions OR attempt to rescue over 40 civilians with limited ground ladders?

24 Die as Flames Engulf Stair Well in Los Angeles

Our recommendation is to attempt to control the conditions, you can possibly save more lives with ventilation than allowing the fire to spread rapidly uncontrolled.

Another fire, more recent, was in Hartford, CT on March, 9th, 2020. Over 40 civilians were rescued by multiple companies using limited ladders, splicing, and aerial devices.

It takes experience and training to understand and operate as a cohesive ladder company.

CHAPTER THREE

BUILDING CONSTRUCTION

CHAPTER: 3 Building Construction

Information in this chapter was pulled from Clackamas FD Manual

Truck work involves [to different degrees] the systematic destruction or dismantling of a building's construction to effect the mission of firefighting; and there is no aspect of building construction that is as important to truck work as roof construction, especially as it relates to vertical ventilation and roof operations. The degree to which roof construction has changed over the past 150 years and especially in the past 30-40 years affects our abilities to properly size- up a roof's construction. The size-up of roof construction can be very difficult even during a drill when there is good lighting and time to study the roof.

Accomplishing this task during a fire can be next to impossible. The materials and techniques that are used today are only limited by an engineer's imagination; and only by understanding all of the techniques and materials used in residential and commercial roof construction can the truck company stand a chance at performing effective and safe ventilation.

KEY CONSIDERATIONS

- Understanding the construction and uses of a building is integral to effective and efficient firefighting operations and essential for all phases of fire suppression.
- While there are similarities between residential and commercial construction, many variations in methods and materials are often found in commercial construction.
- NFPA classifies five general construction types designated Type I, II, III, IV, V. Their are talks about a sixth type (VI) called hybrid, which is a mixture of two classifications , for example , a building that is both two and five, would be called a Type Six.

OPERATIONS

Building construction for truck companies can be broken down into two broad categories: Residential and Commercial. Residential construction is much more basic and easy to understand compared to commercial building construction mostly because the residential materials and methods are more limited in their use and application and it is studied far more at the basic level. Commercial construction is more complex and difficult to master. Much time needs to be devoted to learning commercial construction and especially commercial roof construction.

RESIDENTIAL CONSTRUCTION

Residential construction includes single and multi-family occupancies which are generally one to four stories high and their methods of construction and materials are similar. They typically are unprotected wood frame constructed buildings. NFPA classifies these combustible buildings as Type V construction.

The word ‘unprotected” here references the lack of fire proofing. However, these occupancies usually are protected to a small degree using drywall or gypsum board causing some reference materials to identify them as one hour buildings. Nevertheless, they are combustible and are built using dimensional or nominal lumber as well as lightweight engineered materials. The use, more than the construction type determines the response.

Three basic types of framing are most commonly found in residential construction; post-and-beam framing, balloon framing, and platform framing.

Post-and-beam

Post-and-Beam construction (figure 1) employs difficult construction techniques which requires highly-skilled laborers. Connections in post-and-beam framing are made using mortises, tenons, and dovetails and lack metal such as hangers and nails. These techniques were developed when nails and metal hangers were not available. In the early nineteenth century commercially made nails were produced and sawmills were producing cheaper lumber which gave rise to Balloon Framing techniques.

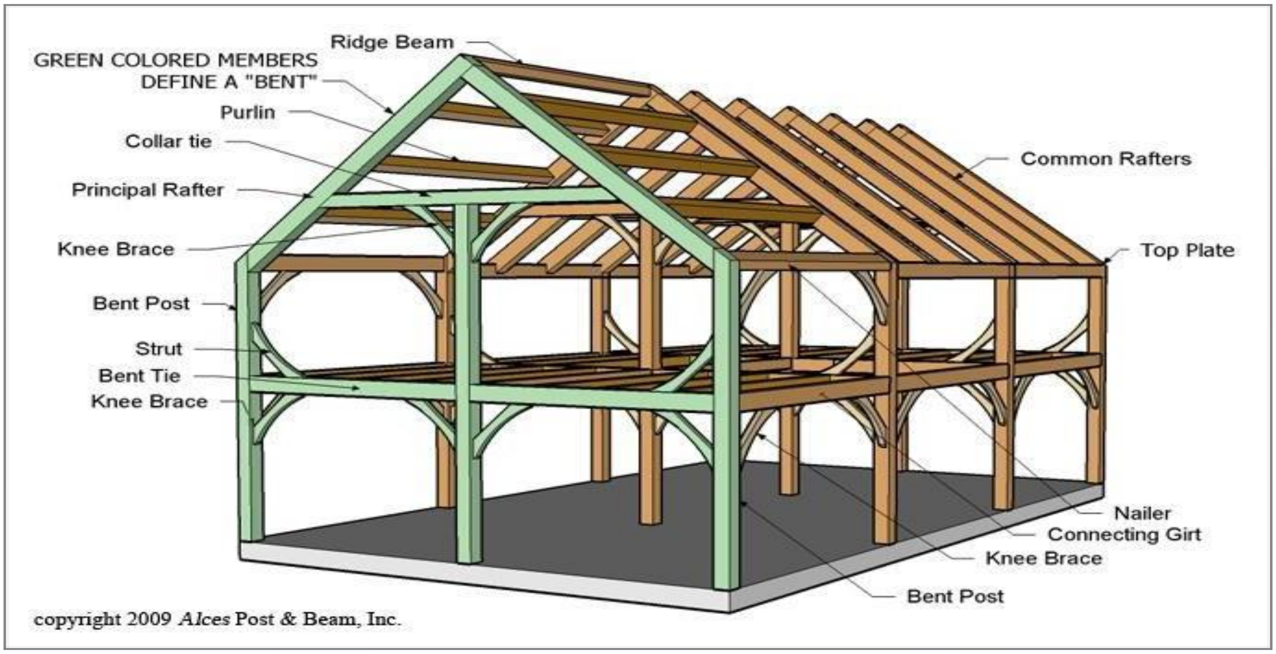


Figure 1: Post and Beam framing is sometimes referred to as Timber Framing. It requires highly skilled carpenters and therefore is very uncommon.

Balloon Framing

Balloon framing (figure 2) is a method of wood construction used extensively in the United State from the 1830s up until the mid-1950s in some areas. It utilized long continuous framing members (studs) that run from sill plate to eave line with intermediate floor structures nailed to them. Once popular when long lumber was plentiful, balloon framing has been largely replaced by platform framing.

Balloon framing has several disadvantages as a construction method. (1) The creation of a path for fire to readily travel from floor to floor. This was sometimes mitigated with the use of fire stops at each floor level. (2) The lack of a working platform for work on upper floors. Whereas workers can readily reach the top of the walls being erected with platform framing, balloon construction requires scaffolding to reach the tops of the walls (which are often two or three stories above the working platform). (3) The requirement for long framing members. (4) In certain larger buildings, a noticeable down-slope of floors towards central walls, caused by the differential shrinkage of the wood framing members at the perimeter versus central walls. Larger balloon-framed buildings can have central bearing walls which are actually platform framed and thus will have horizontal sill and top plates at each floor level, plus the intervening floor joists, at these central walls. Wood will shrink much more across its grain than along the grain therefore, the cumulative shrinkage in the center of such a building is considerably more than the shrinkage at the perimeter where there are many fewer horizontal members. Of course, this problem, unlike the first three, takes time to develop and become noticeable.

Figure 2: Balloon Framing: Studs extend from the foundation to the roof with minimal fire stopping.

Balloon framing is making a re-appearance in some applications. Since steel is generally more fire-resistant than wood, and steel framing members can be made to arbitrary lengths, balloon framing is growing in popularity again in light gauge steel stud construction. Balloon framing provides a more direct load path down to the foundation. Additionally, balloon framing allows more flexibility for tradesmen in that it is significantly easier to pull wire, piping and ducting without having to bore through or work around framing members.

Platform Framing

The most common method of light-weight construction for modern house and small apartment building as well as some small commercial buildings is platform framing (figure 3). The main difference between platform and balloon framing is at the floor lines. The balloon wall stud extends from the sill of the first story all the way to the top plate or end rafter of the top story. The platform-framed wall, on the other hand, is independent for each floor.

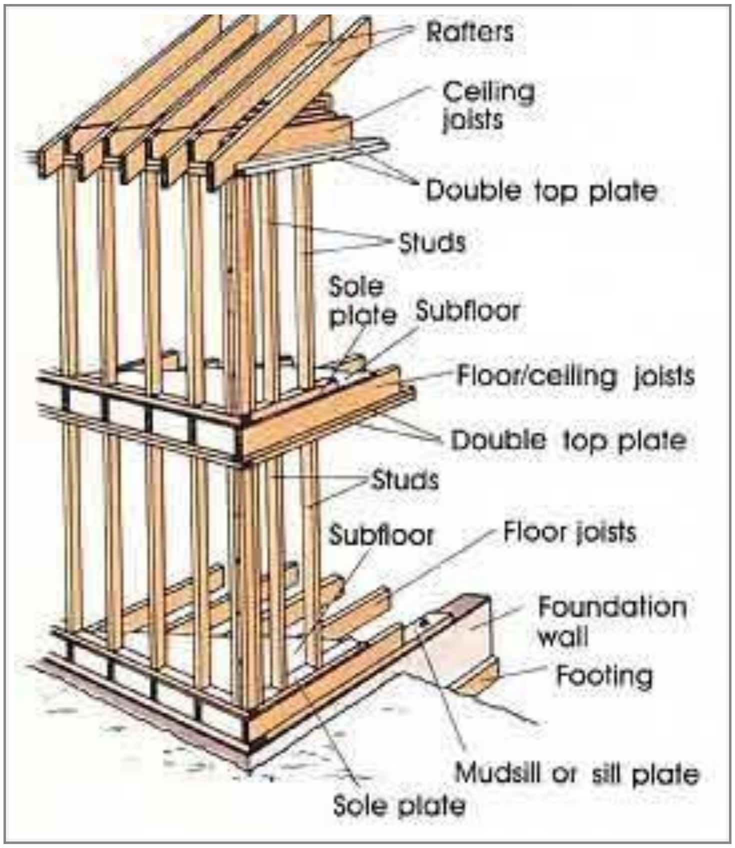


Figure 3: Platform Framing: Wall studs extend from floor to floor. From a firefighting standpoint, this type of framing compartmentalizes fire and inhibits fire spread.

The floors, walls and roof of a framed structure are created by assembling consistently sized framing elements of dimensional lumber at regular spacing forming stud-bays (wall) or joist-bays (floor). The floors, walls and roof are typically made torsionally stable with the installation of a plywood or composite wood skin referred to as sheathing. Sheathing has very specific nailing requirements (such as size and spacing); these measurements allow a known amount of shear force to be resisted by the element. In the past, tongue and groove planks installed diagonally were used as sheathing. Occasionally, wooden or galvanized steel braces are used instead of sheathing. There are also engineered wood panels made for shear and bracing.

The floor (platform) is made up of joists (usually 2x6, 2×8, 2×10 or 2×12, depending on the span) that sit on supporting walls, beams or girders. The floor joists are covered with a sheet material as a subfloor. In the past, 1x planks set at 45-degrees to the joists were used for the subfloor.

The resulting platform is where the framer constructs and stands the next floor's walls (interior and exterior load bearing walls and space-dividing, non-load bearing par ons). Floor joists can be engineered lumber (trussed, I-joist, etc.), conserving resources with increased rigidity and value while decreasing fire resistance.

Additional framed floors and their walls may then be erected to a general maximum of four floors in wood framed construction. There will be no framed floor in the case of a single-level structure with a concrete floor known as a slab on grade.

A framed roof is an assembly of rafters or trusses and wall-ties supported by the top story's walls. Prefabricated and site-built trusses can be found along with common stick framing. Trusses are engineered to redistribute tension away from wall-tie members and the ceiling members. The roof members are covered with sheathing or strapping to form the roof deck for the finish roofing material.

Residential Materials

Light-frame materials are most often wood or rectangular steel tubes or C-channels. Wood pieces are typically connected with nail or screw; steel pieces are connected with screws, nuts, and bolts. Preferred species for linear structural members are softwoods such as spruce, pine and fir because of their relative high modulus of elasticity or stiffness. Light frame material dimensions range from two-by-four inches to two-by-twelve inches at the cross-section, and lengths ranging from 8 ft. or more for walls and 23 ft. or more for joists and rafters.

Wall sections (figure 4) usually include a bottom plate (sill) which is secured to the structure of a floor, and commonly two top plates that tie walls together and provide a bearing for structures above the wall. Wood or steel floor frames usually include a rim joist around the perimeter of a system of floor joists, and often include bridging material near the center of a span to prevent lateral buckling of the spanning members.

Interior wall coverings in light-frame construction typically include wallboard, lathe and plaster or decorative wood paneling. Occasionally, plywood sheathing can be found on interior walls and ceilings which was required by the engineer to attain the proper wind and seismic strengthening of the structure.

Exterior finishes for walls and ceilings often include plywood or composite sheathing, brick or stone veneer, and various stucco finishes. Stucco finishes typically have a foam board beneath the stucco, which can add fuel to any fire involving the exterior finish. Cavities between studs, usually placed 16–24 inches apart, are usually filled with insulation materials, such as fiberglass or cellulose filling sometimes made of recycled newsprint treated with boron additives for fire prevention and vermin control. A new and less common trend for insulating is to fill all of the stud bays with expandable rigid foam, which is then cut off flush to the studs so drywall can be installed.

Engineered wood has become popular with architects and designers. Timberstand and Micro-lam are two brand names of engineered wood that is used. The Timberstand (figure 5) is comprised of small pieces of wood which are pressed together at very high pressures similar to Oriented Strand Board (OSB) and held together with a resin or glue. Microlams are more similar to a glulam. Think of Microlam as "plywood on steroids." Like plywood, thin sheets of wood are sandwiched on top of each other, held together with super-strong glue.

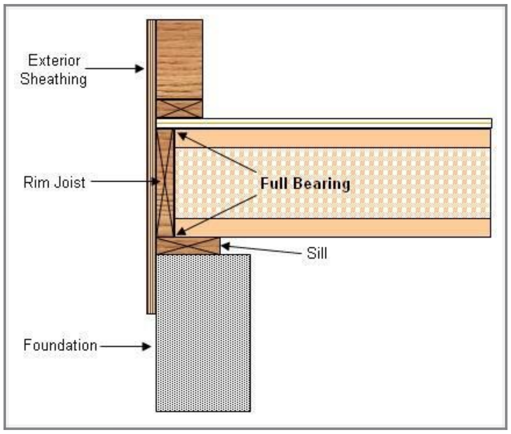


Figure 4: Typical Wall Section

Figure 5: Timberstrand wood being used vertically

Each layer is perpendicular to the layers on either side of it. But unlike brittle plywood, a microlam is very solid, heavy, and construction-grade. Both of these materials are expensive but very strong. They are sometimes used vertically as studs or columns, but more commonly are used horizontally as joists, beams, or girders.

Another type of engineered lumber is I-Joists (figure 6). They are most commonly called "TJI". TJI is a trade name which has dominated the industry and therefore has become synonymous for I-Joist. They are essentially a solid web lightweight truss that is used most often as floor joists. In residential construction, the top and bottom chords are commonly made of small size lumber such as 1 x 2 and the solid web is thin plywood or OSB material.

The main problem with these materials from a firefighting standpoint is the lack of sacrificial wood. They are engineered to save money and have only enough mass to do their job if they are in mint condition. Any amount of degradation such as charring from a fire will cause these members to become weak and fail early. I-Joists are sometimes used as rafters in at and pitched roof construction because they can span relatively long runs and are very straight unlike dimensional lumber which almost always has a crown.

Figure 6: I-Joists being used as floor joists.

Architects sometimes call for steel or aluminum in the framing (figure 7). They can include light gauge steel studs which are cut to length by the carpenter or are ordered at certain lengths, or pre-cut modular aluminum framing to reduce on- site construction costs. Steel beams and girders as well as columns can occasionally be found in residential structures, especially in very large homes with a lot of glass. The steel is needed for strength replacing the lumber that must be removed to install many windows in a wall. Large A-Frame homes with entire walls of glass are one place where heavy steel may be found in the framing.

Figure 7: Steel and aluminum have become popular for framing. Commonly found in commercial applications but it is also used in residential framing.

Roofs

Roofs are usually built to provide a sloping surface intended to shed rain or snow, with slopes ranging from 1 inch of rise to 12 inches of run of rafter length, to steep slopes of more than 24 inches of rise to 12 inches of rafter run. A light- frame structure built mostly with sloping walls comprising a roof is called an A- frame.

Roofs are most often covered with shingles made of asphalt, fiberglass and small gravel coating, but a wide range of materials are used. Molten tar is often used to waterproof flatter roofs, but newer materials include rubber, and synthetic materials can also be found. Steel panels are popular roof coverings in some areas, preferred for their durability. Slat or tile roofs offer more historic coverings for light-frame roofs.

Light-frame methods allow easy construction of unique roof designs (figure 8). Hip roofs slope toward walls on all sides and are joined at hip rafters that span from building corners to a ridge. Valleys are formed when two sloping roof sections drain toward each other. Gable roofs are formed when a lengthwise section of sloping roof ends to form a triangular wall section called a gable wall. Shed roofs slope in only one direction from one side of the structure to the other. Clerestories are formed by an interruption along the slope of a roof where a short vertical wall connects it to another roof section. Flat roofs, which usually include at least a nominal slope to shed water, are often surrounded by parapet walls with openings (called scuppers) to allow water to drain out.

Sloping crickets are built into roofs to direct water away from areas of poor drainage, such as behind a chimney at the bottom of a sloping section.

Dormers are small areas in which vertical walls interrupt a roof line, and which are topped off by slopes at usually right angles to a main roof section. Dormers can be constructed and topped with any kind of roof. You will find gable dormers, Hip dormers, and shed dormers.

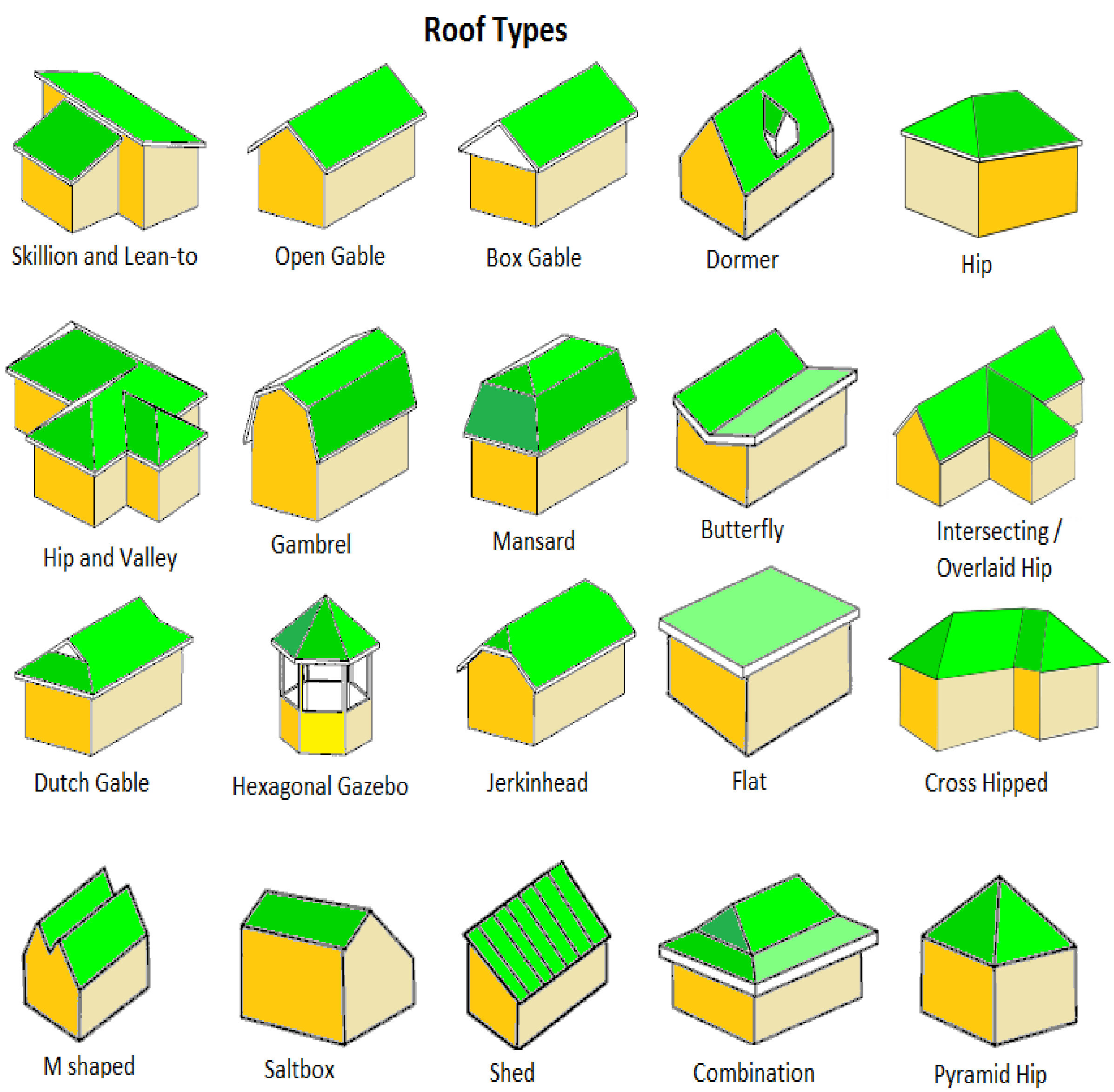


Figure 8: Common roof types found in residential construction versus Lightweight Construction

Legacy virus Lightweight Construction

The term "Legacy" when used in the construction industry refers to conventional materials and methods. It is often misused when describing residential construction during size-ups and training in the fire service. Legacy construction comprises tried and true methods and materials like dimensional lumber. The overriding theme of legacy is that even though new technology and seemingly improved materials are available the designer and contractor use older materials and techniques which have been proven over time.

COMMERCIAL CONSTRUCTION

In comparison to residential construction, commercial construction is more complicated. All of the materials and concepts used in residential construction can be found in commercial applications; however, there are many more variations and materials employed in commercial construction making it more difficult to master in terms of understanding the construction and how it affects our safety and effectiveness. Depending on the era that the structure was erected, and the desired degree of non-combustibility, the fire resistive qualities can vary immensely.

Earlier in this chapter, residential construction was identified as type V construction. NFPA also classifies four other general types of construction. Type I, Type II, Type III, and Type IV. There are two subcategories within each of these standards and are in descending order in terms of their resistance to fire. It is not practical to memorize all of the details within the standards and employ them on the fireground; therefore the information normally presented on building classifications is generalized.

Type I

Type I is considered to be "Fire Resistive" and the International Building Code (IBC) defines it as: "That property of materials or their assemblies that prevents or retards the passage of excessive heat, hot gases or flames under conditions of use." Building codes apply minimum fire-resistance ratings to building elements based on the building's construction type. For example, Type IA noncombustible construction requires 3-hour structural frame and bearing walls, 2- hour floors, 1-1/2 hour roofs, and no rating for non-bearing interior walls; exterior nonbearing walls are rated based on occupancy and distance from the property line. Construction types are assigned based on one or more factors such as building area, building height, or occupancy use.

From a firefighting standpoint, our safety in these buildings during a fire is dependent on the condition of the building, specifically the fire proofing. As we learned from the World Trade Center fires, when the fire proofing is destroyed, the building's fire resistance is significantly reduced.

Figure 9: Lexington Medical Center Hospital is an example of a Type I building with high life hazard.

Type II

Type II construction is classified as "non-combustible." As in all other construction types, Type II has two subdivisions, IIA and IIB. Type IIA employs masonry exterior walls and other load bearing walls. Other interior walls, columns, and floor assemblies are normally built using non-combustible metal. Type IIB (figure 10) is made entirely of non-combustible metal. It is also referred to as light frame non-combustible. We see many of these structures (Type IIB) used in light manufacturing within our district. Since we know that steel loses its strength at moderately high temperatures these buildings are prone to collapse in heavy fire conditions.

Figure 10: These types of metal clad buildings are Type IIB construction and are used for agriculture and light manufacturing. Remember, the contents and often times the roof materials are flammable.

Therefore, the effectiveness of our firefighting efforts can depend largely on our ability to cool the structural members. For our purposes, the practical difference between the two subdivisions of type II construction is their propensity to fail during fire conditions. Type IIA fairs better than Type IIB during heavy fire conditions because of its masonry components. Since unprotected steel fails rather early during a fire, it makes sense that the masonry constructed Type IIA building will fair better in terms of total collapse. We must remember though that the rest of the building (interior walls, floors, columns, and roof) is prone to early collapse as is the entire Type IIB constructed building during heavy fire conditions.

Some Type II buildings have roof coverings that are combustible which can burn and spread fire. The roof covering of a Type II building can be a layer of asphalt waterproofing, with a combustible felt paper covering. Another layer of asphalt may be mopped over the felt paper. Combustible foam insulation may be placed on top of the asphalt, and another layer of asphalt mopped over the foam insulation. When a fire occurs inside a Type II building, flames rising to the underside of the steel roof deck may conduct heat through the metal and ignite the combustible roof covering above. The asphalt, felt paper and foam insulation may burn and spread fire along the roof covering. After a fire has been extinguished inside a Type II building, it is important when possible that the roof be checked for the presence of a running roof fire.

Type III

Type III construction is classified as “ordinary construction”. An ordinary constructed (Type III) building is also called a brick-and joist structure (figure 10). It has masonry- bearing walls but the floors, structural framework and roof are made of wood or other combustible material. Ordinary construction has been described by some firefighters as a "lumberyard enclosed by four brick walls." The major recurring fire spread problem of Type III construction is concealed spaces and poke-through holes. These small voids, crevices and openings through which smoke and fire can spread are found behind the partition walls, floors, and ceilings. Concealed spaces are created by wood studs, floor joists and suspended ceilings. Poke-through holes are created by small openings for utilities. These small openings around pipes and wires allow fire to spread into concealed spaces. Flames can spread vertically several stories or horizontally to adjoining occupancies inside concealed spaces. The largest concealed space is the attic.

This roof space, above a top floor ceiling and below the roof deck, is large and can sometimes extend over several buildings. A fire in an attic or roof space extending over a row of three or four occupancies or stories can destroy the entire row of structures. Heated fire gases and flame in a concealed space can travel upwards several floors and break out in an attic space. When firefighters search for hidden fire, they must open walls and ceilings to find it and extinguish it.

Figure 10: Buildings in a “downtown” or “Main Street” area that are type III ordinary constructed buildings.

Type IV

Type IV construction is called “heavy timber” or sometimes "mill construction" because it was the type of structure used at the turn of the century to house textile mills (figure 11). These buildings have masonry walls like Type III buildings but the interior wood consists of large timbers. The floor and roof are plank board. In a heavy- timber building a wood column cannot be less than eight inches thick in any dimension and a wood girder cannot be less than six inches thick.

One difference between a heavy timber building and ordinary construction is that a heavy-timber building does not have plaster walls and ceilings covering the interior wood framework. The exposed wood timber girders, columns, floor beams and decks, if ignited in a fire, create large radiated heat waves after the windows break during a blaze. If a fire in a heavy- timber building is not extinguished by the initial attack, a greater alarm fire with extremely high heat transfers will likely spread fire to adjoining buildings by radiated heat. As the fire grows, apparatus will have to be repositioned away from the radiated heat waves. Large water supply sources must be located and master streams set up to protect nearby buildings. A collapse danger zone must be designated to protect against a building collapse. Expect the floors to collapse first and then the walls to push outward falling into the street.

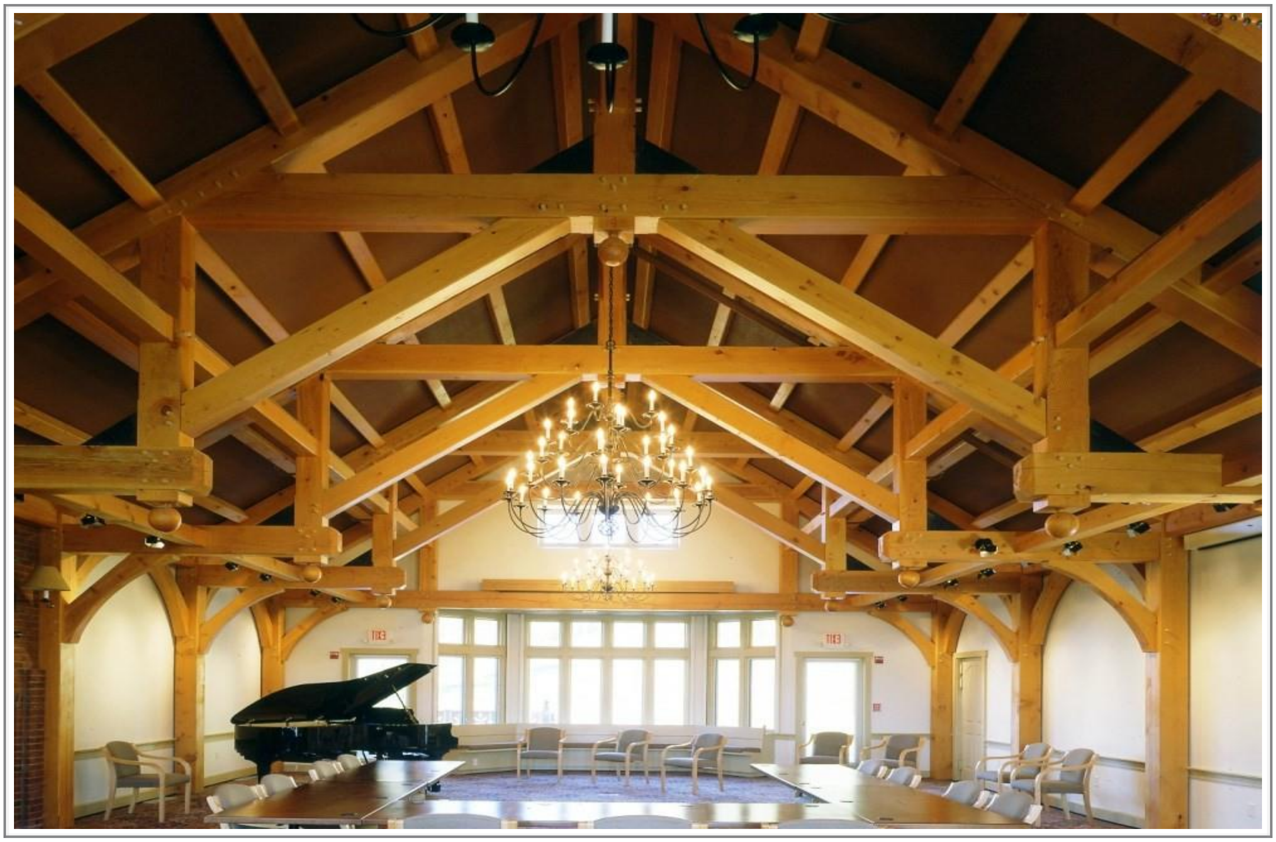


Figure 11: Once ignited, heavy timber constructed buildings present the potential for large fire volumes and rapid fire spread

COMMON COMMERCIAL CONSTRUCTION MATERIALS

Steel

Steel is thought of as an ideal material for building construction. It is relatively light weight and ductile, and is strong and can be formed and welded. Among these attributes, the steel's ductility is probably its most desired trait. Steel can be stressed beyond its yield strength and severely bend but will still have enough strength to resist failure.

One negative attribute of steel is its relative weakness under high heat conditions. Structural steel begins to lose its strength at about 700° F. It will completely fail at about 1000° F. Failure and collapse of the structure can be caused by the weakening of the steel as well as the lengthening that occurs when heated. At 1000° F the steel member may increase in length by as much as ten percent which can place lateral forces on the structure that it was not designed to resist. To combat this, engineers will cover or treat the steel with fire-proofing materials which will insulate the steel and allow it to maintain its strength during a fire. Type IA and IB buildings will have some degree of fireproofing applied to structural steel.

Concrete

Concrete is used extensively as a building material in Type I and Type II construction. Concrete is a mixture of sand aggregate, Portland Cement, and water.

When fully cured it is very strong in compression but relatively weak when placed under tension or shear. Engineers overcome this weakness by using reinforcing bars known as rebar or cables and strands. When concrete has steel incorporated for strength it is commonly referred to as reinforced concrete.

There are several ways to incorporate the steel into the concrete and engineers design the system depending on the use and configuration of the concrete assembly.

Bars can be laid down and the concrete is poured around the steel known as rebar. To add additional strength the steel rods or cable can be placed under extreme tension prior to the concrete being poured. This technique is known as pre-tensioning and most often is done off site in a concrete plant that specializes in tensioning. After a 28 day curing time the tension is released and the slab or girder can be moved to the building site. Post-tensioning is another technique used to reinforce concrete for building purposes. It is done at the jobsite by placing cables, which are in sleeves, and the concrete poured around them. After the concrete cures, the cables are then tensioned to about 28,000 lbs. at which time the forms can be removed from the concrete.

Wood

Wood is used in commercial construction extensively. It can be found throughout structures of varying types. An important point for firefighters to remember is that many times the word "commercial" refers to the building's use and not so much the construction techniques and materials. For example, some apartment buildings and retirement centers are commercial in nature but can be of protected Type V (wood frame) construction. Also Type IV construction can be entirely constructed of wood. Conversely residential homes have seen an increase in the use of concrete wall construction. From a firefighting standpoint, these concepts are important when responding to structure res.

Masonry

Masonry construction materials and techniques are popular in some types of construction. Brick and Block materials are the most common forms of masonry materials used. Many times in modern construction, a building that appears to be brick construction is actually a brick veneer (figure 12). The supporting walls are typically wood frame or block constructed and the brick finish is merely cosmetic in nature. The brick veneer is attached to the wood wall with metal clips and creates an air space between the brick and wood. The space which is created provides additional fire protection from radiant and convected heat but also can negatively affect fire control efforts by allowing fire to spread through these voids.

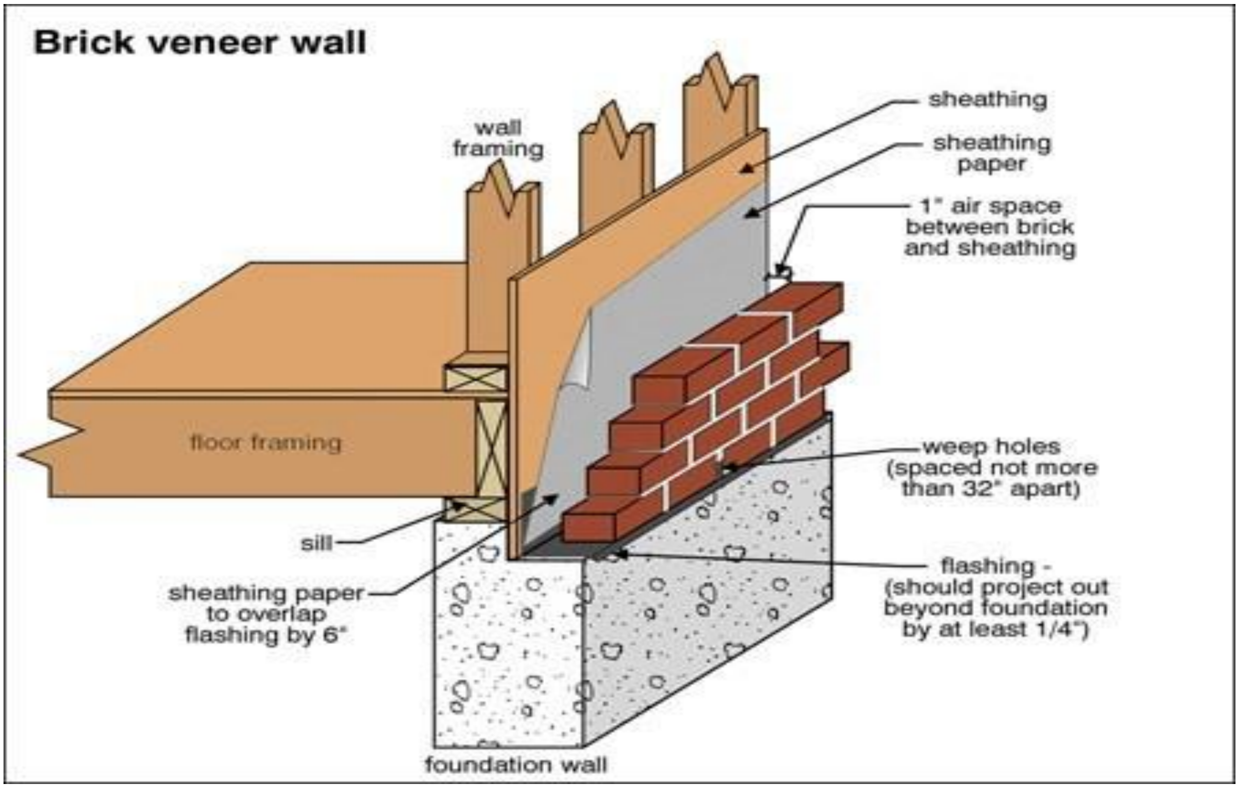


Figure 12: Brick veneer is mainly decorative but can provide limited fire protection from convective and radiant heat.

True brick wall construction is seen primarily in older construction and is the predominant method of wall construction in Type III buildings built earlier in the 20th century. In almost all cases they will have more than one wythe and will have a header course or rowlock course about every 6th course. The "header course" is a course of bricks turned the opposite direction to connect the two wythes (figure 13). Wall construction of this type is commonly referred to as Unreinforced Masonry or URM and is prone to sudden and catastrophic collapse during fires when other parts of the building fail.

Block construction is very common in Type IIA construction where a masonry or concrete supporting wall is present and the roof and floor assemblies are made of steel. Occasionally in new Type III construction you will find block walls, and the floors and roofs are of wood construction. Construction block comes in various sizes but are commonly found in 8" x 8" x 16" block and can be either hollow or solid. Often times the hollow blocks have a certain percentage of their voids filled with concrete and rebar running vertically to strengthen the wall.

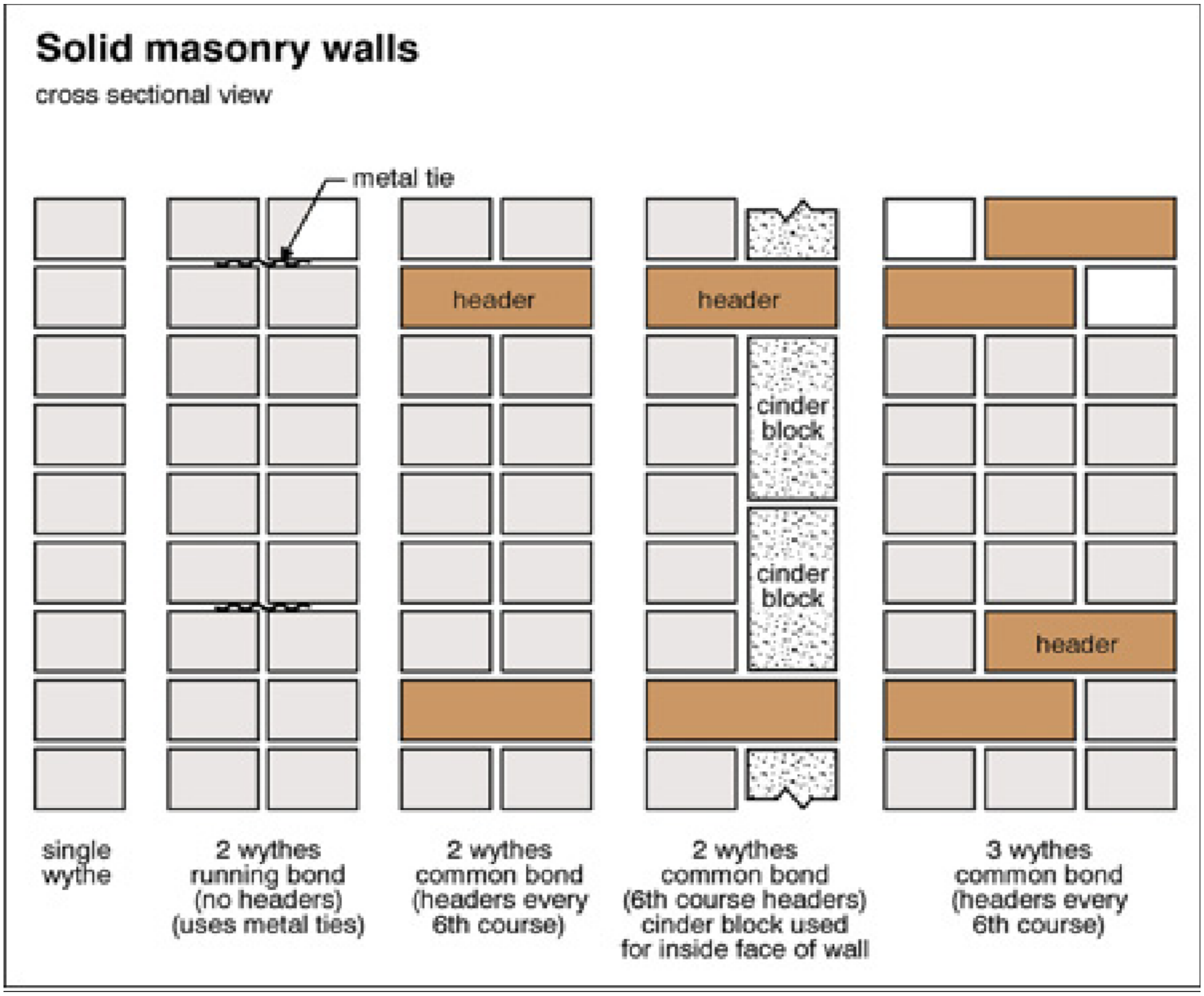


Figure 13: True brick wall construction uses multiple wythes and header courses to tie them together about every 6th course.

Mortar

In masonry construction, the materials are bonded together using mortar. Mortars are mixed using Portland Cement, sand, lime, and water. The percentages of the ingredients are adjusted to give the mortar different strengths depending on the use. For example, mortar for bonding blocks in a bearing wall will be much stronger than mortar which is used for bonding brick used for a decorative veneer (figure 14).

Portland Cement was invented in the late nineteenth century in Europe and did not arrive to our part of the country until very early in twentieth century. Prior to this, buildings of brick and mortar (URM) were built using mortar made only of sand, lime, and water. Collapse of these types of structures should be predicted.

Figure 14: This wall has an inner and outer component. The inner wall is 8"x8"x16" hollow block and the outer veneer wall is 8"x4"x16" solid block. Different mortar strengths were likely used.

ROOF CONSTRUCTION

The idea of understanding roof construction for Truck Operations is vital insofar as it affects our ability to safely and effectively perform ventilation and roof operations at structure fires. Therefore, advanced knowledge of roof assembles is required for truck company members to rapidly and accurately size-up the construction of a roof, particularly when the roof is unfamiliar to the company and/or the conditions are less than optimal. This section will outline some different types of roof construction and offer information and techniques for determining the construction features. Roofs are either flat or peaked and framed or trussed.

Common Trusses

Common trusses have top and bottom chords which are not parallel. Gable Trusses are the most recognizable variety of this type of truss but there are many configurations. Virtually every roof type can be supported with trusses. Figure 15 provides images of a variety of different common trusses. The important lesson here is that it can be difficult to size up roof construction from the street or the front yard of a building. Once they are sheeted and roofed, they often have the look of a custom hand cut or legacy framed roof with many hips and valleys. Additionally, custom homes and high-end wood framed commercial occupancies frequently have the truss tails boxed in so that the ends of the trusses are not visible, eliminating any chance of sizing up the roof construction without cutting into the roof deck or pulling the ceiling from below.

Lexington County Fire employs aggressive ventilation tactics including vertical ventilation where appropriate. Advanced training in this important tactic provides the members with the knowledge and tools to complete the task safely and effectively. The key to lightweight roof ventilation is to get up fast, cut it fast, extend if needed, and get off the roof.

Additional information about lightweight roof ventilation can be found in the ventilation chapter of this manual.

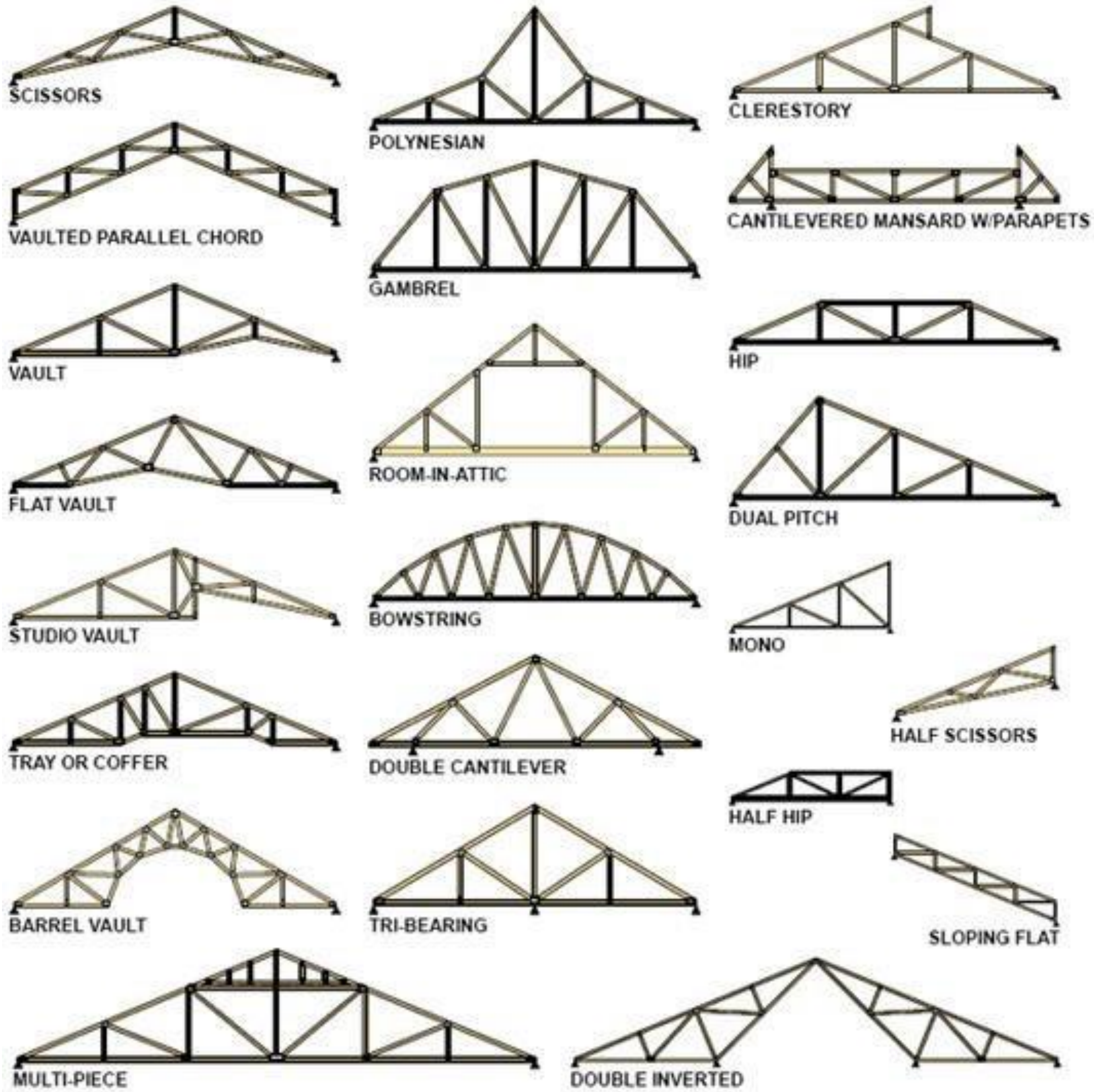


Figure 15: Common Trusses come in many forms and shapes making it difficult to size up a roof's construction from a distance.

Manufactured Trusses

Trusses are complicated and hard to understand on a technical level but can be simplified for our purposes. The components of a truss include web members and chords. The diagonal and vertical components form the web and the horizontal members are the top and bottom chords. Forces in most trusses are one dimensional or planer and the web members can be in tension or compression.

Moments (torsion forces) are not present in most trusses. Trusses come in two basic types, common or pitched trusses and parallel chord or at trusses. Both are found throughout our district in residential as well as commercial construction.

From a firefighting perspective, it is imperative to understand that generally, roof decking (OSB) will fail BEFORE metal gang plates/gusset plates.

Oriented Strand Board(OSB)

1. Begins to fail at 50% loss of strength at 302 degrees.
2. Failure and Degrades at 80% loss of strength at 392 degrees.

Metal Gusset/Gang Plates

1. Built of three layers of lightweight steel and Zinc/Zinc Alloy.
2. Begins to separate at 480 degrees.
3. Begins to fail at 30% of strength at 930 degrees.

In experimental tests, at 1000 degrees, the internal layers of plates were in tact, and the 2nd layer of plates had carbon damage.

Note: To test these findings, attempt to remove a gusset plate with a hammer/tool. It is difficult. Attempt to purchase holes in OSB with a hammer, its easy.

Figure 16: A common manufactured truss with metal gang plates.

Heavy Timber Trusses

Commercial buildings and some high-end homes can have roofs constructed with another variation of common truss known as a heavy timber truss. Older buildings with pitched roofs commonly used heavy timber trusses and newer buildings will employ them for decorative purposes. The concept and technical performance of these trusses is similar to any other common truss. Since lightweight concepts and materials were not used in older construction, these buildings which have peaked roofs should be assumed to be constructed with heavy timber trusses or legacy framed.

Because large framing members have significant sacrificial wood, these types of building components appreciate relatively long burn times during a fire so failure can be delayed, but failure of these trusses can also lead to complete roof failure. Another point worth discussion is the spacing of these trusses. They can have spacing of four to eight feet or more (similar to arched trusses) which can present problems for firefighters traversing the roof to perform firefighting operations. Because the truss spacing is often times far wider than other common trusses, they can be finished or decked in a variety of ways including but not limited to:

1. The trusses can be covered directly with two or three inch tongue-and-groove material running perpendicular to the trusses. Roof covering is then applied directly to the decking.

2. The trusses can be decked by running rafters perpendicular to the trusses either over them or hung between them with metal hangers. The spacing of the rafters is typically 12, 16, or 24 inches. The rafters are then decked with either sheet material or tongue and groove lumber to which the roof covering is applied.

3. The trusses can have purlins installed perpendicular to the trusses (Figure 17). Tongue-and-Groove decking is then installed over the purlins followed by the roof covering.

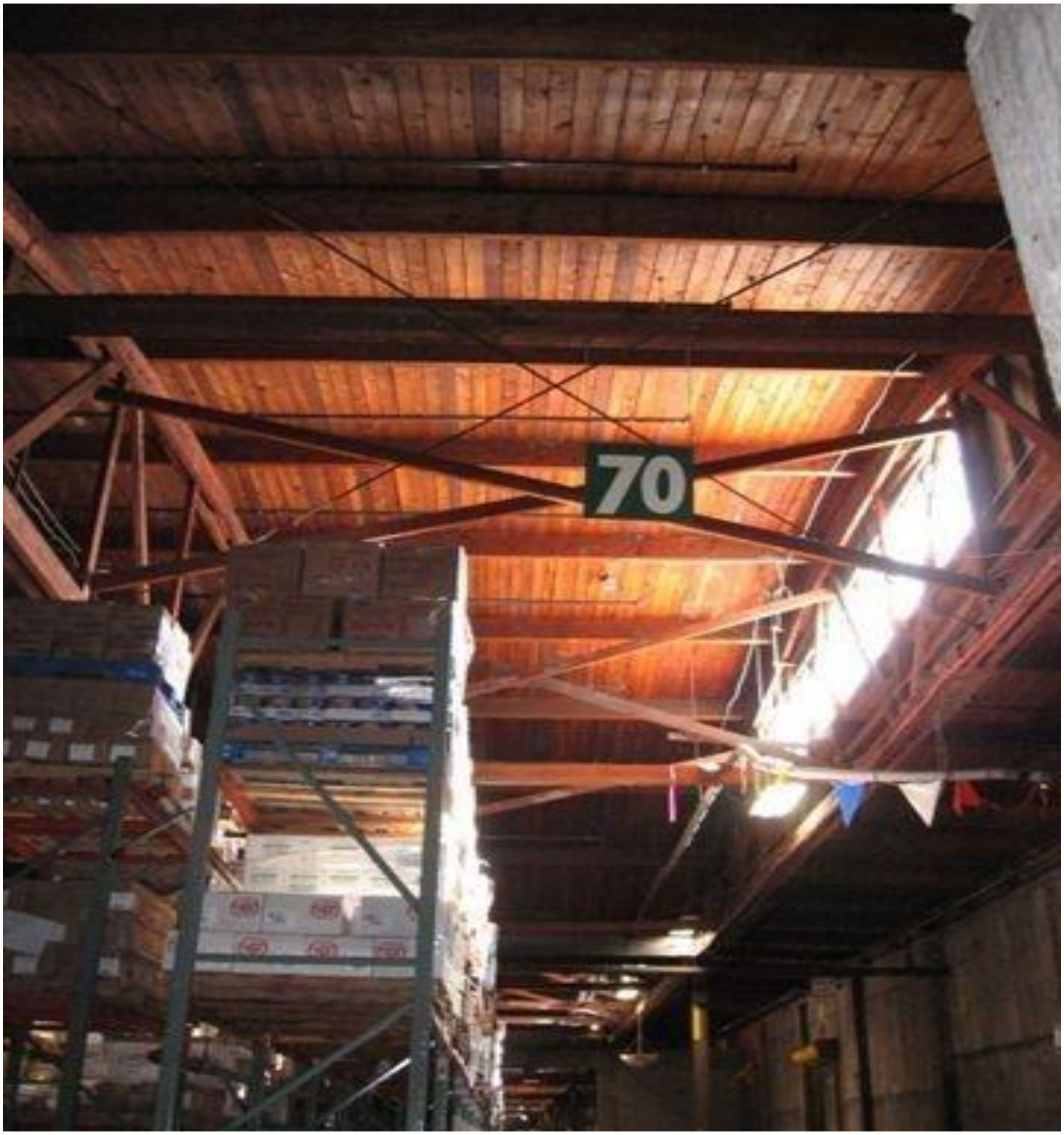


Figure 17: Heavy timber arched trusses spaced about 20 feet apart have purlins installed on top of the trusses with Tongue-and-Groove decking.

For truck operations purposes, the correct size-up of a heavy timber trussed roof and specifically how the roof assembly is finished is the key to effective ventilation tactics because specific methods for cutting different roof types are significantly different. Techniques for ventilating roofs constructed with heavy timbered trusses closely follow those techniques employed on arched truss roofs; and any attempt to ventilate with other methods will prove to be ineffective and potentially dangerous.

The true measure of how any heavy timber framed truss will perform in a fire is predicated on several factors.

- The degree to which the trusses have been damaged by the fire prior to our arrival as well as during the firefighting efforts.

- The degree to which the roof assembly and trusses have been altered over the years during retrofitting and remodeling.

- The age of the truss and the degree to which it has suffered dry rot or damage due to insects.

- The amount of storage in the attic space which stresses the roof assembly beyond its design limits which can also include the weight of water applied during firefighting efforts.

Arched Trusses

There are two types of arched trusses that are common to the fire service which have been studied and written about extensively, heavy timbered bowstring trusses and tied trusses. Another form of arched roof is a lamella roof. All three types of arched roof designs share the arching characteristic visible from the outside but are vastly different in design and performance, particularly under fire conditions. Although arched trusses are rarely used today they were one of the predominant roofs used from the late 1800s until the 1950s when the use of parallel trusses and other at roof assemblies began to gain favor. Tied trusses were one of the last forms of the arched truss to be used.

Bowstring Trusses

A heavy timbered arched truss, known as a bowstring truss employs a bottom chord made of large dimension wood. The top chord, also of heavy timber is curved or arched and there is typically web material connecting the top and bottom chords (figure 18). Unlike lightweight trusses the connections are typically made with steel plates and bolts. The fire performance of this truss is similar to any other form of heavy timbered truss discussed earlier. Documented failures of these trusses, which have claimed firefighter's lives, have occurred approximately 30 minutes after fire companies arrived and began operations.

Since the truss is constructed of large material there is significant sacrificial wood lending more fire resistance than found in lightweight trusses.

Figure 18: Bowstring trusses are built with large dimension lumber and can afford longer operation time than lightweight trusses.

Tied Trusses

Tied trusses (figure 19) share some of the same characteristics as timber framed trusses. One very important exception is that the heavy timbered bottom chord is replaced with a steel rod. The purpose of the rod is to prevent the top chord from pushing the building's walls outward. Knowing that steel fails at approximately 1000° F it is easy to predict early and sudden failure of this type of truss during a well developed fire.

The finishing of any arched truss roof assembly can be accomplished in many different ways as previously discussed in the section describing heavy timbered trusses. During the size-up, the shape of the roof gives away the presence of arched trusses (unless it is a lamella roof). However, the way that the roof assembly is decked and finished will only be evident through pre-fire planning and/or proper sounding of the roof and an adequate inspection hole. The key to choosing effective ventilation techniques is determining the presence and direction of rafters and/or purlins.

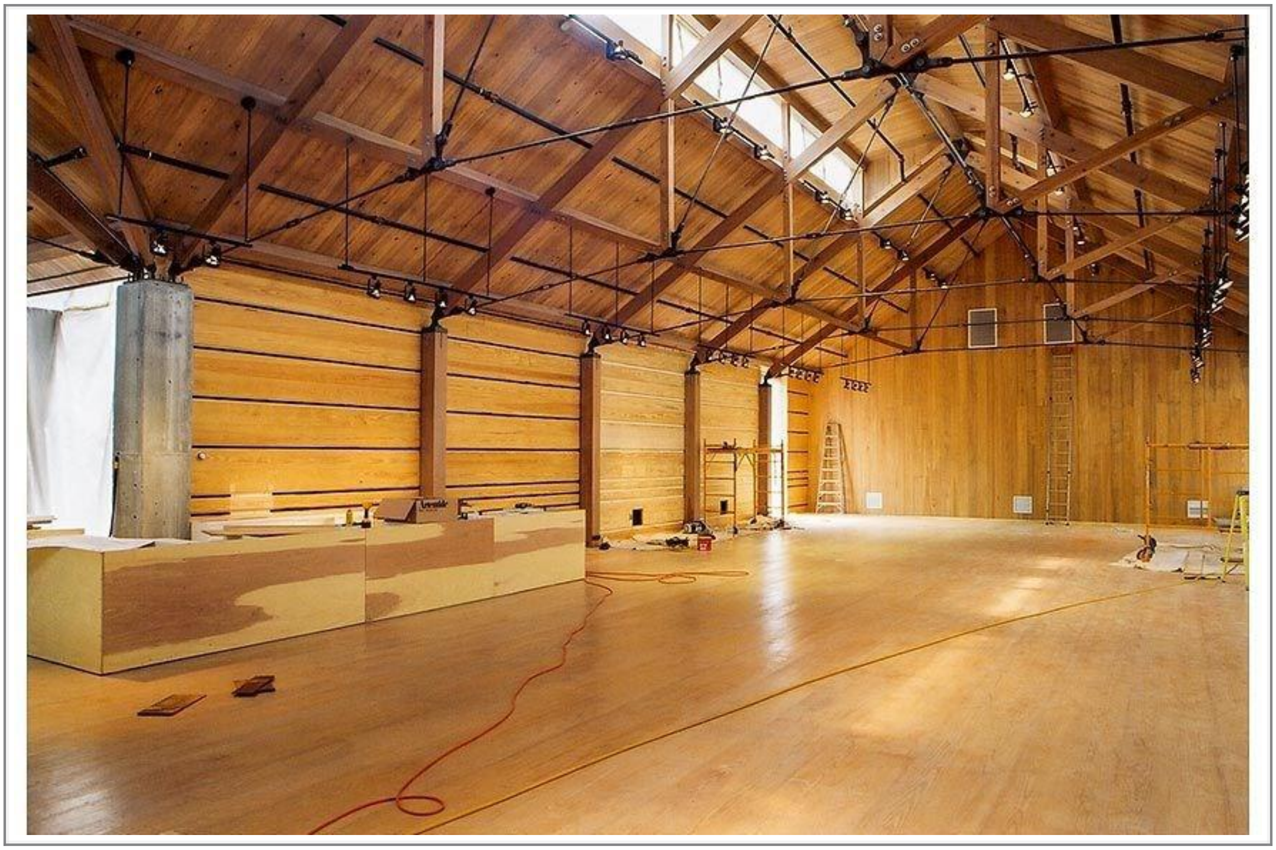


Figure 19: With tied trusses, the heavy timber bottom cord is replaced by a steel cable.

Parallel Chord Trusses

Parallel chord trusses come in two basic styles, open web and I-beam (solid web) type trusses. These trusses' top and bottom chords are parallel, forming a flat surface on top (figure 20). For this reason these products are also used in floor assemblies as well as flat roof assemblies. There are many forms and styles of open web trusses and their main advantage is the ability to easily run utilities through the webs such as heat duct, plumbing, and electrical conduits. The open web truss using metal tubing as web members connected to the chords with metal pins is potentially the most fragile truss on the market during a fire.

A building's roof system utilizing parallel roof trusses can vary greatly. Typically the truss ends will bear on the building walls or a large load bearing girder or beam. But they can also bear on other trusses and the spacing of the trusses can also vary.

Figure 20: Parallel cord trusses come in many styles and are used in roof and floor assemblies.

Open Metal Web Trusses

The open metal web truss (figure 21) employs wood top and bottom chords and the web is formed with metal tubing. The connections where the web material attaches to the chords can be in a variety of ways, all of which form the weakest part of the truss. Open metal web trusses are found in commercial construction predominantly but can be found in a small cross section of residential construction. These trusses would not typically qualify a building as Type II but could be found in modern Type III and Type V construction.

The firefighting efforts must give up real estate to provide enough safety to effect vertical ventilation in these types of buildings.

Figure 21: Open web metal trusses use lightweight metal to hold the top and bottom cords together.

Open Web Wood Trusses

Open web trusses of wood construction (figure 22) do not perform markedly better than open metal web trusses. Generally, these trusses are constructed with small dimension lumber and the connection of the web members to the chords are typically with metal gusset plates. This type of truss is used in modern Type III and Type V construction. As with all lightweight trusses they are built with economics in mind and are adequate for their design purpose which does not include re resistance.

Figure 22: Open web wood trusses are o en built with small dimension lumber and metal gang plates.

Steel Bar-Joist Trusses

A typical steel bar-joist truss is built entirely of steel (figure 23). This truss is used extensively in Type II and Type I construction. Type I construction utilizing steel trusses will have fireproofing applied to meet minimum hour ratings for the building. Additionally, Type I will have non-combustible floor and roof decking whereas Type II can be decked with combustible roof coverings. In both types of construction the ends of the trusses will bear on either concrete or block walls or other steel trusses. They can occasionally be found in modern Type III construction also. Remember, since the trusses form a flat top they are used both for roof systems and floor systems.

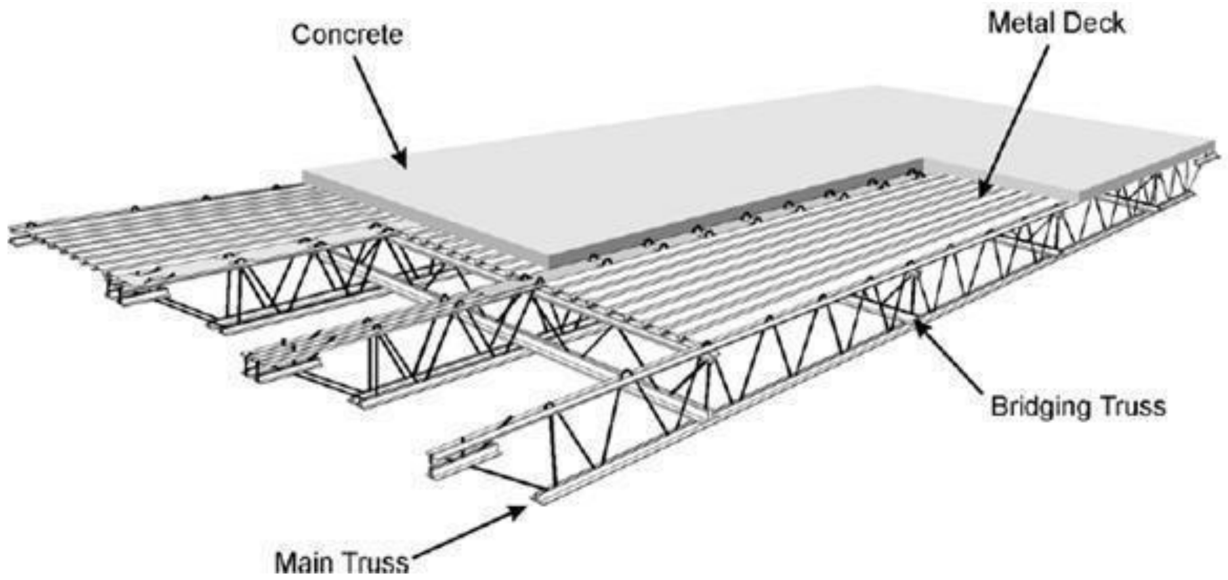


Figure 23: A steel bar-joist floor system. This system was the flooring system used in the World Trade Center Buildings.

Bridge Trusses

A bridge truss is a parallel chord truss that is noticeable by its characteristic sloping ends. Popular during the same periods as arched trusses, they formed a flat roof on the top and had sharply sloping ends, and like the arched truss, they were built with heavy timbers. It would be rare to see a modern application of this type of truss but older versions can be found in some older style buildings. Some commercial occupancies, which have a Mansard style roof design, may be built using a lightweight variation of a bridge truss.

Solid Web Trusses

Solid web trusses were discussed earlier in this document and as stated they are most often found in floor systems. They are however found in both flat and pitched roof systems and in both residential and commercial construction. We have experienced fires in buildings with solid web floor and roof assemblies where they performed poorly when exposed to fire. They will fail rapidly. If the floor system is protected from underneath, these systems can offer some degree of protection from fire extension by temporarily limiting fire extension to a direction parallel to the truss. Open web trusses by comparison allow fire to spread in all directions once fire enters the concealed space.

Panelized Roof Assemblies

Panelized roof assemblies are basic in concept but can be difficult to recognize. Basically they are a roof system which incorporates one (or several) main beam or load carrying component off of which runs purlins and rafters. They become complicated when you consider that they can be built with heavy lumber or trusses, or worse yet a combination of the two.

The typical panelized roof assembly (figure 24) uses a very large beam which is usually a Glue-Lam or lam-beam as the main load bearing component besides the exterior of the building itself. Many times the spacing of multiple lam beams can be as much as 30-40 feet but usually they are restricted to about 20 feet. Between the lam beams, purlins made of 4X12 or larger wood or lam-beams will be installed 8-10 feet apart and then smaller rafters will be installed between the purlins at 16 inches to 4 feet apart. Finally the roof will be decked with plywood or engineered sheet material and then a roof covering is applied.

Figure 24: This is a typical panelized roof employing lam-beams for the main carriers, beams and smaller lam -beams for the purlins and 2x6 rafters.

Lightweight Panelized Systems

If you apply the basic concept of the system you will recognize panelized roofs becoming more popular in the Southeast US. Although they do not contain typical panelized roof materials they are nonetheless panelized in nature. Home Depot and Lowes are two structures which may contain roof assemblies built with lightweight steel bar-joist trusses. Very large steel girder trusses carry the main loads and transfer the roof's weight to the ground through columns (figure 25).

Smaller steel trusses are placed as purlins and then 2X6 material or sometimes even smaller trusses are installed as rafters. Because of the trusses stronger strength-to-weight ratio, the spans of the components can differ from their all wood relative but the concept of larger to smaller remains constant.

Figure 25: Lightweight panel system using steel bar-joist girder truss and steel bar-joist purlins.

Hybrid Panelized Systems

Locally and regionally there are buildings which have a hybrid style of panelized roof (figure 26). They employ, in different combinations, wood, steel, trusses, and dimensional lumber. They may have a lam-beam with trusses and 2X4 rafters.

They could also have a heavy steel bar-joist girder truss with open web wood trusses and 2X6 rafters. The point is that it can be difficult to size-up this type of construction.

There are three basic ways to size-up this type of roof construction. The first, and the safest, is to catch the construction details on business inspections and pre- plans. Secondly and probably the hardest is to sound the roof with a Nupla hook. This takes knowledge of construction, experience, and practice. The third and the most definitive on-scene method is to cut an inspection hole (see chapter on ventilation) to directly observe the construction materials and spacing.

Figure 26: This hybrid system employs lam-beams for the main carriers and then lightweight open web wood trusses as purlins

Conventionally Framed Roof Systems

In general, conventionally framed roof systems will hold up better during fire conditions. Because this type of roof construction utilizes dimensional lumber, and in older buildings rough cut lumber, in contrast to lightweight materials as used in truss construction. Conventionally framed roofs (figure 27) can be pitched or flat and are built on site by skilled workmen.

Particularly, roofs with many hips and valleys are difficult to frame and although they can look similar to lightweight roofs of similar design, they offer a relatively safer platform from which firefighters can operate.

Rough cut lumber features greater size than modern dimensional lumber. For example today, a 2 x 4 actually measures 1.5625 inches by 3.5 inches and rough cut 2x4 measures a true 2 inches by 4 inches.

Figure 27: Conventionally framed with dimensional lumber, this roof has two gable ends, one valley and one hip. This roof will fare better than a lightweight roof during a fire.

Pitched Roof Framing

Pitched roof framing incorporates rafters and ridge beams. Rafters are cut to length by a carpenter onsite and installed. The lower end rests on a bearing wall (frequently an exterior wall) or a girder and the top of the rafter rest against the ridge beam. There are common rafters which form a gable style roof and there are hip and valley rafters also. Jack rafters run from hip or valley rafter to the wall or girder.

There is a growing use of lightweight materials erected with conventional framing techniques. Lightweight solid web trusses known as I-Joists are used as rafters and cut by the carpenter the same as conventional lumber . The important lesson here is that conventionally framed roofs get their strength from the dimensional lumber, not the technique of construction.

Many times a home or Type V commercial business with a pitched roof or flat roof will have both lightweight and dimensional components. It is fairly common in residential construction to have lightweight trusses comprising part of the roof and then conventional roof framing making up the rest (figure 28).

Figure 28: This Type V residential roof incorporates lightweight and dimensional components.

Conventional Flat Roof Framing

In older commercial structures, and occasionally residential structures with flat roofs, the assembly will often be conventionally framed with dimensional lumber. This type of roof system offers some of the best operational time during a fire, particularly when compared to lightweight roofs because of the relative large nature of all of the components. These roofs typically have large columns and beams supporting dimensional or rough cut rafters. Theses roofs are common in older type III, type IV, and type V construction.

In large buildings, conventionally framed flats roof can often be identified by multiple directions of slope which drains water in many directions to roof scuppers and perimeter gutters and downspouts. Because of the cost of building materials, this type of roof assembly is mostly limited to older buildings with flat roofs. Newer construction will usually be constructed with lightweight concepts and materials.

When sounding these roofs it can sometimes be difficult to locate the beams because the rigidity of the rafter assemblies can mask the stiffness of the beams. Additionally the rafters often are installed over the beam which also makes them difficult to locate. Many times the only method to locate a beam is to look for a high spot on the roof or a change in the slope of the roof. It is possible that the only clue to a beam's location is a directional change in rafter run which will only be perceptible by sounding.

Roof Assemblies Summary

A firefighter's knowledge of roof construction and his or her experience will determine their ability to size-up a building. Because different roof systems offer differences in terms of operational time and ventilation techniques, the size-up is critical to effectiveness and safety. Additionally the size-up many times will affect our decision making as it relates to resource needs such as tools and manpower.

See the additional guide on the next page for the most common roof assemblies in LCFS response areas.

ROOF TYPE	MEMBER SIZE	MEMBER SPACING
Gable: Conventional	Rafters: 2"x6"+ Ridge Board: 1"x6" or none	16"-24" on center; Rough Cut up to 36"
Gable: Light Weight	Trusses/Rafters: 2"x3" or 2"x4" Metal gusset plates 3/8" 18 gauge	16"-24" on center (common)
Hip: Conventional	Rafters: 2"x6"+ Ridge Board: 1"x6" or none	16"-24" on center Rough Cut up to 36" on steep pitched roofs
Hip: Light Weight	Trusses/Rafters: 2"x3" or 2"x4" Metal gusset plates 3/8" 18 gauge	16"-24" on center Rough Cut up to 36" on steep pitched roofs
Bridge Truss (*1920-1940*)	Rafters: 2"x6"+ Trusses: 2"x12"	*DEPENDANT ON LUMBER UTILIZED*
Arch: Bowstring (*1930-1950*)	Rafters: 2"x6"+ Trusses: 2"x12" or 2"x14"	*DEPENDANT ON LUMBER UTILIZED*
Arch: Lamella	Rafters: 2"x6"+ Geometric wood framing: 2"x12" or 2"x14"; Steel plates and bolts at framing junctions	*DEPENDANT ON LUMBER UTILIZED*
Arch: Tied Truss	Rafters: 2"x10"+ Top Chord-2"x12"+ (laminated)	*DEPENDANT ON LUMBER UTILIZED*
Saw tooth (*1930-PRESENT*)	Rafters: 2"x8"+	*DEPENDANT ON LUMBER UTILIZED*
Flat: Conventional	Rafters 2"x6"+	24" (common)
Flat: Light Weight Wooden I-Beam	I-Beam Chords: 2"x3"or 2"x4" I-Beam Stem: 3/8"plywood or chip board	24" (common)
Flat: Light Weight Open Web	Open Web Chords: 2"x3" or 2"x4" Steel Tube web: 1"to 2" cold-rolled steel tubing	24" (common)
Flat: Light weight Open Web Bar Joist	Open Web Chords: 1/8" steel Web supports: 5/8" Solid Steel Bars OR 2"x4" wood Joists	If bar-joists used as girders: up to 45' Joists: up to 8' apart
Flat: Light Weight Metal Gusset Plate	Trusses: 2"x4" (metal gusset plates)	24" (common) *dependant on type of application*
Flat: Light Weight Concrete	Steel or wood substructure under corrugated metal (Robertson decking), sand, cement, pea gravel, 4"x4" or 6"x6" wire mesh	
Flat: Light Weight Panelized	Beam (Laminated wood/Metal):6'x36"(common) Purlin: 4"x12" (common) Joist/Rafter: 2"x4"	12'to 40'(20'-Common) 8' 2'
Flat: Light Weight Corrugated	Corrugated steel: 18 to 20 gauge (common) over a wood or metal sub-structure	

ROOF TYPE	SPAN	SHEATHING / SHEETHING	(S) STRENGHTS / (H) HAZARDS
Gable: Conventional		NEW- 3/8" or 1/2" Plywood decking OLDER-1"x4" or 1"x6" space sheathing	S-ridge, rafter/wall crossing H-reduced burn time/early failure rate
Gable: Light Weight	70 ft	NEW- 3/8" or 1/2" Plywood decking OLDER-1"x4" or 1"x6" space sheathing	S-ridge, rafter/wall crossing H-reduced burn time/early failure rate
Hip: Conventional		NEW- 3/8" or 1/2" Plywood decking OLDER-1"x4" or 1"x6" space sheathing	S-Ridge, valley Rafters, rafter/wall crossing H-steep Pitched roofs may need roof ladder, Tiles may become slippery
Hip: Light Weight		NEW- 3/8" or 1/2" Plywood decking OLDER-1"x4" or 1"x6" space sheathing	S-ridge, valley rafter, rafter/wall crossing H-reduced burn time/early failure rate
Bridge Truss (*1920-1940*)		After 1933-1"x6" diagonal* PRE-1933-1"x6" straight*	S-Well constructed H-Sectional failure, Lath/plaster weight
Arch: Bowstring(*1930-1950*)		After 1933-1"x6" diagonal* PRE-1933-1"x6" straight*	S-Well constructed H-Sectional failure, Lath/plaster weight
Arch: Lamella		1"x6" Plywood decking Composition roof material	S-Well Constructed H-Total roof collapse after 20% fire damage (Domino effect)
Arch: Tied Truss		After 1933-1"x6" diagonal* PRE-1933-1"x6" straight*	S-Large Structural Members H-Early Failure of the Tie rods/turnbuckles
Sawtooth (*1930-PRESENT*)		1"x6" Sheathing or 4'x8'- 1/2" thick Plywood (Modern)	S-Well constructed, easily ventilation H-roofs underside may be exposed/open to structure
Flat: Conventional		1"x6" sheathing or 4'x8'-3/8" to 5/8" thick Plywood/particle board (Modern)	S-Perimeter, depends on size & spacing of rafters; decking H-plywood instead of sheathing, metal hangars
Flat: Light Weight Wooden I-Beam		4'x8'Plywood using Nailing blocks every 48"	S-Perimeter H- Stem may burn quickly causing collapse of truss chords and roof, heating & A/C ducts may run through stems allowing fire to spread
Flat: Light Weight Open Web	70 ft	4'x8'Plywood using Nailing blocks every 48"	S-Perimeter H-truss chords weaken quickly causing collapse, lack of fire stops, plywood will burn quickly
Flat: Light weight Open Web Bar Joist	45 ft	Corrugated metal decking covered by alternating layers of tar and Tarpaper, OR 1/2" plywood with comp. Covering/decking	S-perimeter H-steel begins to lose strength at 1000 F, entire roof is comprised of metal
Flat: Light Weight Metal Gusset Plate	80 ft	3/8"-1/2" plywood decking	S-truss crossings (cantilever app.) or where they cross bearing walls H-reduced burn time, sectional collapse
Flat: Light Weight Concrete		3" to 4" thick concrete covered by composition roof material	S-Structurally sound/fire resistant H-must use rotary saw with diamond blade or carbide tip blade to ventilate
Flat: Light Weight Panelized	100 ft+ when bolted	1/2" plywood covered by Composition roofing material	S-Beams, Purlins, and perimeter H-Kraft paper may cause rapid fire spread, reduced burn time under fire
Flat: Light Weight Corrugated		18 to 20 gauge steel (common)	S-Ridge, Perimeter, where beams cross bearing walls H-Rapid failure once 0exposed to fire

***plywood decking used over existing if modified for the earthquake ordinance**

CHAPTER FOUR

FORCIBLE ENTRY

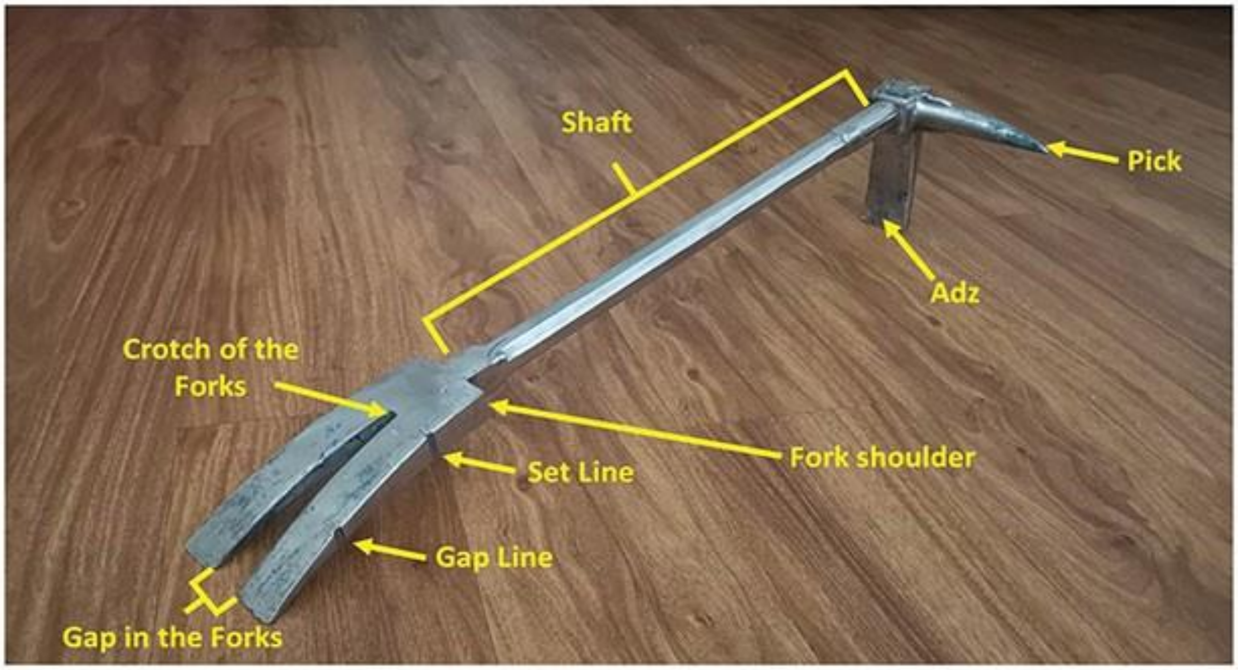
CHAPTER: 4 Forcible Entry

INSIDE OPERATIONS

FORCIBLE ENTRY

The term "forcible entry" is defined as the act of gaining entry into a building or occupancy via a door, window, or a wall, by the use of force. Forcible entry has always been the primary responsibility of the fire service. The fire cannot be extinguished, searches cannot be made, and victims may not be able to get out, until entry is made. Sadly, many firefighters would rather use their boot (foot) than the actual tools designed for entry methods. You control the action of skill, technique, and knowledge. It is not about brute force, which will be discussed in this chapter.

The skill of forcible entry has been part of the fire service since the beginning. The ingenuity and foresight of many talented people developed these techniques, which was handed down to generations of firefighters within the service.



The Halligan bar (30" Pro-Bar) is the primary tool for most forcible entry methods. However, the actual tool and leverage methods are often misunderstood.

The halligan bar, as discussed in the tools chapter, is the workhorse or primary tool of forcible entry methods. The tool is approximately eight pounds and 30 inches in length.

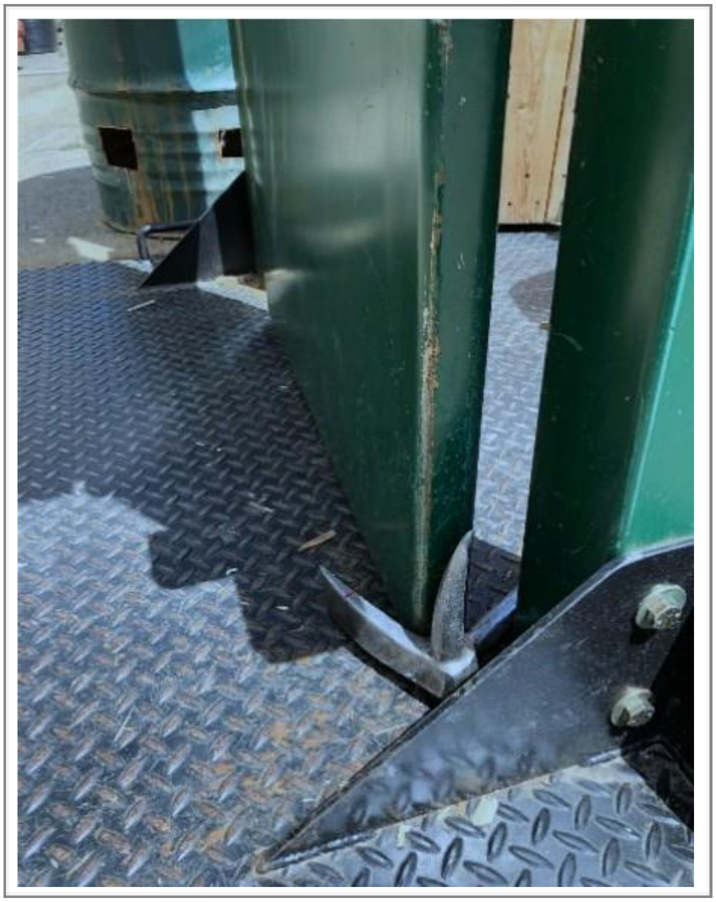
Understanding the mechanical advantage of the tools, will enable you to force harder doors easier and all doors more effectively; however, you should always "try before you pry". Not having to force an unlocked door will save you time, energy, and most importantly, keep the door intact. Forcible entry in regards to doors are ventilation. Door control is a requirement when it opens and injects air into the structure (ventilation chapter). Some books and/or instructors will promote using webbing, rope, or a door strap to control the door. This technique is time consuming and impractical. Use your halligan to control the door, after forcing the door.

Once the door opens, hook your foot around the door frame and reach yourself out into the structure as far as possible, with your head low to the ground.

Quickly perform an interior size-up that consists of Life, Fire, and Layout.

- **LIFE -** Look for any victims in the path of egress and sweep. Ensure you've made contact with the walls and behind the door. Call out "Fire Department" and listen.
- **FIRE -** Look for the location of the fire room, heat conditions/layering, smoke level and/or direction of travel.
- **LAYOUT -** Look for the location of stairs, halls, rooms, and doorways. You could be the first person to see inside prior to the smoke banking down. Use this opportunity to absorb as much as you can and communicate it to other companies.

Once completing Life, Fire, and Layout - pull the door closed, leave the Halligan on the ground between the frame and door. This will prevent it from re-locking and will give you time to mask up and prepare for entry.



After completing LIFE, FIRE, LAYOUT, this FF using the Halligan to capture and hold the door.

COMMANDS

To ensure effective and efficient actions during low visibility or unpredictable events in regards to forcible entry, communication and command is imperative. Regardless of rank, the halligan or "bar" firefighter is in charge and controls the operation and commands when using a tool (preferably an axe) when striking.

- **HIT -** The firefighter calls for the axe firefighter to swing and hit the halligan once. The axe firefighter does not hit unless commanded to, but should anticipate the next command and move as a unit with the bar/halligan FF.
- **STOP -** When the STOP command is given, the axe Firefighter stops swinging immediately. The halligan firefighter must clearly state "STOP" and not other "slang" terms. Stop is stop.
- **WEDGE -** Wedging is the process of capturing any progress/spread that has been made between the door and the frame. The axe firefighter must quickly shift into position and "wedge" the axe into the opening OR if using an aluminum door wedge, places it in the open progress. Calling for a wedge MUST be performed PRIOR to the halligan being removed or repositioned. Some doors are self-closing or tightly constructed and will shut back. This will cause a loss of energy and time.
- **DRIVE -** When the Halligan bar is "set" and the halligan firefighter needs multiple, strong hits, the command should be "DRIVE". This command is used when the halligan firefighter is not going to move the bar at all. The next command will be "stop" when the Halligan reaches its maximum point, just under the "crotch" of the forks.

AXE FIREFIGHTER

The axe firefighter is the backbone of the forcible entry team. Although the "bar man" must understand the physics and leverage of forcible entry, having an inexperienced "Axe Firefighter" can and will deteriorate the forcible entry task, causing issues that can severely delay entry.

The most common tool for this firefighter to use is the Flathead axe. The most common sizes of flathead axes are the six (6) pound and the eight (8) pound. Some organizations like to call the ten (10) sledgehammer and halligan a "heavy" or commercial irons. Many firefighters assume that the weight of the axe plays a significant role in the forcing/moving ability. That is somewhat incorrect.

In Newton's second and third law of Physics, Force = mass x acceleration. In very basic understanding, the acceleration and/or velocity has a very important role in the striking force for the axe firefighter.

Imagine that someone is holding a six pound ball and eight pound ball over your body, approximately one foot from you. They are going to drop one, which one do you want? The answer: six, because they will have the same distance to travel, so we would want the lesser of the two weights. However, now imagine a six pound ball over your body at four feet in height and a ten pound ball two feet at height. Which one would you want to have dropped? The ten, although it weighs more than the six, the velocity would increase causing more energy when it landed on you.

Difference in Force with a flat head axe						
Axe Weight	6	6	6	8	8	8
Swing Speed (MPH)	20	30	40	20	30	40
Kinetic Energy (ft-lb)	80.25	180.55	427.97	106.99	240.74	320.98

The Chart above shows the Force difference in the six and eight pound axe. Notice how the speed increases with the six pound axe, at 40 mph, the six pound axe exerts more energy than the eight. The Kinetic energy is measure in Work-Force or 1 foot per 1 linear pound, i.e., for each foot an object is moved, it exerts xxx pounds of energy. Also note, that in general, the average adult male can throw a baseball at/around 30 mph.

In short, double the speed increases the force by a factor of four. Triple the speed, increases the force factor by nine.

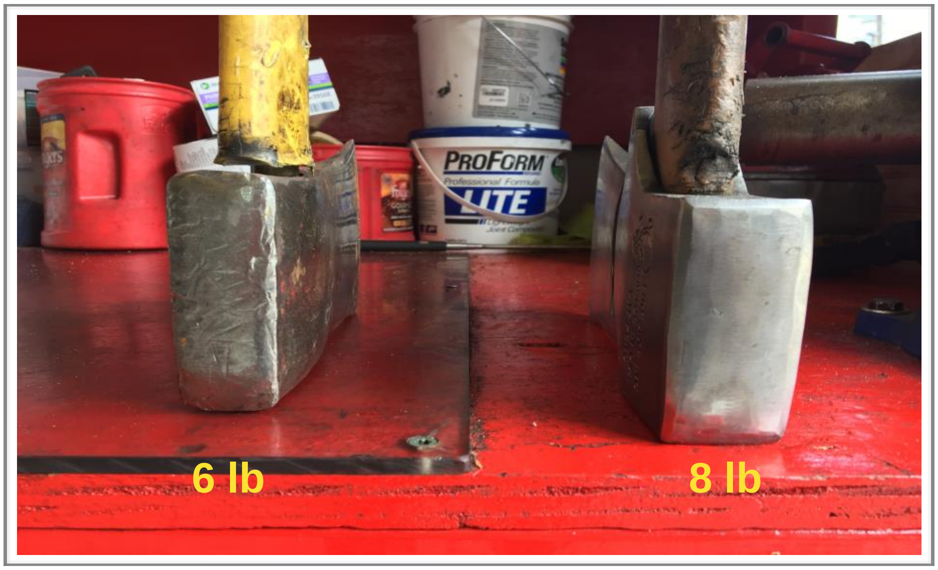
How to use this data:

Some recommendations of the 6lb Axe use:

1. Newer construction houses where lightweight construction is known.
2. Houses/doors where there will be no obstacles or obstructions to prevent a full swing for forcible entry. The full swing will enable the maximum work/ force to the halligan bar.

Some recommendations of the 8lb Axe use:

1. Unknown construction or fortify construction
2. Confined space/hallways where swing distance will be hampered.
3. Needed use of larger "wedge" axehead



As stated above and noted in the picture, the eight pound axe has a wider head, which will provide a large "wedge" when conventionally forcing a door and needs to be taken into consideration in tool selection.

Once the proper axe has been selected, as the axe firefighter, ensure that you always hit the halligan bar perpendicular. Many firefighters swing the axe in a sideways/cross manner, which can cause the following issues:

1. Not achieving the full work/force ratio. When the axe and halligan are perpendicular and strike each other, you are striking and delivering the force on the maximum amount of surface area available. This will deliver a stronger more impactful hit.
2. When swinging the axe sideways/ cross, you have more of an opportunity to miss and/or slip, which can cause severe injury to the striker or halligan firefighter.

As noted in the picture, the axe firefighter is lined up perpendicular to the halligan firefighter, ready for a full strike. Also remember, to allow one hand length of distance from the top of the axe head. This will allow for a comfortable and strong grip with less of a chance to injury to the striker during the swing.

The axe firefighter above is holding the axe, one hand length below the head. In this Fire Hooks Unlimited Axe, it has a protective sheath for easy identification of where to place your top hand.

As a striker, you should stay low and kneel, either on one knee (leg opposite the striking side in front) or on both knees, and in line with the shaft of the halligan. Kneeling down increases balance and power delivered and prevents injury by decreasing accidental misses. If kneeling isn't possible, stay low in an athletic stance.

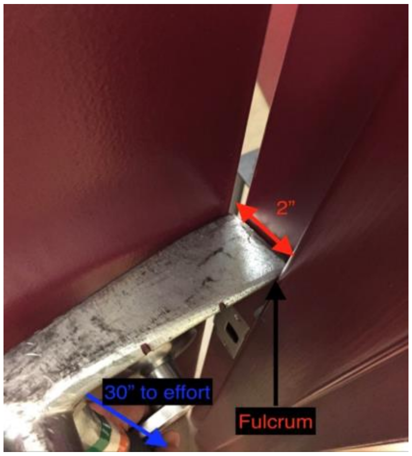
As holding the axe and stance is of the upmost importance in the process, following through with the axe swing is crucial to the forcible entry process. Like many athletic sports (baseball/golf), following through on your strike can make or break your forcible entry efficiency. Many firefighters "predict" when to stop the strike on the halligan, losing speed, energy, and tires the axe firefighter shoulders/arms in fortified or multiple door operations. It is imperative that the axe firefighter swings and completely makes contact with the halligan and follows through afterwards. The axe firefighter should only stop their swing during the process when they hear the "stop" command or the door opens and attempts to assist in the control/entry.

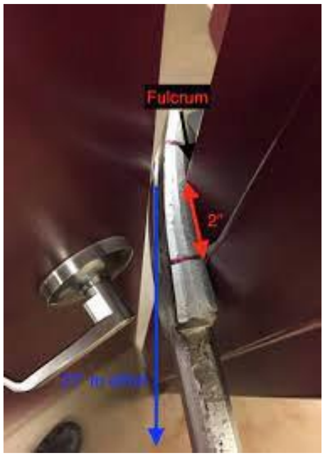
Halligan Leverage

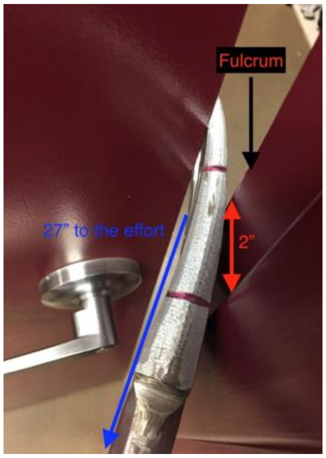
Like the flat head axe, the halligan bar is widely known for it's mechanical advantage. The Pro-bar Halligan has gone through different revisions and modifications, however, the original (owned and produced by Fire Hooks Unlimited) continues to be the most efficient and effective in the world. Many new versions are developed and we encourage those to research and train with those halligan tools, however, nothing has been able to replace the original pro-bar halligan. The Pro- Bar is 30 inches long and weighs approximately 8.5 pounds. Using a halligan bar to force a door relies 100 percent on the user's ability and experience. If you are using the bar incorrectly or inefficiently, the door will not open, delay entry, and/or cause unnecessary damage.

The axe firefighter in the kneeling stance as pictured to the right. In this confined space, outward door, the firefighter chose to kneel to more power delivery and room to work within

When attempting to understand the leverage abilities of a halligan in forcible entry, you have to understand that every piece of the puzzle equals a force/weight/MA. Social Media has allowed hundreds of different versions of mechanical advantage charts to be published, yet they are all generalized based on the tool itself. Using actual Physics, understanding, and formulas; you will get exact (or very close) numbers to understand and master your bar/force techniques.

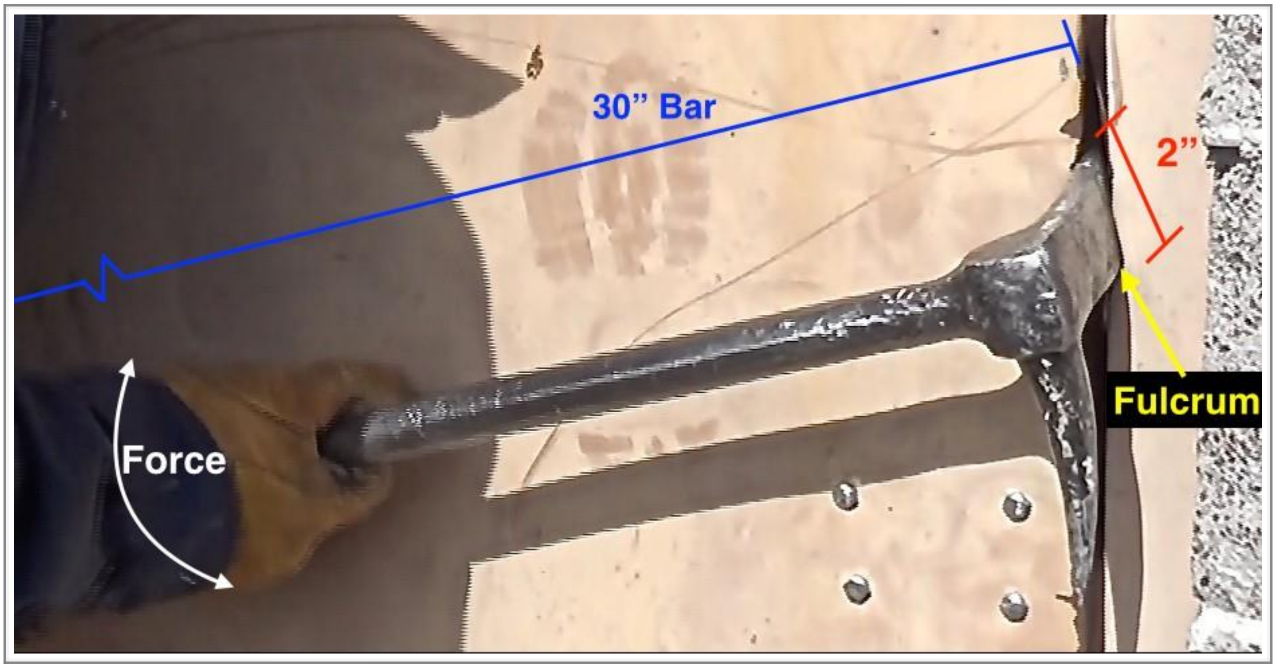






The "numbers" floating around social media/internet are correct in the facts of fulcrum, lever, and force. However, you must take into consideration, the firefighters body positioning weight (mass), and door thickness.

Residential doors are around 1 3/8" or 1.375" Thick with commercial doors around 1 3/4" or 1.75" thick. The firefighter exerting energy/mass onto the halligan bar is different.



LEVER MECHANICAL ADAVNATAGE SLIDES		
lever length(in) / distance between fulcrum points(in)		
Mass (pounds)	100	lbs
Length of lever (inches)	30	in
Depth forks are set (inches)	2	in
Door thickness (inches) example - a residential door is 1.375"	1.375	in
Length of lever during intial force	28	in
Initial - Mechanical Advantage [ ] : 1	20.36	: 1
Finish - Mechanical Advantage [ ] : 1	15.00	: 1
mass(lbs) * mechanical advantage = ft-lbs		
Initial - Force applied (ft-lbs)	2,036.36	ft-lb
Finish - Force applied (ft-lbs)	1,500.00	ft-lb
NOTES		
Residential door thickness = 1 3/8" or 1.375"		
Commercial door thickness = 1 3/4" or 1.75"		

Mass (pounds)	200	lbs
Length of lever (inches)	30	in
Depth forks are set (inches)	2	in
Door thickness (inches) example - a residential door is 1.375"	1.375	in
Length of lever during intial force	28	in
Initial - Mechanical Advantage [ ] : 1	20.36	: 1
Finish - Mechanical Advantage [ ] : 1	15.00	: 1
mass(lbs) * mechanical advantage = ft-lbs		
Initial - Force applied (ft-lbs)	4,072.73	ft-lb
Finish - Force applied (ft-lbs)	3,000.00	ft-lb
NOTES		
Residential door thickness = 1 3/8" or 1.375"		
Commercial door thickness = 1 3/4" or 1.75"		

Using physic calculations, a 100 pound firefighter has the SAME mechanical advantage (20:1) when starting forcible entry on a inward, residential door. However, he only applies 2,036 lbs of force per one foot OR 170 lbs of work per one inch. A 200 lb firefighter will deliver 4,072 ft-lb OR 339 lbs of work per one inch.

Remember, its not about strength but delivery of mass and technique. If the 200lb firefighter has a different halligan, body position, or forks are not set correctly, the numbers will be skewed.

This is also based upon the body position to the door as well. If you are standing at a complete 90 degree angle, you will deliver 100% of the force exerted (straight line to door). If you are standing at approximately 60 degrees (average firefighter positioning) you will only deliver 87% of your force.

Key take-away from data:

1. Stand as straight inline with the door as possible. The more you move towards a wall, the less force and MA you will have.

2. Follow-through on swings (you could lose up to 20% of force)
3. Keep the halligan perpendicular as much as you can (yes you will have to work the forks around the door and frame).

Pictured to the right, is a “wide-adz” pro-bar. This halligan is now produced for “better” gapping results. Once you understand leverages and physics you will know that a wide-adz Pro-bar does not help you in tough situations. The wide adz adds approximately 0.6 MA to your gapping force. However, if it is a fortified door, it will make your effort increase by 150%.

Key Take-away: Wide adz halligans make easy doors easier and hard doors harder.

Understanding the leverage abilities of the tools will enable to accomplish forcible entry in a more professional manner. Most Importantly, <u>do not kick in doors</u>… Being a professional means knowing how to use your tools. Kicking doors is not cool and can cause injury, but most importantly wastes energy and most of the time loses the integrity of the door. It does not put the firefighter in the optimal position to control the door. Some doors you could kick in, however, many you can not. Be proficient in the tools we have and use.

Using physics, a 200 pound firefighter with a size 12 boot only exerts 770 lbs of force per foot or 64 lbs per inch. Using the halligan the <u>wrong way</u> will exert twice as much as kicking in a door. Be smart.

CONVENTIONAL FORCE ENTRY

Conventional forcible entry involved several moves in order to accomplish forcing a door. In order to make it understandable in writing, we broke it into the three basic steps. Each step may have additional maneuvers which we will discuss later on. Once you understand the basic principles, over time, they should become second hand and muscle memory.

Most importantly, always “try before you pry”. Nothing makes forcible entry and door integrity easier than an already unlocked door. Many homeowners in todays society forget to lock or don’t lock the door that is most used often.

Prior to forcing a door, crews should perform a rapid size up. Many times this is performed and discussed on the way to the incident. Understanding the construction and forcible entry challenges in your area will reduce the time and increase your forcible entry skills during an emergency. Some considerations to remember:

- Door and jamb construction: wood or metal; light or heavy door
- Inward or outward swinging
- Left or right hand opening
- Lock/locking mechanisms

INWARD SWINGING DOORS

Once a rapid size up is complete you will begin the following tasks for inward swinging doors:

1. GAP
2. SET
3. FORCE
4. Life, Fire, Layout, control (for this manual we will refer to this step as control)

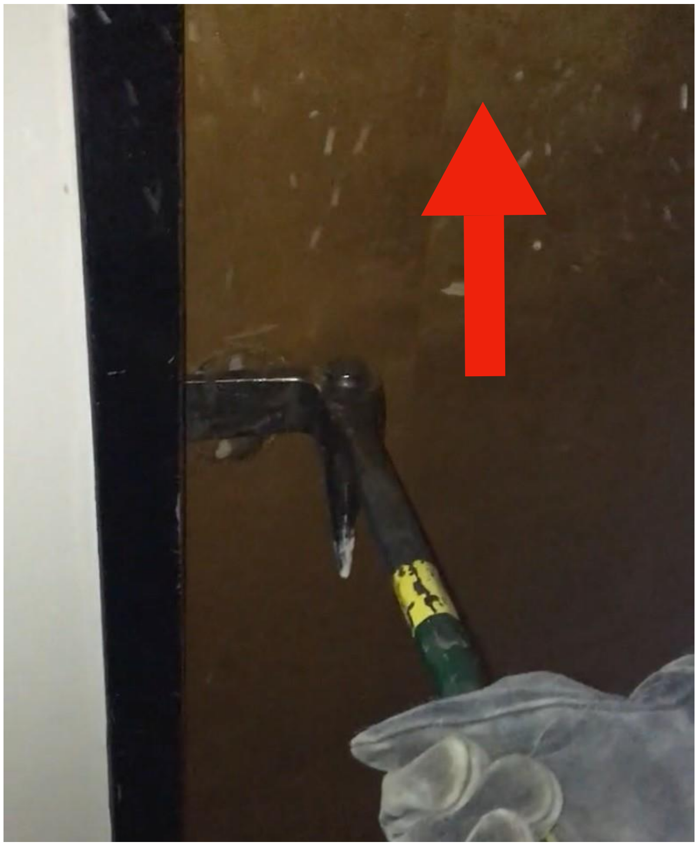
As you notice, the term "shock" has been left out of the process. Shocking a door takes time and experience to understand which door(s) we should and should not shock. Lightweight, exterior residential doors generally do not need to be shocked. In most cases, gapping the door with a halligan bar will open these specific doors, even with additional locking mechanisms. Solid wood doors and possibly commercial doors could benefit from the shocking process. Too many firefighters shock doors multiple times, in which, deforms the door and places pressure on the sides/ seams of the door, next to the frame. This pressure will then make the forcing process more difficult as the pressure and mass of the door is now being placed on the frame, where we generally force the door. If in doubt, shock, however, do not shock a door more than two to three times.

When faced with any door, place your boot on the bottom of the door and hold pressure. This technique called "toeing" or "footing" will not only allow you to "feel" the door, but this pressure will assist you in capturing the progress of the force and will keep pressure on the locking mechanism to assist in failure of the device.

1. GAP

Gapping is the process of using the adz of the halligan to create a purchase point or "GAP" between the door stop/ jamb and the door. Many times, if the door is secured poorly or has cheap locks, it will force the door. Also, by "toeing" the door with your foot, it will assist in your purchase point.

- Start Gapping the door about six inches above or below the lock for maximum effort and force. If there are two locks close to each other, go between them. You may have to initially start near the locks and then work from the bottom or top of the door back towards to locks, gapping as you go, to use the flex of the door to your benefit.
- Once your position is set, place the adz in the frame and roll the adz opposite of the pike. This begins the initial MA of 20.3:1. Many times you will need to place one hand close to the adz to keep pressure on the adz from slipping out of the frame.
- When rolling the adz up; place the bar on top of your shoulder and lift with your legs to exert maximum effort of your body into the bar. When rolling downwards, take an athletic stance, bar close to your core and use your weight/mass and gravity to push downwards.
- Make sure to get to "full width" of the adz. Many times the adz alone will force weak locks.
- When complete, capture progress with the axe or Mini wedge.



In this scenario, the pike is down, so the firefighter will roll the adz up

Tight or secured doors may require a striker to assist in setting the "gap" of the adz

2. SET THE BAR

After capturing the progression with an axe or wedge, rotate the halligan bar and place the forks towards the door to continue the force. This step requires the most skill, experience, and communication. The halligan bar is considered "set" when the forks are locked into the gap between the frame and the door itself. The bar firefighter must pay attention to the sound, sights, and feeling of the halligan as it is hit in. Not paying attention can cause a delay in forcing the door or not "walking the bar" around the door or jamb will cause the forks into the frame and/or skin the back side of the door. This causes severe issues which may prevent the door from opening. This is a priority when forcing outward swinging doors as well.

Forcible entry door props are great for technique but not for teaching realistic reactions of doors. Two separate incidents where the bar firefighter drove the forks into the door or frame, causing the halligan to get stuck. You must "walk the bar" around the frame or door to avoid this.

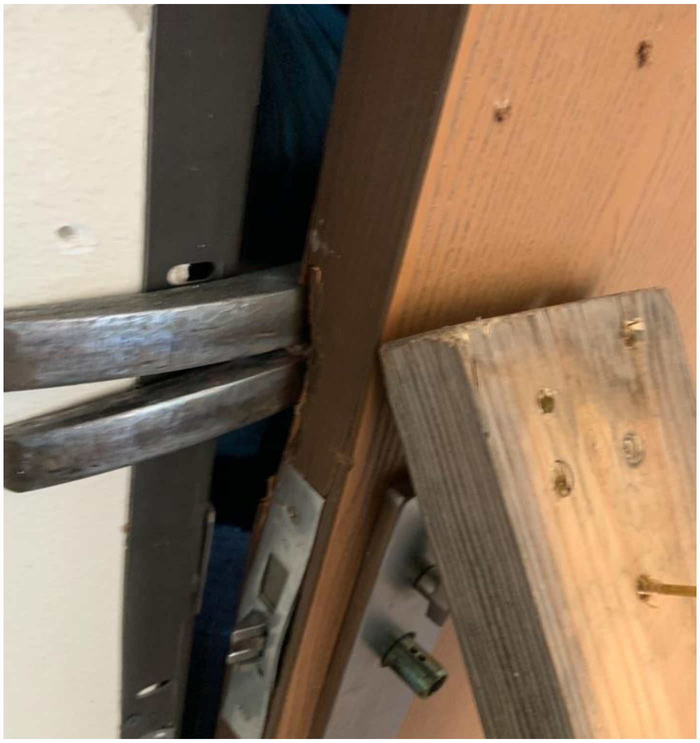
- Position the Fork of the halligan in the same area of the GAP. Position your body perpendicular to the door, as much as you can. Remember, the closer you are to 90 degrees to the door, the more effective your force will distribute on the locks. It also allows for a better striking position.
- Place the Bevel (curved) side of the Forks towards the door for the most leverage and force.

- Place the Bevel (curved) side of the Forks towards the frame for tight, secure doors.

Bevel to Door – More leverage; harder to set; ideal with a good gap or loose door.

Bevel to Jamb – Less leverage; easier to set; good for tight doors as the curve of the fork follows the shape of the door.

- Standing on the outside of the Halligan bar (not between the door and bar), hold the Halligan as you work with your Axe Firefighter to Strike the halligan in. The Halligan Firefighter should always keep their eyes on the door and bar, to ensure a proper "walking" of the forks around the frame/ door. Use the commands "Hit, Stop, Drive, Wedge"
- Strike the Forks of the Halligan bar until the bar is "Set". The Bar is set when the crotch of the Forks is roughly equal to the inside of the door stop. This should ensure that the bar will not slip out when forcing. Continue to drive in, past the crouch, will decrease the MA and usually get the bar stuck in the door.



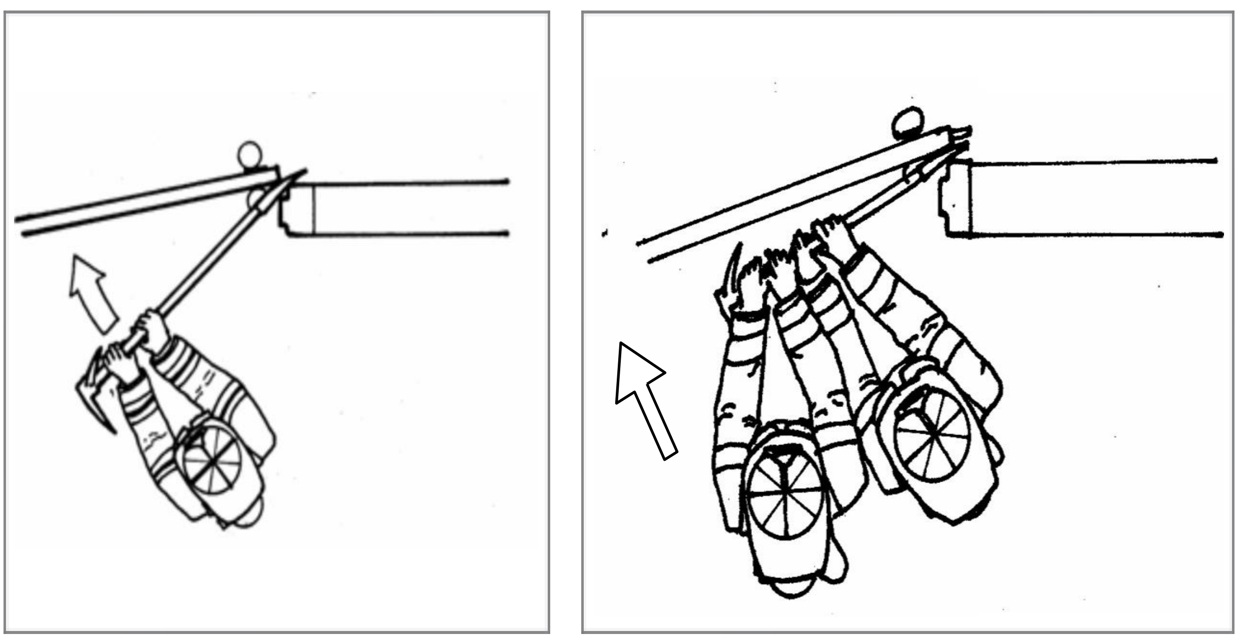
Excellent placement of the Forks in proximity to the locks, as well as, force placement.

- Bevel to the Door provides a more stable platform to “force” against, using the construction and door frame as a fulcrum. It does provide more leverage and works great with most doors, to include loose or a door with a large GAP.
- If you are having trouble “GAPPING” or the door is heavily secured or very tight, use the BEVEL to Jamb. This enables the firefighter to use the natural curve of the Forks to follow the shape of the door. This is much easier to make a SET. You will probably have to rotate the forks to the “Bevel to the door” to finish the force, but this will save you effort and time.

3. FORCE THE DOOR

When the Halligan is set, force is applied to the tool creating that large amount of leverage to force the door open. Ensure that the firefighter(s) are not between the bar and the door.

- Take an athletic, shoulder width apart stance, and push in sharply and consistently to create maximum leverage/force
- The farther away from the door you move, the more force you deliver on the locks.



The figure on the left shows a one Firefighter force. The figure on the right shows two Firefighters forcing a stubborn or tough door.

BODY POSITION		
mass(N) * lever length(m) * sin theta in Nm		
Mass (pounds)	100	lbs
Length of lever (inches)	30	in
Angle force is applied (degrees)	60	deg
Mass (Newtons)	444.82	N
Length of lever (meters)	0.76	m
Force (Nm)	293.54	Nm
SIN Theta	0.87	
Percent of torque applied	87	%
Torque Force (ft-lbs)	**216.55**	**ft-lb**
Mass (pounds)	200	lbs
Length of lever (inches)	30	in
Angle force is applied (degrees)	60	deg
Mass (Newtons)	889.64	N
Length of lever (meters)	0.76	m
Force (Nm)	587.09	Nm
SIN Theta	0.87	
Percent of torque applied	87	%
Torque Force (ft-lbs)	**433.09**	**ft-lb**

The two charts above show the actual numbers in regards to “effort” distributed during the force of a door/lock using a 30 inch Pro-Bar halligan.

As you can see, the two charts show the difference in a 100 pound firefighter and a 200 pound firefighter using a 30 inch lever (halligan) at approximately 60 degree angle. On these charts the numbers are actual as you generally have to move the Halligan (lever) about a foot in length.

- A 100 lb Firefighter will exert approximately 216 lbs of work into the Halligan bar when forcing.
- A 200 lb Firefighter will exert approximately 433 lbs of work into the Halligan bar when forcing.
- Two firefighters could exert 800 lbs of work into the halligan.

You’ll also notice the red percent highlighted. That percentage is based off of the mass of the firefighter, length of lever, and/or angle. The higher any of those items are, the higher the percentage goes up.

- A 100 lb firefighter at a 60 degree angle will exert 87% of 216 lbs of work, which equals 188 lbs.
- A 200 lb firefighter at a 60 degree angle will exert 87% of 433 lbs of work, which equals 376 lbs.

If the space/door allows it, the closer to a 90 degree perpendicular angle, the higher of force percentage.

Later in this chapter, we will discuss extending and addition leverage points.

4. CONTROL - LIFE, FIRE, LAYOUT

Following the previous steps will open the majority of the secured doors that we as the fire service come across during incidents. Some doors will open during a GAP, some will require multiple attempts at SET and FORCE. It is your responsibility to those we serve for and with, to understand locking mechanisms, doors, and construction types in your district/area. Once the door has been forced and opens, as previously stated, the Halligan firefighter needs to immediately drop down and perform the following steps, prior to controlling the door.

1. **LIFE -** Drop down to the ground, hook your ankle around the door frame and stretch out as far as you can with the halligan bar. Call/yell out "FIRE DEPARTMENT, IS ANYONE IN HERE?". Many real life rescues have been documented and performed after calling out to victims that are still conscious.
2. **FIRE** - Do you see the flowpath/ smoke movement? Do you see fire or any indication of the direction of the main body of fire?
3. **Layout** - When entering the structure, you will generally have a few seconds of clearing prior to the conditions banking down. Use this time wisely to look for key indicators of construction features:
   - Where am I entering?
   - Where is the hallway?
   - How tall are the ceilings?
   - Do I see any closed doors?

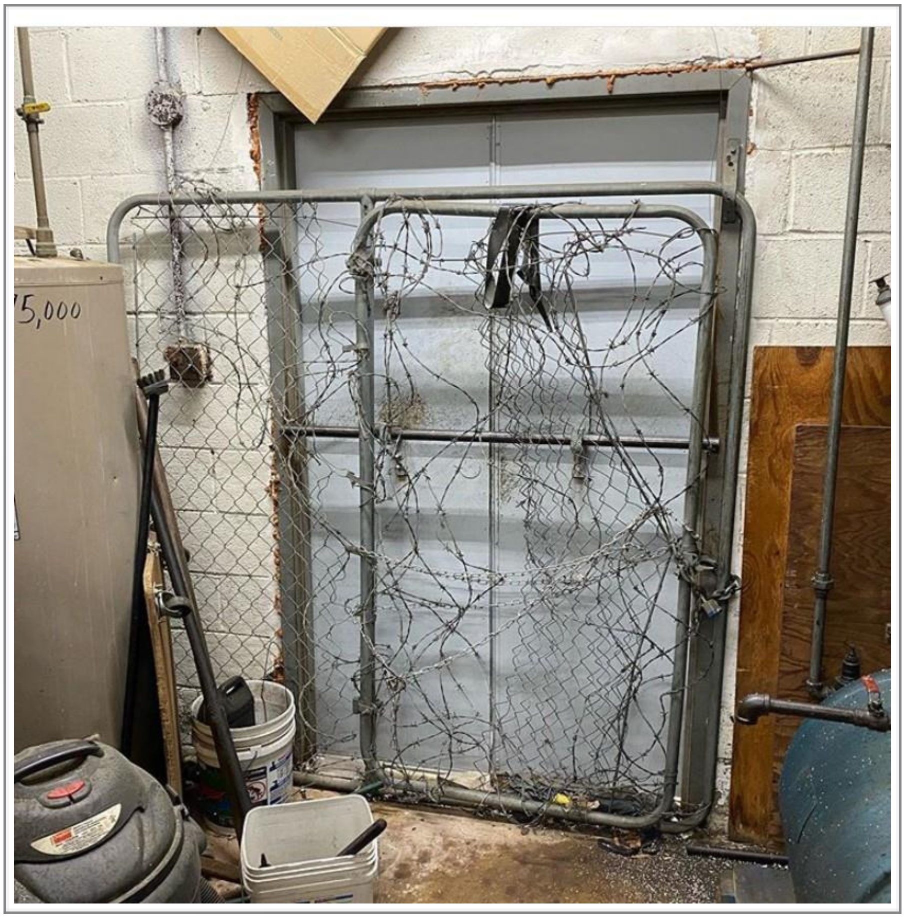
These are the priority questions to think about when you have a clear vision.

In this helmet camera footage, the halligan firefighter had a clear vision (lift of smoke) for about 8 seconds, prior to zero visibility. This is plenty of time to complete Life, Fire, Layout.

4. **CONTROL** - Use your halligan bar (adz) to hook the bottom of the door and close it. Place your knee on the halligan fork to secure it, as the search crew should enter in front of the engine company.

OUTWARD SWINGING DOORS

Outward swinging doors are generally found on commercial buildings, particularly in the rear of the building. They have potential to be solid doors that are extremely well-secured. They can have key in knob locks, slide locks, deadbolts, multiple locks, panic hardware and/or drop bars. These are the most common, but do not include the homemade locking mechanisms that homeowners and commercial owners will build/make.



Above, the building owner added razor wire, fencing, and chains/padlocks.
This is a common picture of "mental manipulation".

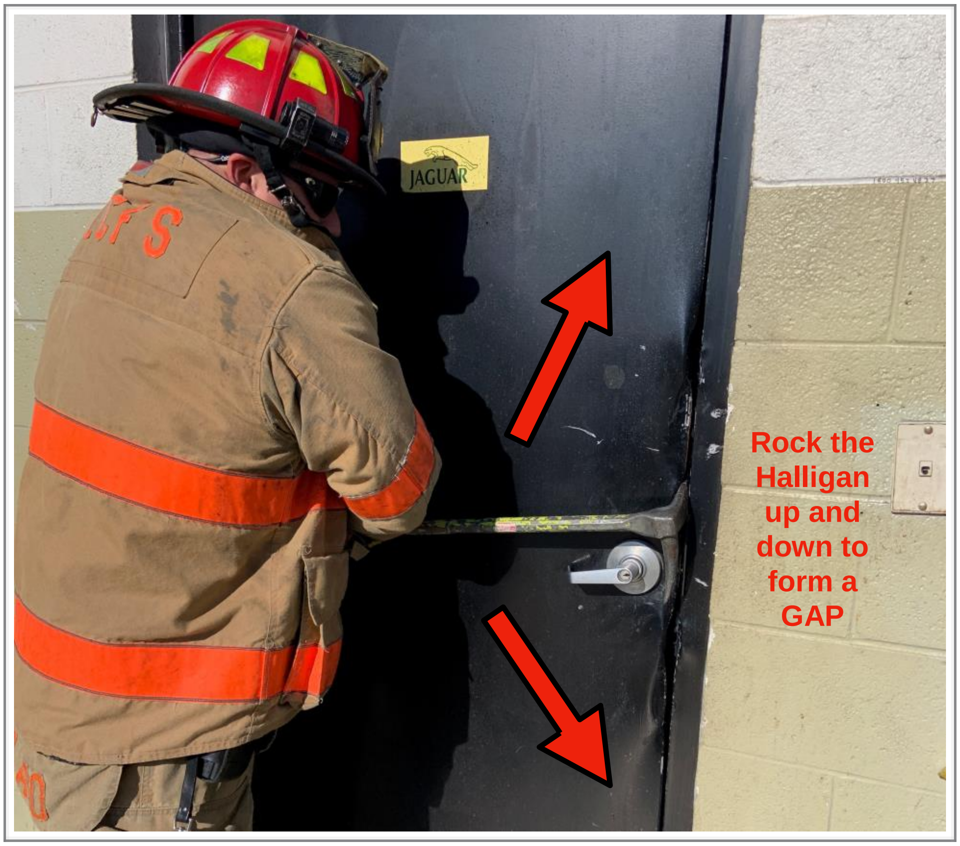
Many times owners use "mental manipulation" to deter burglars/vandals from breaking into the buildings. This tactic uses locks, security devices and other materials to appear difficult and fortified, but generally has no locking/security mechanisms. In the photo above, the outward swinging rear doors have multiple devices on the inside, yet removing the padlock on the right railing will completely disassemble the complete system. Many times personnel see the exposed hinges and believe that attacking them will be the quickest option. This is false, hinges on these doors are usually made of thicker gauge steel and are quite difficult to pull off with conventional tools sometimes. As a general rule, ignore the hinges and attempt conventional forcible entry on the lock side first. Always keep the following tasks in mind:

1. Evaluate the system
2. Overcome Mental Manipulation
3. Simple Problems require simple solutions

When forcing an outward door, the goal is to get the halligan (adz) set on the backside of the door. Most often, the best option is using the adz. This puts the halligan in the best position to force the door once the tool is set, as the adz provides a greater mechanical advantage for forcing (16:1). This requires working the adz between the door and the stop on the backside. Remember, the stop is not visible, like inward swinging doors, so you have to pay careful attention to how deep the tool is being driven into the space and be able to apply the correct pressure to work the tool around the edge.

Standard residential doors are 1.375” and commercial are usually 1.75”. Typically, the tool should be driven into that depth and then pressure applied to the fork end of the halligan, out and away from the door to move the adz around the stop. Understand that you can/may drive the halligan too deep into the stop (which will cause mushrooming) or pulling away too early can cause skinning of the door. Both of these issues will be discussed in depth later on, however, are very common due to the comfortability of using forcible entry door props that do not replicate/react like real doors. Just like inward swinging doors, personnel should use the GAP-SET-FORCE-CONTROL.

1. GAP: Adz Method



Gapping an outward swinging door is extremely critical step of an efficient force. Using the Adz of the Halligan Bar, place it between the door and the frame. Have your back-up Firefighter "hit" the halligan until the adz makes it to the stop.

Once the adz is in place, "rock" the halligan up and down, causing the door to bend or "crush". Ensuring that you "crush" the door and making sure your have a "clear" view of the backside confirms that the door was not "skinned" or the stop has been "mushroomed".

When forcing outward metal doors, follow the terms CRUSH, CLEAR, CONTROL. The picture on the far left shows a great GAP and crushing of the door; the middle picture shows a CRUSH prior to hitting the stop in which skinning of the door occurs. The picture on the far right shows "mushrooming' of the stop, when you continue to hit the halligan into the stop. Both skinning and mushrooming could prevent a door from opening easily.

Another View of a FF using the Adz to GAP and CRUSH an outward swinging door. It is imperative to crush the door to ensure a good SET.

2. SET

Set the Adz of the Halligan into the opening you made in the previous step. Depending on the door security and/or construction, you may have to have your back-up firefighter hit the halligan to ensure a secure SET. The halligan is properly SET when it's buried to the head and the adz is wrapped around the backside of the door. If it is not fully set, it will most likely pop out of the GAP during the force and you will have to start over, losing valuable time and effort.

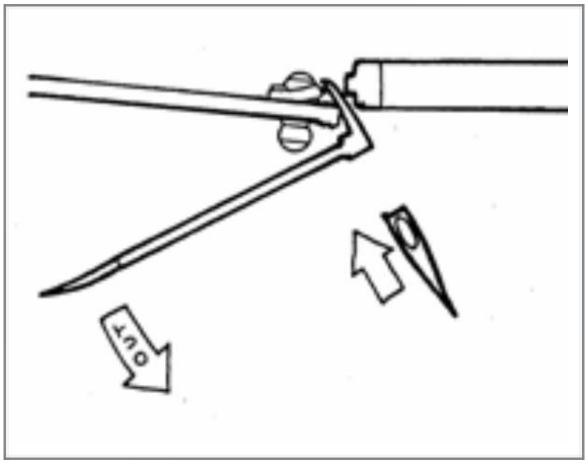


Figure Above shows the top view of a Halligan SET into the door.

Figure left shows a side view of the Halligan SET and buried to the head/neck of the bar.

Two firefighters “pull” the Halligan to force the fortified door.

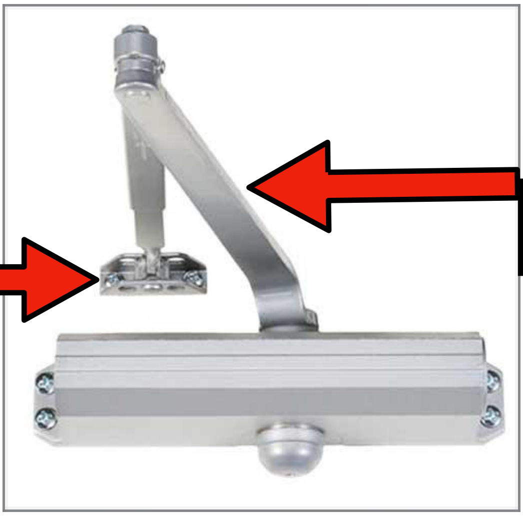
Firefighter above “pushes” the bar for a strong, stable stance of mechanics.

3. FORCE/CONTROL

Force the door, pulling the Halligan outward. Remember, the farther you are away from the "fulcrum" the more leverage you will exert. Many times, using the 2nd firefighter to assist forcing an outward metal door is required, especially if the door is heavily fortified. Extending the halligan will assist in the force (will be discussed later). If able, force the halligan in a "pushing" position. Pulling the halligan will make your body and balance unstable and you will not be able to exert the maximum amount of force.

As the door opens, take a look behind the door. If it is a self-closing door, you may have to disable the closure by hitting it off the frame and/or bending it. Once the door/locks have been defeated, complete LIFE, FIRE, LAYOUT.

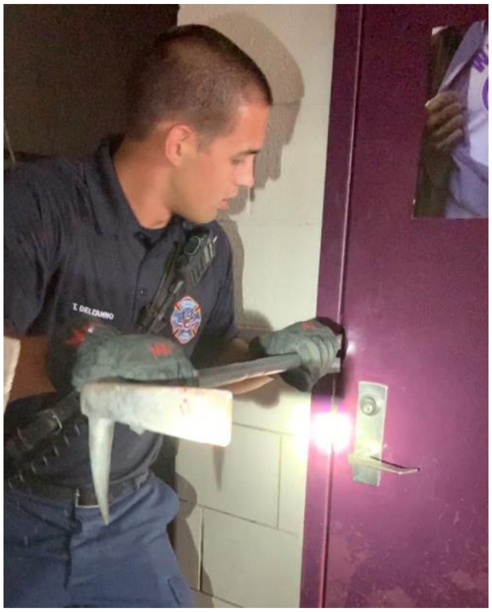
Example of self-closing Hinges



Example of a self-closing device. Force the hinge side off or hit it with an axe or halligan and bend the device's arm

Using the Adz Method maximizes the leverage of the halligan, especially in confined spaces. It is not recommended to use the Fork Method if the space/area is limited in movement.

1. GAP Fork Method



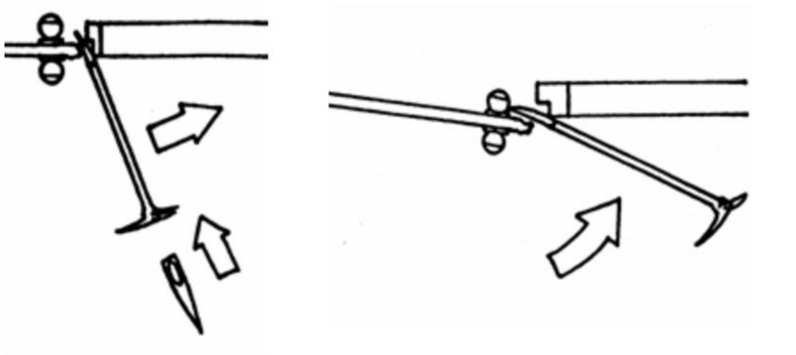
Gap the door by placing the bevel side of the Fork towards the frame, just above or below the suspected locking device. Have the back-up firefighter hit the halligan to wrap the forks around the door/stop.
With the natural curve of the forks, it is easy to skin the door with the forks.

2. SET Fork Method

Pry the door by pulling out on the Halligan so that the Fork works around the door and stop and can be driven past the inside frame.

3. FORCE Fork Method

Once SET, force the door by pushing/pulling the Halligan towards the door.



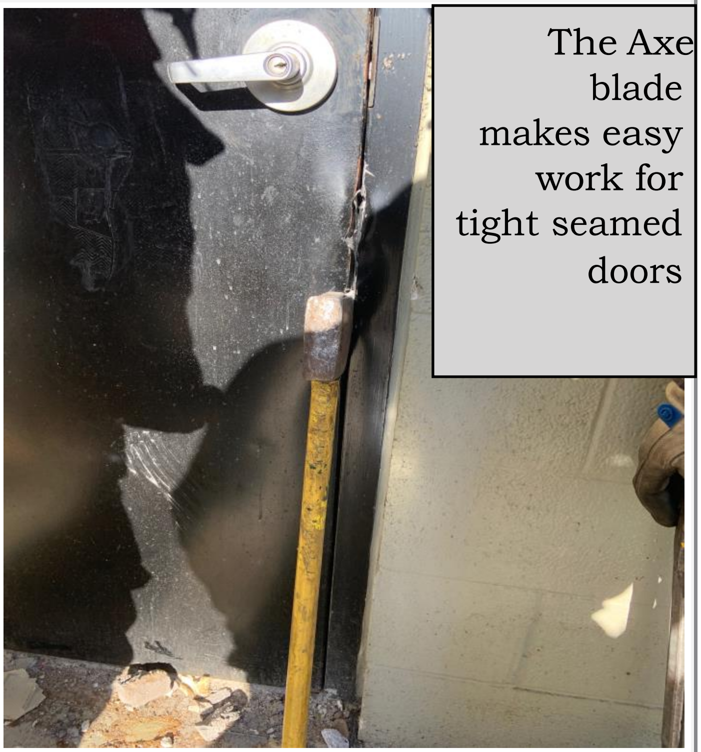
Set (Top View)   Force (Top View)

Outward Doors (continued)

Commercial outward doors, especially in the back of the occupancy (for security protection), can have a multitude of security devices to deter entry. From homemade devices, drop bars, and commercially available products like the Sorniex Security Door, can hamper and slow down crews attempting to force entry. Every product/door has a weak point. Attacking the device/door at its weakest point will ensure an efficient and effective process.

TIGHT DOOR/GAP ISSUES

One of the most common issues you will deal with in regards to outward swinging doors are tight door/gap issues. All commercially made doors have a seam somewhere on the door. The majority of seams are pressed on the locking and hinge side (causes skinning) for production purposes. Higher cost doors press the seam on the bottom or top to ensure an "aesthetically" pleasing look. Either way, tight seams/doors limit and slow our GAP down and generally cause inexperienced personnel to call for a rotary power saw or destroy the door. The following are the process for dealing with tight doors.



The Axe blade makes easy work for tight seamed doors

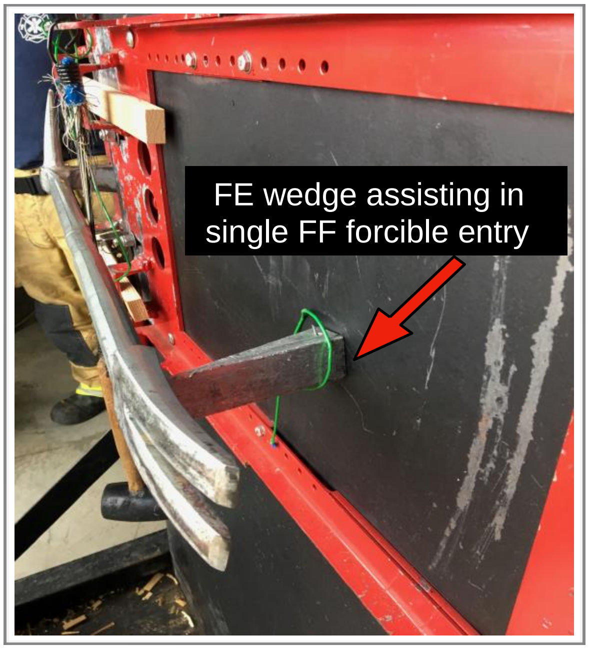
1. **Axe Blade** - The blade of the axe is thinner than the adz of the halligan.

Use this as a wedge, placing the blade in the gap between the door and frame. Hit it with the halligan and drive it into the gap. This quickly causes enough space to place the adz.

2. **Wedge** - Using a metal forcible entry wedge is another quick and effective step to defeat tight seams. Like the axe, place the wedge between the door and frame and strike with the axe or halligan. You will then be able to place the adz in place.

A good truckman should carry a metal FE wedge for Gapping and Wedging purposes. Wood wedges do work, however on stiff doors, they will chip/crack and fail.

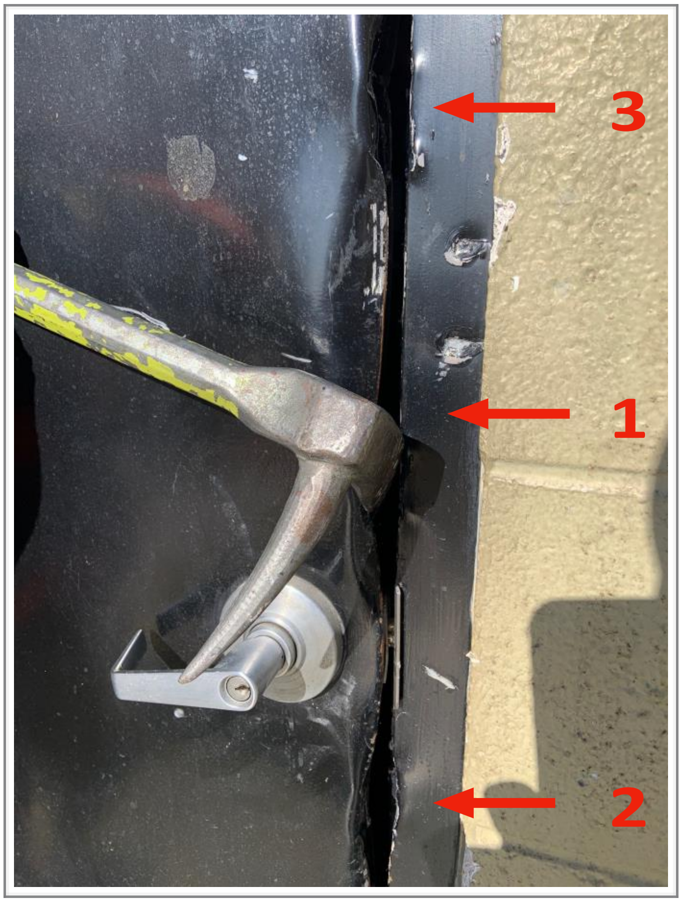
An additional view of the metal FE wedge being put to work. Metal wedges not only assist in Gapping tight doors, but can assist in single firefighter forcible entry and wedging will actually provide an additional mechanical advantage. A three inch metal wedge with a width of two inches, provides approximately 1.5 to 1 MA in regards to forcible entry leverage. Using this example will start the average firefighter with a 22:1 MA (adding the adz MA). No matter how slight it may be, every additional leverage point helps.



3. **Strike/Batter the Door** - Using an axe or halligan, shock/strike the door next to the seam. Many times, a few blows to the door, will dent the door and force the seam to split open towards you, allowing room for the adz. Although this technique is very effective, it has the tendency to increase the chances of skinning the door.

SKINNING THE DOOR

Skinning the door is very common, especially in cheaper metal/fiberglass doors. It is also happens when personnel begin to move the Halligan inward too quickly prior to hitting close to the stop. The most important step in defeating a skinned door is recognizing that you are skinning the door and stopping. If the door is beginning to skin or has opened up already, refer to the following steps.



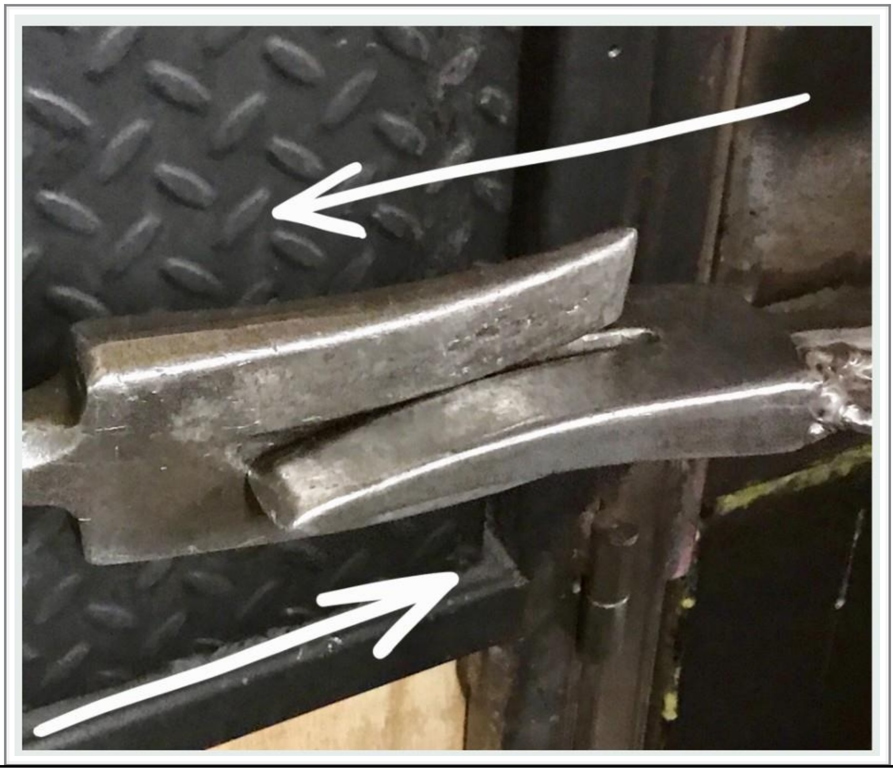
1. **Gap** - Stop forcing the door and begin to crush the door with the adz. If needed move lower or higher and gap/crush the door "like a can opener". This will pull the "skinned" door away from the frame and you will be able to begin the SET process again. If you notice the picture to the right, the firefighter skinned the door just above the lock (where the adz is currently sitting, figure 1). The firefighter recognized it, moved below the lock and crushed it (2). Then moved above the lock (3) and crushed it. This enabled the door to pull away from the frame, allowing the firefighter to reposition back to the original area and continue the gap process.
2. **Forks** - If the GAP process did not succeed, switch to the forks of the Halligan and begin the same process of using it like a "can opener". The length of the Halligan will provide you with additional leverage and will open up space between the door and frame to continue the force process.
3. **Restart** - If needed, restart the entire GAP-SET-FORCE process on the door. If neither the adz or forks could clear the door or if the door is too far skinned, start at least a foot or two away from the starting point and restart the entire process. You will have to work your way towards the original skinned area, however, clear all parts of the door, working upward (or downward) towards the locking mechanism. This will require some

additional time and effort, but will complete your objective.

Extending Leverage

There are times where more leverage is the only force needed to open a door. By extending the leverage, we can obtain greater mechanical advantage, using common tools that we should have readily available.

1. **Halligan** - Adding and attaching another pro-bar to the current halligan will greatly increase the MA to 43:1. This is a very common technique used and is very effective. Many times after the force, the two bars will be locked together. Simply dropping them on the ground will break them apart.



Simply attaching another halligan into the forks will add an additional MA to assist forcing a stubborn door. Remember, the farther you are from the door, the more force you can provide to the tool.

2. **Metal Roof Hook** - A steel roof hook can also be used. It is not recommended to use a fiberglass hook (will shatter). Place the chisel end of the hook over the halligan or under it and let it slide into the forks. Adding a six foot hook can increase your MA in the area of 65:1. If the room allows, place the hook on your hip/body and gently walk out. This uses your body weight to easily force open the door. Make sure to hold the hook where it initially meets your halligan bar. Under pressure, the hooks do have the tendency to slip out if not held.

As pictured above, the single firefighter is holding the meeting point and will use his hip/body weight to slowly move outward to force the door. Also notice that the chisel end is under the pike of the halligan to "lock" it in. This technique can also be used on an inward door. Simply place the chisel end in the Gap (with halligan) and lock them in.

DROP BARS/SECURITY DEVICES

One of the most common and expected security device on commercial, outward swinging doors are drop bars. Drop bars should be expected on every rear commercial door. It is most commonly identified by carriage bolts in the middle of the door, however, additional locking mechanisms will also have bolt heads.

Inside view of this door, shows the drop bar on the top, with metal holders to secure the bar at night.

Not only will carriage bolts identify drop bars, but other security devices will be mounted as such. These bolts and other modifications should be noticed in your door size up.

Conventional methods should still remain the initial plan of attack because many times the bolts are a false indicator of reinforcement and/ or the drop bar may not be in place at the time.

If you notice the bolt heads in the middle of the door, you should begin your approach conventionally. If the bar/security devices are in place, it will begin to weaken the brackets.

Drop Bar/Carriage Bolts - Begin your entry by attacking the bolt-heads closest to the lock side. Removing one or both of these bolt heads will enable you to use the leverage of the door opening and not have to force the other bolts fully.

1. Begin this force by driving the pike of the Halligan through the skin of the door above and below the bolt head. Once the pike is set in the door, rotate the Halligan around to weaken the skin of the door.
2. Move the pike to the opposite side of the bolt head and repeat the process.
3. Take the Pike or Adz and place it directly onto the bolt head and drive it through the door. If there are more bolt heads, repeat the process.
4. Continue with your conventional force as the holder has now been defeated.

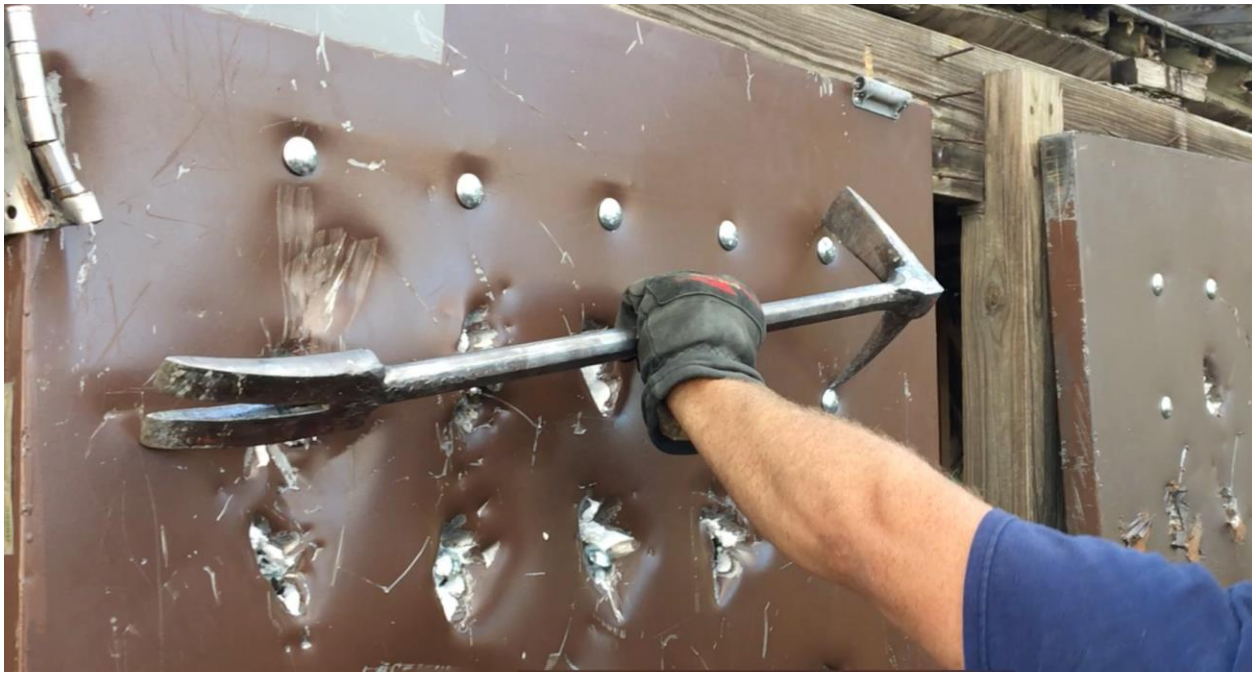
This picture shows the firefighter attacking above the bolt head. He will then move below the head to ensure the skin of the door is defeated prior to attacking directly on the head.

Once the skin is defeated, place the pike directly on the head and drive the bolt head through the door. The device's holder will be rendered useless.

In order for this technique to provide results, you should ensure that you rotate the halligan around the bolt head. Any piece of door skin (also known as tabs) that is touching the bolt can hinder your operation. Make sure it is clear for the head to move through the door.

Often, the Outside Vent Firefighter (OVM) may have to force rear doors until his partner (Engineer) can meet up. Many times, forcing an outward swinging door will be completed by one firefighter. When dealing with carriage bolts by yourself, use the same technique as stated above, with the exception of using gravity to your advantage.

1. Place the Halligan Pike against the top of the bolt, with the Adz and forks resting on the door. This will enable you to start a purchase point with the axe, then transition over to full swinging capabilities once the halligan is set in the door.



The Firefighter above places the halligan against the door and holds pressure until the Pike is set in the door.

The Firefighter continues to hold the bar and rotate down, while swinging the axe.

Once the Halligan is set in the door, the firefighter can let go of the Halligan bar and begin to use both hands to fully swing and distribute the force into the halligan. This will "set" the pike into the door.

The Halligan bar is now "set" into the door and full swings can now be accomplished.

Drop Bar/Carriage Bolts - Rotary Saw

Rotary saw work will be covered in depth in the "Egress" Chapter, however, if a rotary saw is nearby and/or already running, cutting carriage bolts can be accomplished using a saw. There are two options for removing carriage bolts with a saw.

1. Cutting into the Bolt
2. Cutting the Bolt head off

If you notice the door on the right, it has four bolt heads near the locking side. This generally tells us that there is an emergency panic bar mounted on the inside.

Cutting into the Bolt requires you to attack the bolt heads at approximately a 45-60 degree angle and cut into the door to release the bolts. Many people recommend cutting all the way through, however, that can damage the door and/ or mechanism and requires time. Majority of the bolts used in commercial door are Zinc coated bolts. When Zinc heats up it absorbs the "blue wavelength" of sparks and causes the sparks from the rotary saw to quickly turn from orange/ white to yellowish, sometimes blue. Not only should you pay attention to the color of the sparks, but you should sometimes feel and hear the rotary increase RPM's. This tells you have reached our objective. Remove the saw blade and start on the next bolt if needed.

As this firefighter begins to cut into the door, he monitors the color of the sparks and feel of the saw. When the saw "tightens" up (RPM increases) the sparks can quickly change to yellowish, sometimes blue sparks. The bolt is now cut and the saw can be removed from the door. This will save you time, effort and damage to the door/locking mechanism.

Cutting or Shearing the bolt head off is the other option in regards to rotary saw bolt cutting. In this technique you use the rotary saw to shear/cut the bolt head only off, then use the pike or adz of the halligan to drive the bolt off of the bracket/door. This technique is not as successful as the first option and it still requires hand tools to finish completing the bolt head task.

The firefighter in the picture above places his saw parallel with the door and only "shears" the bolt head off. You will then use the pike or adz of the halligan to drive it through the door. This should not be your Plan "A". This process requires multiple tools, effort, and time.

No matter which saw technique you use in regards to carriage bolt forcible entry, you will most likely have to switch to conventional forcible entry to completely open the door. Many times, conventional techniques are faster and easier than waiting for a rotary saw at the rear of a building or having to switch between tools.

SECURITY DEVICES

The picture on the left shows multiple bolt heads on the exterior skin. Once forced, the interior picture on the right shows the two attached slide bolts. Slide bolts are generally not difficult to force, however, they will force you to increase your leverage during a conventional force step as they will add some difficulty. Most occupants do not attach the slide bolts correctly or they do not drill out a appropriate size hole for the slide bolt. Most occupants will have the hole too big for the appropriate bolt and that will increase the chances of failure when leverage is applied during the force.

Commercial owners will go lengths to protect their businesses and employees, especially in todays society. One of the newest commercially available doors that have been contracted out in all Nationwide Pharmacies (CVS, Walgreens) are the Sorniex Doors. These doors are installed in concrete reinforced, block walls, with a solid steel door. Sorniex uses a distinct "S" on the locking mechanism, along with a bolt head configuration on all sides of the door.

This bolt head configuration shows the location of 3/8" steel rods that engage into the steel door frame when locked. The rods are free-spinning, which causes a disadvantage if you attempt to use a rotary saw to cut through them.

Due to time and energy, your focus should be on conventional forcible entry to defeat this door.

Plan A:

1. Like other outward doors, attempt to GAP above or below the lock.
2. Continue to move your halligan up and down the stop and complete a full GAP of the door.
3. Once the GAP is complete, have additional members assist in the force/ leverage.
4. Add additional wedges and tools to assist in the extension of leverage to open the door.

Plan B:

1. Begin the process of Plan A and call for rotary saw.
2. Once rotary saw arrives, sink the blade into the Gap space between the door and frame at the very top.
3. Slowly run the saw blade all the way down to the bottom.
4. Finish Gapping with hand tools and force door.

Plan C:

1. Run the Saw blade from top to bottom, on the locking side in a triangle cut.

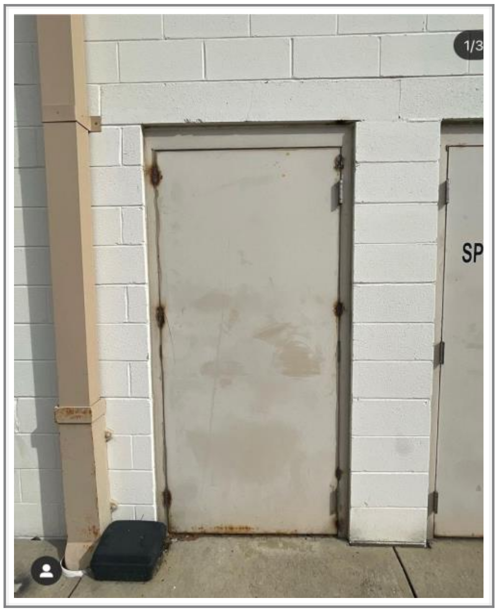
2. Ensure to run the saw blade at full depth to cut the mechanism box/plates and rods if possible.
3. Use Halligan and axe to remove and force the rest of the door.

PLAN A

PLAN B

PLAN C

As stated before, building owners are only limited by their imagination for security devices. Seen below, an owner did not use their rear door so they tack welded the door shut.



Door Guards/Door latch plate - Are usually thin steel and/or aluminum plates that cover and protect the latch assembly/door. Many owners will attach these plates to the door for the protection of the latch mechanism from vandals. These plates are very easily defeated and are considered "mental manipulation".

Plan A -

1. Use Halligan to Gap above or below the guard plate.
2. Conventionally force as necessarily.

Plan B -

1. Place Adz of Halligan on the top of the Guard facing down.
2. Strike top of halligan until the adz is buried behind the guard.
3. Force the halligan up then down. Continue until the plate is removed.

Some Latch Guards will run the entire length of the door seam. These can be easily defeated/removed. Start at the top of the seam and remove it by striking the adz behind it and pry it off.

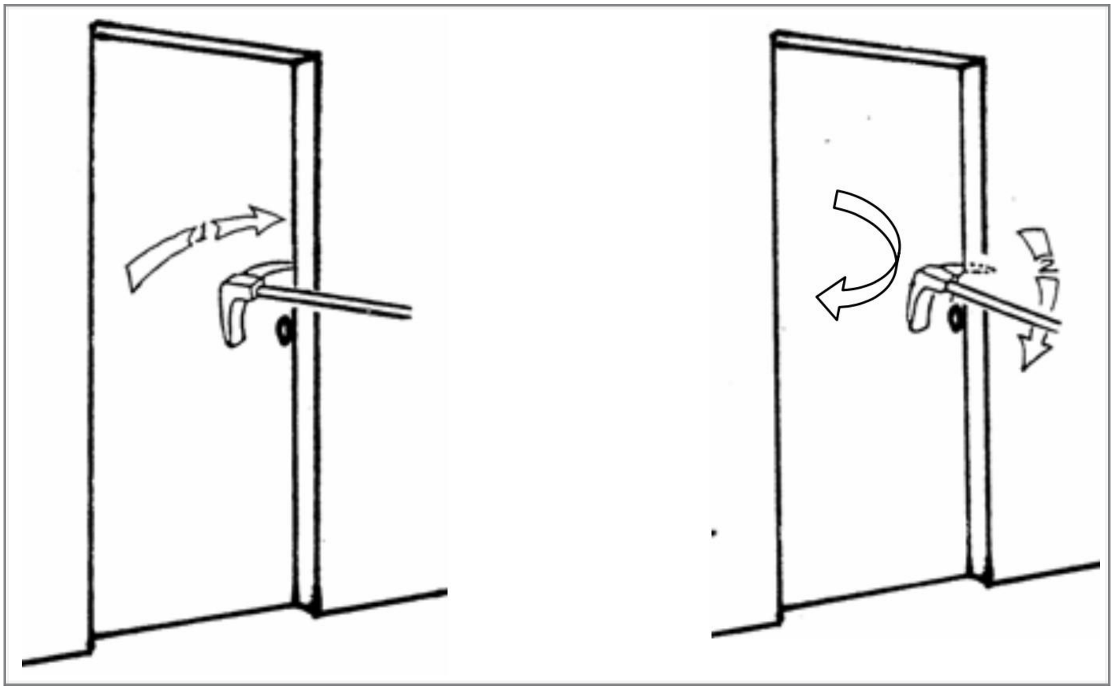
This aluminum latch guard was easily defeated with a Halligan.

ONE FIREFIGHTER FORCE ENTRY METHODS

Many times when the Outside Vent Firefighter is performing a 360 or is tasked with an objective on the side or rear of the building, they will be operating alone. Most of the time, a residential door can be easily forced with just the halligan bar and a single firefighter. There are doors, especially solid wood doors, that will require extra effort or leverage. The following steps are designed for one firefighter methods.

Baseball Swing - One of the quickest and easiest skills for a one firefighter force. Especially on inward, interior, hollow core wood doors.

1. Confirm door is locked
2. Position the Pike of your Halligan towards the wood frame/jamb.
3. Swing the Halligan, like a baseball bat, and seat the pike into the wood frame.
4. Force towards the adz (adz will assist with leverage and splitting the hollow door).



The Baseball Swing procedure is very quick and effective method for wood frame/ wood doors. If initially it does not force the door, it will produce a GAP large enough to place the adz in the space and provide a follow-up force.

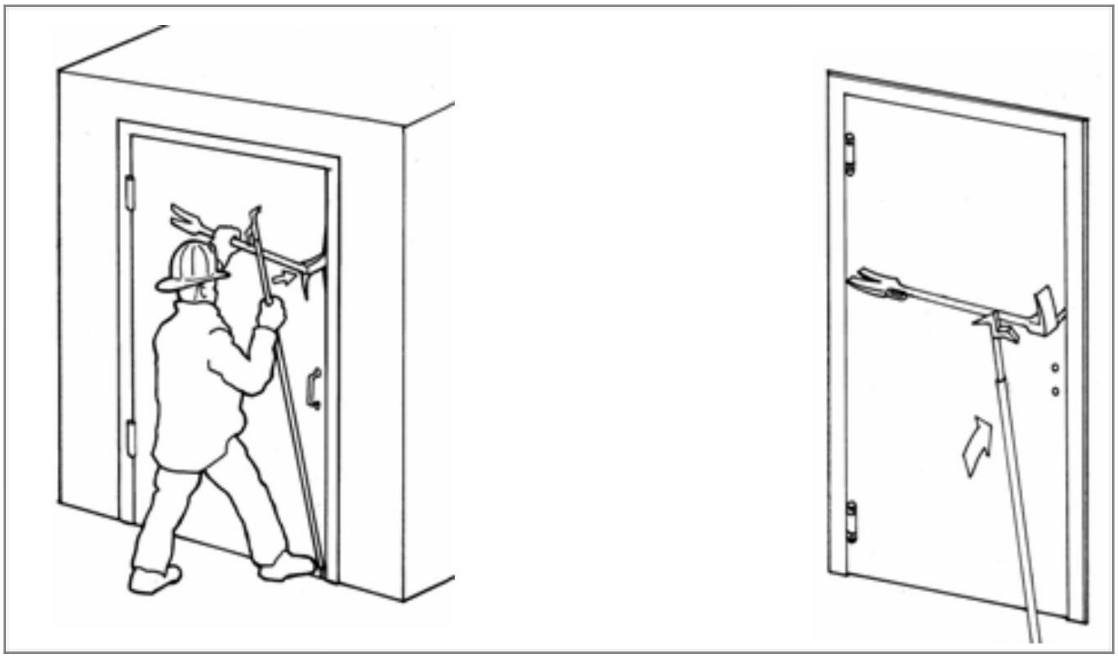
Force Wedge and Halligan - A metal forcible entry wedge is a necessary tool for any Truckman to carry in their pockets. Most wedges are between three to four inches long by one to two inches wide.

Wedge for Inward doors -
1. Take the wedge and place it between the door and jamb.
2. Strike the wedge with your halligan until a purchase point or Gap can be made.
3. Use your halligan to force the door with the adz end and if needed, use the wedge to capture progress of the door.
4. If needed, switch your halligan to the forks and force the door.

ONE FIREFIGHTER ROOF HOOK METHOD

The six foot roof hook and Halligan bar is the most common and recommended tool compliment for Ladder Company Firefighters. These tools together are a great combination to combat most tasks on the fireground. There are multiple uses for a roof hook in regards to forcible entry.

Toeing - Using a roof hook, "toe" the tool head against the bottom of the door. Use it as a striking tool against the halligan bar.



1. **Hip Force -** This technique uses body mechanics and the leverage of the hook for an inward and/ or outward swinging door, the process is opposite (push hip/hook away from door).

- Using the chisel end of the roof hook, place it above or below the locking mechanism of the door. Position your body/hip on the inside of the roof hook.

- Once in position, use the Halligan to strike the head of the roof hook until it “sets” into the door.
- Place the halligan in the GAP, next to the hook placement.
- Push your hip/body towards the hook and leverage your body against the door.

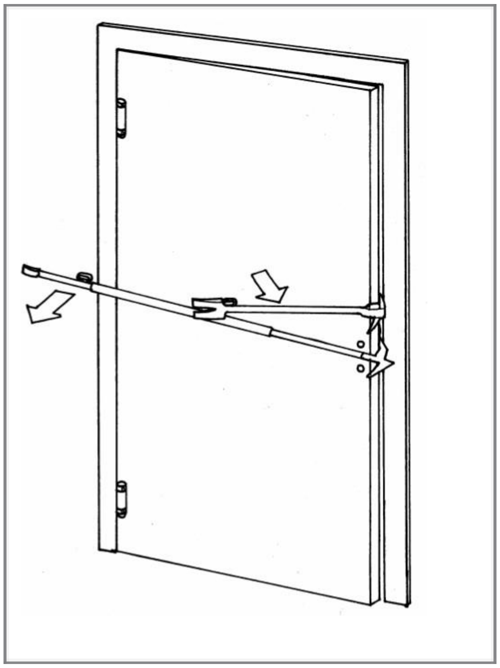
The firefighter above places his hip against the hook for pressure, then continues the force with the halligan bar.

The firefighter to the right demonstrates the same process for outward swingingdoors.

The roof hook is “set” in the doorway, then placed against the firefighter’s hip. In this picture, the firefighter will rotate and move towards the door frame for theforce.

2. **Hook Force -** This technique uses the Halligan to begin the force of an outward swinging door.

- Begin the force with a halligan bar, using the adz end to GAP an outward door.
- Wedge with the Roof Hook head.
- Use the Halligan and hook and pull outward to force the door.

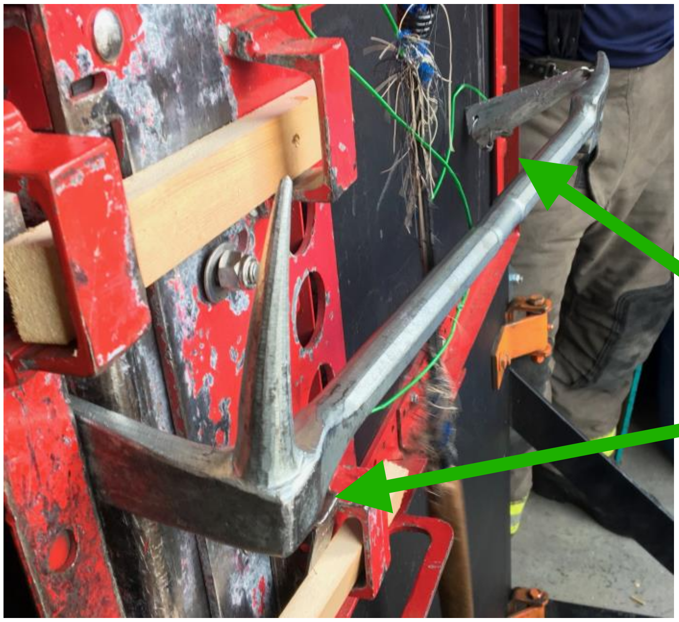


ONE FIREFIGHTER OUTWARD FORCE

One firefighter force - Halligan and wedge.

One firefighter may not have a roof hook to assist with an outward swinging door. In that case, the firefighter can use a Halligan bar, axe, and wedge to complete the force.

- Begin the force by Gapping the door using the Halligan adze.
- Use your metal forcible entry wedge and place it between the halligan bar and the door. Slide it towards the adze end until the wedge is tight and the adze rotates towards the door (Clear the seam to prevent skinning).
- Use your axe to strike the halligan until it is set.
- Force the door.



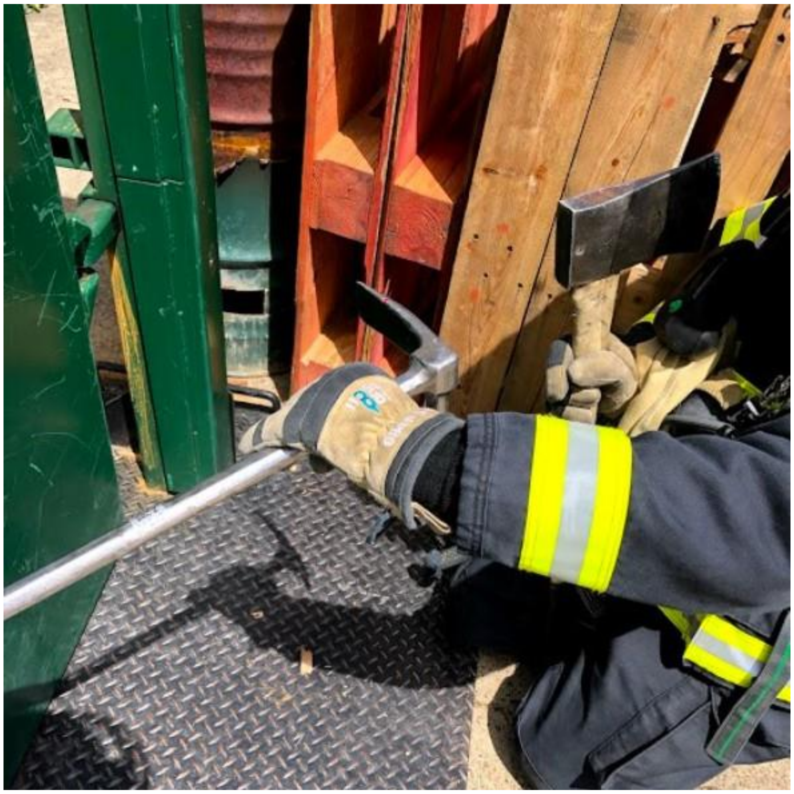
Wedge is placed behind the Halligan, which rotates the adze into positioning for striking and SET.

ONE FIREFIGHTER FORCE CONVENTIONAL

One firefighter conventional forcible entry is the same steps and progression as two firefighter, with the exception that one hand will have to hold the Halligan while one hand holds the striking tool. The lone firefighter will have to "work" the halligan around the door/jamb, while striking with an axe/tool. To assist in the process, the lone firefighter can use the "hand to hand" method or the "Hip swing" method.

Hand To Hand Method

- Begin the GAP-SET-FORCE process
- If able, kneel down for more stability.
- Slide the Halligan hand down the shaft of the bar towards the adz
- With one hand on the Halligan and the other on the axe, hit the Halligan, meeting hand to hand.
- Many instances, moving your axe hand towards the head (choked up) will assist in the striking accuracy and ability.



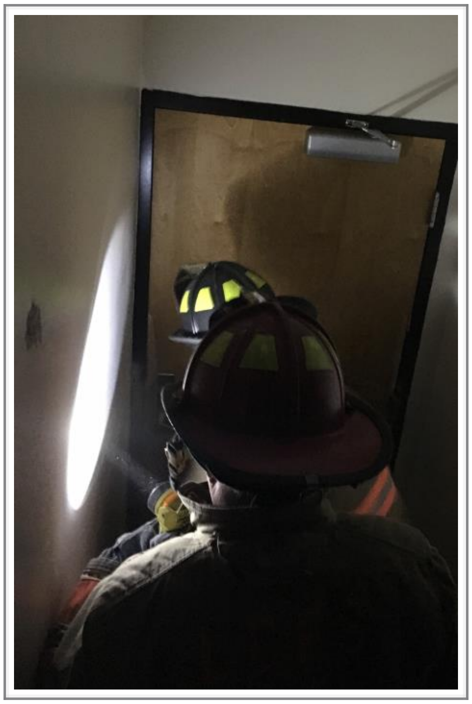
Meeting hand to hand makes it easier to locate and hit the Halligan, especially in low visibility conditions or if

Hip Swing Method

- Begin the GAP-SEP-FORCE process
- Choke down on the axe head and place it perpendicular to the Halligan.
- Tuck the handle under your arm and elbow.
- Hold firmly and use your hip to “swing” the axe head into the Halligan while holding the Halligan with your other hand.

CONFINED SPACE/LOW VISIBILITY FORCE ENTRY

Some scenarios and building construction features present difficult challenges for forcible entry. When access around the door is limited, the firefighters must adapt to the situation and alter the positions and techniques used. Also, the Halligan firefighter may have to position themselves between the tool and the door. The techniques used in these scenarios often do not produce the same amount of force or amount of swing capabilities. With that said, it is recommended to start with the bevel to the frame to make the initial SET of the Halligan easier.



CONFINED SPACE

Making Room - One ability that is often overlooked is making room. If you have the ability to "make space", take it "take space". The statement "make space, take space" can be related to many ladder company tasks, however, if faced with a recessed door in a confined space, make space to rotate the Halligan and exert the leverage required to force the door. Often brick, concrete, and many other materials will quickly shatter and break, with just a few hits of a striking tool.

Chipping away at the corner can give you inches, which many times, is all you need to successfully force a recessed door.

Personnel struggled to obtain the rotation of the halligan on this recessed door.

Using an axe, a few strikes on the corner of the brickwork enabled them to obtain enough space to rotate the tool to completely force the door.

Areas of damage from the axe

Personnel attacking a fortified outward swinging steel door at a courthouse. Many times, the Halligan firefighter may have to stand away from the door and allow the striking firefighter down and up close to the door.

This is not uncommon in tight quarters and will required experience and knowledge from both members. The striking firefighter will have to communicate to the Halligan firefighter on his movement and positioning, as many times, the Halligan firefighter may not be able to see his Halligan bar.

In return, the striking firefighter will have to watch both their strikes, as well as the Halligan to ensure the Halligan is "walking" around the door or frame.

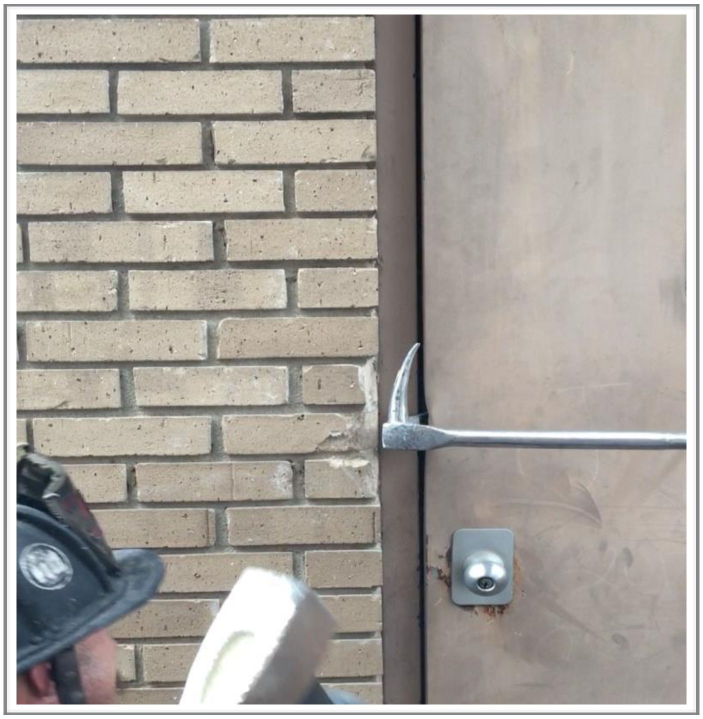
Confined Space - Striking Techniques

Shoulder of the Halligan - The Halligan firefighter will be positioned at the end of the tool with their hands on the pike and adz. The axe firefighter will strike by sliding the head of the axe along the top of the Halligan and striking it on the shoulder of the forks. This requires the shoulder of the Halligan to be filed down and "squared off". If the shoulders of the forks are not squared off, the axe will slide off on impact and the effort/force will be lost.

One firefighter confined space technique using the top of the axe for the "strike" motion and using his hips to assist in balancing the Halligan bar.

One firefighter technique - The same process as above, however, a single firefighter can hold the Halligan or use their hip against the bar. The single firefighter will then have to slide the axe down the shaft of the bar using the top of the axe and not the back. This will balance out the axe for more control with one firefighter.

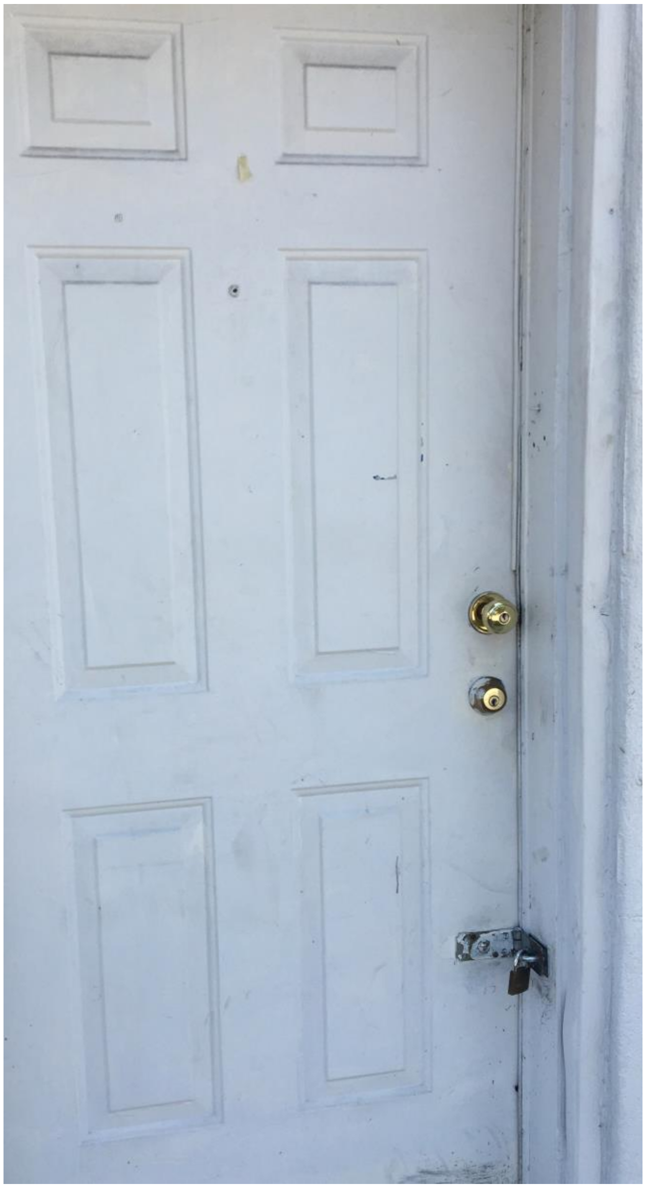
Inverted Tools - Sometimes the only way to deliver a good strike, especially in tight quarters, is to position the axe upside down and deliver a strike. As professionals, we must adapt and overcome in tight situations to be able to complete an objective. Remember, not all techniques work in every situation and sometimes they don't work at all.



Low or No Visibility/Forcible Exit

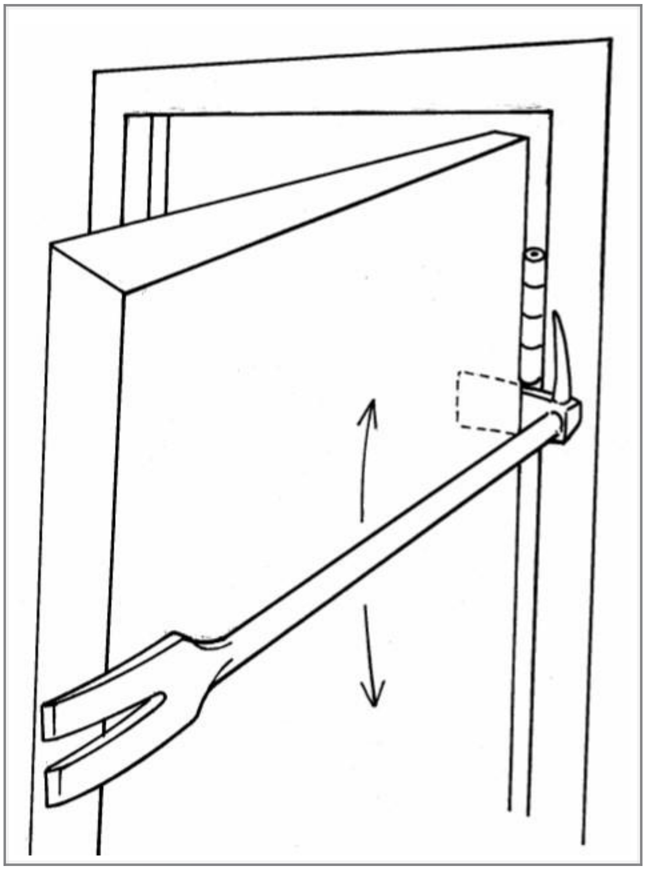
Scenarios with little or no visibility will require different methods for striking the Halligan tool.

- Hand to Hand Method - Discussed before, firefighters especially in low visibility, should take a kneeling position for better stability and stance in low visibility. Hand to Hand method uses the Halligan firefighter holding the Halligan bar in place with their hand on the axe handle. The back up or striking firefighter holds and swings the axe in place. The Halligan firefighter only steers the axe against the Halligan.
- Double Tap - This technique is very effective and useful in confined spaces and low visibility. When a “strike” is called by the Halligan firefighter, the axe firefighter taps the Halligan with the axe softly then provide the full strike. The “tap” lets the halligan firefighter know that the strike is coming, as well as, reinforces the location of the Halligan position to the striker. It becomes a form of “muscle memory” when you double tap in forcible entry.
- Forcible exit - is a term used when you have to force your way out of a structure. Many occupants/owners have now developed security techniques/obstacles that may require us to force our way out of a room/ building. Communication and basic forcible entry techniques are key in quickly defeating any obstacle, especially in MAYDAY/emergency situations.
- Single Room Occupancies (SRO) - are becoming very popular in the midlands area. SRO’s are especially popular in college/high development areas. Owners/Occupants will rent “rooms” to other individuals or contractors for short term leases. Bedroom doors will be reinforced and many times locked with padlocks/ hasps from the outside.



This SRO was found at a small kitchen fire.

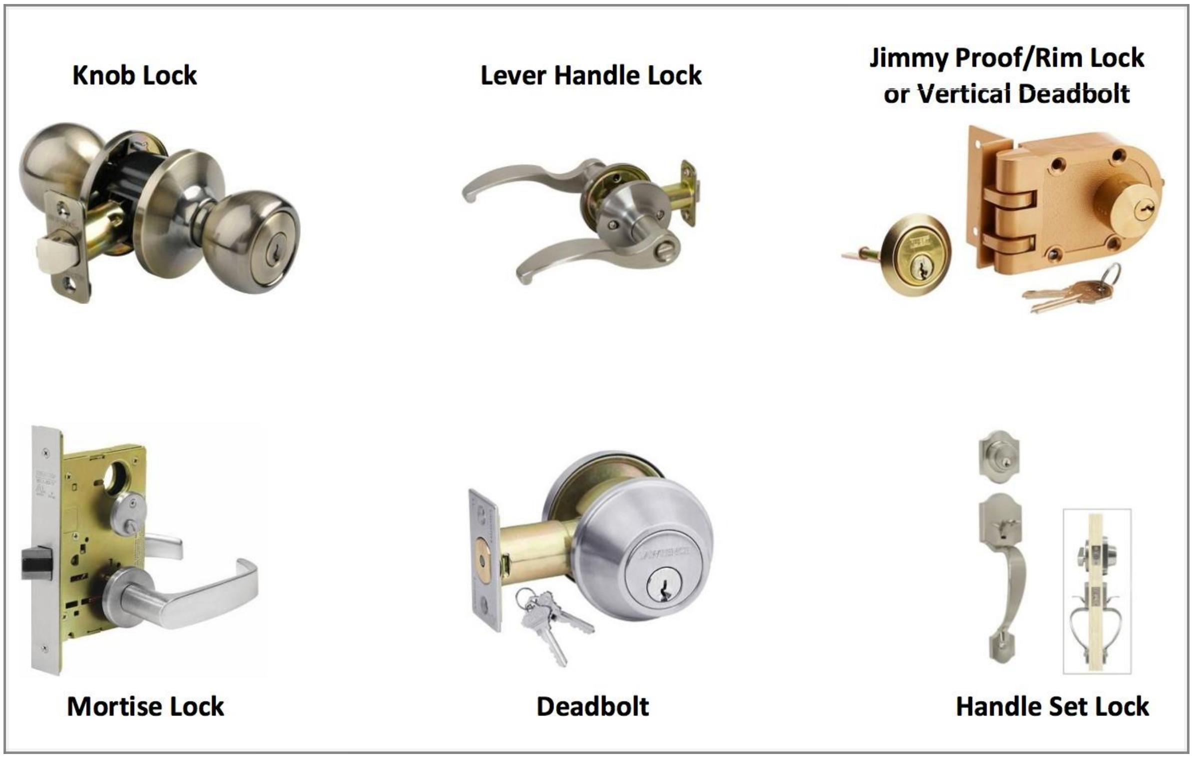
- Storm Doors - When operating at any incident, storm doors must be removed. Almost every time a storm door is attached to a structure, companies are delayed entering the building and/or continuously gets in the way of the hose line and/or additional equipment and personnel moving in and out.
  - Once the door is open, place your Halligan forks on the hinge side and slam the door close. This will break the hinges off. Most importantly, once the door is off, move it away from the building.
  - Another technique is to open the door,
    place the adz on the hinge side and force downward. Once the door is off, move it away from the building.



THROUGH THE LOCK

Through the lock is a means of opening an entryway with little or no damage to the door or frame. Sometimes the locking mechanism may get damaged, but the owner can cheaply replace the locking mechanism. Often during these events, this method can display professionalism and good public relations. Many times this method needs to be used when time and fire are not urgent, however, there will be times when through the lock (TTL) can be quicker and more efficient means of entry.

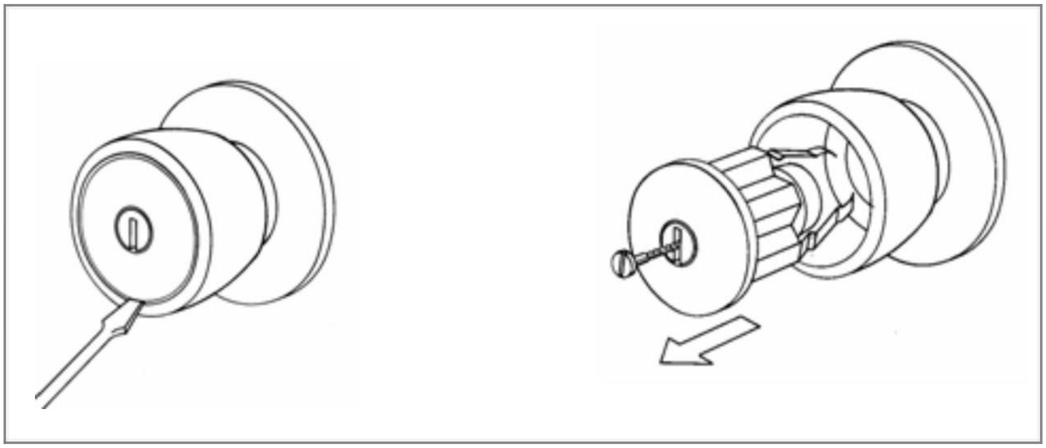
This manual will address the most common locking mechanisms that can be found. For some of the most up to date locking mechanisms, it is encouraged to go to your local hardware store and look at the more popular and latest locking devices. Something to take note, the cheaper the lock, sometimes the more difficult it may be to force. Cheaper locks have a tendency to break up causing entry problems involving the cylinder.



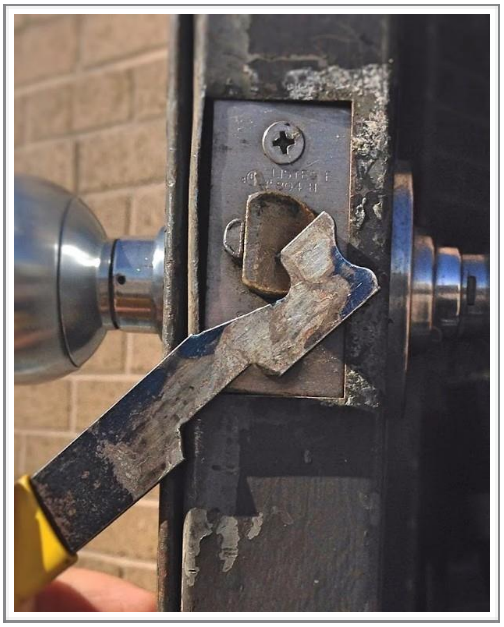
Key in Knob (Knob Lock) - Very common locking mechanism, where the lock is part of the knob. These locks are found on both inward and outward doors and can be single key or double key. Single key, only the outside has a key-way where the double key requires a key on both sides. Double key knob locks are generally found on exterior doors where there is glass or exposed possibility of reaching inside to attempt to unlock the key-way. The spring latch on most of these locks range from 1/2 - 3/4 inch, however, new, more secure locks have have latches up to two inches.

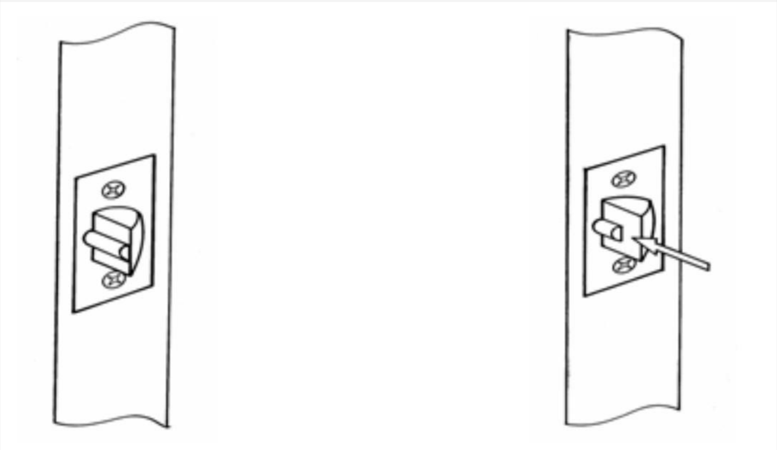
- Using Officer's Tool, A Tool or Rex tool - The doorknob can be removed quickly without damaging the stem of the lock.
- Place the tool behind the knob and quickly lift up and outward on the tool to remove the knob.
- Insert the stem of the key tool into the slot and pull or twist toward the hinge side of the door to active the latch.

- Using a Screwdriver - On some knob locks you can remove the center of the knob with a flat head screwdriver or butter knife.
- Insert the screwdriver in and around the center of the knob. On some knobs, it will require you to loosen and pry around the entire circle.
- Continue to pry downward and out to remove the center.
- Once removed, insert the key tool into the stem or latch and twist or pull towards the hinge side to open.



- Using a Shove Knife - Key in Knob locks on outward swinging doors have a spring latch which can be opened with a shove knife. This technique only works on outward swinging doors. All latches have an anti-loitering pin, which prevents the shove tool from working unless you depress the pin first. Like all other TTL technique this takes training and practice.

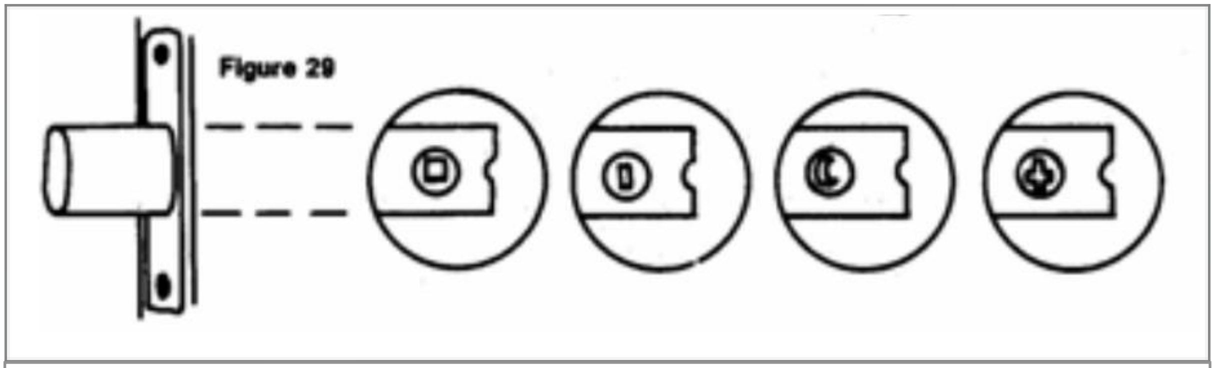




Pin Engaged **Pin Pushed Back**

Tubular Dead Bolt - Another very popular locking mechanism, like the key in knob, can be single key or double key. As the need for security has increased, they have developed hardened rods through the center of the locking bolts. The length of the bolt has been increased to the point that it may take two full rotations of the key to remove the bolt from the keeper. As an example Kwikset locks make a dead-bolt that is four inches long. The cylinder lock face is usually held in place by two screws or bolts. Many times the cylinder is too deep or too wide which prevents the K-Tool from being used. In order for TTL to be used, the cylinder needs to be removed and a Key tool must be used. If the K-Tool can not be used, an A-tool, Officer's tool, Rex Tool, etc must be used to remove the cylinder.

If you are unable to remove the cylinder, then conventional forcible entry must be used. Behind the bolt, is the stem, which can be various shapes.



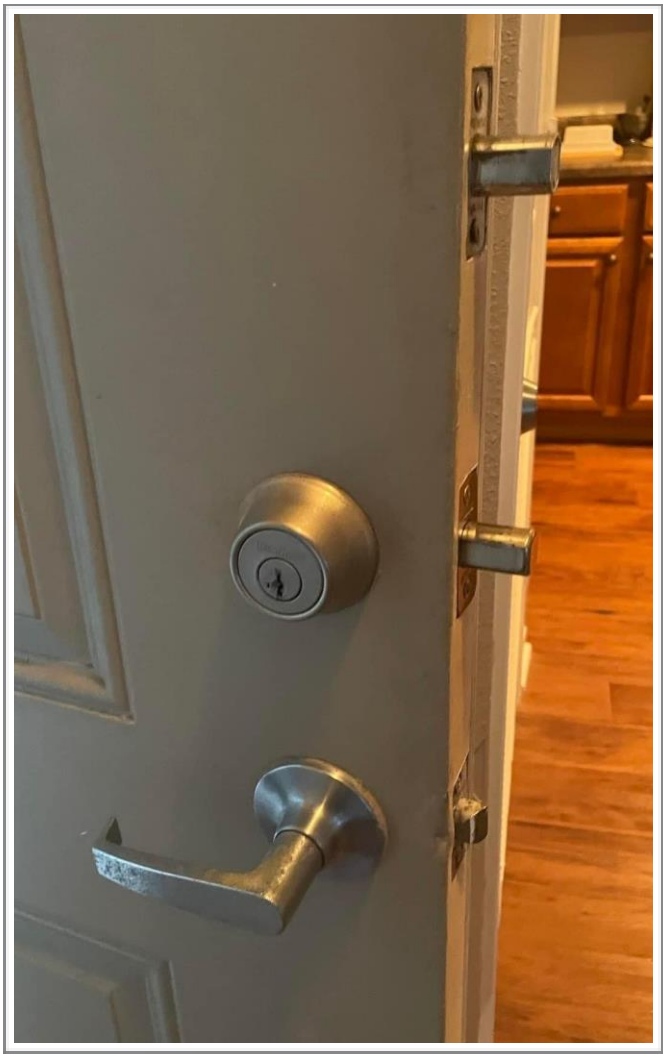
The figure above shows the various shapes. From left to right, a square, rectangle, half-moon, and cross. All of these shapes can be manipulated with a modified screwdriver.

Using an A Tool/Rex Tool - Place the tool at an angle, on top of the dead-bolt.

- Gently "tap" the tool until the teeth of the tool bite down.
- Insert a Key tool or modified screwdriver.
- Rotate the dead-bolt to open.

Using the modified Painter's Tool - A modified painters tool is a homemade device that uses a Diablo sawzall blade welded to a painters tool.

- Gently pry the dead bolt face away fromthe door.
- Slide the painters tool until it touches the two screws holding the bolt together.
- Press down and in a "sawing" motion to cut the screws.
- Remove the face plate and use a key tool or screwdriver to unlock the lock.



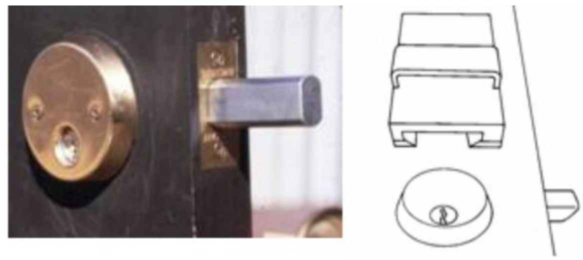
As technology and construction advances with time, some dead-bolts are now made with a back plate only, i.e. you will not see it on the exterior skin of the door.

This picture to the right shows a homeowner installing a newer style deadbolt that is hidden from the exterior. This will require going to conventional forcible entry. Most of the time, the trim/frame will break or crack prior to the deadbolts failing on this door.

Also notice the single lever handle. Single lever handles are ADA (American Disability Act) approved, which may indicate possibly a disabled citizen/ wheelchair bound. Small hints like this may indicate the immediate need for a search.

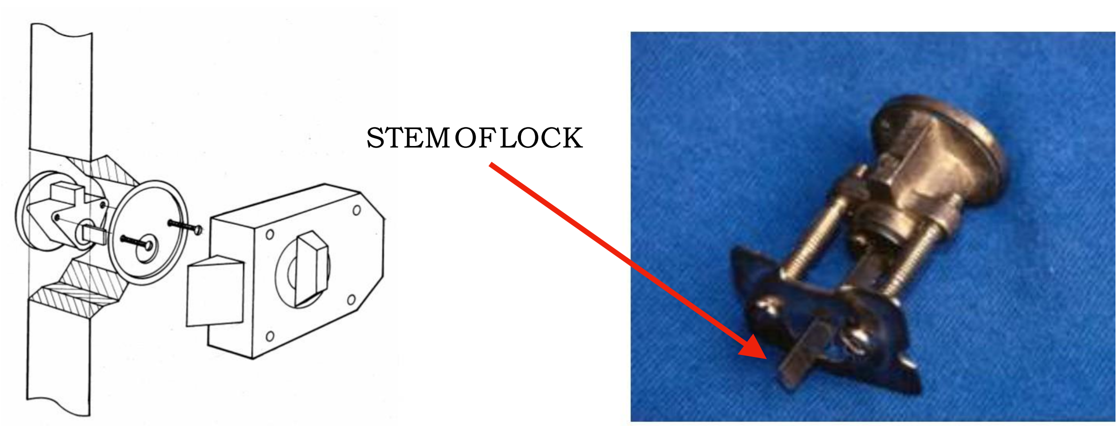
Problems with K-tool/Dead Bolt Issues

Cylinder Too Deep



Cylinder Too Wide

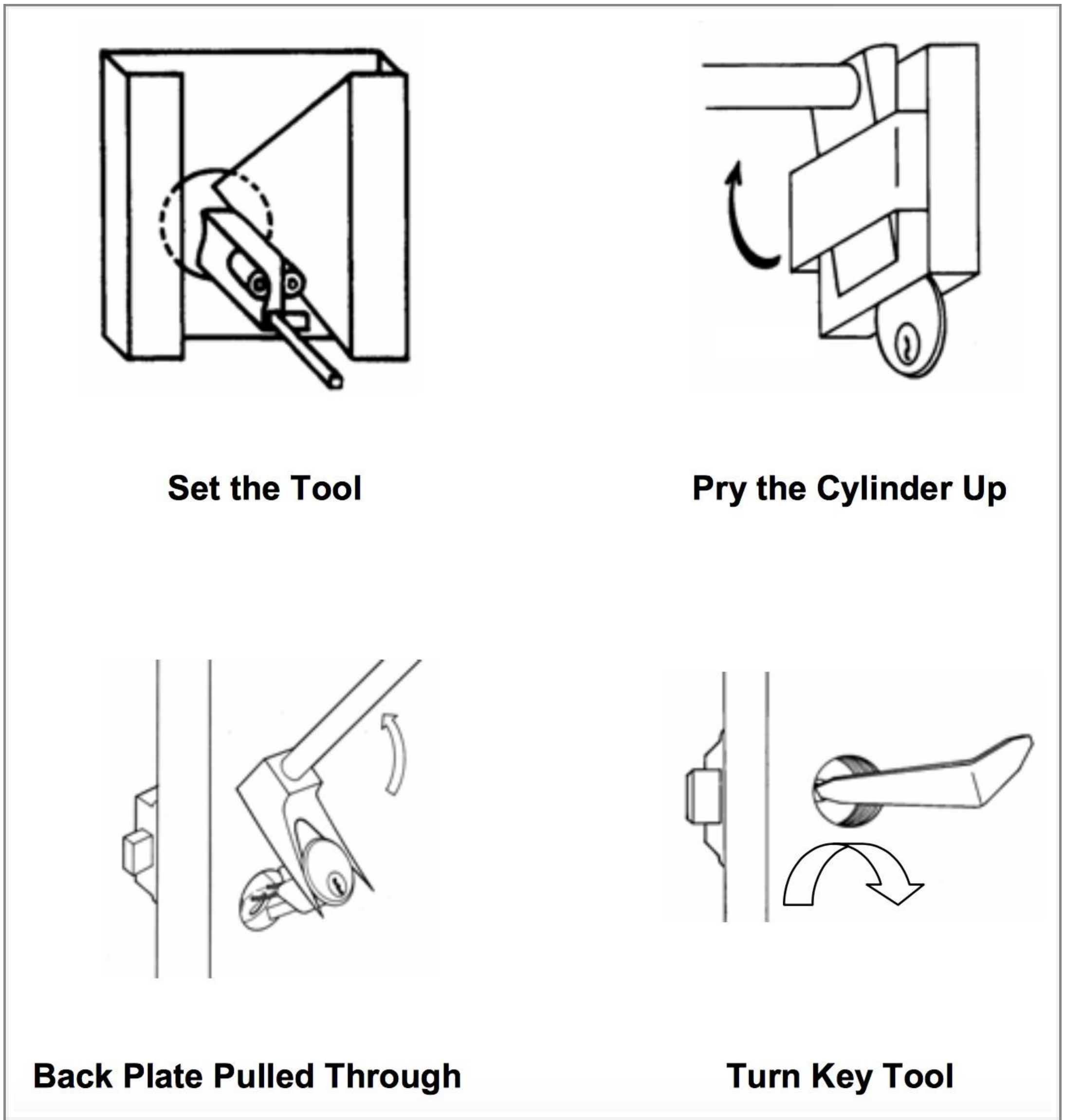
Rim Locks - These type of locks are a very popular “add-on” lock. They are installed on the backside or inside of the door and many times only the rim cylinder is visual from the exterior. Many firefighters refer to “rim” locks as a “night latch” which is a type of rim lock.



Like dead bolt locks, the rim lock has a stem that is inserted into the backside of the lock and goes through to the front. Generally, only two screws hold the lock together.

Using a lock puller (Officer’s tool, A tool, Rex tool, and/or K-tool) -

- Set the tool behind the cylinder to get a secure purchase
- Pry up on the tool, pulling the cylinder from the door.
- Either the back plate is pulled through the opening or the set screws are broken.
- Insert appropriate Key Tool and turn, opening the lock.

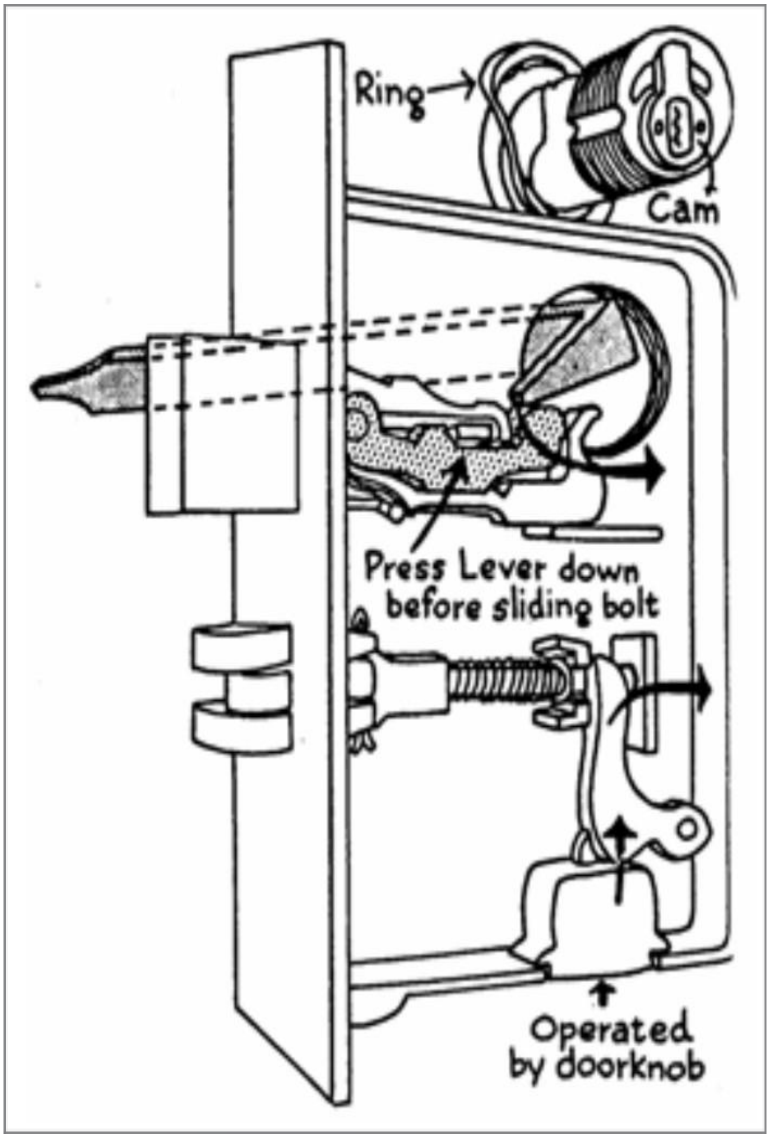


A diagram showing the four steps to removing a rim lock.

There may be situations where the lock cylinder is pulled out, however the latch is still intact, holding the door shut. In this situation, place the pike of the Halligan in the hole of the cylinder and drive the lock off of the door. This should only cause minor damage to the backside of the door for the occupant/owner.

Mortise Locks - are locks designed to fit into a cavity of a door. They have a threaded key cylinder which is held in place by set screws.

Mortise locks are found commonly in aluminum framed glass doors and are probably the most common lock you will have to defeat in commercial buildings. Like other locks, it is imperative that you understand the basic principle of mortise locks, as their are many different types of these locks.



As you rotate a key in a mortise lock, the cylinder rotates and turns a cam on the back of the cylinder.

This cam makes contact with a lever inside the box, removing it from the strike.

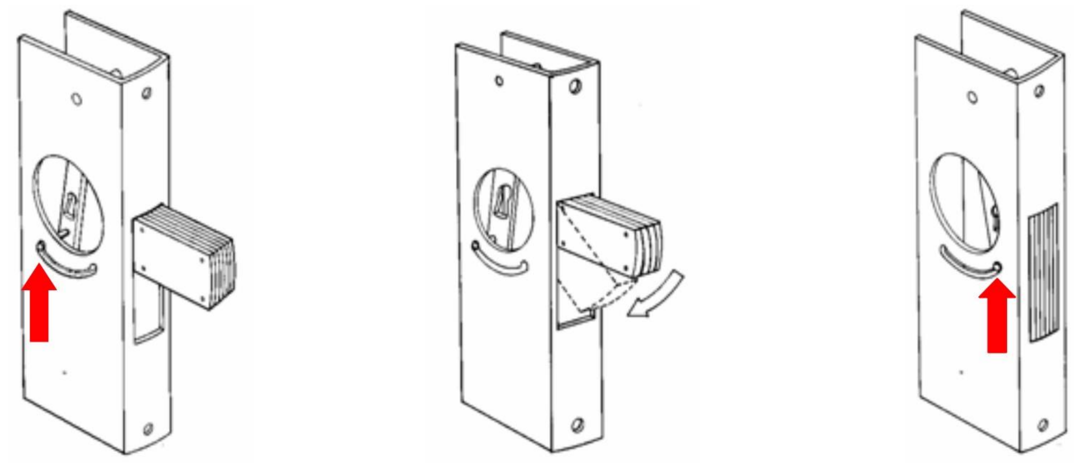
Although the key will cause the cam to make a complete revolution, the actual work of opening the bolt is accomplished between "5 and 7 O'Clock or "7 and 5 O'Clock", depending on the installation/side the lock is mounted on.

Understand that these locks can be mounted right or left and sometimes "upside down".

In order to force this lock, follow the following steps.

- Set the tool firmly on the cylinder and remove it by pulling up.
- Insert the appropriate Key tool.
- Rotate the tool. If the lever is found at "5 O'clock" rotate to 7. If found at "7 O'Clock" rotate to 5.
- If mounted with an attached doorknob, you may have to rotate the cam a second time to remove it from the keeper.

Pivoting Dead Bolt also known as "Adams-Rite" is a very popular lock found on the front doors of commercial occupancies. These locks usually have a laminated bolt, which may extend up to three inches. The mechanism is slightly different than other mortise locks, which requires the exact Key tool to be used to depress the pin in the box, which rotates the bolt. The pivoting bolt allows the throw to be the entire depth of the channel of the door. Many times a wide door frame will equal to a long bolt.



Pin Away Door Locked | **Bolt Pivots Into Frame** | **Pin Forward Door Unlocked**

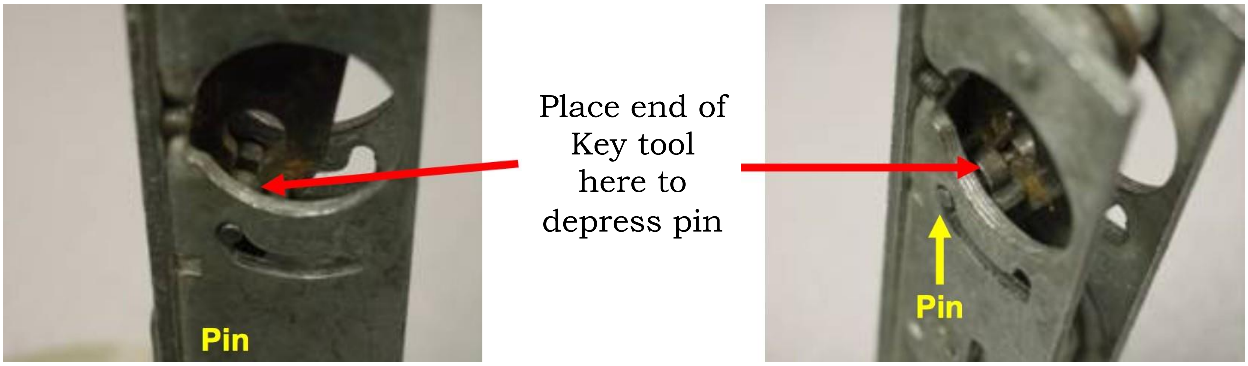
The figure above shows a narrow locking mechanism, approximately 1 3/4 inches. The locking pin is away from the edge of the door, so the door is locked when the pin is in this direction. As it is depressed the bolt "pivots" into the frame. When the locking pin is forward, the bolt is inside the frame and the door is unlocked.

The most important understanding of this locking mechanism and door, is that it is easily forced via TTL and you should not take the glass. Taking the glass in a aluminum framed commercial door will cut personnel, hoselines, and a trip hazard, as the glass is usually tempered and it is extremely slick.

Using the A tool, K tool, Rex tool, etc - Place the K-tool over the cylinder or let the locking tool "bite" into the top of the cylinder.

- Set the tool by driving down or using the K-tool (over the face of the cylinder to lock it).
- Pry up with the tool or halligan.
- Using the key tool, depress the pin and slide the pin in the appropriate direction.

Figure above demonstrating the use of the K-Tool

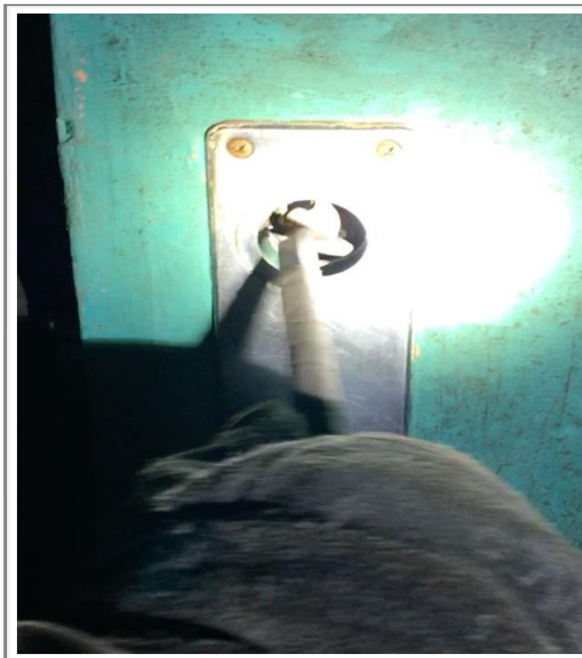


Many cylinders in pivoting deadbolts may have a “guard” around the cylinder. This may prevent the K-tool from sitting over the faceplate. An easier and more convenient method of removing the cylinder is using a modified set of pliers or visegrips. If you clamp down hard enough on the “guard” it will generally bend off the cylinder. At that point, all you have to do is defeat the two small set screws and rotate the cylinder out of the lock box.

This method works on most mortise locks.

Using a modified pair of pliers/visegrips. - Grab the cylinder with the pair of pliers.

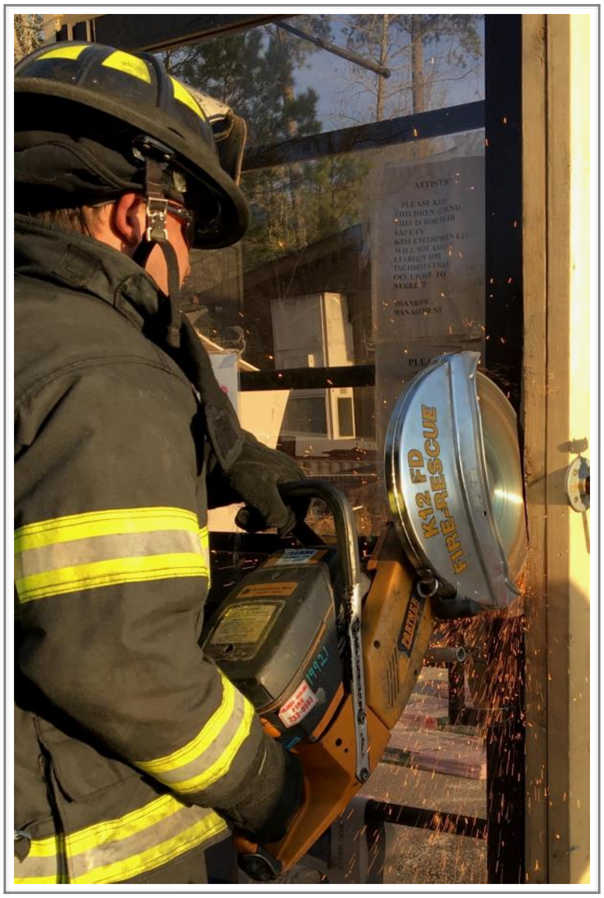
- With a good grip, rotate the pliers counter-clockwise to break the set screws.
- Once the cylinder spins freely, rotate it out of the box.
- Use the Key tool to depress the pin and pivot the bolt to open the door.

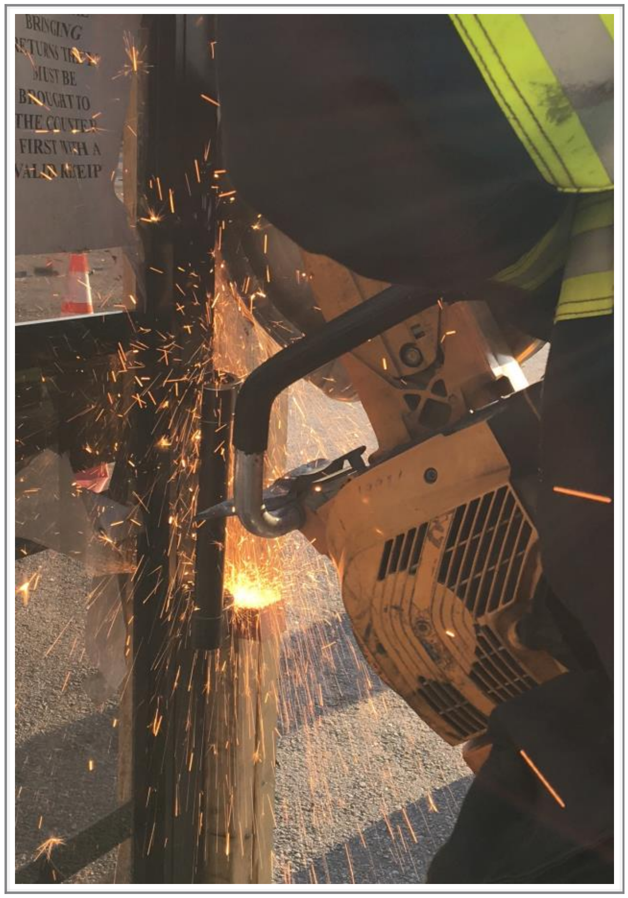


Using the Rotary Saw - An alternate means of forcing a mortise locks is using a rotary saw to cut the throw/bolt.

If the space between the door/frame is too tight to fit the blade in initially, use the Adz of a Halligan and GAP the space. You can use your foot to hold pressure on the Halligan to maintain the GAP or a second firefighter could assist you.

- Once the space is open, run the rotary saw into the GAP.
- Cut through the pivoting bolt.
- Remove the saw and open the door.





DOUBLE HALLIGAN TECHNIQUE

When operating on the interior, sometimes personnel will “stage” roof hooks during initial operating stages and/or searches. At minimum, ladder company members should at least carry a Halligan Bar. The following procedure is recommended for a fortified inward swinging door with two Halligan Bars.

1. Begin the force by Gapping the door with Halligan #1.
2. Hold the GAP as far as you can while the firefighter with Halligan #2 comes in to assist.
3. Halligan #2 places the forks end of their halligan (Bevel to frame) into the GAP and holds pressure.

4. Halligan #1 removes his adz and strikes Halligan #2 for a secure SET.
5. Once Halligan #2 is set, Halligan #1 re-enters the GAP with the Bevel towards the door.
6. Begin to force and move both Halligans in unison towards the door.
7. Once both Halligans are parallel and flush with the door (full leverage of force), remove Halligan #2 and attempt to GAP the door again, using the Adz. This should force the door, while Halligan #1 holds pressure.

Step 1 and 2. Firefighter Gapping and holding door.

Steps 3-5. Both firefighters maintain the GAP with both forks. Halligan #1 is bevel towards door. Halligan #2 is bevel towards frame.

Both firefighters force the Halligans in unison towards the door. Step 6

While Halligan #1 is maintaining their position, Halligan #2 removes their bar and repositions for the GAP (Step 7)

CHAPTER FIVE

SEARCH OPERATIONS

CHAPTER: 5 Search Operations

SEARCH OVERVIEW

This chapter is intended to review the basic ideals behind fireground searches, provide up to date information on rescues that have been performed across the country, and understand the priority of searches.

- Fireground search is one of a ladder companies primary and most important task.
- Obtaining a primary search "all clear" is one of the most critical benchmarks achieved on the fireground
- Fireground searches should be rapid yet through; it is performed before, during and after fire suppression.
- Fireground search and size-up is a conscious process involving the rapid, but deliberate consideration of critical factors and the development of an action plan based on that information.
- An inexperienced firefighter may not have the skill set or experience to recognize the signs of imminent danger. They may search too far without a hoseline, commit too far into the building, and not have enough air to make an exit. These firefighters should be more cautious about how far to commit themselves into the building.
- Rescue efforts should be performed in the following order:
    - The most severely threatened
    - The largest number
    - Remainder of the fire area
    - Exposures

KEY CONSIDERATIONS

The BEST lifesaving tactic on the fireground, is executed with an aggressive mindset and focus on early primary search, interior fire attack, and coordinated ventilation.

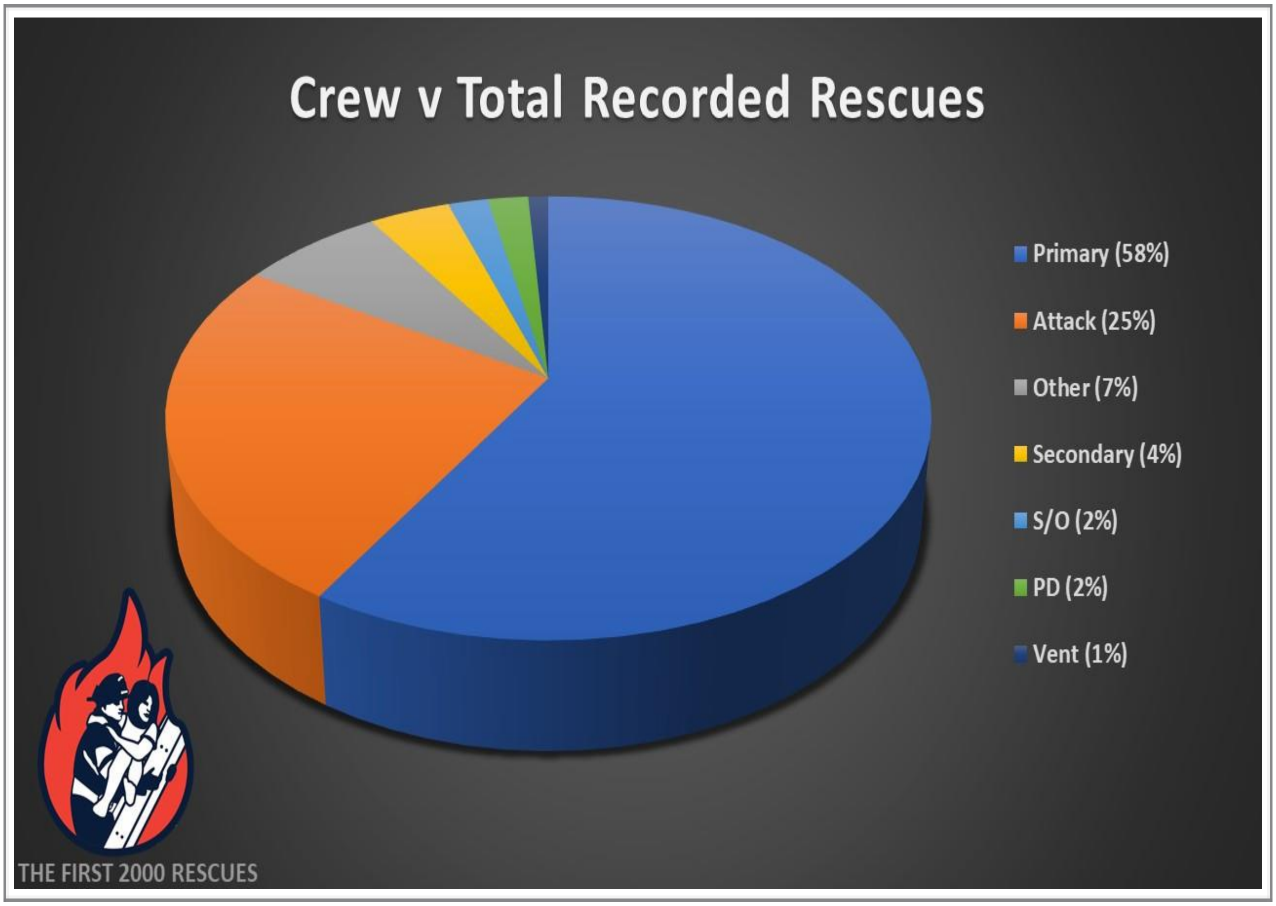
Every year approximately 3,000 civilians die inside structure fires. They rely and expect us, the fire department, to save them.

From January 1, 2008 - January 1 2020: There were 12 Line of Duty Deaths (LODDs) while performing residential search. Of those structure fires with

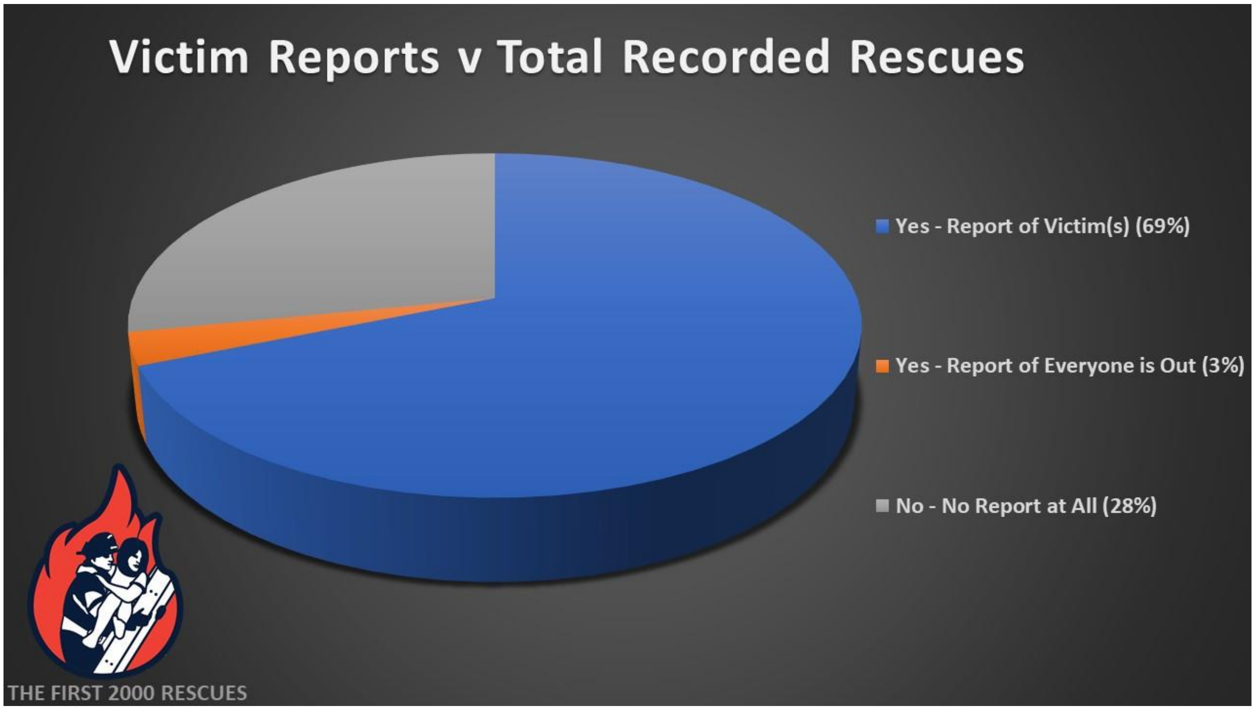
LODDs, there were two civilian deaths and over 25 rescued. One LODD while performing a rescue via ground ladder and ZERO LODDs performing VES search. There were zero LODDs while performing a search in a "vacant" structure. (NIOSH/FEMA)

Before 2016, little to no data existed about victims rescued by firefighters in structure fires. NFIRS and State Fire Marshall's offices only release the "negative" information to include losses, fatalities, and injuries. In the year of 2016 and 2017, a group of firefighters across the country felt the need for positive reinforcement of rescues and the need to report the rescue data to see what information and techniques had been used in real life events. This information would be instrumental in developing and updating new training programs, techniques, and information on real incidents that have been reported.

The survey, Firefighter Rescue Survey (www.firefighterrescuesurvey.com) recorded its 2,000th rescue in 2021, which the following statistics were pulled from.



Primary search crews (with no hose-line) rescued 58% or 1166 civilians.



The Graph above is one of the most important for us to understand when responding to structure fires. Too many companies/firefighters believe that dispatchers, law enforcement officers, and neighbors have all of the information. 28% or 562 civilians were rescued. When there was no report at all of a victim. 3% or 40 civilians were rescued, as someone told the Fire Department that "everyone is out/not home". In 40 different incidents, they were wrong. It is our job to clear and search the structure.

A structure/building is not vacant or clear until WE clear it. Some structures "appear" to be vacant, however, in today's society, some civilians must live in situations or buildings that we may not. In essence, they may have to live in areas, that "we" wouldn't. Every building is occupied until we clear it.

SEARCH TERMINOLOGY

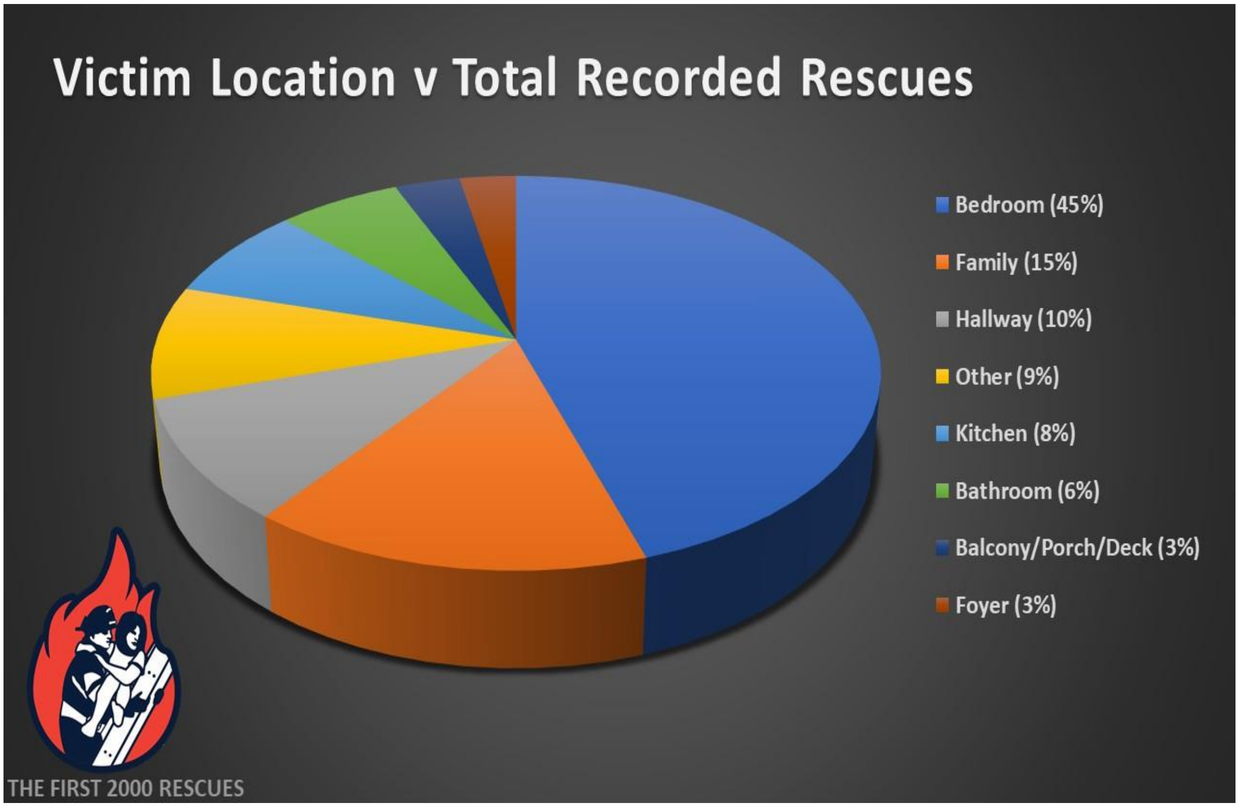
1. Primary Search - Rapid and initial systematic search through all affected areas, to locate victims and/or fire. To remove any and all victims and/or safety evacuate any/all possible occupants
2. Secondary Search - Thorough and methodical search in all areas of the building for life. This is completed after the primary search and usually completed by a different company.
3. Searchable space - any space within a structure that we can occupy with our training, experience, and PPE.
4. All Clear of Building - A benchmark communicated to companies on the scene when both the primary and secondary search are complete and all occupants are accounted for.

SEARCH SIZE-UP

Searching inside a structure with an unknown fire location is the most dangerous position to be on the fireground. The assignment of search has two objectives, locate fire and locate life. Locate - Isolate - Communicate the fire. We confine the fire to create the best opportunity to search the largest area and then communicate the fire location to fire attack. This allows fire attack to properly stretch a more direct route. When searching ahead of the hoseline and we locate the fire, we must communicate to fire attack not only the fire's location but, the best known access to the fire. Announcing the stair location can save seconds if not minutes.

Search Priority

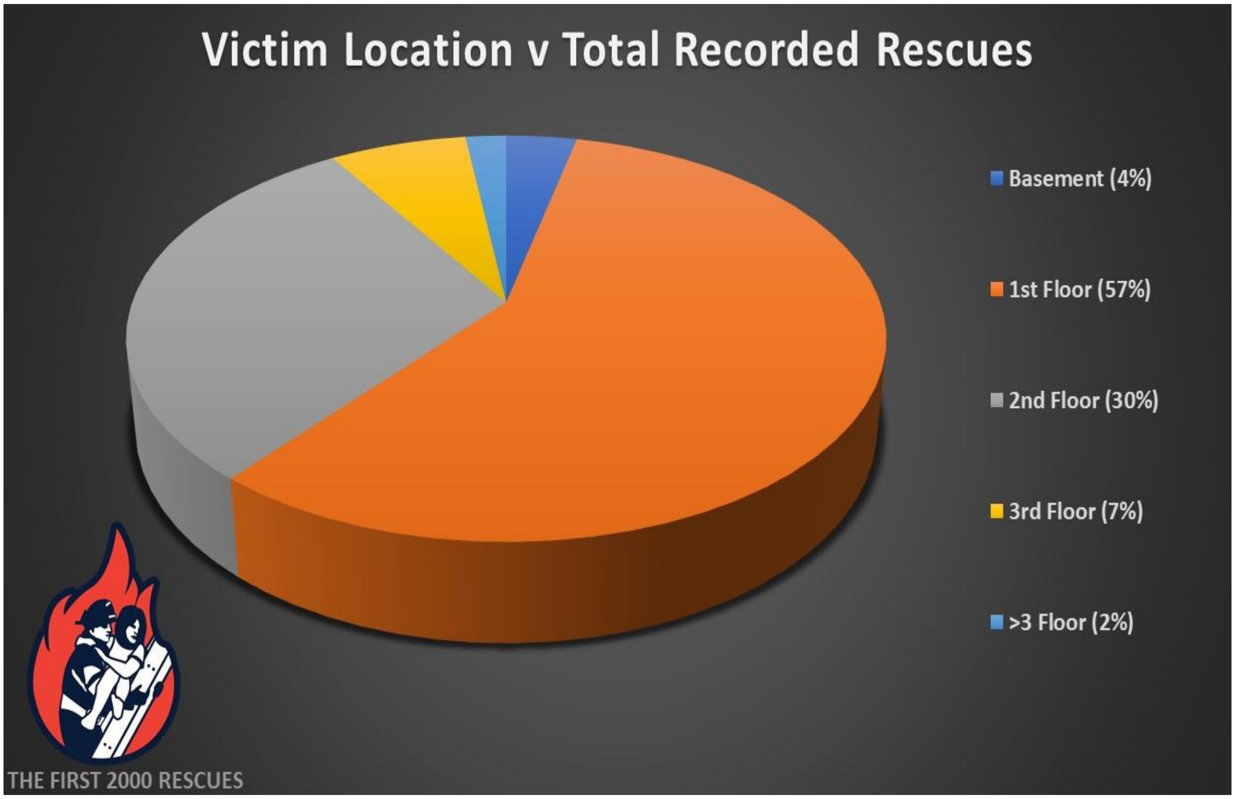
- 45% of victims are located in a bedroom
- 10% of victims are located in a hallway
- 10% of victims are located within 6' of an exterior door.



Our search priorities are the bedrooms and paths of egress as we enter the structure. Victims higher in the elements have a lower chance of survival, such as victims on beds vs floors. We search top bunks first, down to the bed, and lastly under the bed. Check between the bed and the wall and closet doors. Victims in a room behind a closed door will have a greater chance of survival. If we are working down a hall and come upon two rooms, one with an open door and one with a closed door, we prioritize the open door room.

The fire apartment or room is the priority, with fire attack typically searching the immediate fire area. Adjacent apartments and rooms are the next priority, with another crew searching the floor above in the same pattern.

Consider how the heat, smoke and fire will extend within the building. Occupant egress from the building (interior stairs, fire escapes, etc.) can be quickly impacted by the fire conditions, negating their use and endangering occupants. Gaining access to the fire area, or area to be searched, will usually be through the main door that the occupants use.



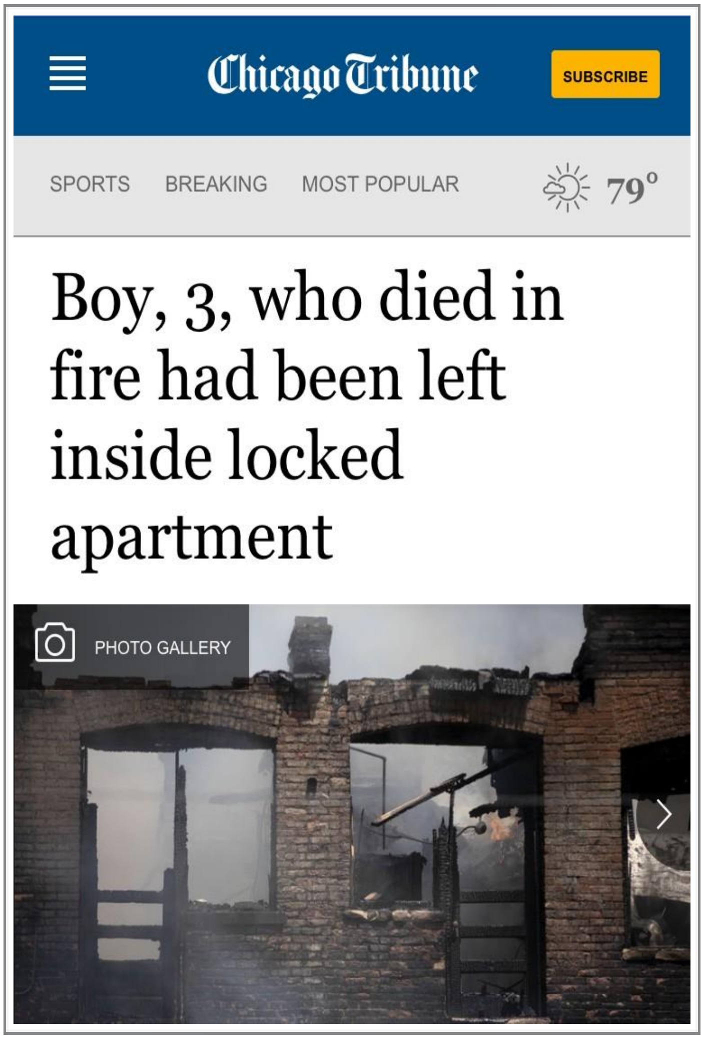
BUILDING SIZE UP

The residential search size-up takes place in three phases; pre-planning, exterior, and interior. The pre-planning size up includes factors such as occupancy type, time of day, and knowing your first due/area. The exterior size-up will include smoke/fire conditions, a 360, building construction, and building styles. The interior size-up includes human behavior, smoke/fire conditions, and construction features. With our experience, training, and PPE, can we occupy the space? If yes, then we are offensive and searching for life.

Understanding and knowing building construction and layout designs is paramount for effective, efficient, and aggressive primary searches. Many new neighborhoods and large scale neighborhoods have the design/ layout plans online at the construction companies website or if a model home is open, all design copies are located there.

Taking the time to pre-plan floor plans will provide great public education for the organization as well.

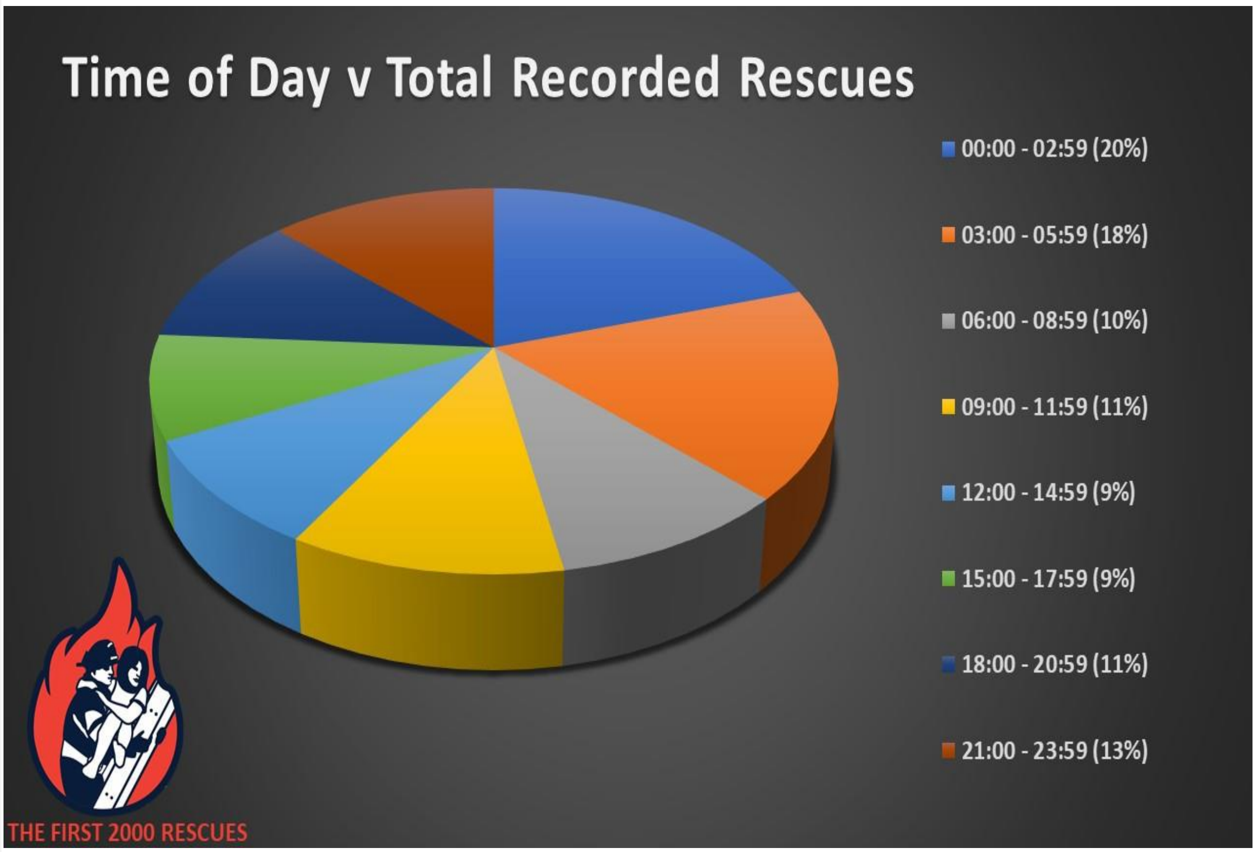
Bystanders can be a useful source of information for LIFE, FIRE, and LAYOUT. This can aid in prioritizing the primary search, but this information should be taken as a guidance and not fact. According to “Firefighter Rescue Survey”, structure fires with victims and bystanders reporting “people are inside,” had a 67% accuracy for location of the victim. When receiving bystander reports, try and get any information that can aid in the search: How many people? Where might they be? How old are they? Do not take much time with them, get the info you need and get inside quick.



A three year old boy died, after his babysitter locked him inside his room to go to the store. When the Fire Department arrived, neighbors reported “no one is home”. Luckily, this department aggressively searched the apartment and gave the child a fighting chance.

Consider sending them to a later arriving company/chief. Remember, offensive mode is rescue mode. We set ourselves up for victims trapped, every fire, until proven otherwise.

On the contrary, if there are any negative reports such as "no one is home", "everyone is out", "the building is abandoned or vacant", we can acknowledge this input only internally. You should not repeat this as a transmission over the radio. Many times the information is only "assumed" and the source of that information may be under stress or scared of the incident unfolding.



Lexington County Fire will not allow the presence or absence of cars in a driveway affect our search priority. Civilians may bike, Uber, park in the garage, or take other types of transportation, making this "clue" irrelevant. One third of the American workforce now works the graveyard schedule. 6.1% of Americans are under the age of five (napping age). 21 of 24 hours in the day, bedrooms are the number one type of room that our victims are located (FFRS).

Civilian life is the primary reason for our professional existence. It is, and always will be our priority. Personnel should not perform victim survivability profiling (VSP). We decide "go or no go", based on the building's conditions if they are tenable for a firefighter in full PPE. We must make every effort possible to occupy the space and search for victims. From the outside, we are unable to know the conditions of each room or area on the inside of the building. Closed doors provide isolated survivable space, certainty of this can only be achieved by completing a thorough search.

This backs Lexington County Fire Service culture of "saving lives" and culture of occupying the interior for search.

Case Study:

On June 1st, 2015, the Muncie City Fire Department arrived at a well involved two story residential structure. On scene firefighters were aware of victims and were aggressively making a push and searching, when the east bedroom floor collapsed. "That's when we decided to go defensive. I didn't feel there was really any real chance anybody could survive this," Chief Baty said. Dispatch then received two hang up phone calls and then a successful phone call where dispatch could hear Pam and Tom Price inside the structure, alive. Dispatch relayed this information to incident command, who then changed the strategy from defensive to offensive. The Muncie City Fire Firefighters then breached through the outside wall on the second story and rescued two unconscious victims <u>38 minutes from dispatch</u>. <u>Both Pam and Tom Price survived</u>.

Keypoint: A search size-up is intended to locate searchable space, not chances of survivability.

Info from Columbus FD Truck Manual

A 360 size up is imperative as the ladder company, to ensure your tactical plan is appropriate for the building. A fire in a one story ranch house would lean towards split (search and vertical vent), where as, a two story split level residence, I would lean more towards search for the inside crew and ladders/VES (assuming fire is located on the lower level).

Understanding common/local building layouts, and being able to identify them from the exterior will assist in formulating a search pattern; if and how the crew will split and clues to search priority, I.e. bedroom locations. Layout can also indicate firewalls, fire doors and stairway locations. The greater the footprint and number of floors, the greater the need for resources to be assigned to primary search. Firefighters staying oriented during search is dependent on understanding the layout of the structure you are searching.

VICTIMS

Victims' survivability depends on search priorities, techniques, and actions. According to Firefighter Rescue Survey, 40% of fire victims are found in the bedrooms and 17% are in major arteries including stairs and hallways. NFIRS reports that 3% of civilians are attempting a rescue, 3% are trying to extinguish, and 36% are trying to escape (usa.fema.gov).

Sadly, this adult victim was found "hiding" under a small kitchen table when he realized their was a fire and unable to escape.

Humans behavior leads to head directly towards the main routes of egress during general duties or an emergency escape. Victims that are unaware of the fire or trying to self-evacuate can be overcome by smoke, leaving them slumped over in chairs, lying in bed or on the floor near windows, doors or in the main pathways. Some adults, like children, will attempt to hide if unable to escape.

Children tend to go towards their parents first, then to their "favorite spots, bedrooms, under or in their beds or closets. If they cannot retreat to their room, they tend to stay at ground level and hide in other familiar spots; low large cabinets, in blankets or clothing piles (see picture below).

When responding to buildings in your area that have multiple false alarms, the companies should have a heightened suspicion for victims, due to resident complacency to the frequent false fire alarms.

Body Orientation- When the search company finds an adult occupant, observe the body position, which may indicate the direction of travel. A victim that is head away from the main entry or exit, was potentially heading "inside" to rescue a loved one.

This picture above shows a St. Louis Firefighter rescuing one of four children left home alone. Their aggressive search culture saved all four children, who were found in a closet, play tent, and a closed bedroom door.

INTERIOR SIZE-UP

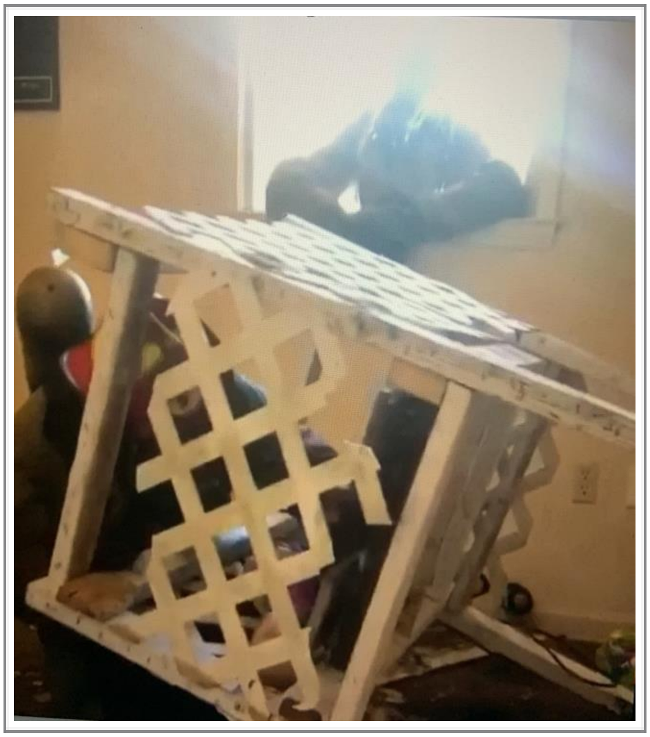
Conditions need to be continually sized-up. Observe the behavior of the fire, heat and smoke. Ladder companies should always have a water can nearby, to keep the fire contained or knocked back.

Rooms - Finding objects in a room, such as small furniture or toys can indicate you're in a childs playroom or bedroom. This can assist in where you search/look or you should be more diligent in sweeping under beds and closets. Many families/children share rooms to include bunk beds. Bunk beds typically have a bottom twin (38 inches wide) or full size (53 inches wide) with a twin size mattress on the top. Always reach above you when searching on a bed. A phrase that has been taught for years in regards to searching any bed: "Corner to Corner, Top to Bottom". This phrase reminds you to wrap your hand around the corner of the bed and search completely around the corners. It then reminds you to "bump" up to feel for a bunk bed and then down to the "bottom" and look under the bed. In many training/burn buildings, beds do not have sheets/clothes or comforters. These items will hide small children/adults if you do not take the time to search.

Cribs - Baby cribs can be found in a master bedroom (parents) or in a nursery room. If a crib is found during search, it should be a standard procedure to perform a "Crib tilt". This provides the infant/baby with the quickest opportunity for fresh cool air on the floor.

Crib Tilt Method - Quickly search the crib and move baby/infant to the side of railing.

- Lower the entire crib to the floor.
- Grab the infant in the appropriate victim rescue position
- Keep baby/infant low and remove from the structure (more on this later in the chapter).



Doors - Characteristics of interior doors can indicate the type of room you are about to enter. Knowing what type of room you are about to enter, is relate to how you will search and if it has a potential egress window or door.

Doors that swing toward the main interior of the structure typically lead to stairs, closets, pantries, a garage, or the outside. If it also has a deadbolt or lock it is likely opening to the outside. These can warn the crew of an elevation change on the other side of the door threshold.

Basement doors can swing inward or outward. Doors that swing away from the main interior and into the room, are usually bedrooms and bathrooms. This can indicate rooms for a place of refuge or egress.

Windows- Although building codes/construction are ever changing, it is generally standard that operable windows have a minimum floor to window sill heigh of 24-36 inches. This is good to remember in case of victim rescue, emergency egress, or large victims. If there is no to low visibilitly, finding a floor HVAC can sometimes indicate a window near or above that location.

The information in this manual should assist and start conversations/training ideas for all personnel within our organization. The fire service is always changing and advancing forward more quickly than ever. Companies and personnel should always assume that there are trapped victims in all structure fires and should continuously size-up and critique the incidents they run.

SEARCH TECHNIQUES

When making initial entry, you should complete a LIFE-FIRE-LAYOUT (as discussed in forcible entry). This involves extending your full length body into the building and hooking your foot around the jamb/frame. Many victims are usually found within ten feet of the doorway.

LIFE -

- Call out “Fire Department” and listen.
- Scan with your eyes and sweep with your hands.

FIRE -

- Look for the fire/glow/smoke
- Which way is it moving or going?

LAYOUT

- What do you see?
- Look for stairs, hallway, or furniture.

Time matters when it comes to a victims survivability. We must be quick, efficient, and effective. Our body position should be strong and balanced and it should put out ears where sound is farthest traveled, where our eyes are the most visible and place our hands where we can feel the most effective. The lower we are, the cooler the air is located, the thinner the smoke, and the most likely where victims will be found.

Our search positioning should be based on the heat and smoke.

Walking Position - When conditions allow, this is a quick and hasty positioning to move. We should not search “clear, non-smokey areas” initially. However, if you can CLEARLY see 10 feet in front of you, walking is ok. Just because you can see your feet, it doesn’t mean you can see the victim four feet in front of you.

Tripod Position - This position should be the standard position for most searches. This position is more effective and efficient than any other positioning. It keeps your center of gravity low and to the rear, which creates a stable and balanced movement. The position leads with a foot and a tool (usually a Halligan Bar) which increases stability, speed, and situational awareness. The foot and Halligan head can easily give warning and reaction time to compromised floors or stairways. This position covers more square footage per pass and allows the use of both hands. Traditionally, when searching, many instructors recommend reaching out with a tool to “feel”. You cannot determine the difference in a human or a piece of furniture with a tool. You need both hands to understand and determine that object. If you enter another room, the transition from tripod to sweep is fluid and efficient. Using the tripod position also places your eyes up to scan for victims, layout design, and conditions.

If you need to investigate an object in the room, place the tool against the wall and move outward. We will not sweep out tools for victims, we search with our hands.

METHODS OF SEARCH

There are three methods of searches which can be broken down into further categories.

1. Oriented Searches
2. Vent, Enter, Search (VES)
3. Rope/Large Area Search

The method you choose is not based on the building, it is based on the fire/smoke conditions and most importantly, <u>what is the fastest way to the potential victim</u>?

ORIENTED SEARCHES

Oriented searches can be broken down into two classifications. Oriented search or split searches.

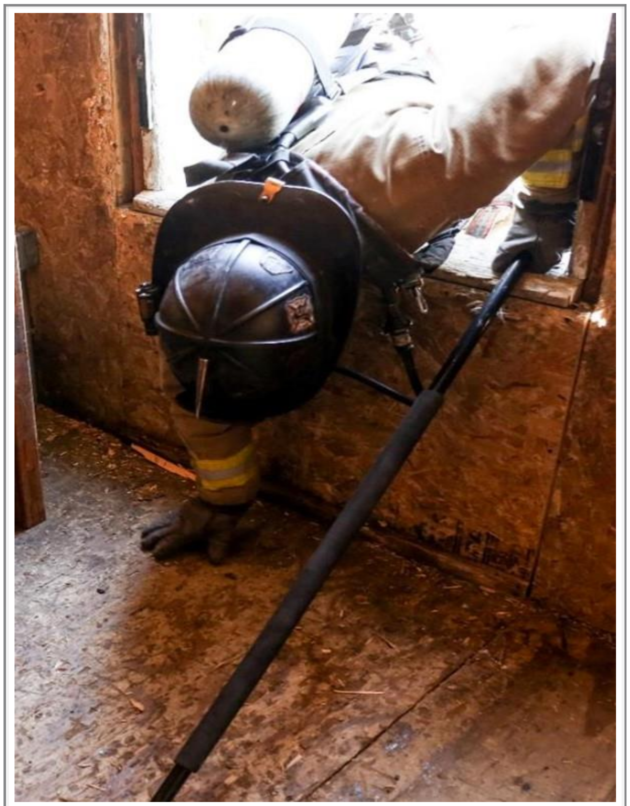
Oriented searches involve the firefighter searching the room(s) while the officer/ firefighter with the Thermal Imaging Camera provides (coverage) at the doorway. Most bedrooms do not require two firefighters entering. The officer stays at the doorway and monitors the condition of the hallway, rooms, as well as, uses the thermal imaging camera to locate shapes, objects, and egress points. Once the firefighter searches the entire room, they move to the next room. The firefighter can continue to search or the TIC Firefighter can search and hand off the camera. While the "search" firefighter is searching, the officer/TIC firefighter can isolate other rooms or assist the engine company to the direction of the fire. Remember that Thermal imaging cameras are only tools. In many studies and actual rescues of civilians, fire companies reported that the victims were the same color or actually darker in color than the room. Many training dummies show victims as bright "white" light, which based on the research, is incorrect. We rely on our hands and experiences, not a tool.

Split Searches involve the ladder company splitting itself in half. This should only be accomplished with experienced ladder company members who are capable in operating alone. This is the preferred type of search, especially when one of the following factors are present: favorable conditions, good crew continuity, and/or fire attack is in place. This split search provides a quicker timeframe and greater chance of survival for victims.

The split search, as pictured above, allows one firefighter to cover one side of the building, the other firefighter cover the other half. Generally, crews are no more than one room apart (voice communication) and end up face to face in the hallway after searching each bedroom. Search crews should only split hallways or floors and not the building. For example, under no circumstances should one firefighter take floor one and the other take floor two.

Vent, Enter, Search (VES)

Upon arrival of a structure fire and a reported victim is reported in a room/area of the house that is not involved, members should consider the immediate deployment of VES. VES is a tactic where we make our own entrance, isolate the room, search, and leave the same way we entered. It has become sometimes a safer route of searching due to rapid fire conditions in other parts of the building. Often, if the incident commander calls a structure fire defensive, there are survivable spaces in the building, VES is an excellent option for those marginal situations.



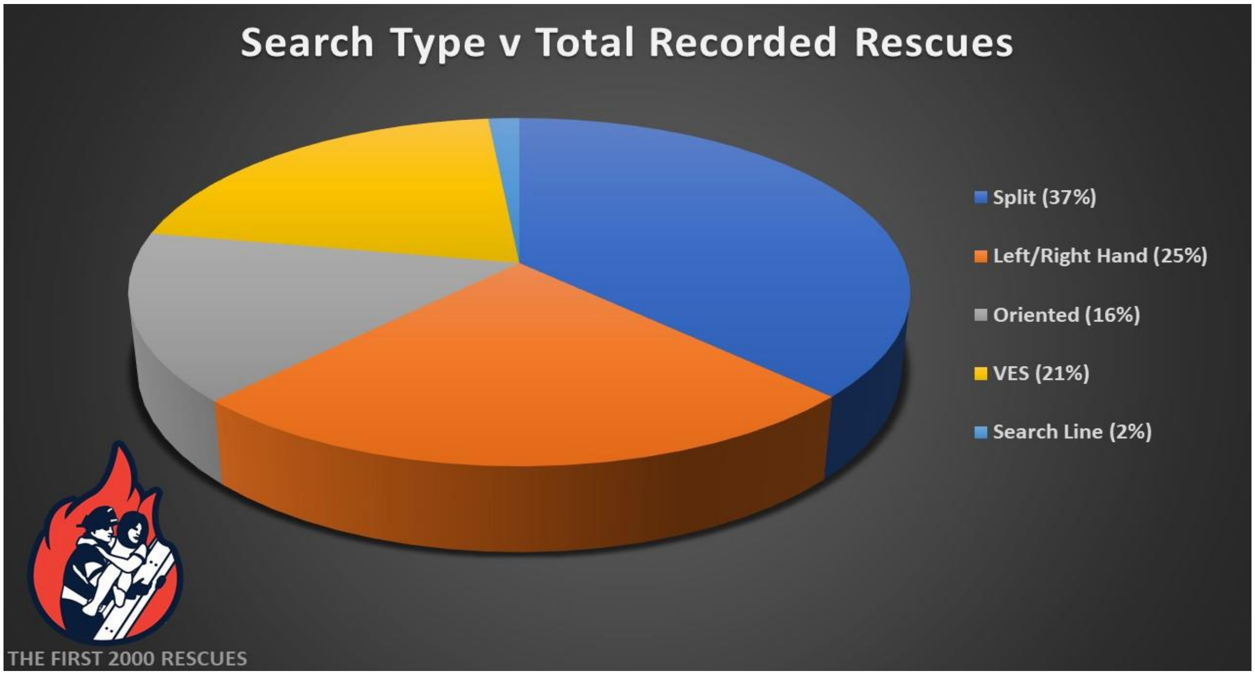
Even if there is no reported victims, if it is advantageous for the ladder company inside crew to bypass the engine, fire/stairs, etc, they should deploy the VES tactic. Often VES will place crews close to the fire location or survivable locations, especially in large or hoarder type of buildings.

Info from Columbus FD Truck Manual

Performing VES –

1. Crews communicate which rooms/ bedrooms to enter
2. FF is masked up and ready to enter, then takes the window completely out with a hook and places it on the inside of the window.
3. FF enters the window and looks below the window sill for victims (sweep for victim).
4. FF sounds floor with Halligan after scanning.
5. FF enters window either head first or sideways and immediately places face to the floor. FF scans room for doorway.
6. FF quickly moves to doorway and searches just outside, prior to closing the door.
7. Once isolated, firefighter continues the search inside the room and completes the search of the room.

Once the crew completes the search of the intended room, they have two options. Both options are based on the crews experience and the fire conditions.

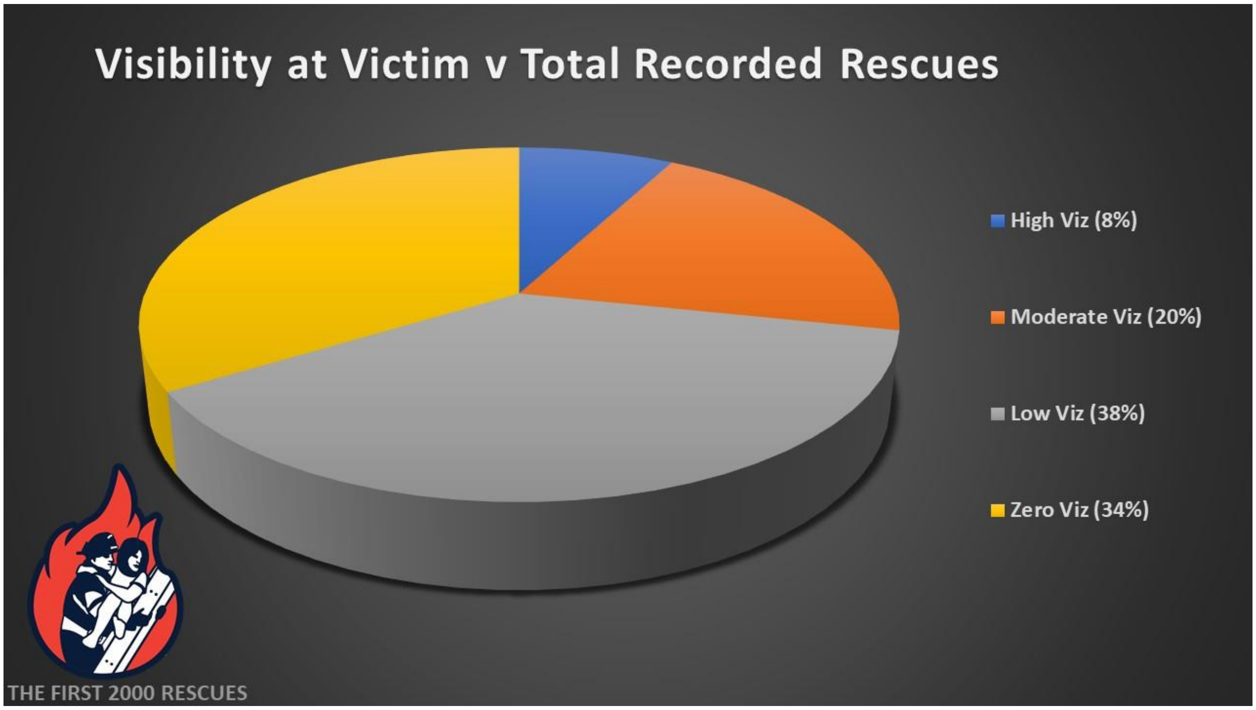


The chart above describes the method of search and the percentage of recorded rescues. VES had the highest percentage of survivable recorded victims.

Option 1 - Crew exits out of the window they entered in and move on to the next room.

Option 2 - Beyond the Door - Once crew completes the original VES room, the firefighter can head back to the doorway and check the hallway conditions. If the conditions are tenable and can support the search, the crew (both of them) can move from the original room to the next room (either next door or across the hallway). Once the crew makes it inside the next room, they close the door (isolate) and begin their search from there. This technique is referred to as “VES beyond the door”. It should only be performed when conditions are favorable and crews are experienced in searches and orientation. The company officer should also communicate to command that the conditions are favorable to “go beyond the doorway”. Many victims have been rescued when this tactic was deployed.

Second Firefighter during VES - The second firefighter during VES has several responsibilities. Ideally, this firefighter will stay at the window, listening for victims and the search firefighter. They will be prepared to receive and communicate any victims found. While the VES firefighter is searching, hopefully the second firefighter has a TIC and will scan the ceiling and room for heat/fire and/or victims. In addition, the second firefighter remains in verbal contact to help keep the VES firefighter oriented.



When you refer to the graph above, 72% of victims were rescued at zero or limited visibility.

LARGE AREA SEARCH/ROPE SEARCH

The main objective of the search rope system is to provide an additional tool for members to aid in the search/location of fire, civilians, and firefighters.

The search rope concept has been utilized in the fire service with great success for many years. The system gives the search team a greater bearing on distance traveled, whether entering or exiting the search area.

Using the bag, requires carrying the bag. Ladder company members should carry the bag on responses to the following types of buildings:

- Large warehouses
- School buildings
- Office buildings/complex
- Hotels
- Any other complex/big box buildings
- Assigned to the RIT Team on working fires.

This list is an outline and the bag should be carried in any complex building that may cause orientation issues. Sometimes the hazard is not the fire, it can be a complex layout, poor visibility (cold smoke/sprinkler fires), or the time possibly required on SCBA air.

There are four "principles of rope bags".

1. Keep it simple. Many firefighters and organizations make rope bags difficult and confusing. If it is not muscle memory or simple, it will cause problems. One of the main purposes of the rope bag is for us to stay oriented (distance and time).

2. Accountability - An additional system built into the rope bag is accountability. Clearing up communications, especially on large big box buildings or mid-rise/ high-rise buildings is key to a successful outcome. Allowing a three or four member search company to search a building of this nature will cause a lot of communication. The members can communicate amongst themselves with the officer providing a single downrange communicator to command.

3. Air Management - As companies move with the rope, it is recommended at every knot for the company to call out an "internal" air check. This allows the company officer to truly monitor the air management within their crew. As the company goes deeper and deeper into the building, the company officer will have a good understanding of when to "retreat" or "exit" the building on rope.

4. Have an Escape Plan - Again, one of the primary purposes of the rope bag is for members entering a complex building to have an escape plan. If

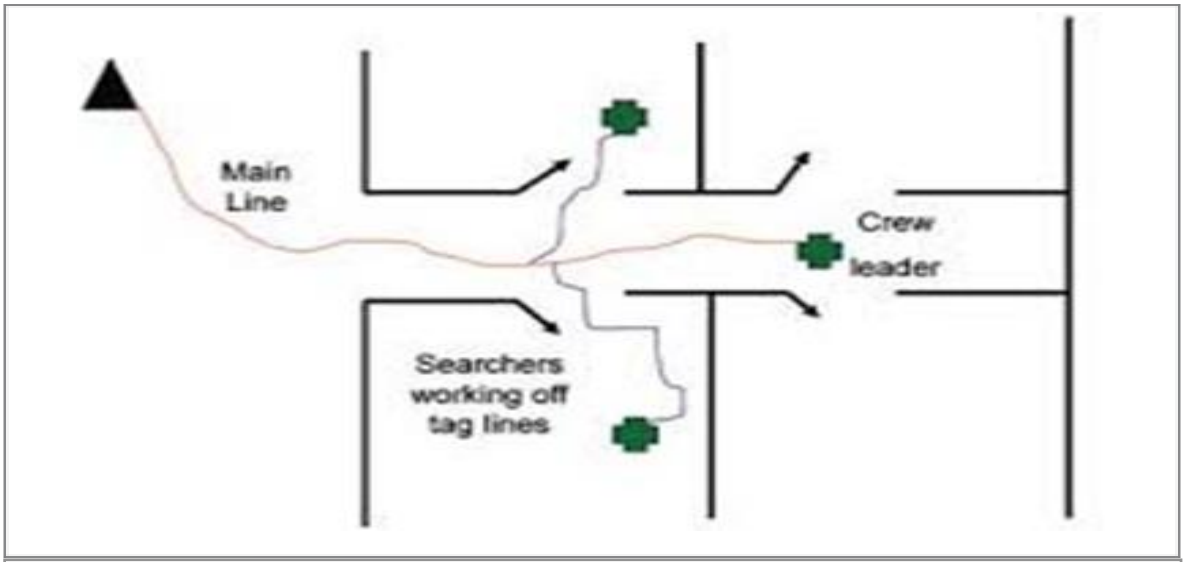
anything goes wrong, the company has a way out and knows how long it will take them and how far (distance) they have searched. It always provides the RIT team or additional search teams a life-line inside or out.

Anchoring the Rope Bag - The key to deploying the rope bag is for the officer or firefighter to attach the bag to an area outside an operating area. It is recommended to attach it outside of the building, however, in mid-rise or high-rise fires, you can attach it to the standpipe, stairwell railing, or inside door handle (fire-rated door).

Rope Deployment - Deploying the rope bag; the firefighters should carry a tool, while the officer carries the rope bag. The officer or “bag-man” carries the main rope bag and the Thermal imager. This allows the officer to scan the room/rooms while the firefighters search.

The Officer of the rope bag should:

1. Feed the rope over their shoulder
2. Keep the rope off the ground/ tension on the system
3. Maintain orientation, communication, and calls out each knot



In the drawing above, the company officer maintains orientation of the hallway of a hotel/dorm style building. The two firefighters within the company search off the rope and clear the rooms to the right and left.

Air Management - Operating off a 30 minute SCBA cylinder, the recommended timeframe is as follows for rope systems.

IN/Forward Movement - 10-12 minutes
Out/Exiting - 10 minutes
Emergency reserves - 5 minutes.

Remember that the deployment, especially in commercial buildings, will depend on the layout of the building. In grocery stores, they could have defined aisle ways that will enable the search firefighters to proceed down each aisle, with the officer staying at the head. Experienced firefighters should not need a rope to proceed down a regular aisle. There may also be sections in that same grocery store that do not have defined aisle ways, which would require the search rope firefighters to stay on the main line or use the tag lines to search off of.

In large open/wide area search buildings, it is recommended that the search firefighters clip their tag lines onto the main bag and proceed as wide as communication allows. Having to stop every few feet to understand what the other firefighter is calling out is not efficient.

A second option in wide area buildings, is to have a firefighter maintain wall contact and for all others, including the officer (bagman) to spread out off of that wall. The "wall firefighter" continues to make contact throughout the search.

Additional Considerations

- Companies should look at floorplans, especially commercial buildings prior to entering an IDLH environment.
- Remember, in large manufacturing plants, large machines and pits are very common.
- If a crew decides to change directions and backtracks while deploying the rope, it may be necessary for the bag firefighter to coil the rope in hand to keep it taut.

Another reason why the bag firefighter should only carry the rope bag and TIC.

- The rope bags are 200 feet in length. If the company deploys the entire bag, it is likely that they are already low or close to low air. Just because you have 200ft of rope, doesn't mean you should deploy the entire bag. Focus on the high priority areas while searching instead of distance.
- If you do not manage the rope, it will manage you. VICTIM MANAGEMENT

When we locate a victim and have the air to continue searching, hand off the victim to another crew when possible. It is easier to hand off a victim, then to try and communicate to another company what has or has not been searched.

Critical victims remain in our care and are our responsibility until WE hand them off to another crew or EMS. We do not leave them alone in the yard, it is our job to start life saving measures.

We do not perform EMS assessments inside fires. They are obviously dead and we are leaving them or we are pulling them out. If possible, get the victim out or to fresh air as quickly as possible. Can you isolate and vent the windows safety?

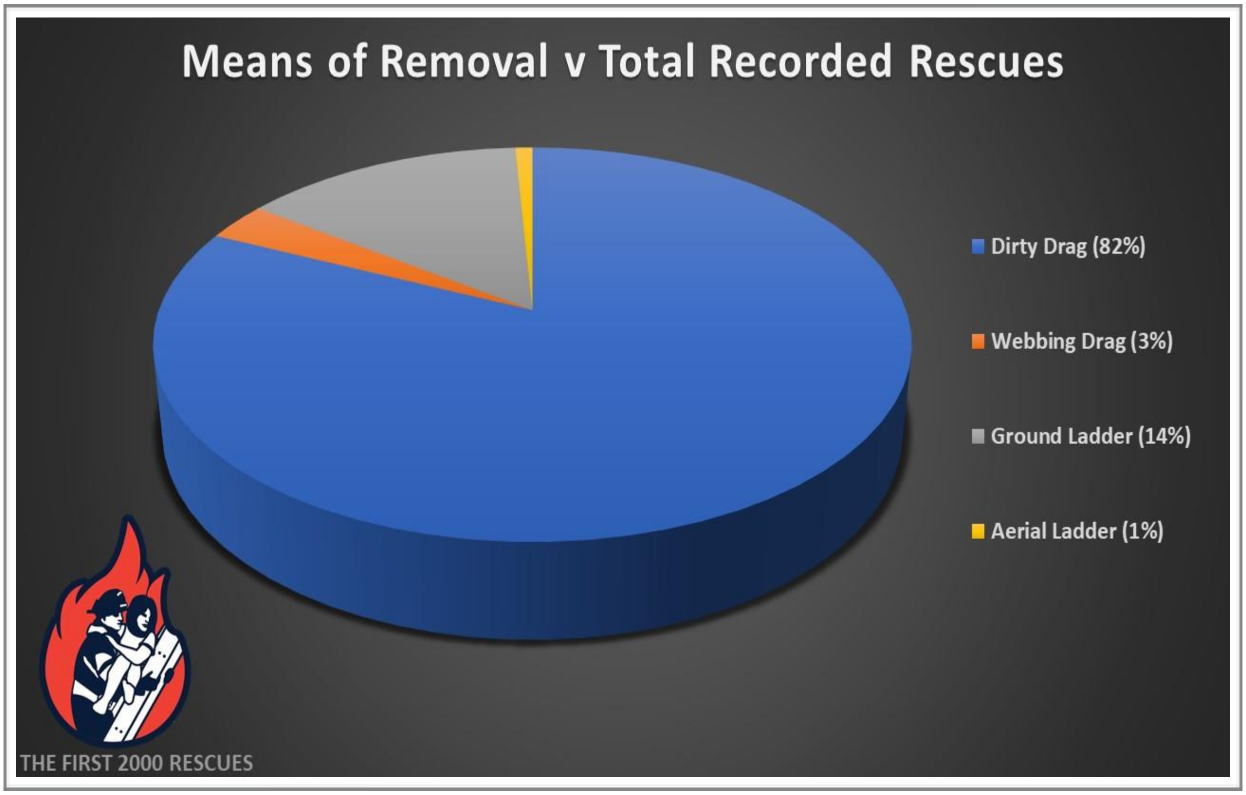
When a victim is found, we immediately call out "Victim, Victim, Victim". This notify members operating inside that you have found a victim. Only two transmissions inside and on the radio are spoken in three. They are Victim, Victim, Victim or Mayday, Mayday, Mayday.

Once a victim is found, quickly evaluate, can we move them by ourselves?

Do NOT delay the rescue by waiting for radio time; get them moving to fresh air asap. When you start moving, the officer should announce via radio traffic "Command, Ladder 311 Officer, Victim, Victim, Victim. Removing victim out alpha side". If we need assistance with the victim removal, state it in your radio transmission, "Command, Ladder 311 Officer, Victim, victim, victim on 2nd floor, removing via A side using ladder, Need company on a side for removal".

Something to keep in mind, when deciding to remove a victim, consider the time spent in making the rescue and the route you will have to exit. What conditions will the victim be exposed to, or should we remove via window?

"Exposure duration is as important of a factor, if no more than dose" -Zevotek, Underwriters Laboratory.



As recorded in the Firefighter Rescue Survey, 82% of the first 2000 rescues (1640) were rescued via “dirty drags”. A dirty drag is finding the victim and quickly grabbing the victim and removing them as quickly as possible. Learning from these actual rescues, we are finding that rescuers are using Gable and Kimora Grip techniques for rescuing civilians. These forms are traditionally used for grappling/fighting. Both are “thumbless” grips where the thumb is on the outside of the grip going the same direction as the fingers not trying to wrap around in the opposite direction as we would normally use when we pick up everyday objects. The goal is to think our hands as big hooks rather than a hand with independent fingers.

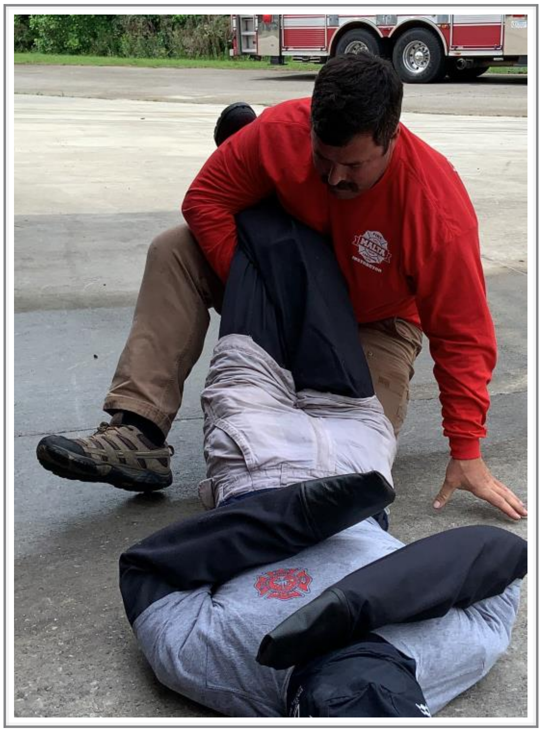
Not only are these grips stronger than traditional grips, but they are also very easy to perform with structural firefighting gloves on and in zero visibility. Whether grabbing the legs, torso or an arm, we should squeeze them as close to our body as possible and utilize one of these grips to give us our best shot at efficiently removing a victim in the fire environment.

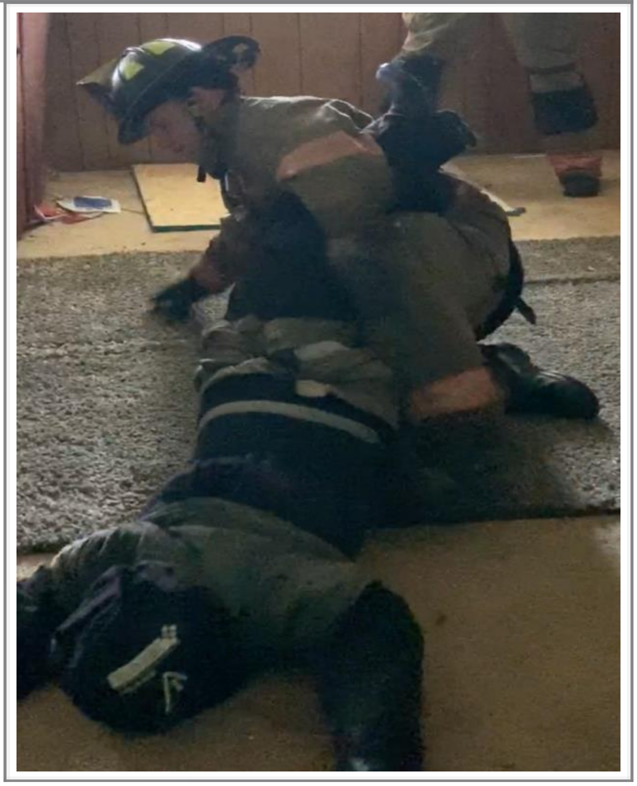
VICTIM DRAGS

Carrying a victim is typically used for lightweight victims, such as a child or infant. When carrying children, especially infants, keep them low in the environment. For infants, “cradle carry” them in your arms, low to the ground. If holding an infant for rescue (waiting), hold them low to the ground or preferably outside the window in the clean air.

The purpose of a drag is to “grab and go.” The weight of the adult victim will take time and energy to remove. Adults will typically take two to three to complete the rescue. Quick and simple drags will keep the victim moving in the right direction.

Feet first drags are the preferred method, as it keeps the victims head low in the elements and the rescuer’s overall body length shorter than head first. Feet first drags can be performed by crossing the victim’s legs, putting the victims feet in each armpit or by two firefighters. Brace your arms behind the victim’s knee for an improved hold. Victims can be spun around by crossing their ankles, lifting their feet in the air and spinning on their back. When pulling victims down stairs, to protect their head, we try to drag head first.





Pictures demonstrating both the right and left handed leg drags.

This enables a smaller frame and uses our core muscles to efficiently and effectively drag adult victims for rescues.

The Arm Bar Drag- Firefighter takes the victim's wrist and put it in your armpit. Take your hand and place on the bicep of your opposite arm and apply pressure to victim's arm. Then, use your other hand to press against the victim's arm and secure the hold. This will complete the arm bar positioning for the drag. Do not grab for clothing as many victims will not be clothed, or it could be possibility burned off.

In some cases, it may be faster to remove a victim out of a window, then dragging them to a exit/doorway.

Whether head first or feet first, the priority of the removal via window is to get the victims hip on the window still. Once the victim's hips are on the still, you can control the victim removal to awaiting personnel or you can "leap-frog" over the victim onto the ladder and remove yourself. However, it is highly recommended to call for assistance and remove the victim to firefighters already positioned on portable ladders. It is also highly recommended to position at least one additional ladder, possibly two, on either side of the main ladder to enlarge your footprint.

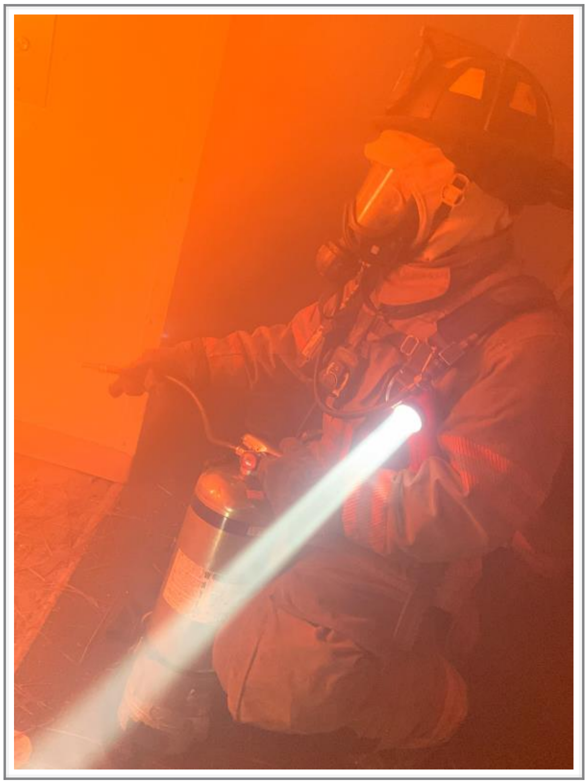
If the victim is very large/obese, rescue crews could call command to initiate a "window to door conversion" for rescue. Outside crews will remove a window and the lower studs/wall and will be able to remove the victim on the floor level. More of this technique will be covered in a later chapter.

SEARCHING WITH WATER CAN

A water extinguisher or "can" should be taken inside on most fires, especially if the ladder company is searching beyond the hoseline and/or above the fire. The water can is able to keep the fire in "check" in case the ladder company finds the fire and the line is delayed.

A properly filled water can will flow water approximately 50ft for one minute with a weight rating of 25 pounds.

The picture to the rightdemonstrates one technique of carrying a water can while searching. This technique is referred to a "football carry."



Another technique of carrying is dragging the water can behind the crew with the carrying strap. You can also drop the can off at each doorway you enter.

Either way, the water can is a very important tool for the ladder company to search with.

SEARCH TIPS

- When calling out for victims, hold your breath, listen and don't move (3-5 seconds). Call and listen when passing through every doorway.
- When using a TIC, scan and then search. Do not move while looking through the screen, you have a narrowed view and TICs have horrible depth perception.
- TIC's can not and will not see every/all victims.
- When you locate one victim, quickly sweep around for an another victims. Many victims are found together
- Try not to move furniture. It can assist in the orientation of a room or potential hiding spots.
- If a night latch/chain or additional locks are in place, this is a strong indication of a victim.
- Roll cribs to the ground to search.

The picture above shows a homemade baby gate made out of wood, drywall, and fabric. A firefighter not properly searching would have possibly missed this doorway. Remember to search above the four foot mark (average height of doorknobs) to ensure the coverage of windows and doorways.

- If you can coordinate, ventilate while searching. Isolate the room, take the window and clear out the room.
- When searching in hoarder conditions, stay in the pathways and on top of the clutter. On a primary search, we must prioritize time and not sift through and move all the clutter.
- When searching for victims, feel for contour and weight.
- Do not forget to search the last 36-48 inches of a room corner. During studies, many search crews missed the last 36 - 48 inches of a corner. Search until you feel something, then investigate to see what it is.

- When a point of interest is found, we must own the opposite 6-8 feet. Objects that have human life form must be investigated and will cause us to miss a significant portion of the room. If we locate a couch, sometimes we focus so much on the couch, we miss the 6-8 feet of the center of the room.

CHAPTER SIX

EXTENSION CHECKS
AND
SALVAGE OPERATIONS

CHAPTER: 6 Extension Checks

Once all forcible entry and ventilation needs are complete and searches are clear, the ladder company inside team should focus on checking for fire and smoke extension. There is nothing more embarrassing or negligent to the community and citizens when organizations and companies have to respond back to a structure for a reported “rekindle” fire.

It was not a rekindle, the first due ladder and engine company did not finish extinguishing it and left. This is disrespectful. This is also dangerous as we now have to respond back to the address and possibly work in already deteriorated conditions and construction.

Extension checks and overhaul are not the most glamorous aspect of the job, but it requires much finesse and knowledge. Having a well-rounded knowledge of fire behavior, construction, and tools are the key for a successful overhaul operation.

As members grow in experience through their careers, it will give them more confidence when performing overhaul operations. For that reason, senior members or officers should help mentor and guide the operation.

Some Key considerations on extension and overhaul operations:

1. Start closest to the source of the fire and work out from there. If you see fire or smoke, that is also a good starting point.
2. Inspect the drywall closet to the source, open a small inspection hole.
3. Inspect around vents, wall outlets, and piping. Small embers can spread fire conditions quickly
4. Burnt trim or “crocodile” trim and baseboards should be removed. Hidden fire and embers can always be found even with no smoke evident at the time.

The picture above shows fire extension in the attic space. Companies had a quick knock down on the fire, however, when they opened the ceiling, the fire had extended up into the attic space via the original fire room.

BUILDING CONSTRUCTION

During overhaul, knowing where potential fire could be located based on the construction of the building, is solely based on knowing your area and the challenges the construction provides.

Pipe Chases -

Common pipe cashes can run multiple floors, especially in apartment buildings. These can be behind the kitchen or in bathroom locations. They generally contain plumbing and vent pipes that run all the way to the attic or roof space. In apartment buildings and newer style "cookie" cutter home designs, bathrooms are often built back-to-back between units or floors. Fire reaching these areas will spread quickly and have no obstacles that will slow down fire spread in other areas, floors, or rooms. Any room that may have a pipe chase needs to be investigated quickly after fire knock down to ensure no other fire has spread elsewhere.

The pictures above show the fire travel via copper piping from the 1st floor to the attic space.

Knee Walls -

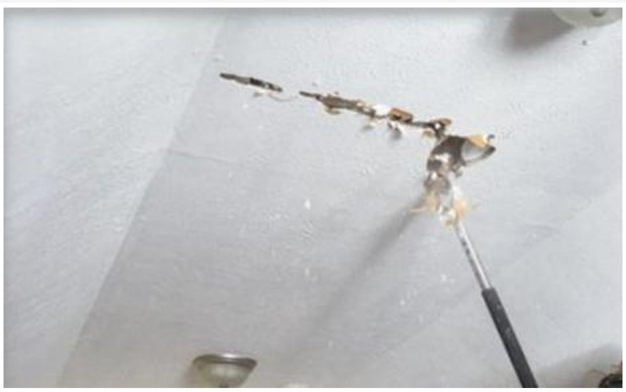
Knee walls are a common construction feature in today's building society. It is imperative when opening up knee wall construction, always have a charged handline ready to open up if needed. These void spaces can hold enough fire and smoke to cause a rapid fire event. In knee wall operations, focus on the walls of the interior room first, then focus on the ceiling space.

Balloon frame/Farmhouse Style Homes -

Balloon frame construction, as discussed before, is very important to recognize on the initial size up. The origin of fire in these buildings can be deceiving and can potentially cause rapid fire events. Crews should quickly search above and below each void space and especially in the attic and basement area during balloon frame operations.

OPENING UP

Their are two tools that provide easier removal of building materials and debris than any other tool. The Halligan Bar and the six foot New York Roof Hook. The



roof hook should be your primary means of opening up and removing trim. Ceiling/drywall - Take your hook and outline your "hole" between the studs using short jabs or "punches" with the hook. This method is referred to the "punch" technique. Once the desired outline is complete, use the hook to pull down the ceiling in one or two pieces.

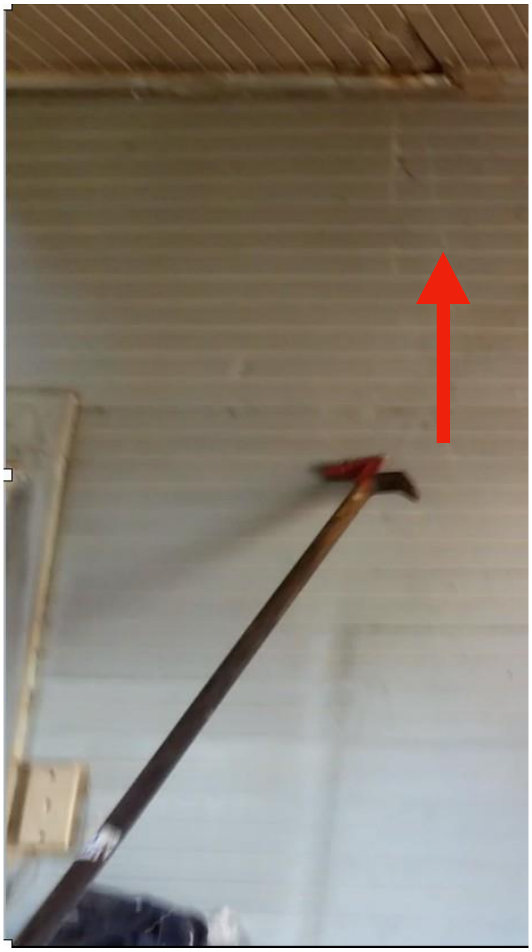
- Remember, drywall, especially wet, can be heavy and you should not go more than three to four stud bays to pull down large pieces.
- When pulling ceiling overhead, use the reach of the tool in front of you. You should not pull down ceiling on top/above you.

Trim/Baseboards -

Good Truckmen should remove trim and baseboard in as few pieces as possible. This finesse demonstrates your respect for the property and the art of good truck work. Use the angled roof hook and slide it down behind the trim. Pivot the tool in the opposite direction, to allow the roof hook angle to use leverage against the wall. This will allow the trim to be removed easily and in full pieces.

A NY Rook Hook with the chisel end is perfect for baseboards. Slide the chisel end of the hook down the wall steadily and allow the chisel end to make it behind the board. Pivot the hook outward to use leverage to your advantage.

Tongue and Groove ceilings-



Tongue and groove ceilings can be hard to open up during high heat conditions. During overhaul process, with limited heat conditions, you should have better luck opening it up more efficiently.

1. Start with the bevel end of the NY Roof Hook halfway up the wall.
2. Using your arms, slide the hook up the wall quickly, using the momentum to break the edge of the tongue and groove.
3. Continue step 2 until a small hole appears on the edge of the boards.
4. Rotate your roof hook so that the angled hook is sitting above the boards.
5. In a quick jerking motion, pull downward with the hook.
6. The boards should begin to fall down.

Picture above shows what happens when you slide the roof hook against the wall. Hitting the edges (weak point) will form a hole.

Rotating the Roof Hook head and using a downward force, will loosen the boards. Using this weaken board, remove it and continue to remove the boards with your hook.

SALVAGE OPERATIONS

The most common example of property conservation a Ladder Company will perform is salvage operations. This operation, like overhaul, should not be overlooked or taken lightly.

When fire departments were first invented, homeowners relied on the fire department for saving their property.
Sadly, due to insurance companies and lack of salvage techniques, many fire departments have "lost the art" of salvage operations. In today's society, many families still don't have insurance. Most of the time, what is inside the occupancy is all a resident may have, therefore we must save what we can.

If it was your house, how would you want your belongings to be treated?

How and when to start salvage operations is mainly dependent on the situation and incident. Most importantly,

Companies covered the furniture on the 1st floor of this 2nd floor fire. As soon as searches and extension were complete, companies placed covers on the furniture below them.

if the fire is not under control or searches have not been performed, you need to focus on those tasks. Once those tasks are completed, salvage operations should begin immediately.

Companies must be proactive on salvage, calling for RIT team members to drop salvage covers at entrances (out of the way) for later use is one example. On multiple floor fires or apartment fires, you may have to deploy a full company and multiple tarps/covers for furniture.

CHAPTER SEVEN

PORTABLE LADDERS

CHAPTER: 7 Portable Ladders

Portable ladder operations are a core responsibility of ladder company operations. It is an expectation that firefighters assigned to ladder companies should be highly motivated to become “experts” in ladder carries and raises. With that said, truckmen are expected to be adept at selecting the right ladder for the job. Size-up of the incident is critical to ladder selection and its needed location.

Many incidents require more than one ladder and we need to prioritize the order in which ladders are deployed.

This chapter will focus on setting up the ladders for success, choice, and priority. Actual raising of the portable ladders are best covered in single company training evolutions. Ladder companies should, at minimum, throw portable ladders once a week, to maintain proficiency and ensure ladders are in working operation.

Nothing is more important than having an operation or gameplan. Developing an operation requires having a “Plan A” and training to execute that plan. Once the plan has been mastered, companies should work on developing “audibles.” Plan B and C cannot be developed until all members understand Plan A.

PORTABLE LADDER PREPARATION

If your ladder bed/chute is not set up for success, if your ladders aren’t in optimal working order, executing portable ladder operations becomes difficult. Its your job to invest in and take care of the equipment, because it matters, for them.

Ladder Chute/bed -

The ladder chute should be well organized and clean. All portable ladders should be clearly marked from all four sides with the length. Some organizations like to mark the bottom of their ladders with the bedded length/full length. If you have enough room, that method is highly recommended I.e: 14/24 or 16/28. The first number is the closed length and the second number is the full length.

The Ladder chute should be emptied and cleaned on a monthly basis, at minimum. This authors of this book recommend bi-weekly (also based on usage). When the chute is empty, the front of the truck should be elevated and the chute should be swept and washed out of all debris. The ladder holders should be checked for any spurs or imperfections that may cause turbulence when removing portable ladders. The portable ladder holders (sometimes made out of teflon) should be lubicated with wax once the chute is wiped down dry. There are two brands of surf wax that is highly recommended (and cheap) for the ladder chute and portable ladder beams.

Mr. Zogs Sex/Surf Wax and Sticky Bumps Surf Wax are excellent choices for lubricating the portable ladder chute and ladder themselves.

Portable ladders should be cleaned on a weekly basis. Each ladder should have a clearly marked balance point and tip coloring/label for emergency purposes as well.

The halyards should have a little slack in them, but not too much that they get in the way or caught while carrying. It is also recommended that all natural fiber halyards are replaced with the newer high strength synthetic rope. This rope is much more durable and easier to grip than the provided natural fiber rope provided by the manufacturer.

During cleaning, the ladders should be washed with water and a mild detergent. Inspect the ladders for any spurs, heat indicators, and ensure that all moving pulleys are in working order. Pulleys and ladder locks (dogs) should be lubricated with a white lithutim spray and the beams and guides of extension ladders should be dried then wiped down with the surf wax. You will notice an immediate difference with wax on the beams. All portable ladders should be pulled out of the ladder chute with minimum effort and should slide out.

PORTABLE LADDER SPECIFICATIONS

The LCFS is transitioning to all Duo-Safety ladders. Until the fleet is completely replaced, Alco-lite ladders are on some apparatus. Duo-Safety ladders have the same strength as Alco-lite, however they are much lighter in weight, have full smooth beams for carrying and replaceable heels and tips for ease of maintenance. The Duo-Safety ladders also have the ability to attach tools with the open style tips.

Duo-Safety ladders are rated at 750lbs with a 4:1 safety factor (3,000lbs). The following chart explains the weight/length ratio.

AL = Alco-lite
DS = Duo-Safety

Ladder	Bedded Length (feet)	Full Length (feet)	Width (inches)	Weight (lbs)
AL - 14' Roof	14.3	14.3	18.5	42
AL- 16' Roof	16.7	16.7	18.5	48
AL - 24' Ext.	14.3	24.8	21	75
AL - 2 Section 28'	16.7	29.5	22	114
AL - 2 Section 35'	20.1	35.3	22	140
AL - 3 Section 35'	15.8	36.8	25	170
DS - 14' Roof	14.2	14.2	19	28
DS - 16' Roof	16.2	16.2	19	39
DS - 24' Ext.	14.275	24.875	21.75	72
DS - 2 Section 28'	16.325	29.125	24	87
DS - 2 Section 35'	20.325	35.525	24	122
DS - 3 Section 35'	15.3	36.3	24	129

It is imperative that ladder company personnel understand the bedded and full length of their ladders, to ensure appropriate placement.

PORTABLE LADDER PLACEMENT

Building construction, tactics, and size up will dictate when and where portable ladders are placed on the fireground. The following statements are general guidelines and rules for prioritizing the order of ladder placement. Keep in mind that many times these tasks can be accomplished by multiple companies (to include the RITTeam).

Placement Guidelines:

1. Rescue and/or Fire Floor
2. Roof
3. Floor Above Fire
4. Opposite and/or additional floors.

It is also recommended that we ladder every window, on every side of the building, on each floor. If multiple companies are responding, especially ladder companies, the pre-set plan should be:

1st Due Ladder: Alpha and Bravo Side
2nd Due Ladder: Charlie and Delta Side

This should be communicated amongst companies so that efforts are not duplicated.

Priority 1 for Portable ladders is imminent rescue needs.
Upon arrival, placement of ladders for the rescue of immediately endangered occupants must be addressed or ruled out.

Priority 2 for Portable ladders is primary fireground objectives.

After any imminent rescue needs, the next priority is to facilitate the primary objectives on the fireground. This includes placement of ladders for searches, ventilation (roof access), and access to fire attack (engine company) if needed.

Priority 3 for portable ladders is anticipated or emergency needs.

This priority is to place as many ladders as possible to address anticipated problems before they arise. This could address egress, access, firefighter or victim rescue, or any other fireground tasks that would require the use of a ladder. Ideally, a ladder would be placed at every window, balcony, railing, and other potential access or egress points. Utilizing as many ladder as possible at an incident will increase a firefighter's chance of escape if necessary and ladders will be more readily accessible for rescuing victims. When placing ladders for anticipated needs, they should be placed in such a way that they can facilitate any of the above needs as possible. In most cases, a ladder thrown at a shallow angle to the sill or railing will allow for access or egress, as well as potential rescue.

LADDER CHOICE

The following information is intended to be used as a guideline to assist the firefighter in choosing the right ladder for the job and the intended use of each ladder. These guidelines should not deter a firefighter from thinking and prioritizing laddering as the fireground dictates.

Ladders for Rescue:

Placing ladders to accomplish imminent rescue of trapped victims shall take precedence over other ladder tasks. When placing ground ladders to windows for imminent rescue or potential rescue, the positioning of the ladder is the same.

The tip should be placed at or just below the window sill. If the window is large enough to allow a person to exit the window with the ladder on the sill, the ladder should be placed at the sill. It should be positioned against the side of the window frame to limit lateral movement. For small windows which limit a person's access, the ladder can be placed just below the sill to allow full use of the available area. Just below the sill means exactly that. A ladder placed even a few inches below the sill is too low. It will be difficult to access from the interior. In some cases, the window may be very large and can accommodate the ladder being extended into the window and still allow plenty of room for the person to exit. In such cases, the person will benefit from being able to grasp the ladder while climbing through the window. Instances where the rescue of a person who is unable to assist is needed, the tip of the ladder shall be placed at or just below the window sill regardless of the size of the window and to the center of the window. When placing ground ladders to balconies or fire escapes for rescue, they shall ideally be placed in one of two configurations. Balconies which protrude from the building face shall be laddered with the tip against the building wall, next to the balcony end, and with 2-3 rungs above the railing. Balconies which are flush with the building face shall have ladders placed to the balcony railing with a minimum of 2-3 rungs above the railing and against the side wall of the building to limit lateral movement of the ladder. Remember when laddering windows for rescue, adjusting the climbing angle takes a back seat to proper tip placement. Choosing the right ladder for rescue is predicated on size-up and ladder availability. Size- up will identify construction features of the building and help the firefighter establish where the ladder is needed. In cases where the ideal ladder for the job is already in use, the firefighter may need to choose a different ladder.

Remember: TIP PLACEMENT is the priority in rescue, NOT angles.

-2nd Floor residential windows: a 16 foot roof will generally be a perfectly sized ladder. A 28' would be our second choice (16' bedded). A 14 foot roof ladder will work, however, it is generally at a steeper angle than preferred.

-3rd Floor residential windows: a 28 foot ladder is preferred or a 35 foot ladder. A 24 foot ladder will work, but will most likely be close to full extension and/or not reach due to terrain.

- Commercial buildings: heights can vary considerably. You need to get out in your area, measure and throw ladders to discuss your options. Most commercial buildings for a 2nd floor window, you will need a 28 foot ladder and 35 foot ladder for the 3rd floor.
- For balconies, the railing heights are similar to window heights for any given story. Accordingly, similar ladders can be chosen for this task as for window rescues.

LADDER CLICK SYSTEM

Another preferred technique on estimating ladder lengths and raising ladders is the "click system" also known as "counting the clicks". The inside distance between rungs are 14 inches, which is reduced down to 12 inches or one foot for ease of numbers. If you know you have a 28 foot ladder that is bedded length of 16 feet, you will need four (4) clicks to reach a 20 feet.

Ladder Type	Bedded Length (feet)	Number of Rungs	Total Working Height (feet)
14' Roof	14	11	12
16' Roof	16	13	14
24' Extension	14	12	22
28' Extension	16	14	26
35' 2 Section	20	17	33
35' 3 Section	15	13	33

Each ladder click is one foot with the exception of any three-section ladder. Each three-section ladder, one click is two feet (two rungs) instead of one.

Ladders for Vertical Ventilation:

Ladder positioning for ventilation will be also covered in the ventilation chapter and aerial operations chapter. In vertical ventilation, generally, the aerial ladder should be one of the ladders used to access the roof. Many times the outside vent firefighter should throw a portable ladder to the roof, while the Chauffeur accesses the roof with the aerial ladder. This not only provides two means of access and egress, this enables the vent crew to sound in multiple locations as well. At most fires, the aerial ladder should be deployed to the roof and/or window for rescue. This is another ladder to use for access or rescue purposes. Ladder Chauffeurs should be able to deploy the aerial ladder just as quickly, if not faster, than the OVM throwing a portable ladder to the roof, with the exception of one story houses.

When placing a ladder to the roof, ladder the uninvolved part of the building and travel/sound your way to the involved area. Corner placements are usually good spots, however, they are not always the right placement. Laddering uninvolved areas provides the safety path of travel to the location of ventilation. This placement will also allow the roof team to monitor progression of the fire and trade space for time as needed, minimizing the potential for the fire to come between the crew and their path of egress. The only exception to this rule is the placement of the primary ladder for a steep pitch or non-walkable roof. In this situation, traversing the roof via a load-bearing wall is not possible. The ladder must be thrown to the involved area to facilitate the appropriate vent hole location. Attempts should be made to throw a ladder close to corners, hips, or valleys as these areas have increased structural integrity compared to others.

In situations with Cape-Cod style houses/roofs, a longer ladder, generally, 28/35 foot ladder, should be thrown to the roof at full extension and placed at the angle of the roof.

Ladders, especially on flat roof commercial buildings, should be placed at a minimum of four to five rungs above the roof line. This will allow companies operating topside to easily see the egress if/when the smoke lowers down.

On extended roof operations, at minimum there should be up to four (4) ladders placed for egress. Safely, one portable ladder can quickly rescue two, possible three firefighters. For that reason, multiple additional ladders should be placed and communicated to the roof team on incidents as noted. As with any incident, the RIT team should communicate that portable ladders are thrown on all four sides of the building, once their 360 size up is

Firefighters using fully extending 28' ladders to access this cape-cod style house for vertical ventilation.

completed. They do not have to be specific and take up valuable radio traffic, only the communication of "RIT Team to all units operating, portable ladders are on all windows of the building."

It should also be noted that on commercial fire responses, the second ladder company, should position their aerial ladder to the roof as an additional ladder.

ROOF LADDER REALISMS

As explained in basic firefighter classes, the discussion of "roof ladders are used to distribute weight and provide traction while operating on roofs". This is be discussed in the ventilation chapter as well, however this is a false statement.

Roof decking has been proved to fail earlier than trusses. Roof construction/roof pitch in our operations, should be placed into two categories. Walkable Roofs and non-walkable pitches. Generally, a roof with a pitch 6/12 or greater is non- walkable. If the building is of newer construction, then the roof ladder will not have anything to distribute the weight of the firefighters working.

Using a roof ladder, also takes the "sounding out of the tactic" meaning, firefighters generally don't actually sound while climbing up a roof ladder and therefore is not able to efficiently sound and understand where the vent hole should be placed. This also takes much more time, which is something we don't usually have on the fireground. If you are on a walkable pitch roof that is in less than perfect shape and need traction, by all means, use a roof ladder. However understand the following explanation of a roof ladder.

The chart to the right, shows the weight distribution of a 200lb firefighter using a 16' roof ladder on a 8/12 pitch. Weight plates and load cells were used to measure the load.

Set	Lbs
Just Ladder	35
One Leg	243
Both legs	172
Rung 1	176
Rung 2	184
Rung 3	185
Rung 4	191
Rung 5	196
Rung 6	204
Cut off slide	252
Both Legs Back	236

Notice as the firefighter goes higher up the ladder, the load is actually greater than the 200lb firefighter. When the firefighter leans off the side to make their cuts, the load increased. This chart demonstrates the lack of understanding that roof ladders do not distribute weight on non-ridgepole/lightweight buildings.

It is of the recommendation of this book to use roof ladders as "parapet ladders" or balcony ladders. If needed, deploy the hooks on the stable railing or wall and climb upwards. Many rescues have been documented by using a roof ladder as a Pompier or scaling ladder.

This ladder company was short. They deployed the roof ladder and wrapped it quickly with webbing to scale to the roof.

Double Hop or Double ladder operations is a common operation on large, built-up homes like located on Lake Murray.

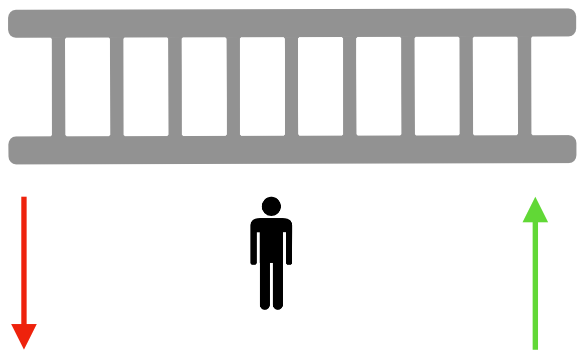
Companies should train and become proficient in this type of operation. Companies can also use porch roofs (if stable) to be able to reach objectives as well.

LADDER RAISE

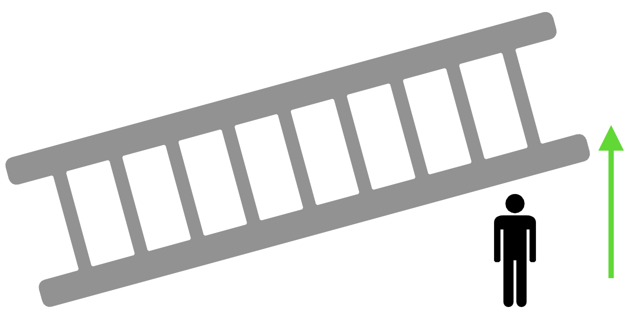
As stated earlier, we will only cover the basic movements for ladder raises in regards to this book. Portable ladder raises are broken down into two classifications.

Class 1 Lever and Class 2 Lever

Class 1 Lever is when the firefighter is in the middle of the ladder high shoulder carrying the ladder. In this operation you pull the ladder up.



Class 2 lever is when the firefighter places the ladder against an object and pushes up from the tip or 2/3 length. In this operation you push the ladder up.



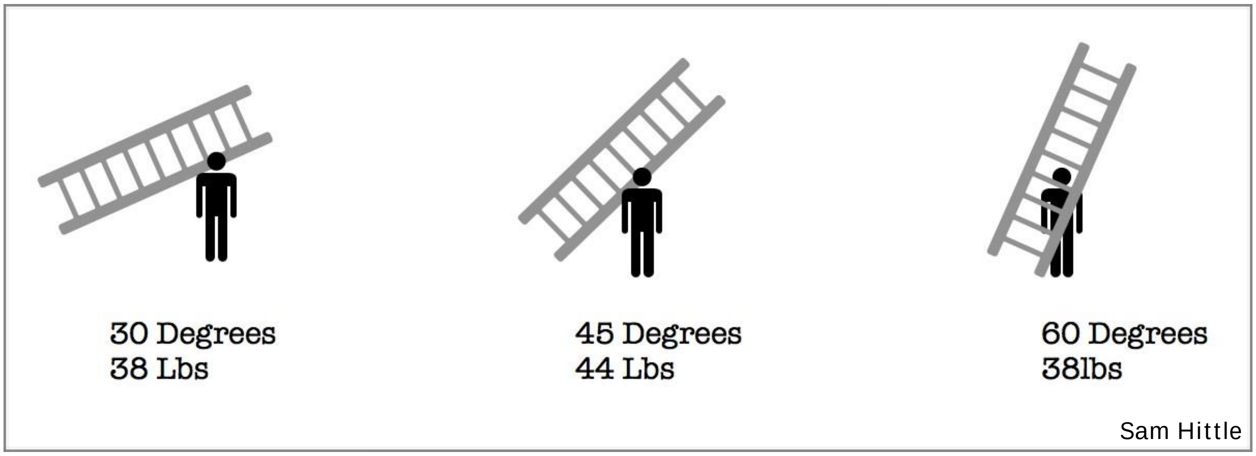
Using the examples above, if we are using a 2-section 35' Ladder (20' bedded at 122lbs).

Using the Class 1 lever, we exert approximately 98lbs of effort (push).
Using the Class 2 lever, we exert approximately 341lbs of effort (pull).

As discussed in forcible entry, many times when weight becomes a factor, it is much easier in terms of physics to PUSH than PULL. This also shows the importance of the location of the fulcrum or pivot point.

LADDER RAISE ANGLES

When throwing ladders, we have to rotate the ladder from 20-30 degree angle (carrying) to a 90+ degree angle (against the building). When raising a ladder, our most problematic rotation is typically between 30 and 60 degrees, with 45 degrees being the most difficult. The diagram below will explain the weight to angle ratio using a 2-section, 24' ladder at 14' bedded and 72lbs.



Manipulating the ladder into a steeper angle moves the center of gravity forward in relation to the fulcrum (ground) which means it is easier for the firefighter to raise and push the ladder into position.

Another way to defeat or "cheat" the physics is to "front load" the bottom of the ladder with a Roof Hook or halligan.

By attaching a tool to the bottom, will add total weight, however, changes the center of gravity towards the fulcrum and will shorten the front end of the ladder, allowing us to be at a steeper angle quicker.

Most importantly, find what carries and raises work for you and your body. There are advantages to using the high shoulder carry, especially if going a longer distance, alleyways, or in tight backyard spaces.
Sometimes for the heavy, larger ladders, you may want to use the low shoulder or suitcase carry.

Ladder Footing/Heeling-

When a portable ladder is placed on uneven terrain, concrete, or a steep angle, a firefighter needs to be at the bottom of the ladder footing it. There is a difference between heeling and footing.

Heeling - Firefighter is holding the ladder and pulling towards the building. They are unable to see what is above them, if a rescue is in progress, smoke is changing.

Footing - Firefighter has their feet against the butt of the ladder and hands against the beam/rungs. They have full vision of what is going on and can assist in case of an emergency. This position is also stronger.

Using a load cell, a 200 lb firefighter, and a 24' ladder, the following weight movement was recorded:

Heeling from underneath the ladder, the ladder began to slip at approximately 80 lbs of pressure.

Footing from the outside of the ladder, the ladder began to slip at approximately 160 lbs of pressure.

Firefighter heeling the ladder

Firefighter footing the ladder

LADDER LOCKS/STABILITY

Ladder locks are designed to increase your stability when operating/performing a task while on a ladder. There are three recommended locks when working off a ladder for any objective. Leg locks, like many other tasks, should maximize your stability and potential for receiving victims or moving in emergency situations. These three locks ensure that those guidelines are met and were invented by

Mike Ciampo of the FDNY.

Hyper Extend Leg Lock - (HELL) - While climbing or operating on a portable ladder, a victim attempts to remove themselves or a mother is franticly attempting to throw you their child.

- Immediately move your dominant leg/ knee between the rungs and push against the beams.
- Take your non-dominant leg/knee and push against the other beam.
- Receive the victim with both arms/ hands.
- Figure 1 shows a FF using the HELL Lock to quickly take a window using a hook. This is a very comfortable lock and frees up both hands.

Figure 1 - HELL Lock

Hook In Leg Lock - (HILL) - figure 21

- Using your dominant leg, slip it one rung above your current placement.
- Take the middle of your boot and sit it on top of your non-dominant toe.
- Move your body against the beam (side dependable).
- Place your body weight on your dominant leg, so that the pressure "locks" in your top boot into your bottom boot (non-dominant).
- You are now "locked" on that rung.

Arm Lock - Great for using a long hook/ tool for venting, overhaul, etc. If you are working off the right side of the ladder:

- Take your left arm and place it through the rung.
- Take your right arm and place it on the outside of the right beam.
- Complete the lock by holding the tool with both hands.
- Figure 3 shows a FF venting a window, off the right side of the ladder using an arm lock.

Figure 2 - HILL Lock

Figure 3 - Arm Lock to ventilate a window

LADDER RESCUES

According to Firefighter Rescue Survey, out of 2000 rescues, 14% (280) of rescues were on portable ladders and 1% (20) were via aerial ladders. No matter how many times you train on victim removals, is it going to be difficult and tiring. To assist with a victim removal, it is recommended to throw another ladder parallel to the "rescue" ladder and have another firefighter assist with lowering down.

Remember, many victims will be without clothes and possibly burned. If unconscious, it will be dead weight. Ensure you have a good hold/grip and ask for help.

Especially with unconscious victims, any portion of the ladder tip inside the window will hinder the operation. We must make sure the tip is just below the window still for optimal rescue potential.

Note: Portable ladders and ladder rescues are a primary focus of a Ladder Company. No other companies have 35 foot ladders or the training that truckmen should. Be proficient and experts on portable ladder rescue situations. The only way to perfect it, is to train on it and do it on incidents. This includes fire alarm activation and actual fires.

FIXED VARAIBLES

Fixed variables are situations that generally fit all scenarios. These are ideas and recommendations to think about while responding to and operating at incidents.

1. Consider the Aerial first for ventilation and laddering.
2. Place as many ladders as possible on the fireground.
3. Minimum of two ladders, per company, for roof operations.
4. Always clear overhead obstructions, especially energized lines.
5. Heel ladder from the outside.
6. All ladders below 35’ are one firefighter throws. If needed, Truckmen should be able to throw a 35’ by themselves.
7. Avoid placing ladders over the main entry/exit point.
8. 60 Degree ladder angles are easier to climb and safer to remove victims.
9. Duo-Safety ladders can be thrown fly-in and fly-out. You only lose 4% of the strength (30 lbs).
10. On uneven terrain use wedges and/or extra tools to stabilize ladders.

CHAPTER EIGHT

VENTILATION

CHAPTER: 8 Ventilation

Ventilation is one of the most critical and important fireground tactics performed to support fire attack and search. It is so important, that it may be one of the first tasks performed to facilitate entry and searches by the ladder company. It can be complicated because of the many different variables due to building construction and fire behavior.

Ventilation has to be the front mindset of the first arriving ladder company. It can always be scaled back, however, if interior companies need it and call for it, many times we are too late. Preparation, planning, and execution are crucial to successful operations.

The objective of ventilation is to lift the heat and smoke away from trapped occupants and firefighters to improve survivability, visibility, and tenability. These three environmental impacts will improve upon our opportunity to provide aggressive interior fire operations which will include, search and hoseline advancement to the seat of the fire. There are also times where ventilation can be used defensively to control the lateral travel speed and/or direction of fire spread. Prior to roof operations, a ventilation "profile" needs to be developed, as well as task prioritization. Many pieces come together to form this profile and the roles and responsibilities of the team will also be explored below.

There are various tactics to achieve ventilation; vertical, horizontal, and mechanical. Building construction and conditions are the key in choosing the right tactic to be most effective. Not every window needs to be broken, not every roof needs to be cut, HOWEVER, ventilation must occur at every fire. If we do not control the building and the ventilation of the fire, we will lose the building and possibly injure or kill civilians or firefighters.

NIST/UL's vertical ventilation study even stated "In the modern fire environment, we need a better understanding of ventilation". Not only do we need to understand ventilation, but understand how we control it and provide direction for ventilation and conditions to work in our favor. Truckmen need to be experts in ventilation control.

For ventilation to be coordinated, companies must train and operate together and understand true coordination. Coordination is not calling on the radio stating "ready for ventilation", coordination is ensuring that engine companies can stretch hoselines efficiently and communicate the benchmark "water on the fire". This benchmark notifies all personnel on the fireground that ventilation is good and needs to focus on improving the atmosphere and conditions inside, once water is on the fire.

Due to the enormous heat in the hallway, the engine company at this house fire called for pre-water vent (vertical and horizontal) to allow the lean/lift of conditions. After venting, the engine company was able to knock down the majority of the fire within minutes.

Prior to water on the fire, ventilation will cause a temporary improvement in conditions. If the searches and fire attack are not able to make it down the hallway, then ventilation should be called for immediately. However, with that said, NIST/UL have confirmed in experiments, if water is not on the fire within 180 - 300 seconds, ventilation will rapidly feed the fire growth.

A ventilation profile will take into account many factors and establish what type of ventilation needs to be performed. Options include horizontal or vertical ventilation, either offensive or defensive. Having a working knowledge of roof construction for both commercial and residential structures is imperative as the features of the construction method will dictate roof operations. The first step to developing a ventilation profile occurs during size up of the structure. Fire location and progression should be identified quickly as the offensive heat hole needs to be placed as close as possible over the seat of the fire to have maximum effect in releasing heat and not drawing the smoke and heat through unaffected areas.

Weather can have a big impact on the vent profile. There are effects to the roof surface similar to debris and rain will decrease traction and additional safety measures must be taken. Wind direction should be considered if it is significant. Placement of the vent hole should be on the leeward side of the structure. As heat, products of combustion, and potential fuel in smoke escape, fresh air pushing into the structure should be prevented as it could drastically change the interior conditions and increase fire growth.

Property use can dictate layout and give cues for optimal hole placement. Uses could include commercial or residential, single or multi-family. Overall nature of a business, ie: furniture sales vs manufacturing involving chemicals, provides important info as well. Obstacles to accessing the roof should be taken into account when developing the vent profile.

ROOF CONSTRUCTION

Truckmen need to understand and be experts in roof construction, types of roof assembly in their first due areas and how to defeat them.

RESIDENTIAL ROOFS

Residential roofs are broken down into two categories, walkable and unwalkable. As discussed in building construction, decking fails before trusses. In order for you to know the stability of the roof, you must be on it, sounding appropriately.

Walkable and unwalkable pitches are defined by the rise/run which provides a stable footing. Generally, a roof that is a 7/12 pitch (7 inches of rise over 12 inches) or more is unwalkable.

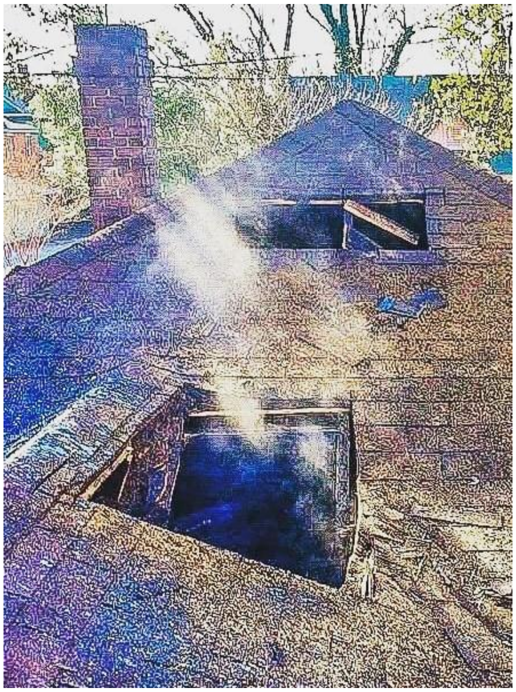
2 in 12	10°
3 in 12	14°
4 in 12	18°
5 in 12	23°
6 in 12	27°
7 in 12	30°
8 in 12	34°
9 in 12	37°
10 in 12	40°
11 in 12	43°

Most roofs that are 6/12, are usually walkable.

When outside vent teams are performing a 360 at a house fire, take a look at the side or gable end of the roof. The steeper the triangle, the more of a pitch the roof has. Remember, that is a roof is not taken care of properly, a 4/12 pitch may be “unwalkable”, due to deteriorating conditions. The only way to find out, is getting topside and sounding the roof.

Residential pitch roofs have a truss/stick built rafters at the base, followed by lumber (OSB, plywood, or dimensional). Tar paper is tacked down on top, then usually shingles or the protective layering.

Protective layering can include : shingles, slate, clay, and metal.



Asphalt Shingle roofs - Very common roofing material in the county. They can deteriorate and degrade over time, leaving slippery areas if not careful. Most shingle roofs you will be able to feel the rafters if sounding appropriately. Many homeowners will continuously add shingle laying over time, which can begin to gum up your chainsaw doing roof operations. This can also slow down

At this house fire, ventilation companies found 19 layers of shingles which significantly slowed down their saw operations. Another reason to always carry two saws with you to the roof.

Slate roofs - Not very common in Lexington county, however, can be found on older homes (especially older mill homes) and around Lake Murray. Slate roofs can withstand a lot of weight, but can break easily and are very sharp. Our saws will have no issues cutting through these, however, it is recommended to break them first, rake them out of the way, then cut a ventilation hole.

Clay Tiles/Terracotta - Not as common as asphalt shingles, but becoming more popular around the Chapin area and Lake Murray homes. Manufacturers have designed clay tiles with built-in solar panels as well. Clay tiles are usually secured to 1x2 furring strips over regular wood sheathing. Clay tiles, like slate, are heavy and sharp, but are very easy to remove. Topside companies should focus on breaking clay tiles with a LA Roof Hook and "raking" them off. This will expose the wood sheathing beneath and will make saw cuts very quick and easy. Like slate, due to the lack of experience with them, many personnel are not familiar with how easy they are to remove and vent over.

Note: Clay tiles are easily broken and removed quickly, however, the underside of the tiles can very slippery which is why companies need to remove them from their operating area.

Residential Metal - Not as common as shingles, however, becoming very popular throughout the county, especially on newly built homes or older homes being remodeled. Metal is of lightweight gauge and can be easily cut through with our chainsaws. Generally metal roofs are more slippery, which may require a roof ladder even on low pitch operations. Metal decking on homes are generally secured to purines that run horizontally across the roof and are sometimes placed on top of older/pre-existing roofs. One of the few residential roofs that may require an inspection hole initially and quickly. More will be discussed in rain roofs section.

COMMERCIAL ROOFS

Commercial roofs are generally also referred as “flat roofs”. Some commercial buildings are operating out of existing residential buildings with a pitched roof. However, majority of commercial buildings in commercial built occupancies are flat roofs. It is also a requirement to state that flat roofs are not actually flat, but a very slight sloping angle for water and debris run off. All flat roofs are made up of three components above the rafters/joists assembly.

Rafter/Joist assembly

1. Base layering
2. Thermal insulation layer
3. Vapor/water barrier

Rafter/Joist Assemblies –

The most popular joist assembly in commercial buildings are Bar joists. They are formed from steel/steel grade materials and are designated by a three part code on building plans. The first part of the code is a number, the second part is a letter or series of letters, and the third part is a number. The first part tells your the joist depth, the second indicates the “series” and the third part of the code indicating the make up of the chord cross-section.

When new buildings are being constructed, you can immediately know, talking to the contractor, the exact information of the joist construction. This will not only help you in future incidents at that building, but others built like it.

Below are the general breakdown of the series of the steel bar joist with minimum and maximum depth for each series.

K SERIES - Common open web joists- These common open web joists are standard size joists used for typical applications. The span of K series joists is from 8 to 60 feet and have depths of 8 to 30 inches. The K series joists have chord section numbers from 1 to 12. The smallest K series joist is a 8K1 and spans up to 16 feet. The largest is a 30k12 and spans from 30 to 60 feet.

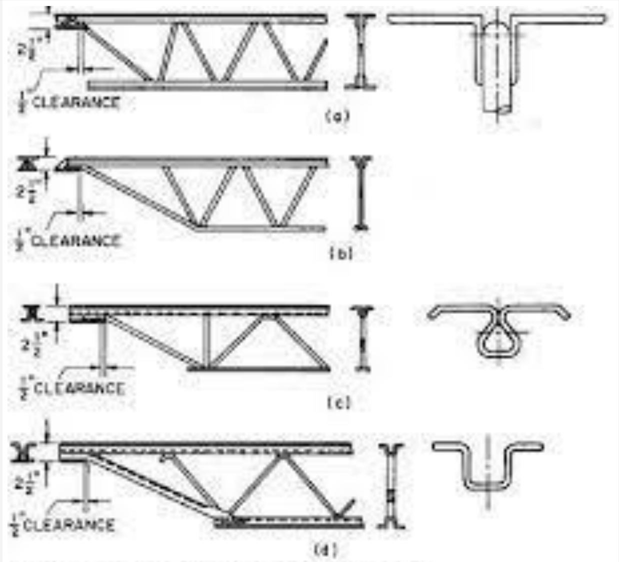


FIGURE 8.22 Some examples of open-web steel joists.

CS SERIES - Constant Shear Joist – These CS are specially designed for non-uniform loads and concentrated loads. The CS series joists depths vary from 10 to 30 inches with chord section numbers from 1 to 5.

LH SERIES - Longspan Joist- These joists span from 25 to 96 feet. The LH joist depths are from 18 to 48 inches with a chord section number of 2 to 17.

DLH SERIES - Deep long span - These can span very long. From 89 feet to 144 feet and have a depth of 52 to 72 inches. The DLH chord section numbers run from 10 to 19.

SLH - Super Longspan - These span from 111 feet to 240 feet with depths of 80 inches to 120 inches. Chord sections numbers are from 15 to 25.

At this commercial hotel built in the early 90's, construction used 2 x 12 beams spaced every 12 inches underneath the membrane.

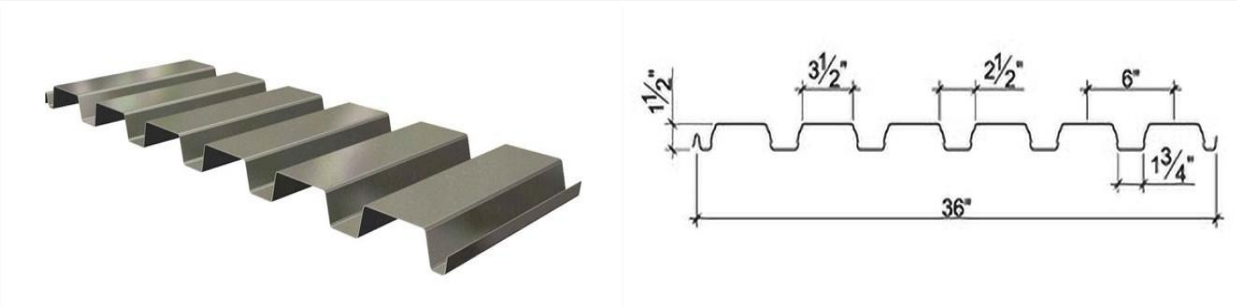
If the system is not of a bar joist/open web joist construction, older buildings especially are built from conventional wood or newer buildings may have Glue-Lam or lam-beam as the main load bearing component. Both of these construction features are very strong, but sometimes are hard to sound and feel for joist spacing once the additional layers are applied on top.

Lam-Beams - Very large beams with spacing as much as 30-40 feet, but usually restricted to 20 feet for weight distribution. Between the lam beans, purlins made of 4 x 12 or large beams will be installed 8 to 10 feet apart and then smaller rafters will be installed between the purines at 16 inches to usually 4 feet apart.

BASE LAYERS -

There are two materials for base layers of flat roof construction in our area. They are metal decking and/or lightweight concrete.

Metal Decking - Also known as "Q" decking (Quick Lock). Metal decking is a corrugated lightweight metal piece usually from 36' to 48" wide sections. You can find it as heavy as 16 gauge to 22 gauge.



Metal decking is attached to joist layers using one of two methods. Structural screw fasteners or tack welds.

Tack welds showing where the joists are located on this particular roof

Structural Screws set into the joists

THERMAL INSULATION LAYERING

Like the base, there are two typical layers for the thermal insulation in this area of South Carolina. Rigid foam insulation and fiberboard also known as “chip lathe”, are the two layers that builders will apply above the base layer.

The foam boards are usually applied in 4 x 8 or 8 x 12 foot pieces and can be anywhere from 1 to 8 inches deep.

It is usually applied with the same type

of fasteners as above (6 inch screws with metal tabs.

Fiberboard (chip lathe) - is a crushed wood by-product that manufactures press together in large pieces and use an glue/adhesive to hold together.

When the fiberboard is under a newer or well-kept roof, it can be easily removed in pieces. However, if the roof has been leaking, many times the fiberboard will absorb the water and asphalt layering and will not only break apart in pieces, but also may be "fused" together and hard to pull up.

Fiberboard from a leaky roof that absorbed the asphalt membrane.

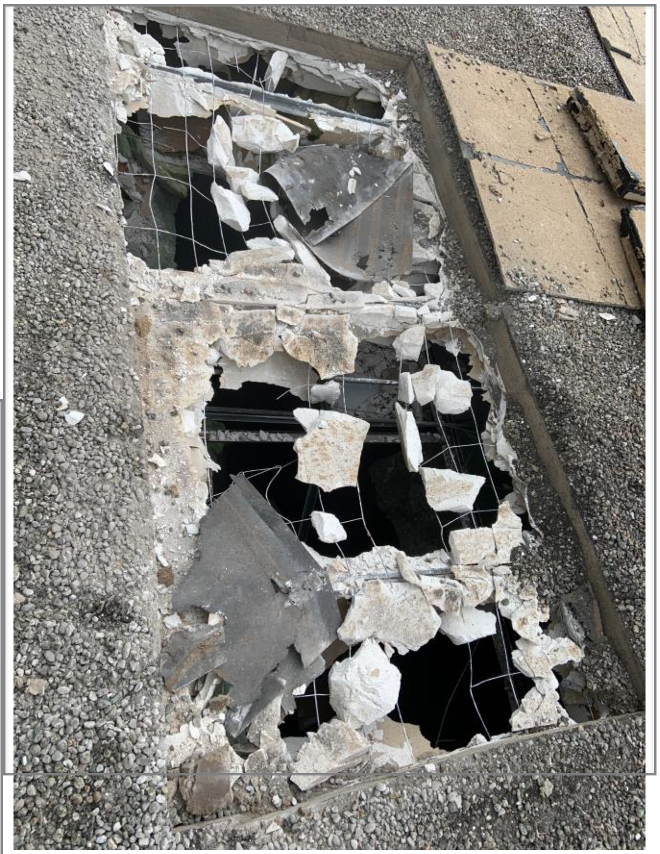
Regular fiberboard or chip lathe layering glued down.

LIGHTWEIGHT CONCRETE -

Lightweight concrete is the second base layer or thermal layering that can be used on commercial buildings. Metal/Q decking can be used as a base layer with lightweight concrete as a thermal barrier or lightweight concrete can be used as a base layer and as a thermal layering.

Lightweight concrete is a mixture made with lightweight coarse aggregates such as shale, clay, or slate which gives it its low density characteristic. Lightweight concrete has a density of 90 to 115 pounds per cubic foot. Regular concrete has a range from 150 to 170 pounds per cubic foot. Lightweight concrete is a very common roof material here in the midlands because of its weight and forming capabilities.

Lightweight concrete, when hit with a blunt tool, quickly breaks apart into pieces, making it easy for roof crews to open it up for ventilation options. It has an white/yellow appearance and looks like drywall.



The picture to the left shows the three layers of this flat roof.
1 - The top (rock)
2 - two layers of fiberboard (thermal),
3 - Base layer of lightweight concrete.

Lightweight concrete can be anywhere from one inch to over one foot in depth.

WATER/VAPOR BARRIER - The top layer of a flat roof can be a variety of materials. Also note, that over time and renovations and additions to the structure, the layers of roofing material can vary as well.
Here, in the midlands of South Carolina, you can almost 100% expect a waterproofing composite/ membrane due to the weather and humidity. The top layer protects the lower two layers from the elements and general maintenance.

There are two general membranes that we will run into on flat roofs.

1. Asphalt based with rock
2. Membrane/composite based

Asphalt based is a layer of a asphalt layering that is covered by rock. The asphalt laying is usually between 2 and 4 inches thick and covered by river rock or smaller gravel rock also called marble chips. Also covered in the cutting section, it is not worth the time or effort to “shovel” or move the smaller gravel/marble chips. If the building has the large river rock, it is in fact advantageous to remove the larger rocks.

Membrane/composite based can be broken down into a few different material based/application based layers:

PVC - short for Polyvinyl Chloride and Vinyl, is a single-ply thermoplastic roofing membrane known for its superior durability, longevity, and energy efficiency.

- The seams of PVC membrane are hot air welded, creating a permanent bond. The seams are stronger than the membrane itself.
- PVC roofs have been successfully installed on low-slope (flat) roofs since the 1960s.
- Residential grade PVC comes in 50 mil thickness while commercial grade comes in 80 mil thickness.
- This membrane is glued to the roof insulation and decking and usually not mechanically (screwed) attached to help prevent the seal and wind uplifting.

EPDM Rubber - short for Ethylene propylene diene terpolymer, is a rubber roofing membrane that is considered a low-cost alternative to PVC roofing.

- EPDM rubber manufacturers try to minimize/avoid seams with their membranes as EPDM seams are often common points of failure with this type of roof. To help mitigate roof failures at the seams, wide span EDPM membranes are commonly used.
- EPDM rubber membrane sizes can reach 50' wide by 200' long. These huge pieces are great for avoiding leaks at the seams, but are very difficult to handle during installation.
- EPDM are not as thick at PVC membrane roof material.

TPO - short for thermoplastic polyolefin is a single-ply thermoplastic roofing membrane that offers good overall performance and great energy efficiency.

- TPO membranes are newer as they made their initial appearance in 1990s, but were plagued with performance issues until recently. Manufacturers have invested into TPO roofing and have been performing excellent since 2010.
- Similar to PVC, TPO membranes are hot air welded, but the two systems have different chemical composition and cannot be combined.

This picture series shows the process of hot-air welding. The seams are heated and melting on top of additional layers of membranes

- TPO membrane chemically bonds rubber, as well as numerous filler materials. In that sense, its somewhat closer to EPDM rubber than PVC, although, unlike EPDM, TPO seams are hot-air welded (not glued like EPDM).

Modified Bitumen (asphalt based) - is an asphalt based multi-ply roofing system, is considered the newer and modern take on its close “cousin” built-up roof or BUR.

- It is installed in multiple layers, each is torched to the surface below at every 1/4 turn of the roll. This is a very labor intensive process that is performed by professional and commercial companies.
- This type of roof does have “cold” rolled technologies available now, but it involved a lot of application of roofing tar.
- Very expensive but strong roofing materials.

Built-Up Roof or BUR is also called Tar and Gravel. It is the “cousin” of the Bitumen, with often an added layer of gravel on top.

- BUR installation includes applying multiple layers of ply sheets that are bonded together using hot asphalt. The top layer can be a reflective coating or membrane for energy efficiency.
- Marble chips or pea gravel can be added to durability purposes only.

WOOD FLAT ROOFS

Especially on older commercial buildings, wood construction is still very much a possibility when operating on a flat roof.

Like composite/membrane, flat wood roofs are have some sort of insulation attached to them on the underside.

Also, it is very much a possibility when operating on a membrane roof to have wood slats or boards underneath the rubberized membrane.

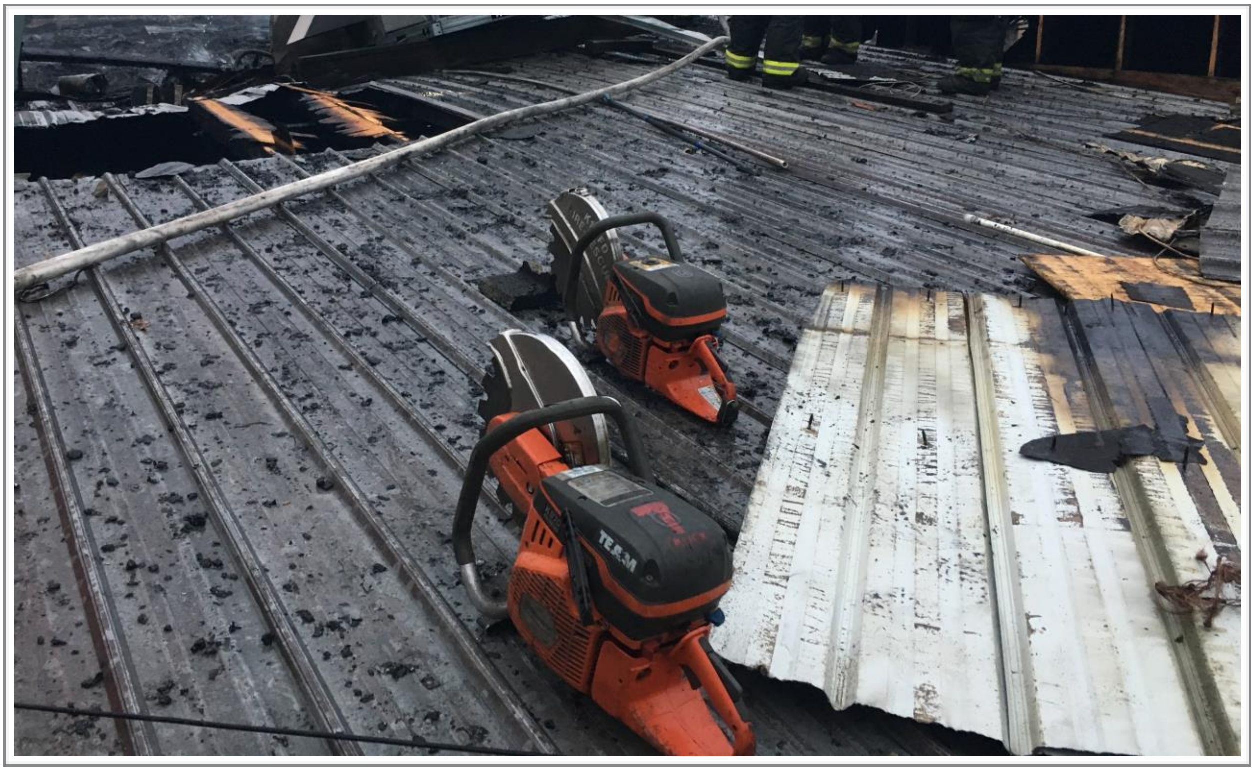
Wood flat roofs are very stable and very reactive to sounding techniques and are generally very strong to work on. Wood flat roofs will be discussed later on cutting techniques, but are generally much quicker and

Wood OSB decking along with 2 x 12 wood joists that were covered by a rubber membrane.

easier to work on and cut compared to membrane roofs.

METAL/FIBERGLASS ROOFS

Lightweight metal roofs are still a viable option for construction purposes. Metal roofs are very reactive to sounding, however may not be as stable as other roofing materials. If possible, it is recommended to cut metal and fiberglass roofs from a Tower Ladder/Aerial.



Some metal roofs, like pictured below, have a wood base, which makes it much stronger during fireground operations.

Fiberglass roofs are usually found on metal commercial buildings/shops. Almost all of these roofs are bolted or screwed into the metal I-Beams that can be spaced 12 to 36 feet apart. These roofs can be very unstable and even when not on fire, walking on these roofs should be carefully sounded.

Many firefighters have slipped on these roofs and a few have fallen through the covered skylights that many times have been painted over or covered in debris. The City of Columbia Fire Department had an experienced Ladder Chaffeuer medically retire after catching his partner who slipped through a covered fiberglass skylight. The shop had a small fire in a piece of machinery that spread to the roof insulation. Companies were sent to the roof to check for any extension to the roof material, when the firefighter slipped into the painted over skylight.

This roof has been modified multiple times.

- Top layer - asphalt BUR with pea gravel.
- Insulation of over 12 inches of chip lathe/ fiberboard
- Base layer - two inches of lightweight concrete.

A typical commercial roof layering of

- Asphalt with pea gravel
- Thin (1 inch) of fiberboard
- Two inches of foam insulation
- Base layer of Q/ metal deckings

Another commercial roof modification of:

- Top layer of asphalt with gravel
- Fiberboard layering of one inch
- Foam insulation of four inches.
- Base layer of metal Q decking.

Double Roof - The roof above is also referred to a double flat roof. The Top layer of rubber membrane has two layers of foam insulation, a layer of asphalt membrane, additional layer of asphalt gravel, fiberboard and than metal Q decking. The depth of this roof was approximately eight inches.

TOOL AND SAW SELECTION FOR VERTICAL VENTILATION

RESIDENTIAL

On residential roofs, whether walkable or unwalkable, the following tooling and assignments are the same. It is important that all ladder companies perform ventilation operations in the same manner. It is not uncommon for a company to consist of members from different shifts or experience levels. The following roles within the ladder company have been developed in order to be consistent. Much like inside/outside assignments, roof team tasks are established at the beginning of each shift to ensure each member knows their role. These roles can be given as a team of two or four.

Lead Hook - Most experienced firefighter for sounding purposes and heat hole identification. They should be carrying a LA Roof Hook and axe. If the axe is not on a scabbard, the axe can be dropped on the roof, at the tip of the ladder. This member is also responsible for opening up after the cut is made.

Sawyer - Main sawyer, should carry the saw (running) along with a roof hook (should be left on or near the ladder). The main sawyer will follow the lead hook and not break off until the area is sounded properly.

It is always recommended to have an additional saw on even residential roofs.

- Axe - Pick or Flat, Pig or Piglet.
- Stihl Chainsaw x 2 with carbide chain
- LA Roof Hook.

COMMERICAL

On commercial fires, at minimum their should be four members going to the roof initially, with the second ladder company also reporting as well. A total of six to eight personnel should be assigned to the roof of a commercial building.

Lead Hook - Most experienced firefighter, sounds roof and provides direction and initial inspection hole and heat hole direction and position.

Sawyer #1 - Main sawyer to cut inspection hole and initial heat hole.

Sawyer #2 - Additional sawyer and experienced firefighter to open up inspection hole and identify construction and show the crew. Will assist Lead hook in direction and type of cut needed. This sawyer will also switch out to chainsaw or switch rotary blades if needed, based on construction material.

Officer - The Officer will be the last on the roof and last off the roof. They will be overseeing the operation and assisting with opening up when needed. Will assist in sounding in the rear as the company moves on the roof and make all radio transmissions. This officer will designate himself as “roof” division and will manage the second ladder company and monitor all radio communications and needs for the roof division.

Lincoln Bar
Axe/Pig
LA Roof Hooks x 2
Chain saw
Rotary Saw x 2
Saw bag

SAW SELECTION FOR VERTICAL VENTILATION.

*Reference Chapter 1 tooling for more information

Residential Roof Saw –

STIHL 461/462 Chainsaw with RDR Carbide chain

Commercial Roof Saw-

STIHL 461/462 Chainsaw with RDR Carbide Chain

Husqvarna K1270 with 14” Carbide Blade (Recommended Saw)

Husqvarna K970 with 14” Carbide Blade and 14” Multi-purpose blade (Minimum rotary saw taken to the roof)

Saw Roof Bag:

1. Small Can of TruFuel
2. Small can of Cooking Spray (spray on blades prior to use)
3. Small can of WD-40
4. Small can of marking paint
5. Small can of Brake cleaner
6. Multiple wrenches for STIHL saw and Husqvarna saw (Top Saw Set)
7. Extra 14” Carbide Blade
8. Extra 14” Diamond Blade
9. Extra pull cord assembly
10. Razor Blade
11. 75’ of small diameter rope ROOF SIZE-UP

The most important step in the vertical ventilation process is the roof size up and roof report. If companies do not provide an accurate and informative roof size up, venting for trapped occupants and/or the engine company will be delayed and can cause serious injury or death.

For residential fires, a 360 is generally enough for the roof team to make initial topside decisions until they get on top of the roof and begin the sounding process. For commercial roofs, due to the size and construction a more detailed roof report is needed.

<u>The roof report that ladder companies should adhere by is as follows:</u>

Initial Roof Report

1. Type of Roof
    1. Flat, pitch,
    2. Membrane, LW Concrete, Metal
2. Condition of Roof
    1. Stable or Unstable
3. Actions being Taken
    1. Inspection hole, Sounding and moving, Heat Hole, Trench cut

<u>After the Initial Roof Report and the inspection hole is made, the following report should be communicated.</u>

1. Material/Roof
    1. Confirm material description
    2. Communicate additional needs for second ladder company
        1. All Saws, all tools, manpower
2. Roof Loads
    1. Any additional roof loads including HVAC
3. Basic Blueprint
    1. Approximate shape and size of building
    2. Location of Heat hole

These reports must be communicated to assist other companies and crews of the timeframe and construction expectations. The Ladder company officer should ensure that his firefighter's radios are on, but turned down and that his is turned up. The officer should be managing and making all communications from the Roof Division.

SOUNDING AND WALKING ROOFS

Sounding and traveling on the roof is the second most important task a ladder company must execute. As of January 1, 2022, it has been nine years since the last LODD involving vertical ventilation (Bill Carey/NFFF).

Firefighters normally slip and/or are injured on roofs because of poor and inadequate sounding techniques. Sounding and traveling on roofs should be lead by the most experienced firefighter.

Proper sounding - Using your legs and your back, take a shoulder wide stance and raise the LA Hook up and strike swiftly down with the backside. Using a NUPLA LA HOOK, the honeycomb fiberglass is rated for strength and flexibility. This will ensure a good, strong sounding along with the flexibility of movement with the handle. Using the NUPLA hook (stronger/wider hooks) you will sound a larger area compared to using a "NY Roof Hook" which generally pierces the surface and not sounds like a LA Hook.

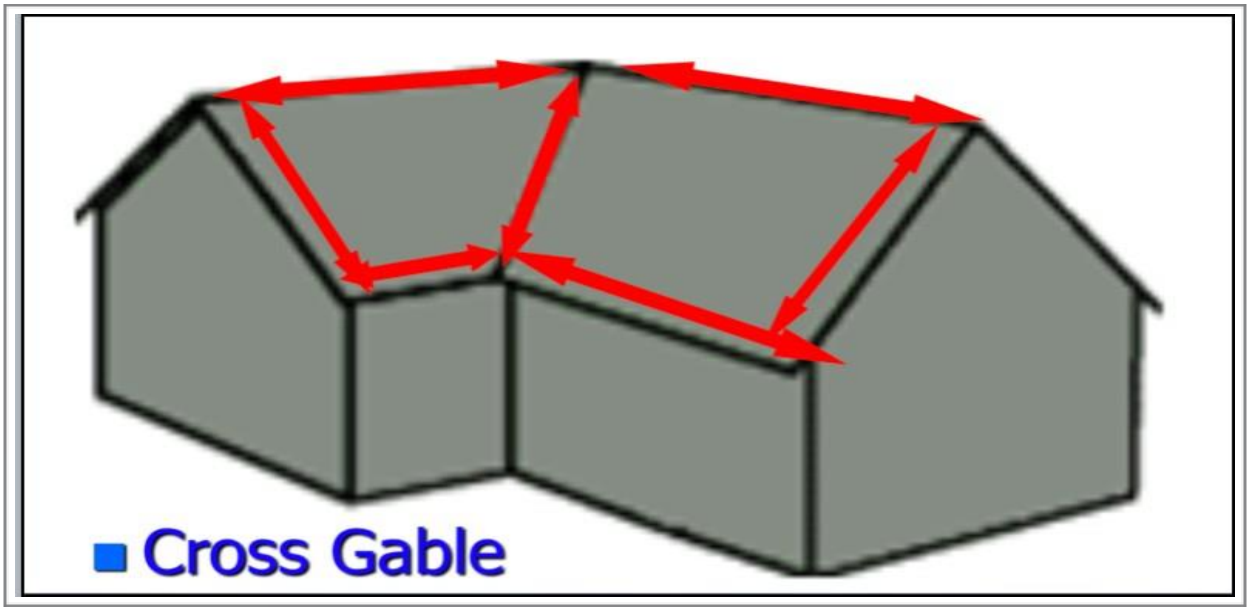
Remember that you should sound first THEN step. Many firefighters step and sound at the same time. This is wrong.

1. Sound High
2. Sound Low
3. Sound Middle
4. Step.
5. Repeat process

The company/personnel behind the Lead Hook (Sounder) should follow in the same path of travel and should only take 90 degree turns. Do not take 45 degree turns to ensure you do not cross over unsounded joists.

Residential Travel -

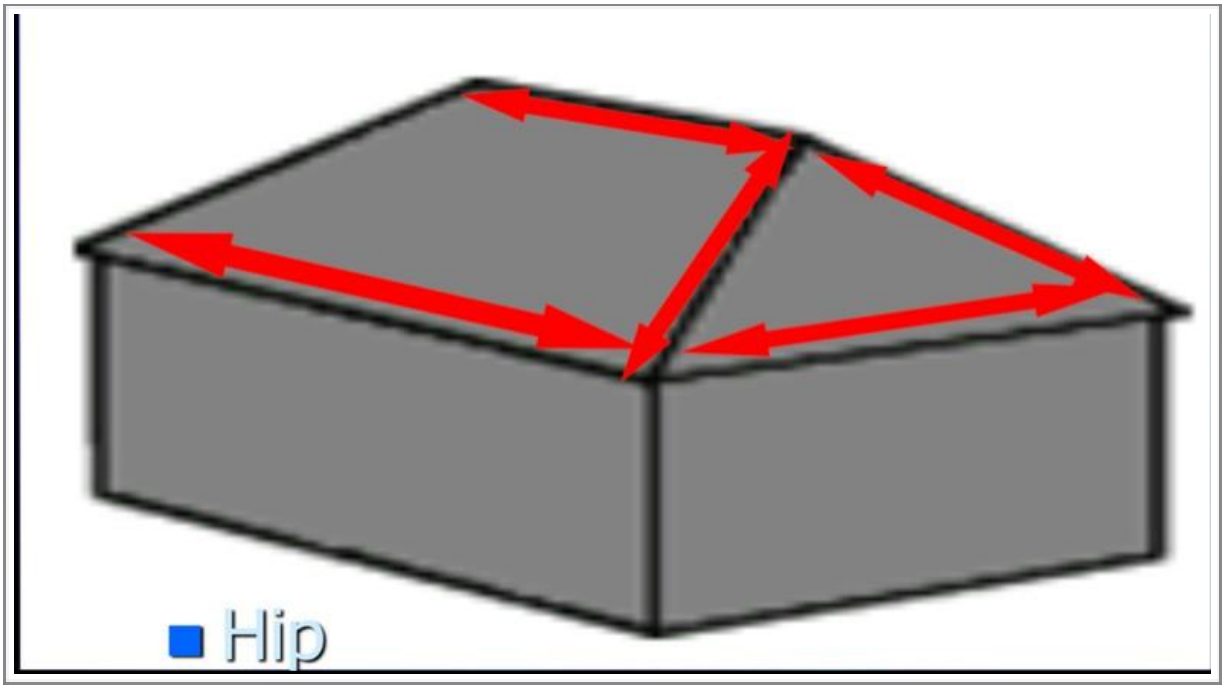
Traveling on residential roofs should focus on the load bearing members.



1. Ridgepole (older or stick built home) - Travel up to the ridge and sound until the desired location. Take 90 degree turns only.
2. No ridgepole - Travel on lower load bearing "wall" and work up.

Remember that hips and valleys are also very strong and can be traveled on with appropriate sounding.

These diagrams show the stronger locations for traveling on residential roofs. Remember on residential roofs, OSB and decking fails before trusses. If you begin to feel too much "soft" decking and/or failure up top, it is time to get off the roof and communicate that to interior companies. It is imperative that



ladder companies get out in their districts to see what roof construction is common in their first due. Just because it is newer or older buildings, doesn't mean it wasn't modified or changed. Information and construction is key in identifying ventilation points and cuts.

Commercial Travel -

Commercial roofs sometimes do not provide us with the reaction that residential roofs will exert because of its construction and/or thickness. This is why the lead sounding member must be the most experienced firefighter. They will be the first onto the roof and will direct the travel and location initially of the company.

Once the company has made it topside, the lead hook should sound towards the fire/vent location. In regards to commercial building, staying within six feet of the wall is recommended as this is the strongest artery for moving around a commercial rooftop. As the company precedes to the inspection hole/ heat hole location, the lead hook and officer (rear) should continuously sound and monitor the condition of the roof, as well as, the signs and information that the conditions/building is telling the members.

Like residential roofs, anyone operating topside on a commercial building should not cross joists at a 45 degree angle. They should always be 90 degree angles and you should sound then step. Another difference in commercial roof operations is distance. Many times, companies need to ladder far away from the vent location and will have to travel a distance to the vent location. This gives us a “safe haven” incase of failures/emergencies as well as, dropping and storing of equipment.

Companies above noticed the melting asphalt shingles and smoke pushing through the shingles. This one of the most common identifiers on where to properly place your vent hole.

VENTILATION LOCATION

Ventilation cut locations depends on the smoke conditions, company locations, and building construction.

Identifying vent locations is referred to SKIRTS

- Sounding - Especially on residential roofs, when the decking begins to get “soft” in an area near the fire, take a step back and begin your cutting there. Sounding will assist in identifying where the best location to vent would be.
- Known Fire Location - Upon finishing your 360, if you know that the fire is on the C/D side, then move towards that location for your cutting sequence.
- Interior Reports - Communicate with the interior ladder company and/or engine company for interior reports. Where is the thickest smoke and or heat?

- Roof Division - If you are responding as a second ladder company, communicate with the Roof Division (already established) and report to them.
- Thermal Imager - A TIC can be a great tool to use on the roof. Many times, especially on residential or thin commercial roofs, it will allow you to quickly identify the fire location and joists/rafter location.
- Smoke Indicators - Where is the thickest, most dense smoke pushing from?

Look at vents and plumbing pipes to assist in the location of smoke indications.

The most common identifier for proper location of ventilation is melting asphalt shingles/melting membrane roofing. One residential roofs this one of the most common sights seen, as well as, smoke pushing rapidly through the shingles. This tells us that the most heat/fire is located below and needs to be opened up.

VENTILATION CUT SEQUENCE

There are two general types of vertical ventilation holes: offensive heat holes and defensive cuts. Heat holes are cut in an offensive posture either over the fire or as close to the fire as safely possible. The goal of the offensive heat hole is lift/lean, to release the heat and smoke from the building and if needed, allow it to lite off outside the building (leaning of fuel ratio).

To be effective, a heat hole must be made in the correct location and be large enough to relieve the pressure inside the structure. If one heat hole is not sufficient, the first hole must be expanded or another hole should be cut. When the structure is pressurized by the fire, the products of combustion are still being forced into all parts of the structure. Only when the ventilation hole (or holes) relieves the pressure, can the heat and smoke begin to draw toward the vent hole and lift from the floor to allow crews to operate effectively inside.

To determine if the ventilation hole size is adequate, look at the smoke being produced from the heat hole. If the smoke from the hole is still under pressure, the hole must be extended and or additional holes placed. If the smoke leans out (this is good) you will observe Vent point Ignition (VPI). This is excellent!

Vent Point Ignition or VPI tells us that the smoke and fuel ratio needed to be leaned out to ignite and if it happens inside the structure/attic space, this could be detrimental and cause flashover and/or smoke explosions to personnel inside. Many Chief officers and personnel that do not have aggressive ventilation experiences will begin to call companies off of the roof and outside of the building when this happens. VPI is one of the best outcomes of a ventilation hole. It tells us that the building needed and wanted to be vented and topside crews should continue to extend and/or cut additional holes until the smoke and fire tempers off and “leans” out. Interior crews and topside vent crews need and should communicate any changes or none at all.

Companies encountered thick and dense smoke at this house fire. As soon as the roof was opened, the turbulent smoke began to light off and finally ignited (VPI). As soon as the topside company began their additional extension and heat holes, crews inside reported low heat and excellent visibility. Their initial interior reports communicated no visibility and extremely high heat. Within seconds of this picture, initial engine company crews knocked majority of the fire down and extinguished.

The initial picture shows companies operating on the roof with thick, turbulent smoke pushing out of two already cut ventilation holes.

They extended one additional hole and then proceeded off of the roof when the smoke began to lean out of the ventilation holes.

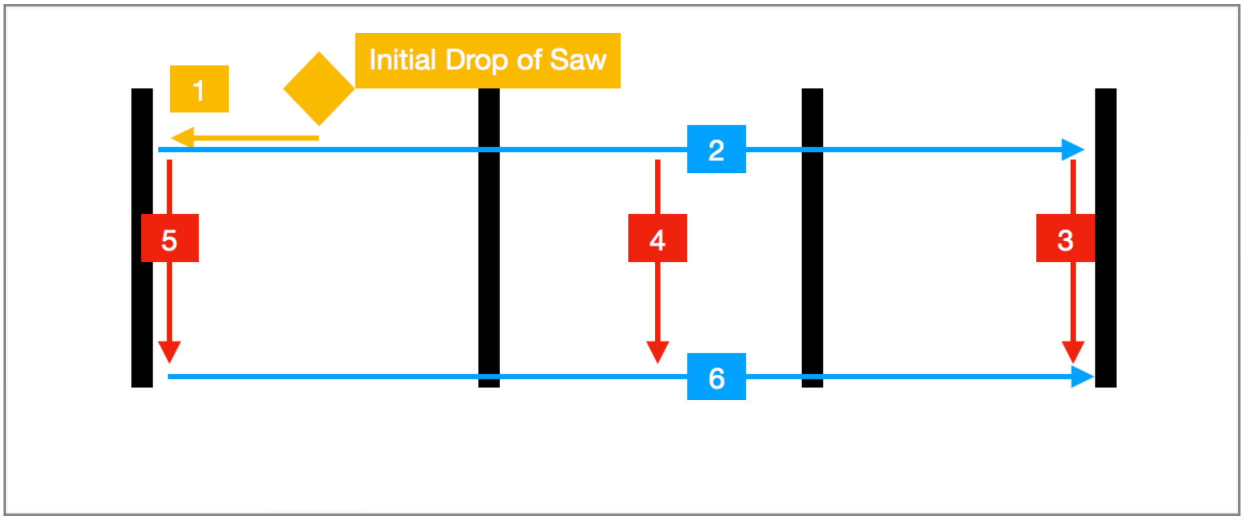
The bottom picture shows the Vent Point Ignition from the ventilation holes.

Communication from the engine company inside was a "relief" of high heat and smoke conditions. Two adults and one dog were rescued from this house fire and all three survived.

Walkable pitch ventilation-

The following process and steps are the primary vertical ventilation cut sequence on walkable pitched roofs. The LCFS pitched roof cut sequence is a double louver cut or Roll 2, Cut 3.

1. Initial ladder thrown to roof
2. Company properly sounds to heat hole location
3. Lead hook points and/or double taps the roof with their hook on cutting location.
4. Sawyer drops their chainsaw blade approximately 4-6 inches into the decking and cuts the opposite direction to “feel” for the initial rafter.
5. Sawyer hits the initial rafter and immediately pulls in the opposite direction (towards fire location) and rolls over two rafters and stops at 3rd rafter.
6. They rotate the chainsaw and cuts downward (also known as dice cut) next to the last rafter.
7. The dice cut should be about four to six feet in measurement.
8. The second dice or downward cut is in the middle of the cut sequence.
9. The third and last dice or downward cut is next to the initial rafter location.
10. Rotate the saw and complete the bottom or “skim” cut.
11. This will complete the double louver or Roll 2 (rafters), cut 3 (dice) sequence.
12. The Load hook will then move in and get down on their non-dominant knee and push down any and all ceiling/space underneath the decking.
13. Once opened up, the crew will monitor the smoke and/or fire coming out of the current hole.
14. If the smoke is thick, turbulent, and pushing/filling the hole, company will extend the hole, if the smoke leans out/laminar smoke, company will make their way back to the ladder.



The double louver cut is a very simple, quick, and efficient cutting sequence. The additional advantage is that the cut can be changed if needed for any problems that may arise, fire and/or construction issues.

Use the top of the bar to feel for the initial rafter. As a sawyer, the top of the bar is more sensitive to feeling for rafters, and as soon as you feel it, you can pull towards the additional rafters as needed.

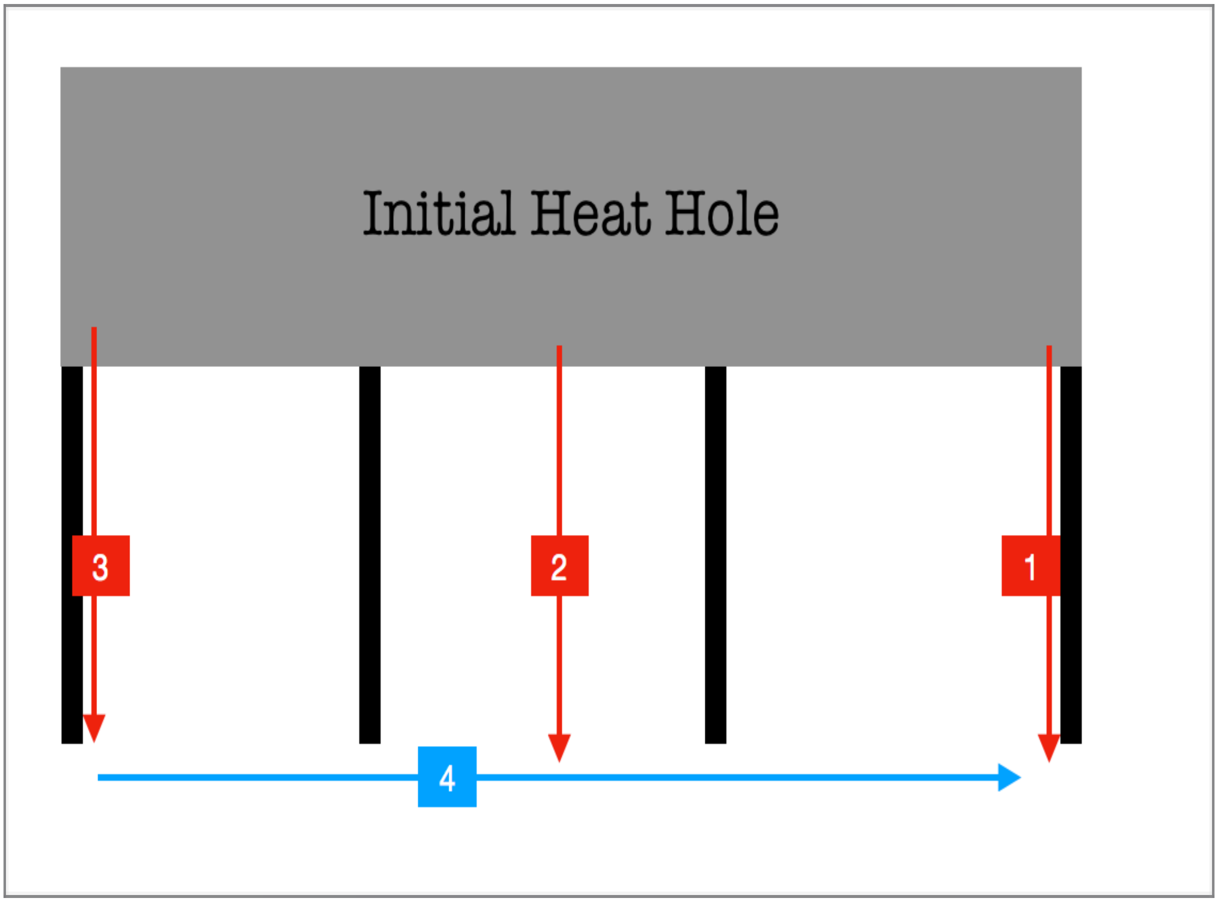
If the initial heat hole does not provide enough ventilation(lift/lean) for the space below then the hole must be extended and/or additional hole cut (if there are multiple void spaces).

Extending the hole downwards is the easiest, most efficient extending cut sequence.

If unable to extend downward, then side to side would be the secondary option of extending.

Extending the hole downward:

1. Drop your chainsaw on the inside of the rafter closest to the fire and cut downward (dice down) three to four feet.
2. Move your saw to the middle of the initial cut and dice downward a few feet.
3. Move your saw to the inside of the last rafter and dice downward.
4. Rotate your chainsaw and “skin” the bottom cut.
5. Open up and observe the conditions.



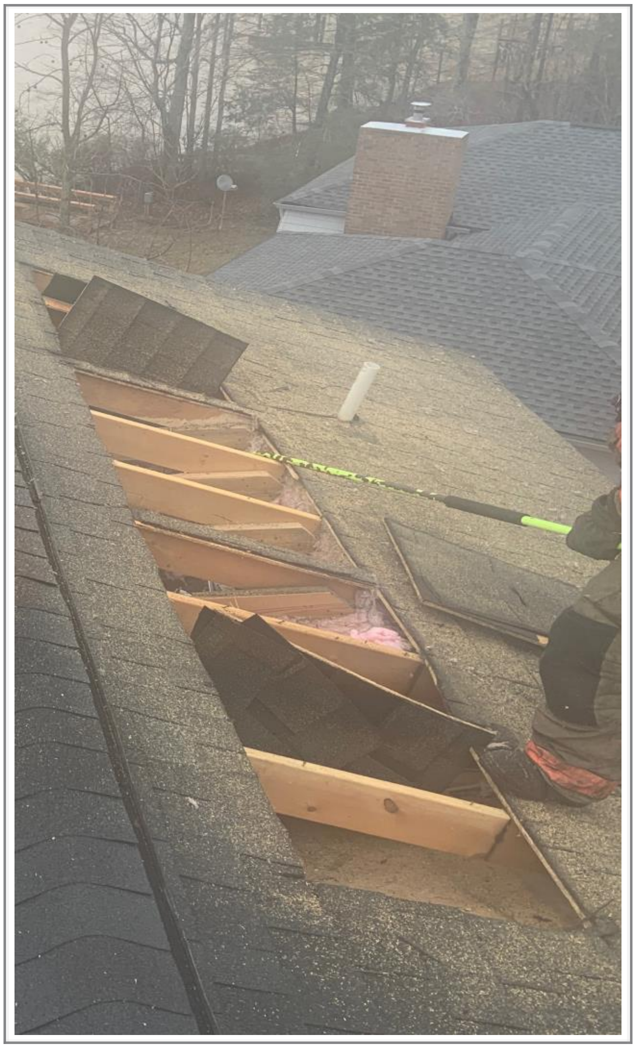
In previous vertical ventilation studies, this downward extension cut has taken less than 45 seconds from start to finish.

This heat hole was extended downward to double its size within two minutes of the start time

The picture to the right shows how companies extended the initial heat hole to the right (Charlie side).

Once the initial hole is cut, the sawyer moves his saw back to the top cut position and continues to "roll" rafters.

The sawyer then dices downward and skins the bottom until the hole is doubled in size.



Using 240 acquired buildings, with walkable pitched roofs, the following experiments were provided.

Two firefighter companies with equipped with the same tools and started ten feet away from the marked vent hole location. The following experience and timeframes were recorded:

Experience Level of Ventilation Crew	Total Time from start to finish.
Probationary Firefighters (less than 6 months)	3:02 minutes
One to two years of experience	1:21 minutes
Three plus years of experience	37 Seconds

The crews measured and cut a standard double louver (6 x 4) ventilation hole. Again, the information recorded shows that the more time and experience firefighters had, the more efficient the timeframe was recorded and the more comfortable the firefighters were in sounding, saw handling, and opening up.

Companies operating topside at this fire had heavy turbulent smoke and can be seen extending the cut downward for maximum air exhaust.

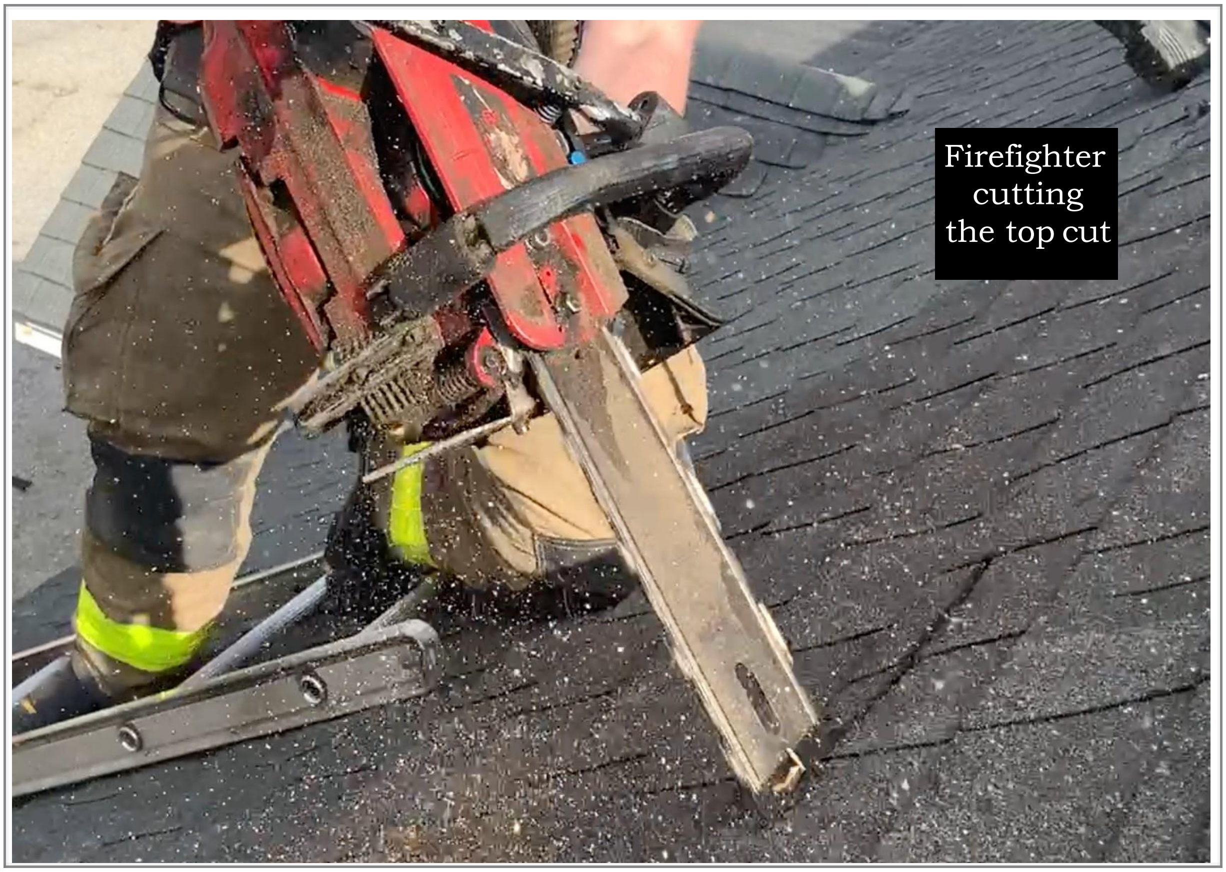
Unwalkable/Steep Pitch Ventilation

As discussed earlier, if the rise/run slope is more than 6/12, you will most likely need a roof ladder to assist with footing.

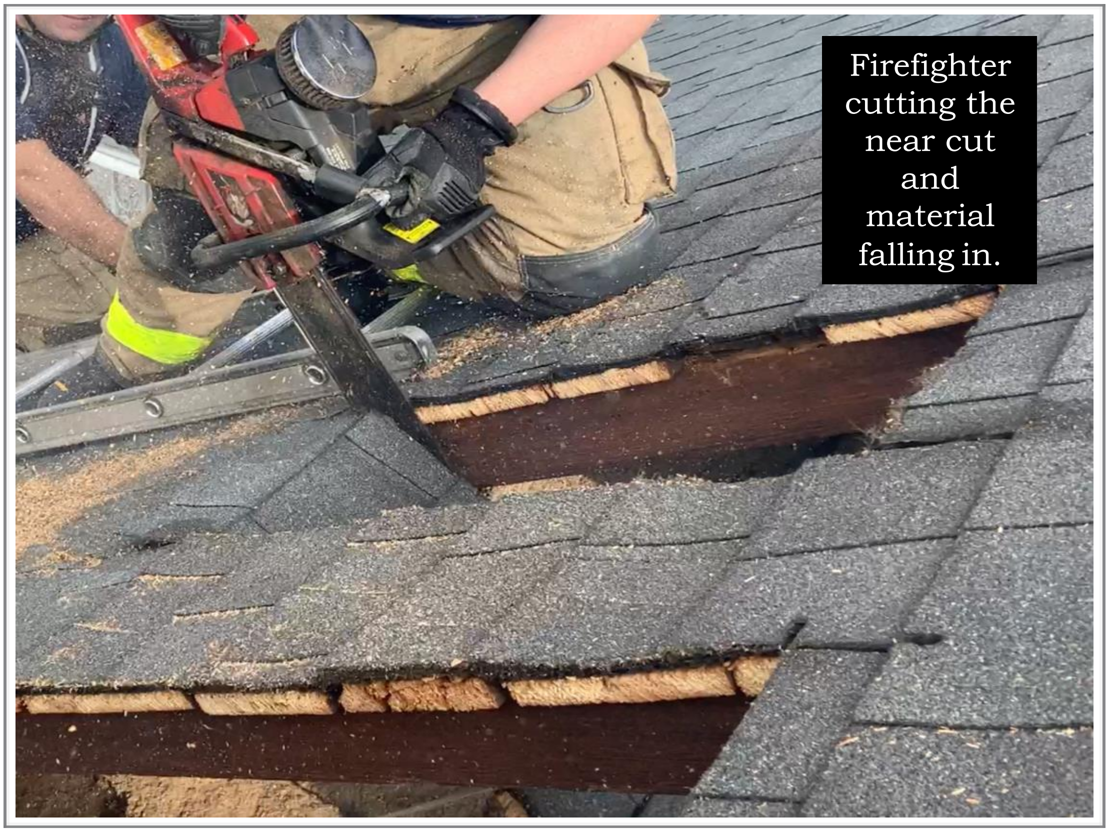
Once the roof ladder is set in place near the ventilation location, the following steps should be followed for a what our primary steep roof cut sequence will be:

Steep Roof "Strip" Cut

1. Lead Hook sounds their way up towards the ridge.
2. Sawyer Firefighter follows behind with chainsaw running.
3. Lead hook places the hook on the ladder and the Sawyer slides the chainsaw up.
4. Lead hook cuts the top horizontal cut between a single rafter bay.
5. Lead Hook cuts downward (dice cut) on the far side, approximately 4 to 6 feet down.
6. Lead Hook removes saw and cuts downward (dice cut) on the near (ladder side), the same distance down.
7. Lead hook then allows the sawyer to take hold of the saw and repeats the cut sequence, far side first, then ladder side.
8. While the sawyer is cutting the lower section, the lead hook begins to punch through the attic space.

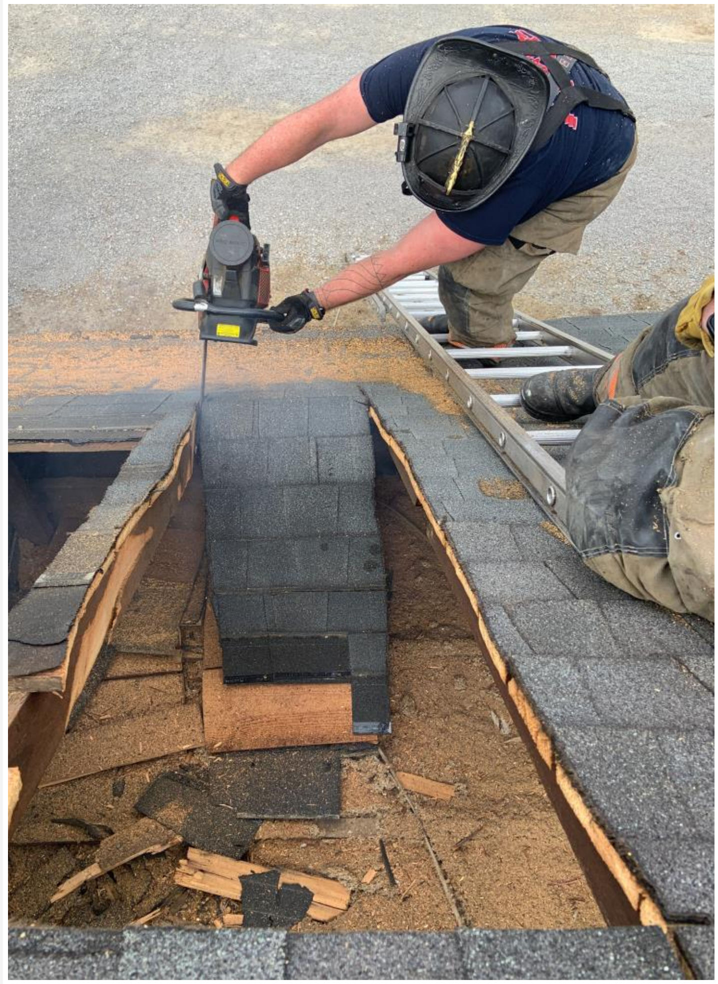


This steep cut will allow the decking and material to fall downward into the attic space.



Once the initial hole is complete, the second firefighter (sawyer) takes the saw and completes the strip cut by continuing the cut an additional four to six feet.

This cut will allow the structure to be vented quickly and will help also stop the lateral fire spread, as it is very common in steep roof attic spaces to have fire spread issues.



The firefighter on the left uses the valley of a steep roof to assist in the cutting of a ventilation hole. Using the valley is one of two ways to assist in good body mechanics for steep roof ventilation.

Notice the positioning above. This is the recommended positioning on very steep roofs.

- Rotate down onto the roof ladder, wearing an airpack, the pack will fit into the roof ladder comfortably.
- Stretch out the underside arm (if cutting on the right side, use the left arm; cutting on the left side, use the right arm).
- Lock out that arm on the side handle of the saw and use the other hand to run the throttle of the saw.
- In this position, especially on very steep roofs, you be able to move and rotate the chainsaw comfortably using a strong, stable body positioning that matches the roofs pitch.
- If you attempt to stand or knee during the steep roof cut, your body will be off balance and slipping and/or falling is greatly increased.
- If the firefighter feels like underside arm is slipping or not comfortable, they can bend their elbow into the side of the roof ladder to displace the weight and allow the roof ladder to take the displacement off of the firefighter. Just understand that by bending the elbow into the ladder, this will reduce the mobility and reach of the firefighters cut.

Another view of the firefighter using the steep roof positioning.

TRENCH Cut Sequence

Trench cut on pitch roof structures can very much provide the necessary lean/ lift inside the structure, but stop lateral fire progress better than any other task on the fireground (with exception water).

Apartment buildings, townhouses, and commercial buildings with common attics should be trenched or “strip” cut on both sides of the pitch to stop the lateral fire spread in the attic. In order for this tactic to work, an initial heat hole must be cut and help provide the fire with air. Many times this becomes the last offensive tactic, prior to switching to defensive operations.

The incident above shows where companies placed an initial heat hole, followed by the Strip/Trench hole. There was very dense, turbulent smoke throughout the entire roof system.

This offensive tactic allowed engine companies to make the large amount of fire underneath and stopped the lateral spread of the fire prior to hitting the main building (right side).

A strip/trench cut on a pitched roof is just like a steep roof operation with the exception you roll one rafter. You must open up BOTH sides of the pitch roof to completely prevent the lateral spread of the fire.

COMMERCIAL ROOF OPERATIONS

Since the early 1950's it has been documented thatthe 7, 9, 8 coffin cut has been utilized in the fire service, especially in the Northeast, on commercial roof ventilation. This cut sequence has been adopted in many fire department's across the country.

Conditions after ladder companies cut a heat hole in a common attic building fire, but just prior to the trench/ strip cut beingcompleted.

However, the South Carolina construction does NOT make the 7,9,8 coffin cut the most efficient or effective flat roof cut sequence. The roof construction has discussed earlier in this chapter has unique characteristics to the area and we should develop our cut sequences based off of the construction and manpower.

Manpower, equipment, and cut sequence are all fixed variable factors in flat roof ventilation operations. Companies need to identify the construction and base all decisions on which sequence to use, off of the construction and conditions observed.

There are two recommended routes to find out the construction of a flat roof building: pre-plans and inspection cuts.

INSPECTION CUTS

Inspection cuts, also referred to diagnostic cuts, are mandatory on flat roof operations. Under no circumstances will the first due ladder company ventilate a flat roof building without cutting and communicating an inspection hole. Unlike residential structure where we would typically vent directly above the

fire, commercial/flat roof operations need to plan and think farther ahead. We still must ventilate over the effected area, however, based on the construction and timeframe, we must anticipate the direction and location in front of the fire.

The inspection hole shall be cut within ten feet of the initial access of the roof. The inspection hole should be located between the fire and our access, but not in the travel route where firefighters may trip and/or fall into it.

The inspection hole serves four main purposes:

1. Determine the roof material/construction and thickness
2. Determine our cut sequence
3. Current fire and smoke conditions
4. Gives advanced warning to crew who are cutting the main ventilation openings. For example, if we look over and now see fire or dense smoke pushing from the inspection hole, the fire has advanced past the company and you need to change tactical priorities.

Once the initial inspection hole is cut, an additional inspection hole shall be placed:

1. Every 20 feet of travel on large flat roof buildings
2. Companies crossed over a fire wall or major separation
3. Companies notice a possible change in roof construction

An inspection hole is a three sided hole, in the shape of a triangle, approximately 12-14” wide. The inspection hole needs to be large enough so that a firefighter can pull a small amount of material out, check the joist spacing underneath and able to monitor the conditions below. It should be small enough so that it is not a hazard to companies operating topside and it takes minimum time to cut and open.

Once the inspection hole has been cut, the lead hook or sawyer should remove the entire triangle piece, which is called the “plug”. The plug should be removed and shown/passed around to everyone in the company to visually identify the thickness and construction materials. The plug should be placed by the direction of travel for additional companies making their way onto the roof. This will enable additional companies to visually identify what material they will be assisting to open up.

Picture shows a typical "plug" from a flat roof operation. This plug will be passed around to all members operating topside to identify the construction and thickness. The plug will help identify the cut sequence.

As the plug is quickly passed around, the sawyer will lay down and insert their arm into the inspection hole and rotate 360 degrees to feel and identify the joist material and spacing. Depending on where the inspection hole was placed, they may or may not feel a joist. If this is the case, then you should assume that your inspection was cut within the middle/ center of the joist spacing. The average firefighter should be able to reach five to six feet in each direction.
Most commercial flat roof construction

Picture of how the firefighter should reach in and insert their arm (up to their shoulder) and rotate around to feel and identify additional construction joists and materials. If fire exhausts out of the inspection hole, you should NOT insert your arm into the hole and should quickly communicate the fire is past the opportunity to possibly cut.

should have about on average, eight foot spacing.

Once the firefighter felt and identified the joist spacing and direction, they should remove their arm from the inspection hole, make eye contact with the other members of their crew, and visually swing their arm in the direction of the joists. This will ensure that all members of the company are on the same page and understand the direction and spacing of the joists and materials.

Once the inspection hole is complete, the company should continue sounding their way towards the fire location for the main ventilation hole location. Once the location of the ventilation hole is identified, companies will choose of the following cut sequences based on the construction material and manpower availability.

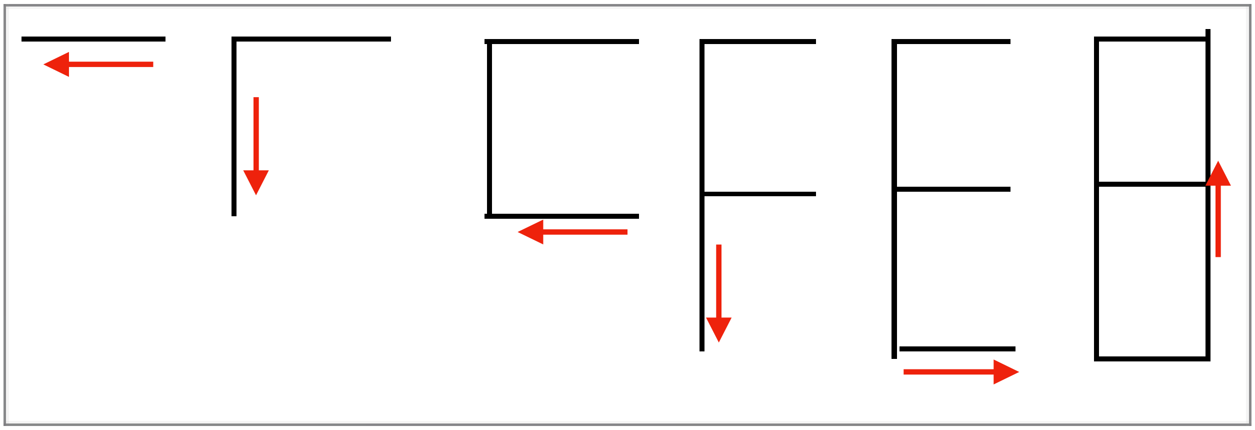
A. 3/1 Cut
B. 3/8 Cut (mirror cut)
C. Channel cut
D. Hot Side L's Cut.
E. Trench (defensive cuts)

Communicating the cut sequence just prior to starting will provide a more efficient and effective operation. It will limit the duplication of energy and effort, allow all members to work together efficiently, and enable non-verbal communication (as working topside on a fire is loud). Once the cut sequence has began, the officer will communicate via radio to the additional ladder company making their way to the roof, and let them know what the cut sequence is, roof material, and what additional saws and/or tools they may need.

3 / 1 CUT SEQUENCE

The 3/1 cut is a simple cut sequence that should be used for the following situations.

- Limited saws (less than 2).
- Built up roofing of more than 6" in thickness
- Lightweight concrete and membrane based construction.



As noticed in the table above, the cut sequence makes an "E" or "3" then the sawyer finishes off the cut with the final "leg" or the "1". The red arrow demonstrates the direction the sawyer should be cutting. Generally all middle cuts should be worked from the middle out.

Working cuts from the inside or middle outward provides the following advantages:

1. Sawyer is able to make eye contact with other crew members.
2. If running multiple saws, both saws are always running away from each other.
3. Personnel will stay outside on the main joist sections and not in the middle. Personnel will and should not have to cross over cuts like in the older "coffin-798 cut".

At any point in time during this and other cut sequences, an additional sawyer can be introduced drastically increase the capabilities of the company.

It is also imperative that members run the saws with the appropriate handling. Members should place their non-dominant hand on the top of the powerhead of the rotary saw, also called soft hands. Using this technique will give the sawyer:

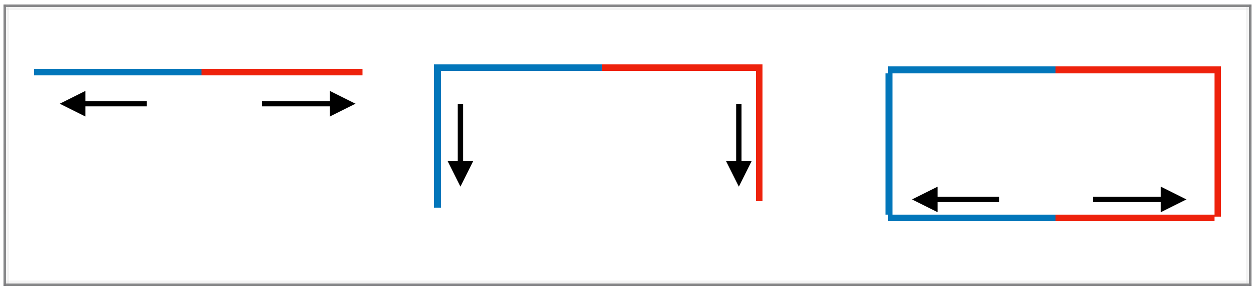
- More stable stance
- Soft hands allow the firefighter to "feel" the powerhead rev upand possibly hit a joist or construction feature
- Soft hands allows consistent saw movement and reduces the "bog" down issue of "pulling the saw"

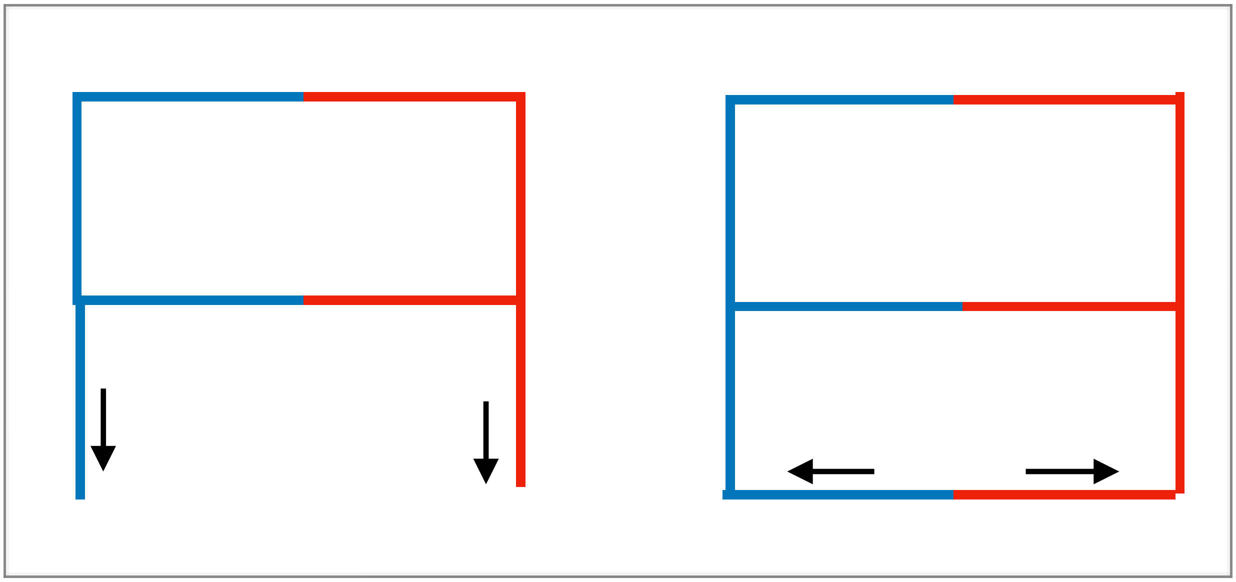
3/8 CUT SEQUENCE

The 3/8 Cut sequence is based off of the 3/1 cut and should be used in the following situations:

- Multiple saws readily available or close-by companies (manpower heavy)
- Any roofing material less than 6” in depth.

The 3/8 cut sequence is also referred to “mirror” saw cuts.





As you can understand from the diagram above, the 3/8 cut works best with two sawyers operating away from each other for each cut. Both are “mirroring” each other by cutting a “3” which turns into an “8”.

Depending on the roof material and joist spacing, this cut can either be located between a single joist bay OR I can cover two joist bays. Companies need to understand that it will take work to remove the decking and material that is structurally attached to the joist underneath.

Picture of a 3/1 Cut sequence completed

Many times during a 3/1 cut, the material within the vent hole will fall down into the building. This is another advantage, using gravity and the building construction to assist our operations.

3/8 Cut using dual rotary saws. If two saws are available from the initial beginning, this is a great saw sequence to use.

Picture to the right shows a 3/8 “mirrored” saw cut sequence maximizing in one joist bay.

The picture to the bottom right of the page shows a 3/8 “mirrored” saw cut sequence maximizing over two joist bays. This is especially useful if you confirm that the decking is less than 5-6 inches thick and have multiple saws and personnel to assist with opening up a large ventilation hole. The larger the hole, the more weight the companies will have to displace upon opening up.

It is also imperative to understand that when operating dual or more rotary saws they should beworking from the middle/ inside to the outside and away from each other.

This allows members to move around the hole, away from a weakened spot and allows the saws to be continuously moving and progressing.

CHANNEL CUT

A Channel cut is a cut sequence when members begin the cutting process by dropping the saws into the decking material and cutting two side by side cuts the width of the vent hole desired.

Most widths of this nature should be within one or two joist bays, but can be more if needed due to the fire conditions.

This channel will be then opened up and the metal decking underneath will be examined to find the tack welds or screws of the joist spacing.

Once the joist spacing is identified, the sawyers will run two additional cut lines from the channel to the desired length.

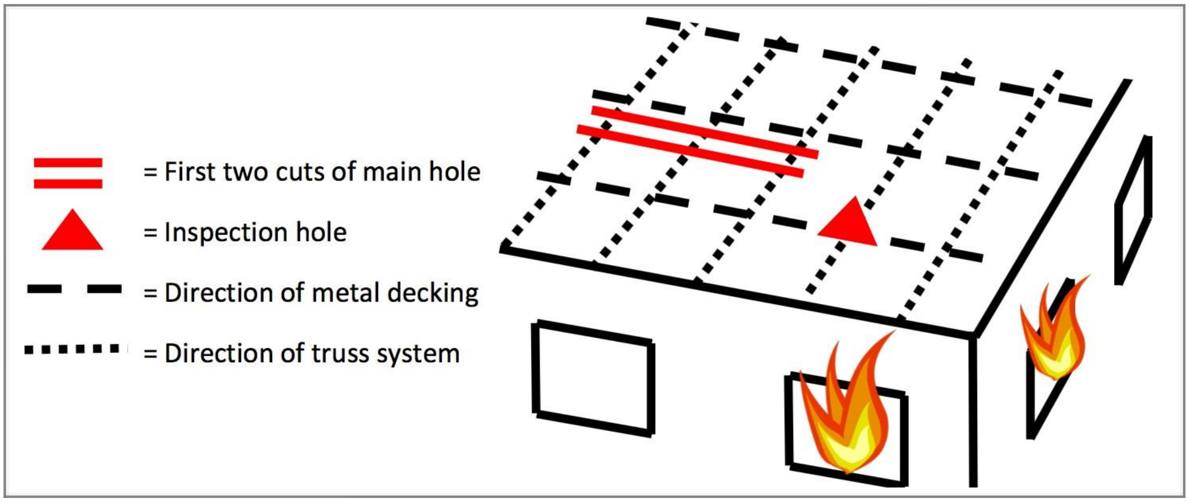
Depending on the thickness of the material, if the material is less than 5", as the sawyers cut, the material will fall into the void space automatically opening the hole.

If the thickness is more than 5", then the sawyers may have to make a "step cut" or multiple cuts stepping into the desired ventilation hole.

A channel cut sequence should be used in the following situations:

- Extremely thick (6"+) material or thin material.
- Any Composite, build up or membrane roof.
- Does not work well on lightweight concrete roofs
- Experienced crews
- Easily expandable holes are needed
- Unknown material or decking information
- Single or multiple saws available

The basis of the channel cut is defined on the size of the building. Generally the main joists/truss system is ran the shortest distance of the building. Metal decking is placed on top of the joists in the opposite direction for strength. Once the top layer of decking/material is removed, it is generally very easy to spot the tack welds or screws that are run parallel with the truss system and perpendicular with the metal decking.



The additional advantage of the channel cut sequence is when the roof is made of extremely thick material (6+) inches.

Using a Chainsaw with carbide chain, you can quickly outline and “skin” the top layers and quickly remove them.

Once the top layers are removed, companies are able to quickly identify were the welds or screws in the metal decking are located and can use a rotary saw to cut the decking.

All of our current carbide blades will cut through the metal Q decking, however, while the chainsaws are removing the top layers, sometimes it is advantageous

to swap out both rotary saw blades with diamond/multi-purpose blades for a more efficient and effective cutting movement.

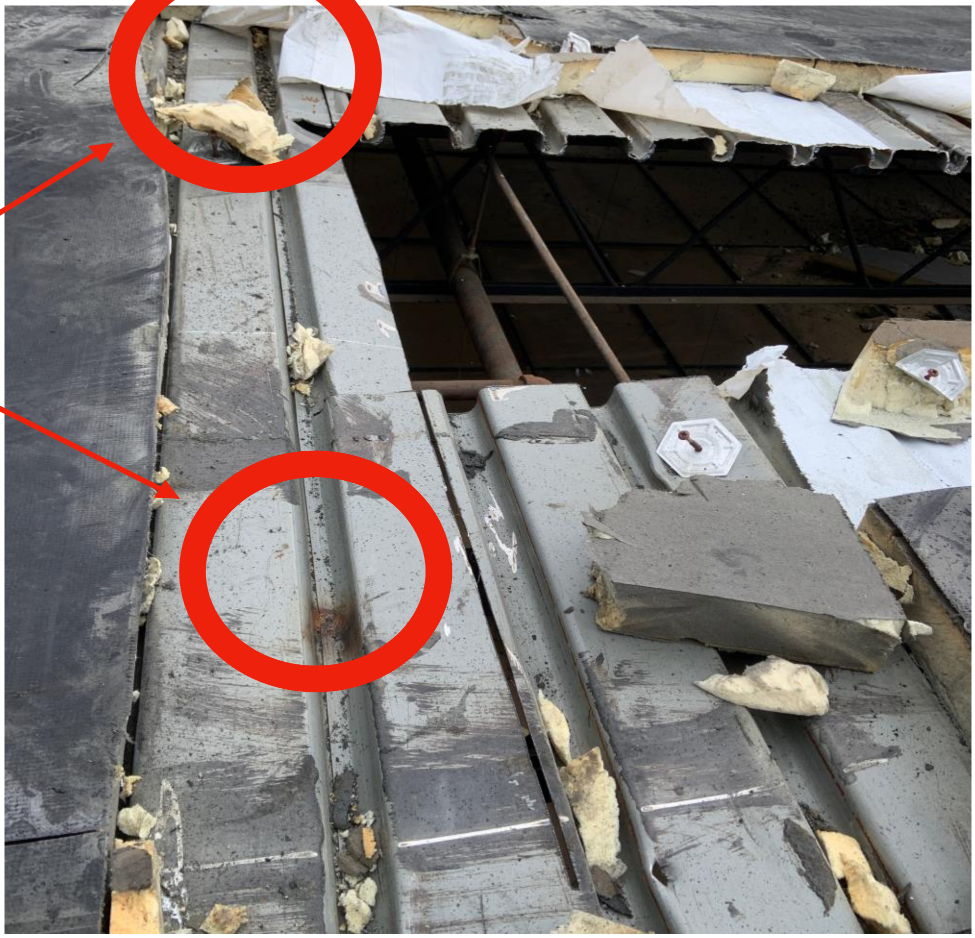
Chainsaws make quick work of this building with over a foot (12”)+ of fiberboard layering. Using the chainsaw to quickly remove this layering, enabled companies to “step” into the cut and quickly use rotary saw blades to cut the metal Q decking and open up a ventilation hole.

The initial channel cut can be made with one or two sawyers.

Once the channel cut is complete, the sawyers find the welds and cut on the inside of the welds (joist attachment points)
As seen here, as soon as the cut is complete, the material falls in.

These two firefighters are running dual saws from the channel location to the end point. Due to the thickness of the decking material, a firefighter with a chainsaw has cut and already removed the initial decking to exposed just the Metal Q decking for the rotary sawyers.

The red circles indicate the tack where the metal Qdecking is attached to the joists.




TACK
WELDS

HOT SIDE L's CUT SEQUENCE

Hot side L's cut sequence is a "West Coast" version of the louver cut. This cut sequence is excellent when dealing with wood flat roofs. It will require multiple chainsaws or rotary saws with carbide blades.

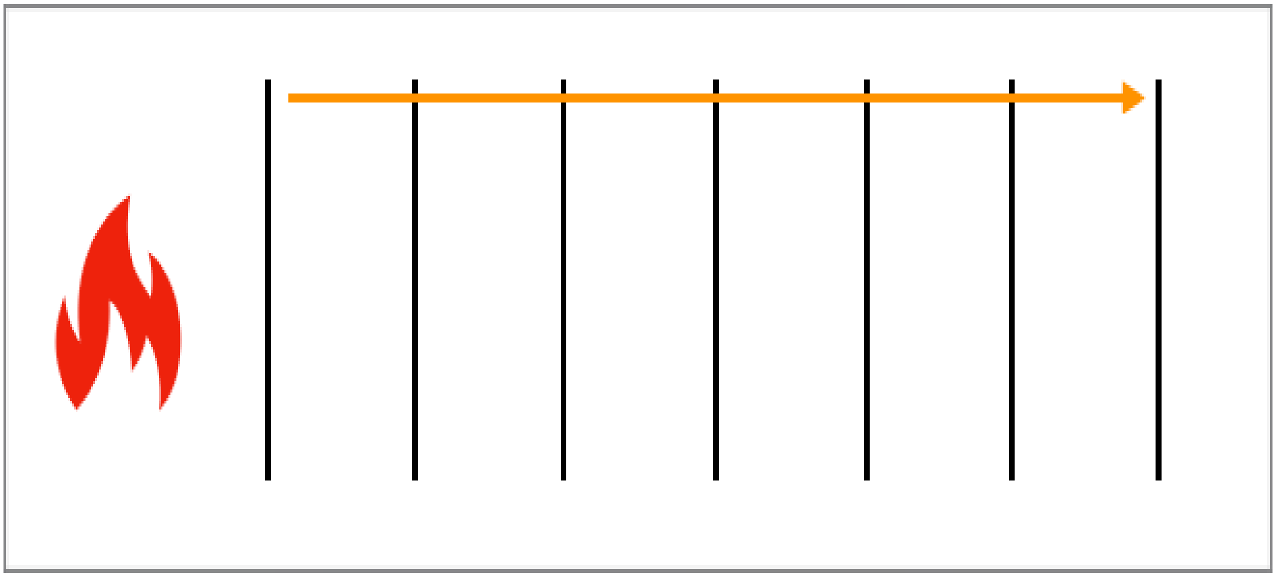
Hot Side L's should be used in the following situations:

- Wood flat roof (or low pitch) which can be covered with membrane.
- Multiple chainsaws
- Rapidly moving fire needing a large and fast ventilation hole

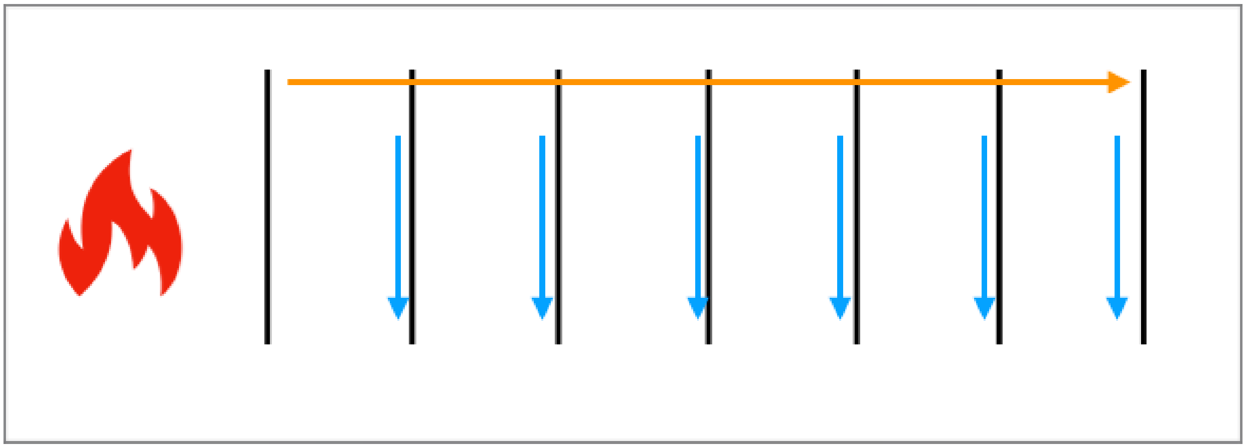
This offensive heat hole requires at minimum two sawyers. The first sawyer cuts the head cut, while the second sawyer cuts a downward "dice" cut on the non-fire side of thejoists.

Once the first sawyer is done with the head cut, they relocate to the initial starting location (fire side) and beginning cutting an "L" downward dice then bottom cut. These "L" cuts are made from the fire side (hot side) to the way of access.

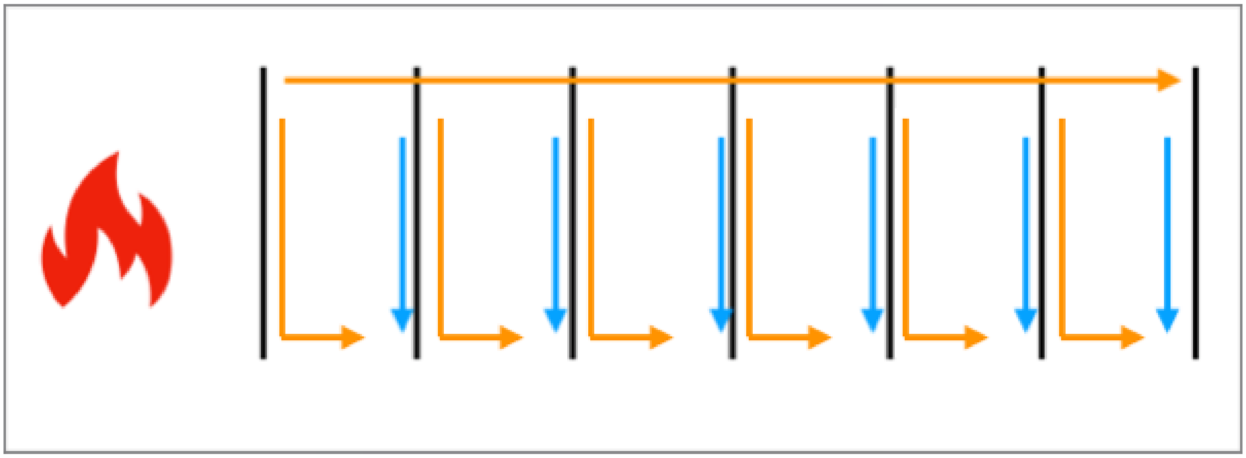
Using this cut sequence in a very rapid fire situation will allow the conditions to begin to vent from the heat hole as members are continuing to cut and extend it, if needed. As the sawyers are finishing the "L" cuts, the Lead Hook or secondary hook firefighter should be punching through.



In this diagram, the fire location is on the left. This will be called the "fire side" or "hot side".



DEFENSIVE TRENCH/STRIP CUTS



DEFENSIVE TRENCH/STRIP CUTS

The above stated ventilation techniques and sequences all support offensive firefighting. Unfortunately, advanced fire, limited manpower, or factors out of our control, the fire is defensive in nature. Defensive trench cuts and strip cuts are extremely powerful tactical considerations and must be properly placed and executed to stop the lateral fire spread.

A few tips to keep in mind for defensive trench cuts:

- Trench/strip cuts alone will not stop/put the fire out, well placed engine companies underneath the trench cut must be in place and ready to flow large amounts of water
- Plenty of time and equipment are needed for this operation to be effective.

Utilizing a defensive vent tactic must be communicated with enough time so that companies going topside can drop enough inspection and heat holes to monitor conditions and provide enough time and space for the ventilation cuts to be effective. This technique is called "trading space for time" when ladder companies drop inspection holes and "write-off" space to delay the fire, so that they have the time to complete effective defensive cuts.

The following cut sequences are designed as "defensive cuts"

- Trench with construction
- Trench against construction

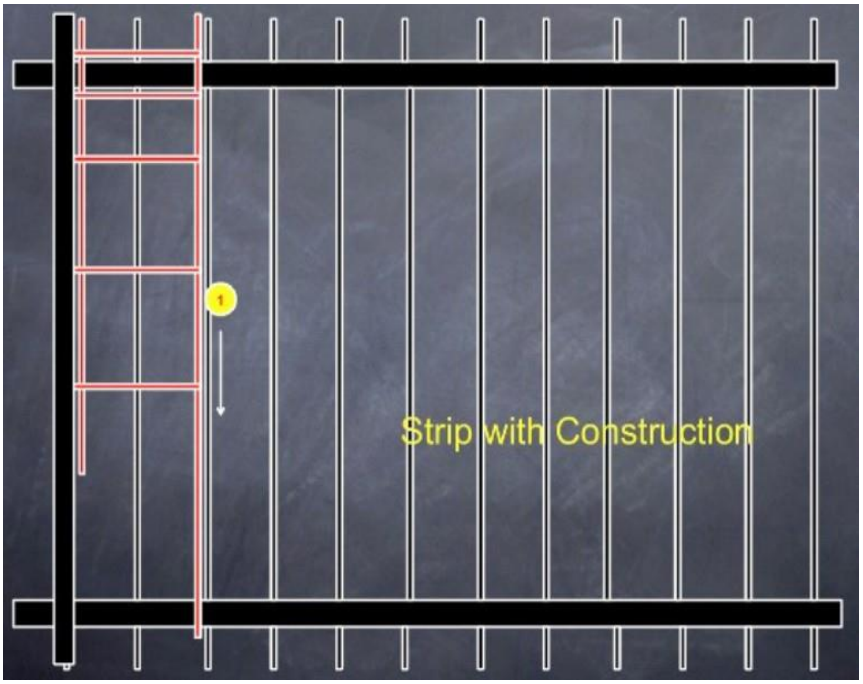
The cut will be either with or against construction depending on the orientation of the smallest structure members in the roofing system. If the cut is cut parallel to the joists or trusses it is said to be "with" construction. If the cut is perpendicular to the joists it is "against" construction. To further improve chances for success, the roof team should consider dropping back ten feet or so and cutting another tench cut to augment and support the first one.

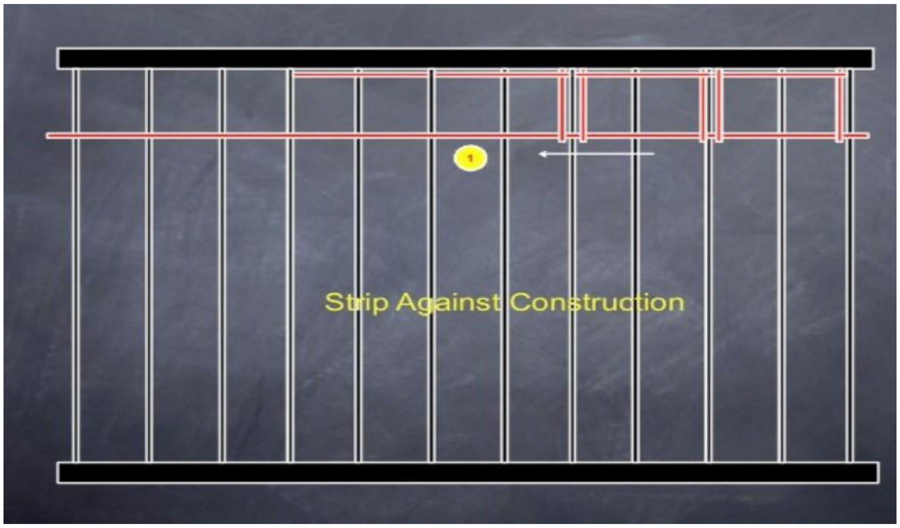
A defensive cut requires a lot of cutting and is best accomplished in crews of six or more. All members will be working, with the officer monitoring the conditions and inspection holes for fire spread and timing.

In studies performed within the organization we have averaged one minute per ten feet of roof material needed to cut.

A 60 foot wide by 3 foot deep trench, took six personnel and three sawyers on average 5:50.

A 60 x 3ft wide Trench cut in 5:50





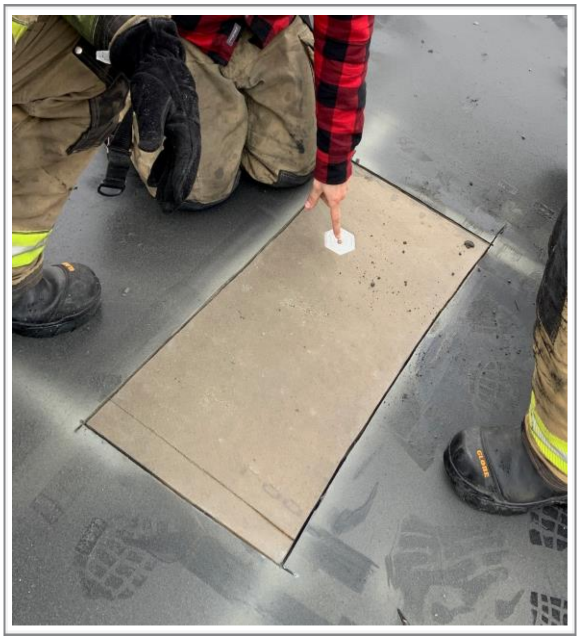
A 40 plus foot trench cut on a membrane based roof decking. This trench was a combination between a basic trench with construction and a "channel" cut.

NUMBER OF PERSONNEL	L.W. CONCRETE	MEMBRANE/COMPOSITE
COFFIN CUT (7,9,8) - 2 Personnel	18:02	12:30
(3/1) OR (3/8) MIRROR CUT - 2 Personnel	6:32	7:05
COFFIN CUT (7,9,8) - 4 Personnel	12:00	10:00
(3/1) OR (3/8) MIRROR CUT - 4 Personnel	4:40	4:35
COFFIN CUT (7,9,8) - 6 Personnel	5:15	8:15
(3/1) OR (3/8) MIRROR CUT - 6 Personnel	4:00	3:00

The table with timeframes above were tested on over 40 different flat roof buildings. This table reinforces the need to change the mindset from the "older" Coffin cut to this offensive mirror style cut for our local construction.

ADDITIONAL CONSIDERATIONS FOR FLAT ROOF VENTILATIONS

When working on flat roofs that have fiberboard screw attachments (see picture below), use the fork end of a Lincoln Bar or LA Hook to break them apart. This is the only attachment point for fiberboard, which can be removed very quickly.



SCOOP Method - An additional and efficient way to remove foam and/or fiberboard as well - use the Forks end of the Lincoln Bar to “scoop” it up and away from the hole. We have heard of departments bringing an actual shovel to the roof. Although this is the most efficient way of removing this insulation, carrying an additional “scoop” shovel to the roof is not a primary tactic. The Lincoln Bar and LA Hook are outstanding tools that do just as good of a job as a shovel, but also can be used for other purposes on the roof decking.

RAIN ROOFS

Rain roofs are a very common issue that we deal with in the southern states. Rain and moisture force building owners and companies to build additional roofs on top of previous roofs. This causes false condition reports and requires a large amount of equipment and manpower. Rain roofs allow fire spread to quickly move throughout a structure and cause issues when companies go to vertically vent or check for extension underneath.

Some rain roofs are only inches above the previous roof and can be "step" cut and vented, while some rain roofs are very deep and are unable to be vertically vent.

No matter what type of rain roof or depth, this needs to be communicated very quickly to all units operating on the fireground and the incident commander. Many times we have to resort to horizontal ventilation to assist companies operating interior.

VENTILATION PIPING

On many rooftops, "whirly-bird" or turbine ventilation covers are installed to assist with the ventilation assist for attic spaces. When members make the roof and begin sounding, many personnel will knock these ventilation covers off. If the turbine is NOT spinning, knock it off to assist in ventilation.

However, if the turbine is spinning and producing smoke/fire, this is great! These turbines are designed to operate using negative pressure and remove heat. Allowing these turbines to continue to spin rapidly will greatly assist in removing the products of combustion and assist in ventilation.

HORIZONTAL VENTILATION

Horizontal ventilation uses windows, fans, and natural air currents to control the air inside a structure. The two basic methods that ladder companies use are:

- Positive Pressure
- Negative Pressure

Out of these methods, positive pressure ventilation is the most effective from removing conditions of smoke and heated gases after the fire is knocked down and under control, especially where vertical ventilation is not needed or attainable.

Unfortunately, positive pressure ventilation is commonly misunderstood and when improperly applied can create a dangerous situation in which civilian and firefighter lives are at an increased risk. Taking the wrong window or applying a fan at the wrong location/timing, can cause a "wind-driven" fire. If extension has not been checked or cleared, this can quickly push fire to unaffected areas of the building and possibly cause additional damage, injuries, or fire deaths. Understanding the basic principles of ventilation can reduce the number of issues. Horizontal ventilation is a great tool for the fire service and is one of the few options we have when ventilation is needed in a multi-story structure that

This window is about to be "taken" by the Ladder Officer performing this 360. He observed the engine company making this room of fire and is about

did not involve the top floor or attic space of the building. Knowing that smoke and fire will spread from high pressure to low pressure, and especially towards openings, ventilation crews must take caution NOT to vent behind the engine company. This action can make conditions behind the engine/hose-line worse and has been the cause of many injuries.

A coordinated effort between interior fire attack and vent crews on the outside of the building can result in quick efficient attack to the seat of the fire. This method allows the engine to knock down the fire and cool the environment and contents, while venting allows the smoke and steam that becomes pressurized to exit through an opening made by the Outside Vent Team.

VENT FOR LIFE

As mentioned in the search chapter, when inside ladder crews are actively searching for possible trapped victims and they make a bedroom with thick smoke, crews can employ the tactic “Vent for Life”. The officer or firefighter shuts the bedroom door and while the firefighter is searching the room, takes the windows. By removing the windows in this room and shutting the door, it “isolates” the conditions to quickly clearing in this room and “gives” the possible civilian “ventilation for their life”. This tactic is strongly encouraged in thick smoke filled bedrooms with reported victims trapped. When the search crew leaves and/completes the bedroom, it is imperative that the crew closes the bedroom room to keep the window that was opened “isolated” and not contribute to the overall fire spread of the structure.

CLEARING WINDOWS

When clearing windows for rescue or ventilation the following rules should be applied.

1. Everything is cleared out, including the sash.
2. Any curtains or debris between the window is removed
3. Wood Windows should be repeatedly hit with a halligan or hook in the middle of the sash. A wood windows strongest point is at the joint and/or corner. By repeatedly striking it in the middle, the wood sash will easily break.
4. Fiberglass/vinyl windows should be repeatedly hit with a tool at the corners of the sash. If firefighters hit vinyl or fiberglass windows in the middle, they are designed to absorb stress and flex, which will make your tool bounce off the window. Repeatedly strike these windows at the joint of the sash for efficiency.

SMOKE REMOVAL USING FANS

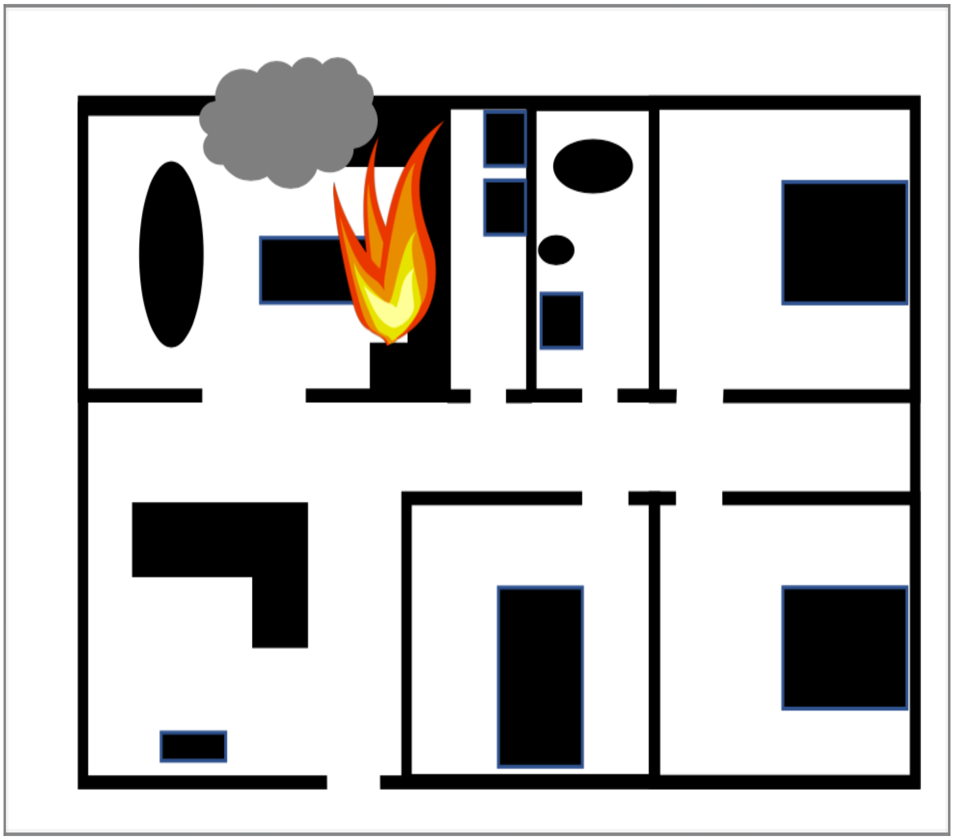
LCFS ventilation fans are primarily used for positive pressure “smoke removal”. Once all fire has been knocked down, extension checked and cleared, we introduce fans to the building to clear out the toxic smoke and gases.

Once the fan is on, allow the building to "build up" pressure and then begin the opening of exhaust or exit paths. We dictate the removal of the smoke and gases by opening and closing separate exhaust points. As long as you SEE air movement, the building is pressurized, however, do not open every window and door. It is important to remember that the exhaust point should be smaller than the intake for maximum smoke removal.

Ratio	Flow (CFM)	Air Changes Per Hour	Time for Single Air Change (mm:ss)
5:1	22187.5	154.2	00:23
3:1	18579.8	129.1	00:28
2:1	15979.7	111.0	00:32
1:1	8999.4	62.5	00:58

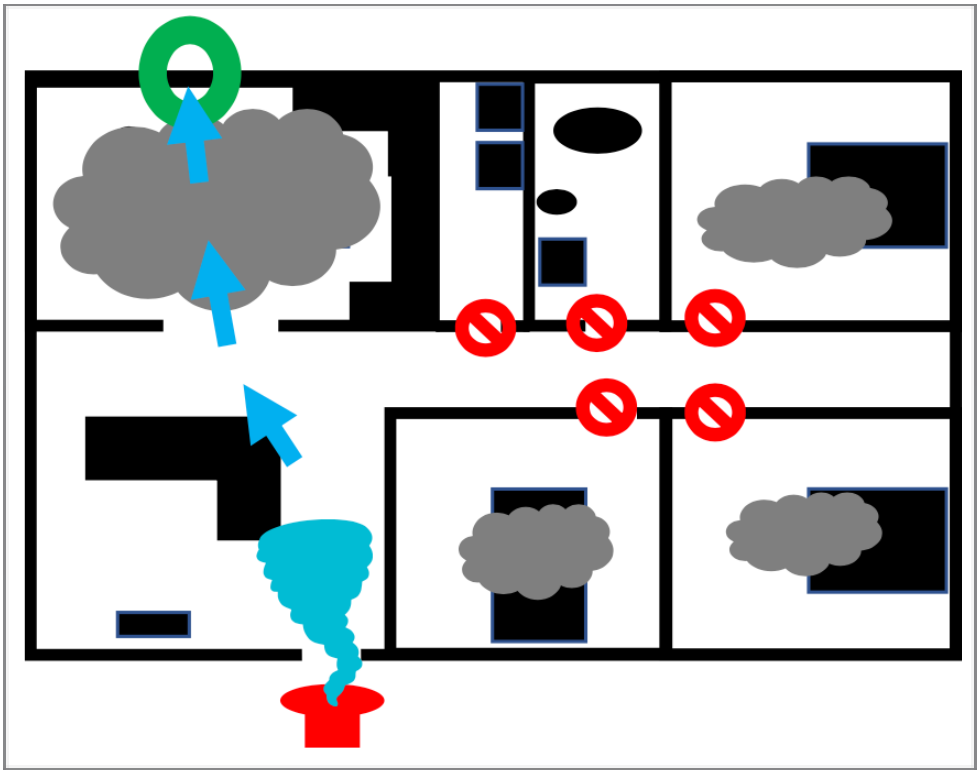
As noticed on the table above from NIST/UL ventilation studies, the most efficient ventilation ratio is 5:1. That does not mean five windows to one door. One door equals about 1.5windows.

This diagram will demonstrate the PPV Smoke removal process of the simulated fire.

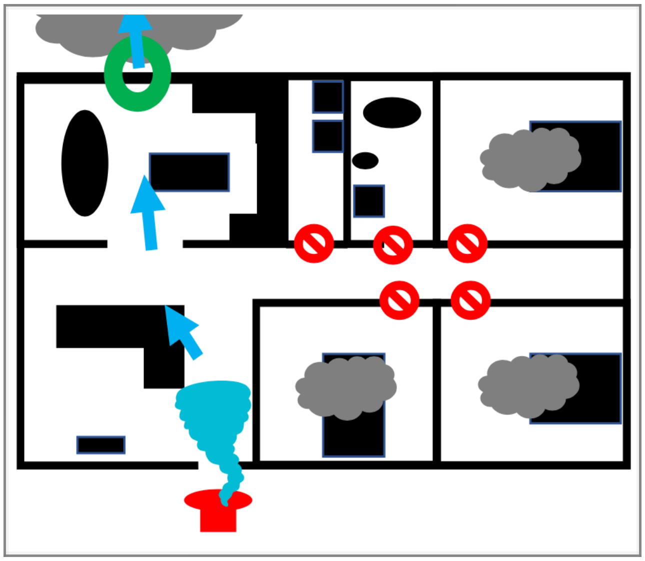


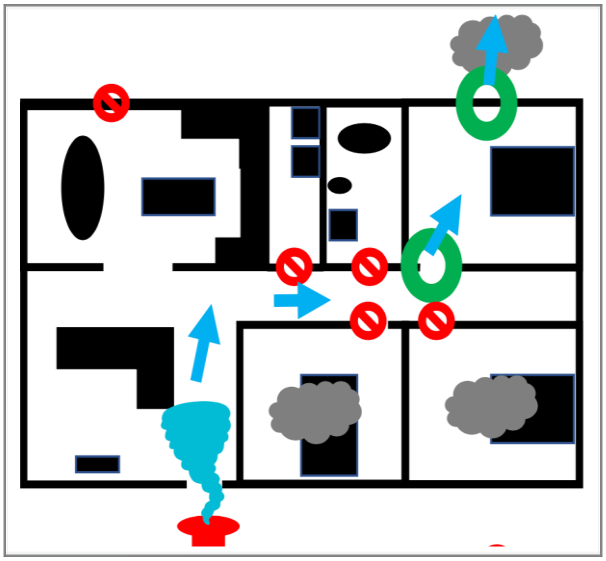
Picture from Columbus FD Truck Manual

The red circles are doors that were closed and the green circle represents a window in the fire room that was open. A PPV fan is placed at the front door.



Picture from Columbus FD Truck Manual





As the fire room is cleared of toxic products, that window is closed and another window and door is opened. This should be a systematic process. As the next room is cleared, we move to the next smoke filled room, until the entire structure is clear and air monitored.

In summary, ventilation is a highly effective tactic when performed in coordination with attack and search crews. We remove (lift/lean) smoke and products of combustion to offer relief to both firefighters and victims, increasing the visibility to aid with fast moving searches and locating the fire. The tactics and sequences discussed in this chapter have been found to be the most efficient and effective. Assigning the most experienced members to the roof will help ensure the correct ventilation technique and location is used. In the modern fire environment we need to control the building and ventilation better than ever before. Remember, ladder companies operate to “fight” the building and its conditions. This is especially true in large occupied buildings like apartment buildings. Choosing ventilation to make a difference in conditions for multiple rescues might be the right priority over ground ladder rescues initially.

CHAPTER NINE

ACCESS AND EGRESS

CHAPTER: 9 Egress

This chapter is going to focus on the different egress problems that ladder companies will face. As stated before, this book does not cover every egress problem that members will face. If members find a unique and/or different egress problem, pictures and information should be obtained and passed throughout the department. Both residential and commercially manufactured egress obstacles (window bars/doors) are not hard to overcome. It is the homemade equipment and devices that both homeowners and business owners will make and manufacture to protect their family and businesses.

- Egress is defined as the action of going out or leaving a place.
- Access is defined as the means of approaching or entering a place.

The Fire Department uses these terms within the same reference, but it important to understand that getting into a building is just as important as getting out. If members are attempting to access a victim inside a building that should become a priority for companies. If companies are in harsh and unsafe conditions it should be the priority of outside vent teams or RIT, to make egress a priority.

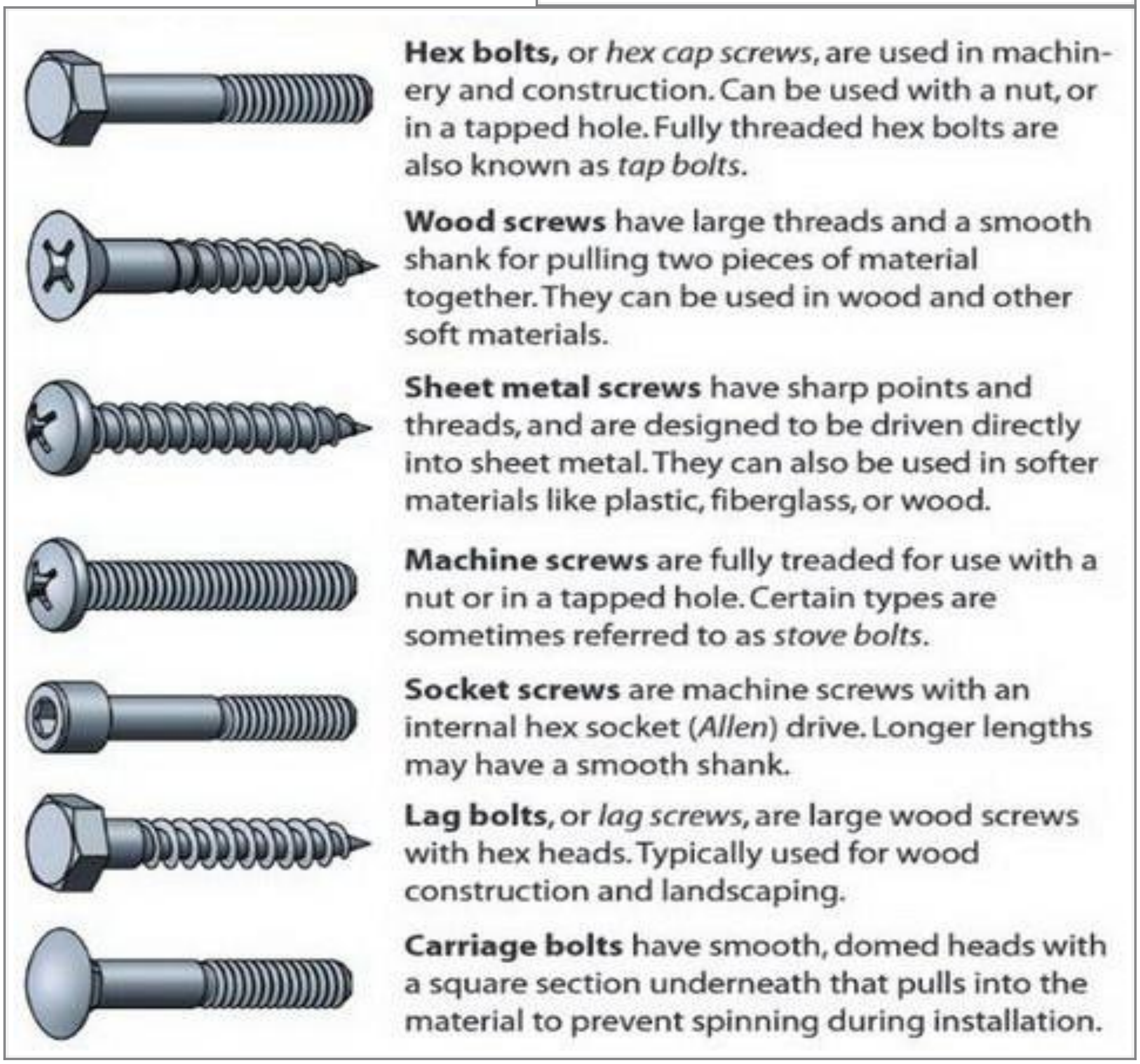
A family trying to escape a reported fire in the apartment next door, but the window gate is blocking their egress.

Multiple firefighters have been injured when a rapid fire event pushed them into a interior space and were unable and/or delayed on exiting the structure to due security/window bars. Both access and egress issues are significant safety issues and must be communicated via "urgent message" to all personnel operating at and responding to the incident. If security devices may hamper access or egress it should become the priority of the outside vent companies and/or the RIT team.

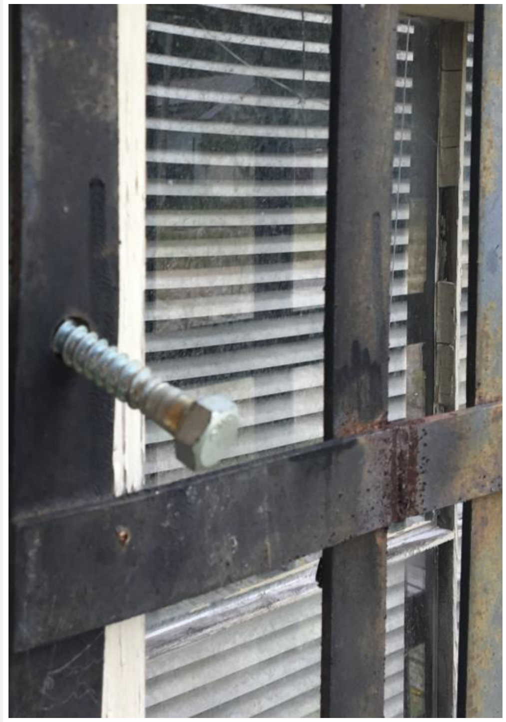
Depending on the size of the building, location and type of device, the incident commander may have to assign additional resources to the security devices and/ or slow down or delay current tactical positions until the devices can be secured open. The absolute last communication any firefighter wants to hear is "mayday, mayday, mayday, I am unable to get out due to window bars".

WINDOW/SECURITY BARS

Window bars, also called security bars, are a priority on the fireground and can be found in the richest neighborhoods or the poorest, residential and/or commercial. Most "commercialized" window bars can be easily defeated by attacking the attachment points or using hand tools for leverage. Homemade window devices are very much of a concern because of the material and time put into securing and attaching the devices.



Referring to the fastener chart above, these are the seven most common fasteners for security devices and window bars. If you see devices attached with a carriage bolt, lag bolt, and/or hex bolt, it should raise a little bit of concern. If you see any of the other four fasteners, you will be able to force the device using leverage and force.



Poorly installed fastener which is very common

Many times security devices are installed incorrectly, in the wrong material, or with the wrong attachment fasteners. Many owners want burglars and vandals to see the security bars and run off not attempting to force into the building/house.

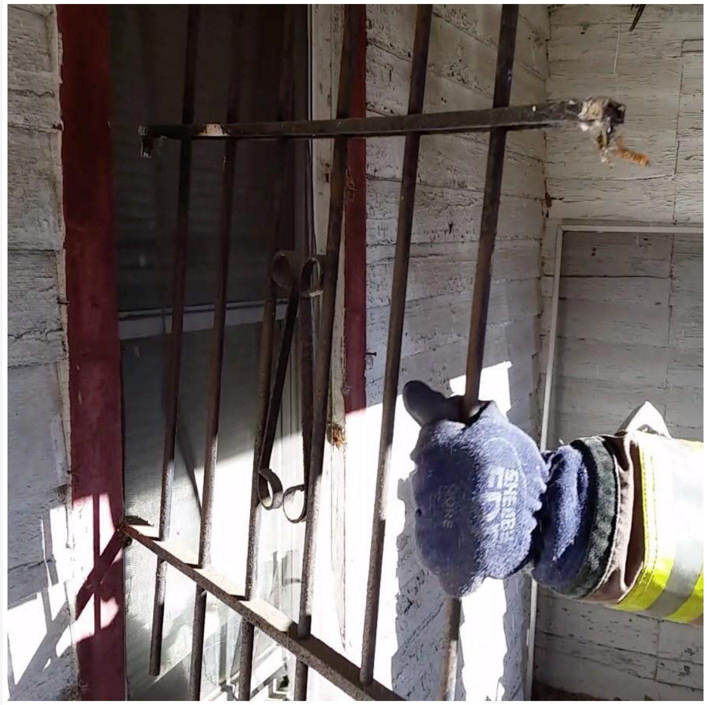
As far as tools for the Outside vent crew to carry: Halligan bar, Roof Hook, and Lincoln bar. All three of these tools marry up together to become a monstrous force and all use enormous amounts of leverage and force to easily defeat many devices.

Window bars can be broken down into three methods of removal:

1. Leverage
2. Force
3. Saws

LEVERAGE - Using a one of the previously mentioned tools, basic window bars can be quickly pulled off the building using leverage.

Halligan/Lincoln Bar - Using one of these bars, place the adz or fork next to the fastener attachment head. Roll the tool up and down then out. The attachment fastener should be removed from the building.



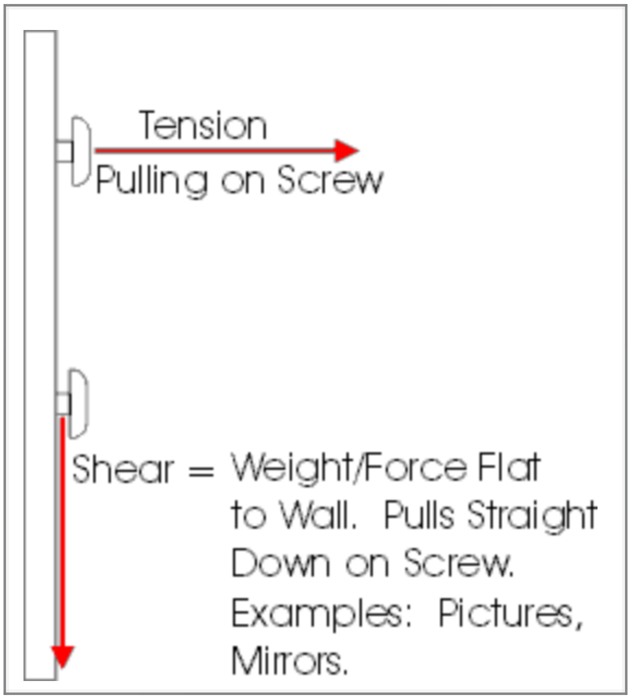
Repeat with another attachment fastener and then grab the entire window bar and remove from the building.

-Generally, you will have to only defeat two out of the four attachment fasteners to remove the window bars. By pulling the bars themselves "out" of the fasteners, the other two screws will fail.

Roof Hook - The advantage of the Roof hook is the height and length of the tool. Using a roof hook for taller or higher window bars easily allows you to place the hook behind the bars/attachment points and lift up and down. The curvature of the hook will push against the attachment points and quickly release the bars.

Another option with the roof hook, if your able to get the entire hook behind the bars, you can slide the hook behind them and pull out. This should weaken and/or remove two attachments at a time.

FORCE - The second option to removing window bars and other security devices is to force by directly attacking the screws. This can be done with any of the previous tools mentioned, along with a flat head axe. By attacking the screw heads directly, you can easily cause them to shear and fall off/out or you can destroy the material they are attached to, and fail.



Truckmen have to remember, just like hanging pictures in your own house, that every fastener attachment screw has a tension and shear rating.

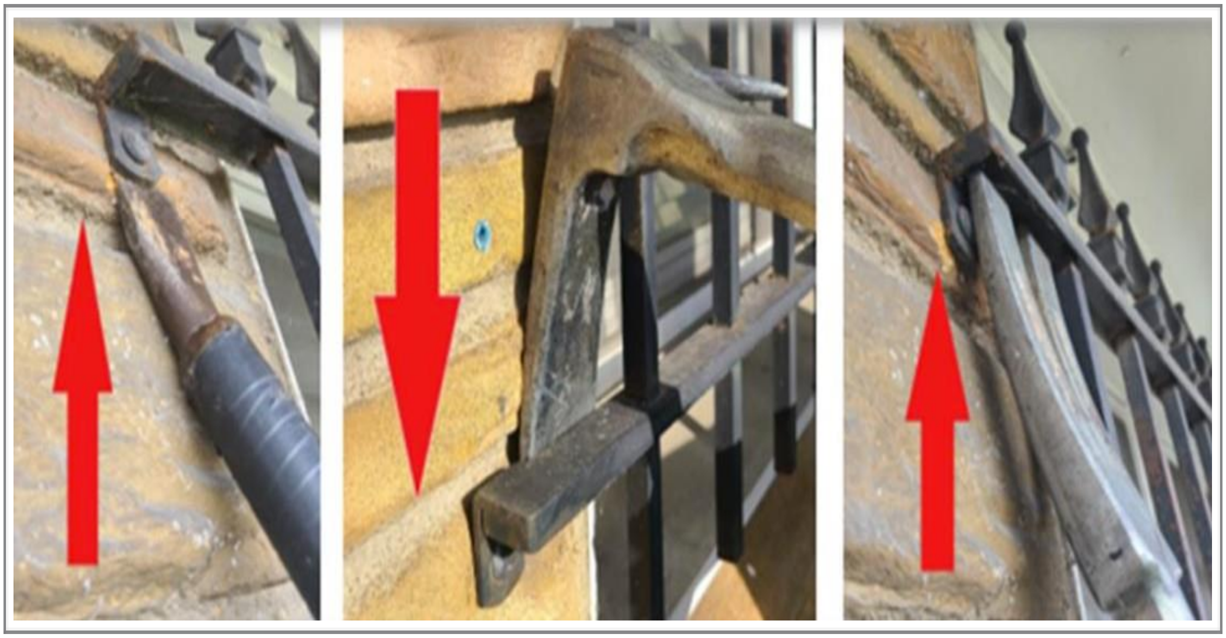
Tension is when an object/weight pull straight out on a screw.

Shear weight is the rating of force that pulls straight down. Most screws purchased have a stronger shear weight than tension.

<u>We focus exerting more tension weight than shear.</u>

Many times by using a halligan bar or axe and striking the fastener directly will destroy and "crumble" or "powder" the material around it. This will weaken the tension strength immediately and cause the fastener to be rendered useless.

If the window bars are attached to wooden sliding or the window itself, it is recommended to exert the shear strength first, then the tension strength.



As picture above, using a halligan or roof hook, you can easily attack the attachment screws in wooden sliding by force.

SAWS - The final attempt unless the window bars are recognized as “heavy-duty” should be the rotary saws. Many times companies have immediately called for rotary saws when majority of the windows bars can be quickly defeated using hands tools. It is imperative and a minimum standard for any firefighter assigned to a ladder company to be able to operate a rotary saw in all 16 saw positions.

16 Saw positions that Members should be able to operate a rotary saw:

Right Hand, saw vertical - Above head, shoulder level, hip level, ground level.
Right Hand, saw horizontal - Above head, shoulder level, hip level, ground level.
Left Hand, saw vertical - Above head, shoulder level, hip level, ground level.
Left Hand, saw horizontal - Above head, shoulder level, hip level, ground level.

These are the minimum positions and ladder company members should feel confident and comfortable using the saw in these positions, along with above ground/off a ladder. There are many techniques to assist in holding and operating a rotary saw.

Over Head method - When using a rotary saw over your head, you should take the time to get comfortable with your hands on the handle and/or guard as pictures show. On long horizontal cuts over your head, you should lock the arm that is holding the saw (not the throttle hand). This will help keep your saw straight and balance.

Shoulder level- There are multiple positions on the shoulder level, however a few to mention: Resting the guard on your shoulder and moving with your back. You can also hold the belt guard and/or blade guard (pictures attached) and run the saw comfortably.

Hip Level - Based on the height of the firefighter, some firefighters it is more comfortable to stand up and “cradle” the saw while cutting at the hip level. For some firefighters it is more comfortable kneeing down and resting the saw on their knee and/or locking their elbow against their knee to run the saw.

Ground Level - All forcible entry saws should be in the outboard setting. This will enable to get the blade as low as possible and drag the saw along the ground. If needed, the saw can rest on the firefighters boot if a few inches is required for cutting purposes.

The most important factor in running a forcible rotary saw is training and practicing with it. You must be comfortable and understand YOUR body mechanics to efficiently, effectively and safety to run a rotary saw.

Practice with your body height and figure out which technique works for your body.

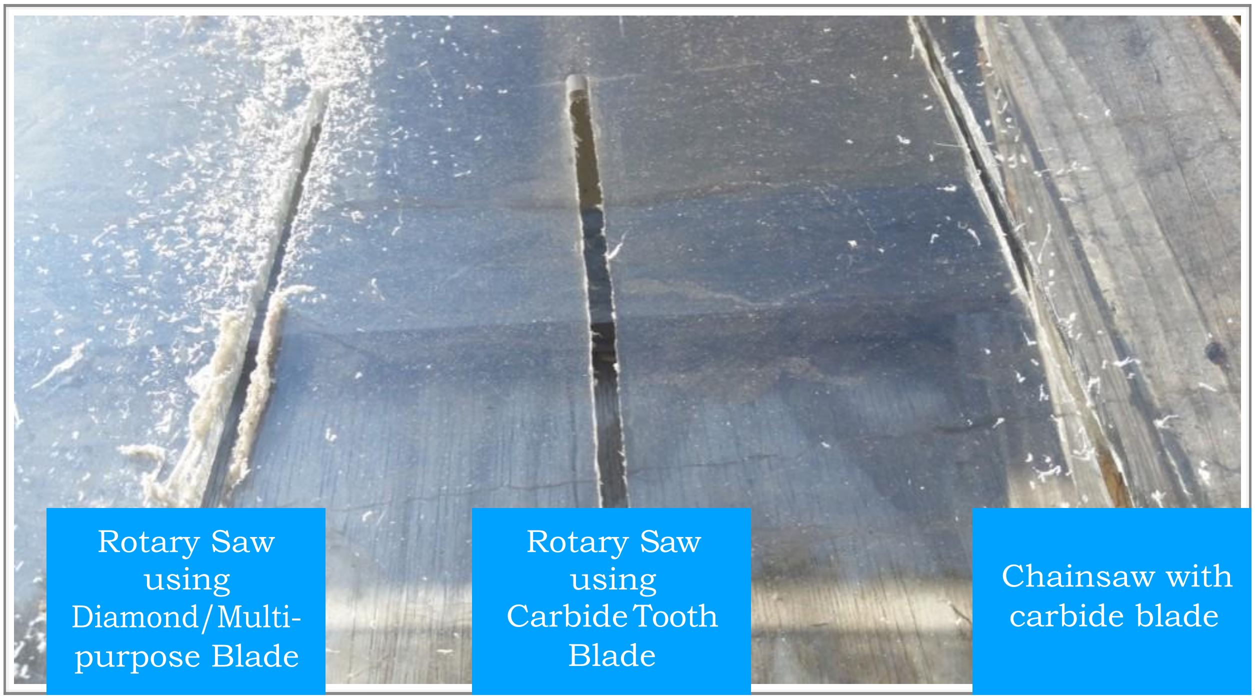
Rotary saws should be used on window bars when they can be identified as "heavy-duty" or leverage and force did not succeed. As shown in the pictures, carriage bolts, hex bolts, or bag screws are generally a sign that the owner or occupant of the building heavy fortified their security devices and rotary saws will have to be used.
Like discussed early, cut two to three sides of the window bars and remove via pulling out and leverage.

If you size-up window bars and they are thick metal rods that are inside the cinderblock or concrete building itself, that is also a sign to use the rotary saw as well. In the pictures below show fortified window bars that are reinforced in the building materials itself.

LEXAN WINDOWS

Lexan windows have become very popular on vacant or bank owned properties here in the midlands of South Carolina. Lexan Polycarbonate resin thermoplastic. Lexan is a solid plastic/acrylic substance that is used in windshields, fighter pilot windows, and bulletproof"glass".

The lexan glass is attached using wood screws and a construction adhesive to ensure a good "seal". Companies have seen on average, six to eight screws in each side of the window (approximately 24-30 total screws per window). This attachment process makes using a drill or hand tools in efficient.



As you can see from the demonstrations and experiments, the rotary saw with the carbide tooth blade was the most efficient and effective means of cutting and removing the lexan from the egress points. When using a rotary saw with a diamond/multi-purpose blade, there were a few spots where the lexan actually fused together to prevent full removal of the lexan. The chainsaw was very unstable and destroyed all chains on the bar.

Most importantly when dealing with lexan windows and doors, it must be communicated and removal process must be started early.

CASEMENT WINDOWS

Casement windows are windows that are attached to its frame by one or more hinges. These windows open like "doors" using a knob or small handle. They were very popular in the early 90's when many homeowners built "Florida" rooms as additions to their homes. They are also found in many lower income/Section 8 housing apartment complexes due to their strength and safety features.

These windows are some of the most dangerous and difficult windows to open and/or force for firefighter access and egress. If any working incident has casement windows; an "Urgent message" must be communicated to all operating companies and the incident commander must deploy multiple units to removing and opening these windows

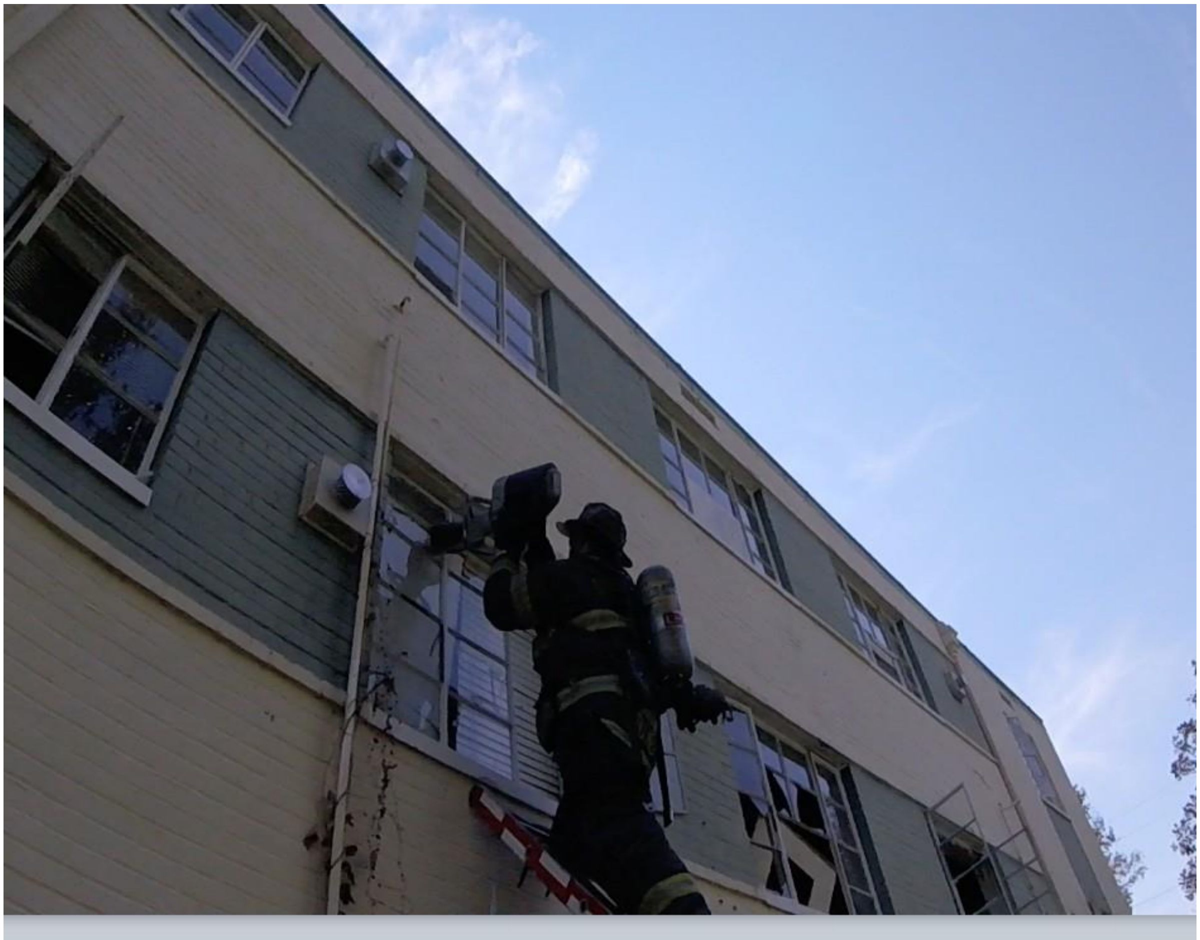
Order of removal of casement windows. Using over 100 casement windows, we have found the following removal techniques being the most efficient and effective:

1. Battery Operated Hurst Cutters
2. Rotary saw with Diamond Blade
3. Battery Operated Sawzall
4. Hand tools

1. Hurst Cutters - Using the Edraulic Hurst cutter was the easiest and quickest mode of removing these windows. Cutting the windows at their frame attachment points while the second firefighter removed the window had the best operation timeline.

2. Rotary saw with Diamond Blade - Having a firefighter on a smaller VES ladder and cutting a horizontal line across the top and bottom was the second most efficient process. Once both cuts were made, the second firefighter could remove the window with a hand tool while the saw firefighter moved to another window.
3. Sawzall - The sawzall was the next best tool. Like the rotary saw, it was best to start on the top of the window and then move to the bottom. The sazwall becomes very unstable when cutting into the window frame and only lasted about three windows before the Blade and/or battery needed to be changed out.

4. Hand tools - This was our last option. Although it was faster than the sawzall per window, companies were exhausted after attempting force and remove casement windows after just two. Firefighters should remove and break the glass first, then move onto taking out the attachment points with force and hits from an axe or halligan. Once broken, the window could be removed with a hook.



Firefighter using the Edraulic Hurst Cutter on the 2nd floor casement window. Using the Hurst cutters was the safest and easiest tools to use on the 2nd and 3rd floor windows of this apartment complex.

GARAGE AND OVERHEAD DOORS

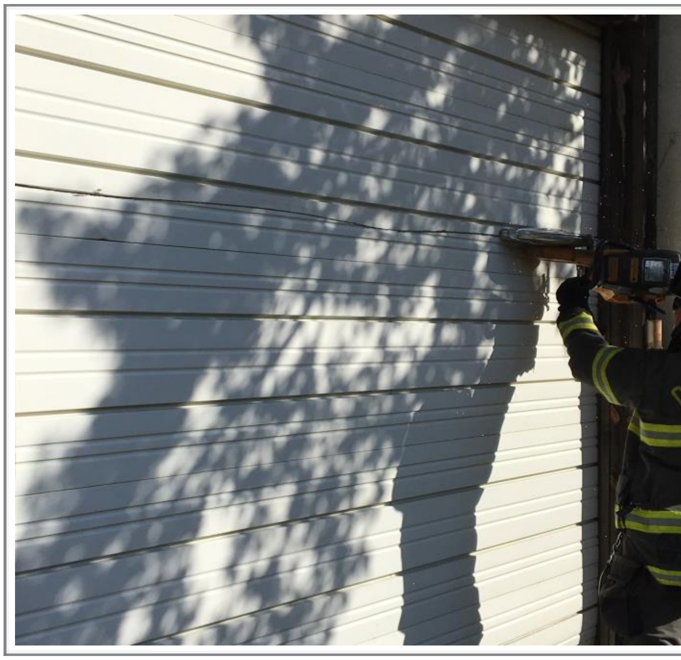
Garage doors and/or roll-up doors can be found on almost every structure fire we respond to. Whether a residential house with a garage door or a commercial building with a receiving/loading dock, garage doors are instrumental in outside ladder company work. These overhead doors are not only a safety issue, but a ventilation and access/egressissue.

On June 16, 2001, Firefighter Jeff Chavis was fatally injured and burned when the garage he was operating in at a house fire, collapsed onto him. He was transported to the hospital via helicopter where he sadly passed away on July 12, 2001. We should always remember and never forget Jeff Chavis's sacrifice to the County of Lexington. This solemn remember should be on the forefront of every firefighter in Lexington County when operating with any building with garage doors. They need to be removed and secured quickly.

Residential Garage doors -

Residential garage doors are either lightweight steel/metal or solid wood core. Lightweight steel doors can be cut very quickly and removed from the operating area of the garage.

Solid wood doors are extremely heavy and will take a few minute to cut. These doors when cut, become unstable and need to be carefully removed as they usually weigh an excess of a few hundred pounds, at minimum.



Cutting a residential lightweight metal door:

SQUARE CUT

1. Horizontal cut as high as the firefighter can reach.
2. One downward cut from the top to the bottom.
3. Rail cut on the bottom.
4. Pull cut side out and secure.

Many times on these lightweight garage doors, you can bend them out of the way with just two to three cuts as pictured below.

If the garage door does not bend out, of if it is wood, the following steps are recommended:

BOX CUT

1. High horizontal cut
2. Downward cut
3. Rail cut
4. Additional down cut on opposite side
5. Remove door from operating area.

The average cut time on a garage or commercial door using a BOX cut was 1:16 seconds using one firefighter. Although this is three times longer than the tradition "tee-pee" or "A" cut, it was more effective and safer for personnel operating on the fireground. The Square or Box cut is the standard operating procedure for all LCFS Ladder company personnel. The tee-pee cut does no provide enough access or egress for members to be operating inside the building.

As you can see at the incident picture below, while operating at a large warehouse fire, two different companies cut multiple overhead doors. These two doors are right next to each other, but investigators and firefighters are working under the door on the right. Why? Due to the cut design, there is more space and area to work around compared to the A cut. This cut does not provide enough access, egress or ventilation than the box cut.

COMMERCIAL ROLL-UP DOORS

In our response area, we have two very common roll-up doors used in commercial buildings.

1. Rolled Steel doors
2. Sheet curtain doors

Rolled Steel doors are very common in warehouse and large commercial buildings. They some of the most common commercial roll-ups, as they are usually made of heavier gauge steel. The door consists of individual pieces of steel rolled at their ends that allows them to be interlocked together.

They can be identified by their recessed seams (slats) horizontally across the door and by the rivets at the end of the slats. The rivets will indicate where there are guides for the door tracks. Often on the bottom will be two pieces of angle iron or steel at will be visual from both sides of the door.

Rolled steel doors or “slat” doors can be opened very quickly in one or two ways.

Firefighter making a single cut in the middle of this slat roll-up door.

Single Door Cut.

1. Firefighter goes close to the middle or 2/3 into the door and sinks the rotary saw as high as they can vertically.

2. Firefighter cuts one vertical cut all the way down to the railing.

3. Firefighter sinks Halligan pike (horn) into the door and begins to remove slats.

Once a few slats are removed the door will fail. It will either slam open or drop down.

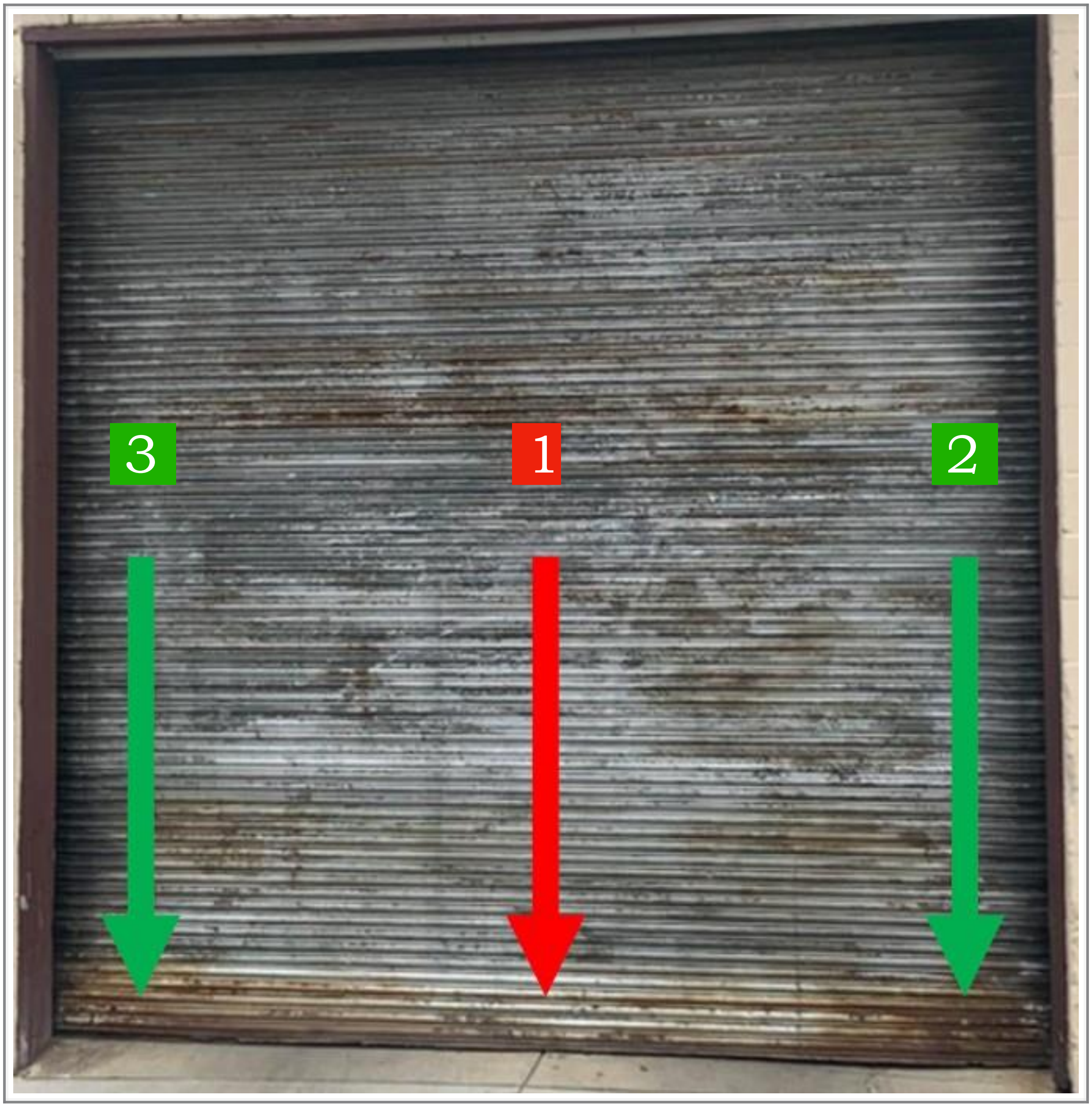
If the slats of the door are painted, welded, or rusted together, it may take another firefighter a striking tool to help start and “release” the slats.

Paint, age, or warping can make pulling slats by hand very difficult. Driving the pike of the halligan into a slat can provide much better grip and leverage for removing the slats. If initial resistance is felt, firefighters should attempt to pull the slat above or below the first one they attempted. You do not want to start on a slat that is attached or riveted to the guide. When pulling slats, they will generally follow in large sections and come free of the tracks. If the slats are riveted on every slat, then you must proceed with the following cut instead.

Triple Door Cut

For a triple door cut we have identified all slats are riveted, the owner welded the slats together or the door is just not opening with a single cut.

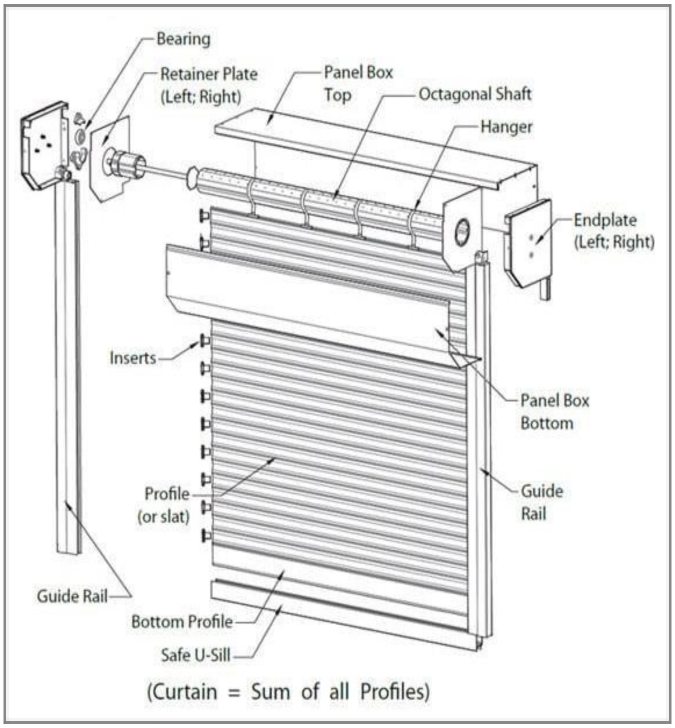
1. Once a single middle cut is complete, move your rotary saw to one side of the door.



2. Cut a single vertical cut about 8-12" inches inside the rivets (to ensure we miss the track and guide).
3. Cut another single vertical cut on the other side of the door (mirror step 2).

No matter what style cut you use on commercial roll-up doors, be careful as you finish your last cut. The door will most likely "slam" upwards into the guide and can drop and/or debris can fall. Notice in the picture above, when the last slat was pulled out, the rest of this 1,000+ pound door, slammed rapidly and under pressure into the mechanism on the ceiling. It can slam hard enough to dislodge and drop the door.

The diagram below shows the breakdown and parts of a commercial style roll-up door (slat) as well as the red circles highlight the rivets in the guides for slatted roll-up doors.



Sheet Curtain Doors

The second common commercial door that ladder companies will face in our area is the sheet curtain door. These doors are similar to rolled steeled doors but are found in storage facilities and in newer commercial buildings. Sheet curtain doors differ from rolled steel doors in that they do not have individual slats that are interlocked. The door may be one solid piece of metal without breaks in the door or may have shorter metal sheets with the ends pressed together. These doors are also made of much thinner metal.

Since there are no slats to be pulled in this style of door, we have one of two options of removing this doors.

1. Force external locks that are frequency used to lock these doors.
2. Square or Boxcut.

Keep in mind, when forcing the locks off of these curtain doors, many times the locking devices are stronger than the door or the track itself. This can

cause issues of bending the track and not being able to open the door. If this happens, you must cut the door via square or box cut.

PADLOCKS

Padlocks are detachable locking devices that have a sliding and pivoting shackle that will pass through a fixed or portable hardware and then made secure. They are used everywhere, from residential to multi-family apartments to commercial and warehouses. They are used on both exterior and interior applications and you will find them in the least expected places. Padlocks are broken up into three different categories.

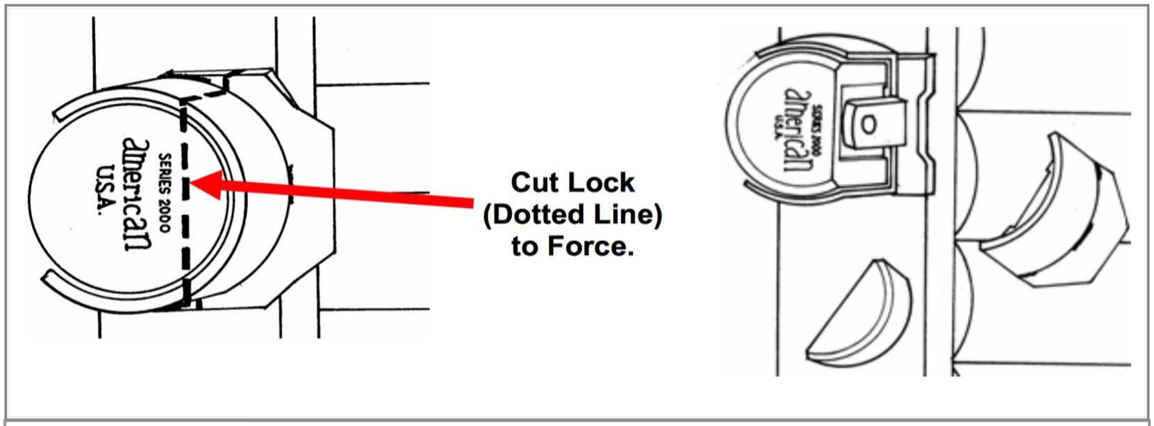
1. Light duty padlocks
2. Heavy duty padlocks
3. Special Purpose

Light duty padlocks usually have a shackle that is 1/4 inch or less. They are usually not case-hardened and the body is made of solid or laminated metal.

Heavy duty padlocks are 1/4 inch or large, case-hardened steel and have both toe and heel locking mechanisms. These padlocks also have a guarded keyway to prevent the keyway from being tampered with.

Special - A special padlock is one like the American Series 2000 also known as the "hockey puck lock". It is a specialized lock used for security purposes. Other special locks include those made of "Boron Steel" This steel is used for armor in tanks as well as rocket ships. If a lock is made of boron steel is must be cut with a rotary saw.

As stated before, take a trip to your local hardware store and walk down the lock aisle. Many "newer" style and material padlocks can be purchased from any hardware store and as students of the craft we should take pride in



The hockey puck lock needs to be cut 3/4 up from the bottom of the keyway. This will be the direct location of the throw and locking mechanism.

knowing andlearning about the newest style and material locks available to citizens in our districts.

MISCELLANEOUS ISSUES

WINDOW A/C UNITS.

Window/portable air conditioning units are becoming more popular as homeowners and business owners look for “cheaper” way to provide condition without spending tens of thousands of dollars for climate control units. A few years ago, a window a/c unit fell on a FDNY firefighter breaking his neck and critically injuring him. Many residences including mobile homes in the southern part of the county have many window a/c units and there is a standard operating procedure around these units.

If the structure is less than two stories: a firefighter working exterior should communicate that they will “drop” the window unit exterior or outside to the ground.

If the structure is more two stories tall: a firefighter must sweep or visually clear the room first, then push the A/C unit inside theroom.

Both of these procedures should be communicated to all personnel operating on the ground.

If any firefighter is working interior, they should be pulled inside, after they sweep underneath the window. Portable window a/c units are usually attached poorly and have the potential of severely injuring or killing civilians or firefighters.

In summary, when dealing with access and egress issues, the priority is communication and removal. Not all window bars or devices are the same. Talented homeowners who can weld or have access to metal/ workshop shops can easily build and put together fortified and sophisticated security devices. The pictures on the right show a older gentlemen who stated the “government” was watching him. He lined his entire residential structure with chainlink fencing on the inside along with fortified window bars on the exterior. Companies delayed interior fire attack until the fencing could be removed.

CHAPTER TEN

AERIAL OPERATIONS

CHAPTER: 10 Aerial Operations

Positioning and operating the aerial is one of the driver's most important tasks. On most fire scenes, drivers only get one chance to position the truck; they have to be thinking about positioning the truck correctly every time they pull up to an incident.

Positioning the truck correctly on the scene requires knowledge, training, and a lot of practice to be proficient. Great ladder company operators position the rig on every single call; fire alarm to structure fire. This is the only way to get great at positioning and operating the rig.

When responding and arriving to structure fires, generally the first due ladder company will take the front of the structure. That does not mean that the ladder will park or operate in front of the building, directly in the front could be one of the worst places is can be positioned. It means the most suitable position and/or use for the aerial.

TYPES OF AERIAL APPARATUS

Straight ladders (also called sticks)

LCFS has two different straight ladders. We have a mid-mound straight Stick and a rear-mount straight stick.

Some of the advantages of a rear-mount stick:
- Great for access
- Small configuration for small/tight access points
- Easy to operate

- Limited restrictions on aerial operations.

Disadvantages of a straight stick:

- Slow, difficult removal of victims
- All equipment must be hand carried
- “Mediocre” elevated master streams

Tower Ladders (Tower 10)

Some of the advantages of the tower ladder:

- Great strength and load capabilities
- People move as the bucket moves
- Brings the equipment with you as you move
- Safe removal of conscious or unconscious victims

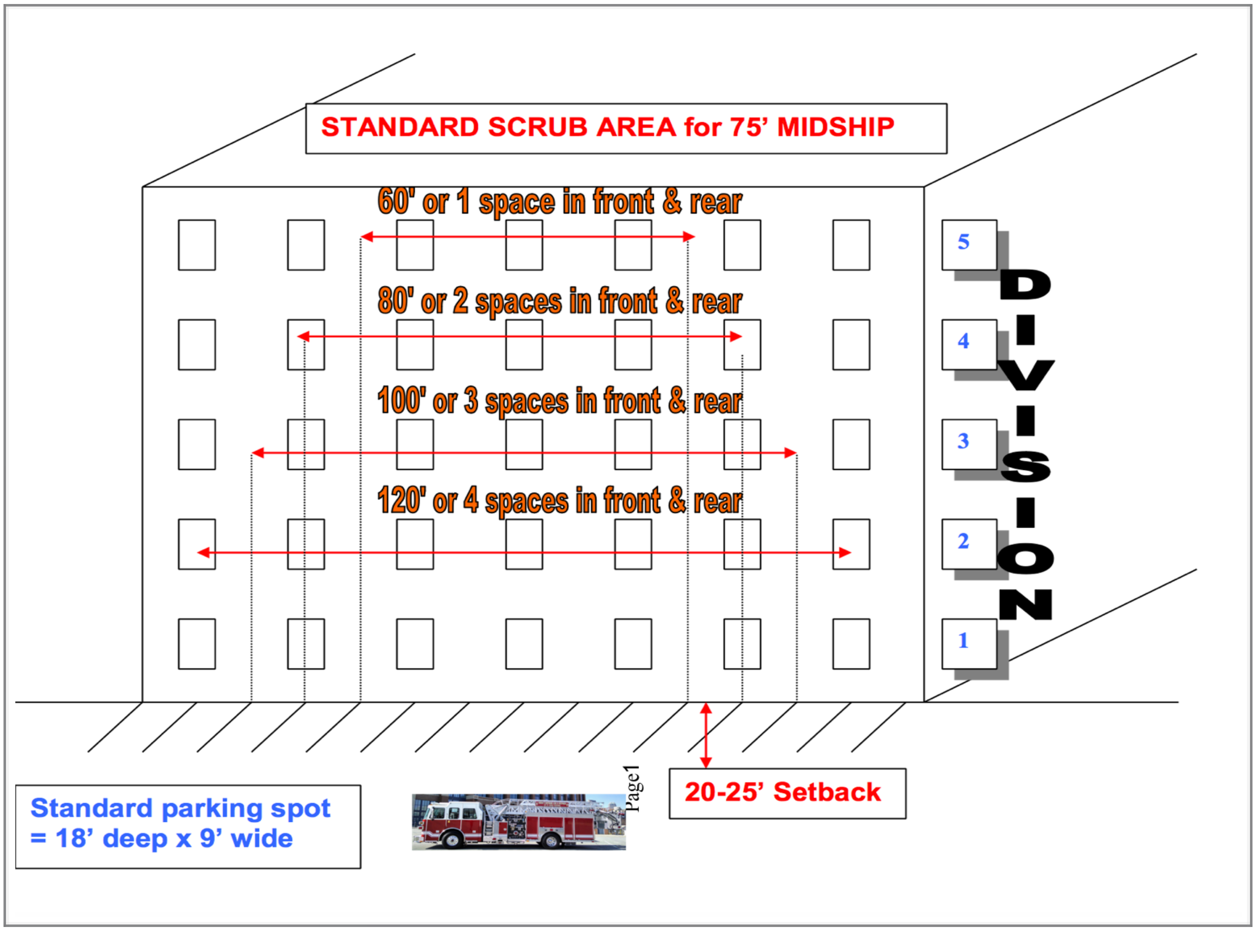
Disadvantages of the mid-mount tower ladder:

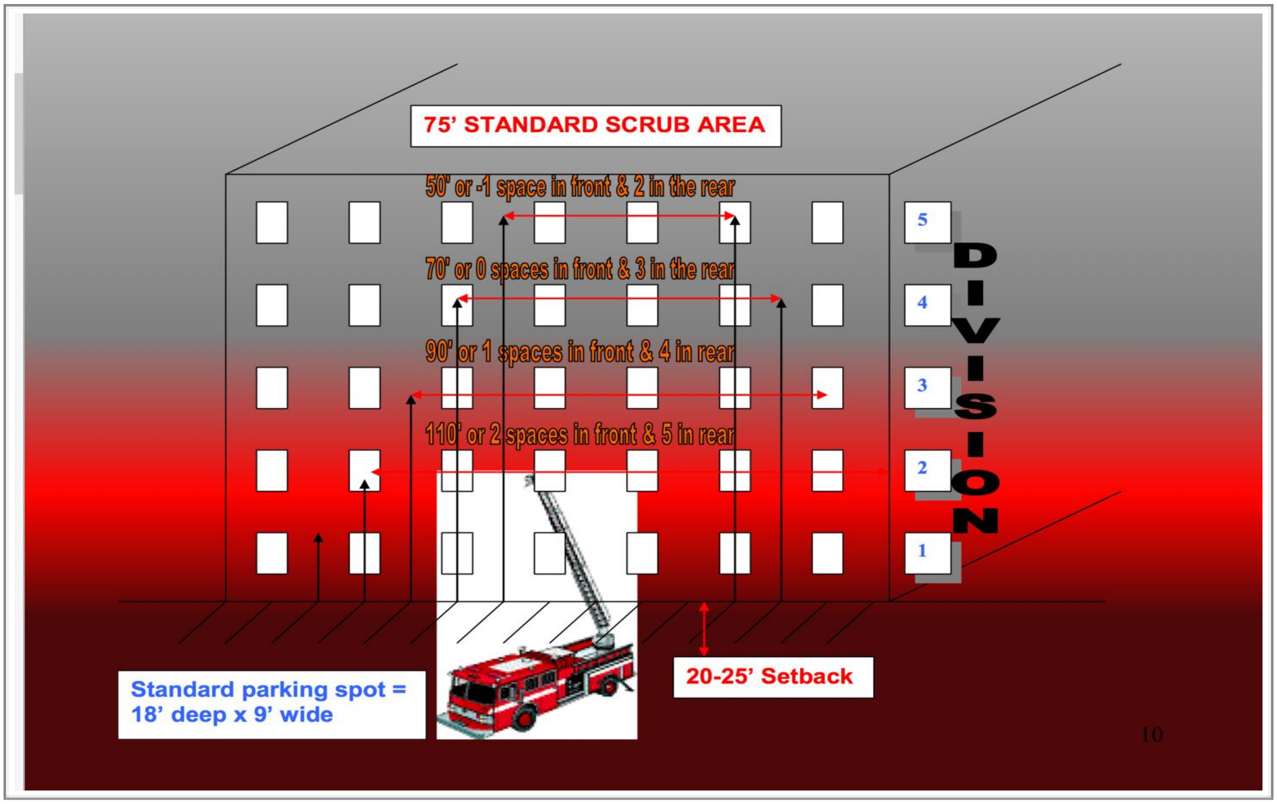
- Optimum use requires optimum positions.

When responding to and operating either of our aerial apparatus, drivers must understand the capabilities of each rig. When responding to a reported commercial fire with large bay doors or a“storefront” opening, it is advantageous for the Tower

Ladder to take the front for "storefront" operations, while the straight stick should take a corner, side, or the rear.

With proper positioning, drivers must understand the apparatus scrub angle. The scrub angle is everything the tip of the aerial can "touch" on an objective. The following charts and diagram were developed for our apparatus. The scrub area chart is based of an average parking lot spot and number of windows and feet in distance on the building.


STANDARD SCRUB AREA for 75' MIDSHIP
60' or 1 space in front & rear
80' or 2 spaces in front & rear
100' or 3 spaces in front & rear
120' or 4 spaces in front & rear
5
4
3
2
1
DIVISION
Page1
20-25' Setback
Standard parking spot = 18' deep x 9' wide


75' STANDARD SCRUB AREA
50' or -1 space in front & 2 in the rear
70' or 0 spaces in front & 3 in the rear
90' or 1 spaces in front & 4 in rear
110' or 2 spaces in front & 5 in rear
5
4
3
2
1
DIVISION
20-25' Setback
Standard parking spot = 18' deep x 9' wide
10

Understanding the scrub distance and markers is crucial to operating and positioning your aerial ladder. Also understanding and knowing your operational distances is key.

The following pictures and numbers show to reach limitations on our aerial apparatus.


Dimensions
LEXINGTON COUNTY
FIRE SERVICE
21'
6'
4'
33
Total Foot Print 16'


Foot Print
65'
33

Total Foot Print = 16’

60’

Memorizing and being able to apply these figures to your apparatus and response takes experience, positioning, and operating the apparatus on all runs.

Understanding and communicating to already on scene engine companies, can ensure proper placement while enroute or arriving on scene.

When responding in the same direction/route as an engine company, the engine company should pull past the structure to allow enough distance for the aerial to have optimal positioning.

When responding in the opposite direction as an engine company, the engine should stop short to allow the ladder company enough distance and space for the company to have optimal positioning.

You can always stretch hose-lines, you can not stretch a ladder.

Some additional information on positioning the aerial:

If the ladder company takes an inside position on a structure, we refer to this positioning as **High and Tight**. This will allow the ladder to get “tight” to the building, but understanding that the ladder will be at a “High” angle for operations.

If that ladder company must park on the outside or away from the building due to obstacles and/or parking issues, we refer to this positioning as "**Long and Low**". You will have to ensure you are close enough to the building to use the length of the ladder "long" and the climbing angle will be "low" or a comfortable climbing angle for crews.

Utilizing mid-mount tower ladders, many times are trained for "kicking out the cab" 10-15 degrees to maximum the scrub angle and to "keep the cab" away from the operating area. However, when a close distance is needed to maximum the scrub angle, you have to position as we refer to as **"shooting back" or "overcab"**. Positioning is when the mid mount tower passes the building on fire and actually turns into the exposure building and "shoots" the ladder back towards the building. This positioning provides multiple advantages in distance, angle height, and exposure protection, all while allowing the engine company to have the front of the building.

"Shooting back" also enables the aerial ladder to get under the power lines as pictured above.

Remember, when dealing with your mid-mount tower, we must keep the cab out of the aerial ladders scrub or it will limit your scrub and rotational abilities.

Roof Access (Flat Roofs) -

Roof size, building height, parking access, height of parapet walls, and the incident type will all play a role in tip placement and access abilities. During a fire, firefighter wants to ensure that tip of the ladder is visible for firefighters on the roof, and that mounting and dismounting the ladder is possible for for a firefighter in full PPE and SCBA.

Tip Level or just above the roofline/parapet wall-

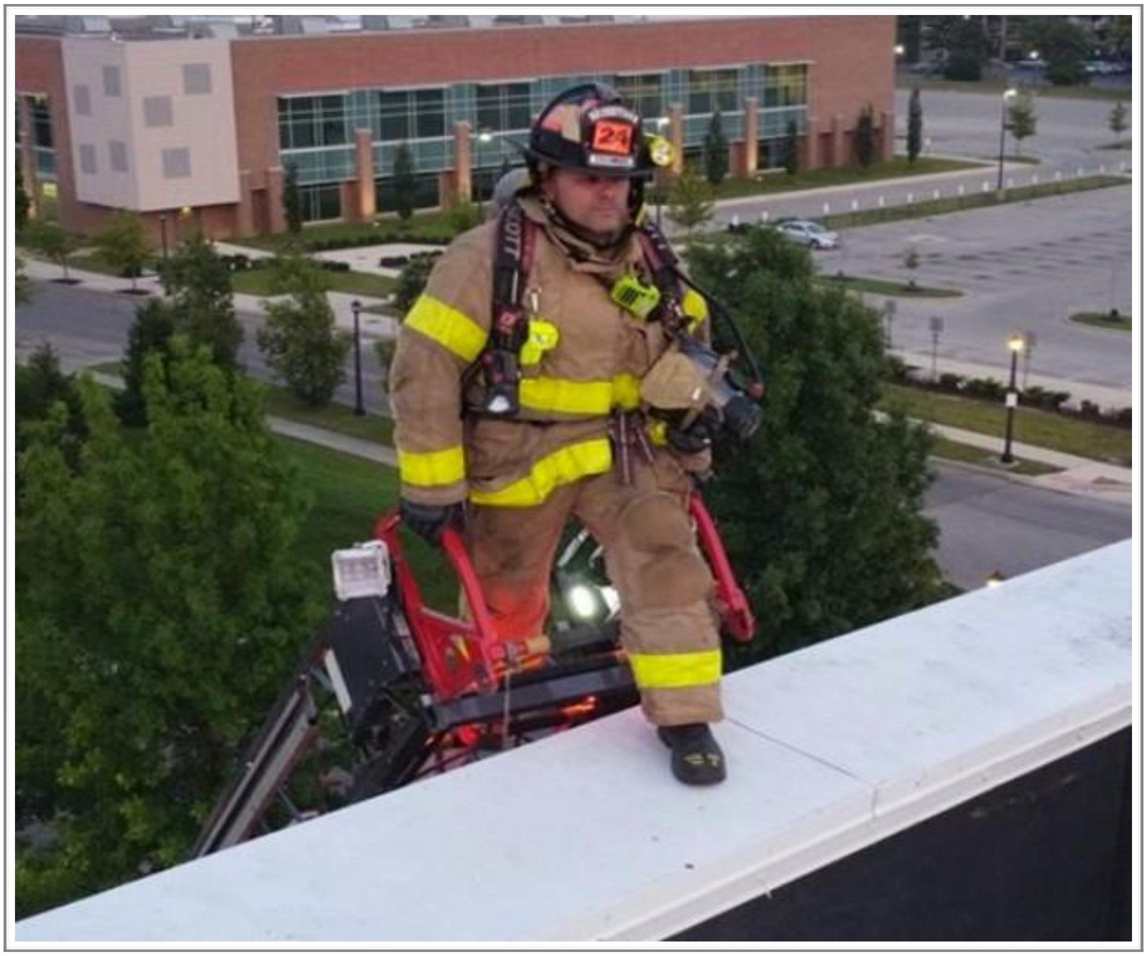
- This is an option for flat roofs that are not very high
- The Aerial is at a low angle (30 degrees or less)

Cons -

Cannot see the aerial in a smoky environment because not much of the tip is showing above the roofline.

Pros -

Firefighters do not have to climb over the beam of the aerial to dismount. It is also very stable positioning.



Tip Extended eight feet or more over the roof line -

This is an option for larger roofs and/or when the aerial is at an angle greater than 30 degrees.

Cons -

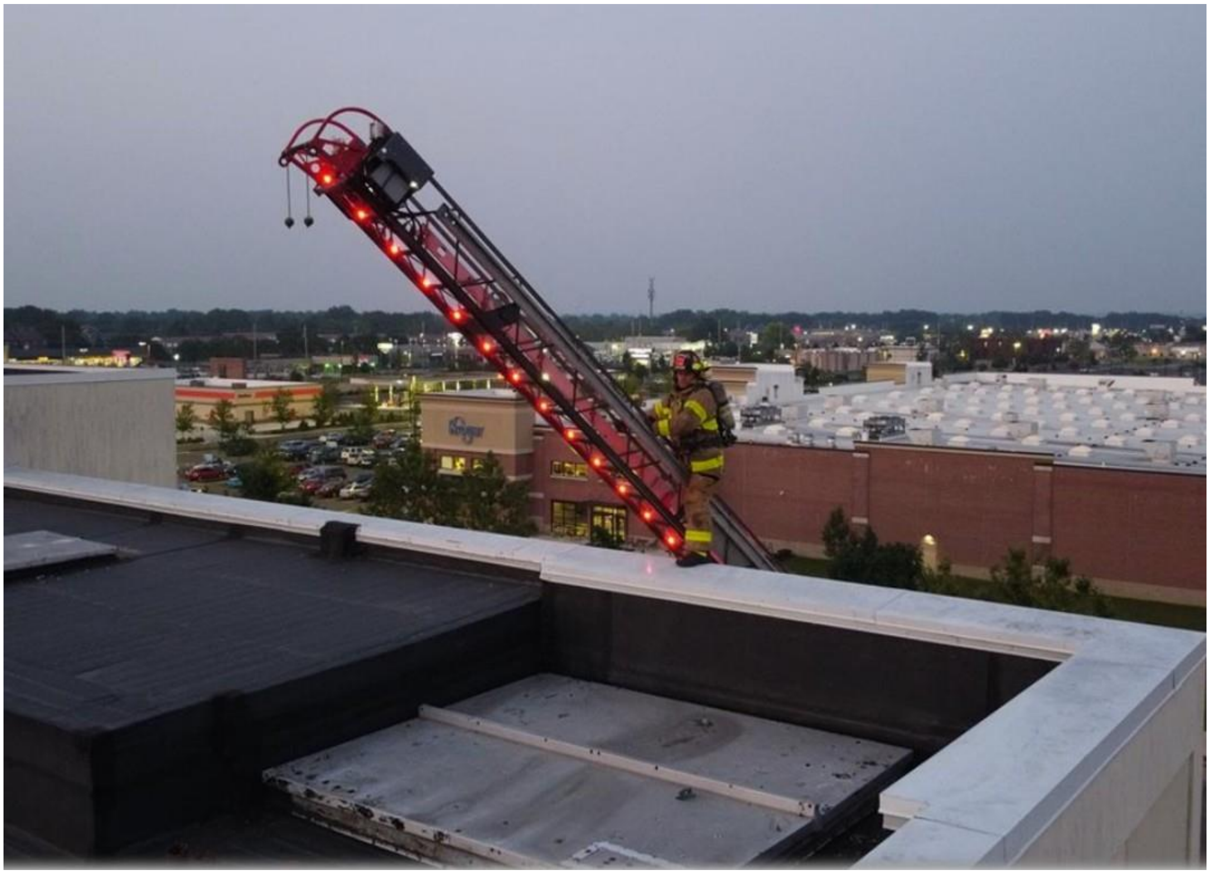
Firefighters cannot just walk off the tip to dismount the aerial.

Pros -

More of the aerial is visible from anywhere on the roof.

When mounting or dismounting, members have more of the aerial to grab to assist them during the transition from the roof to the aerial.

Info from Columbus FD Truck Manual



Squaring the corner-

This is an option on any flat roof where the truck can be positioned at the corner of the building. Its very advantageous on steep roof or multiple roof line buildings. By squaring off at the lower roofs, many times, you can hit the upper roofs as well.

Cons -

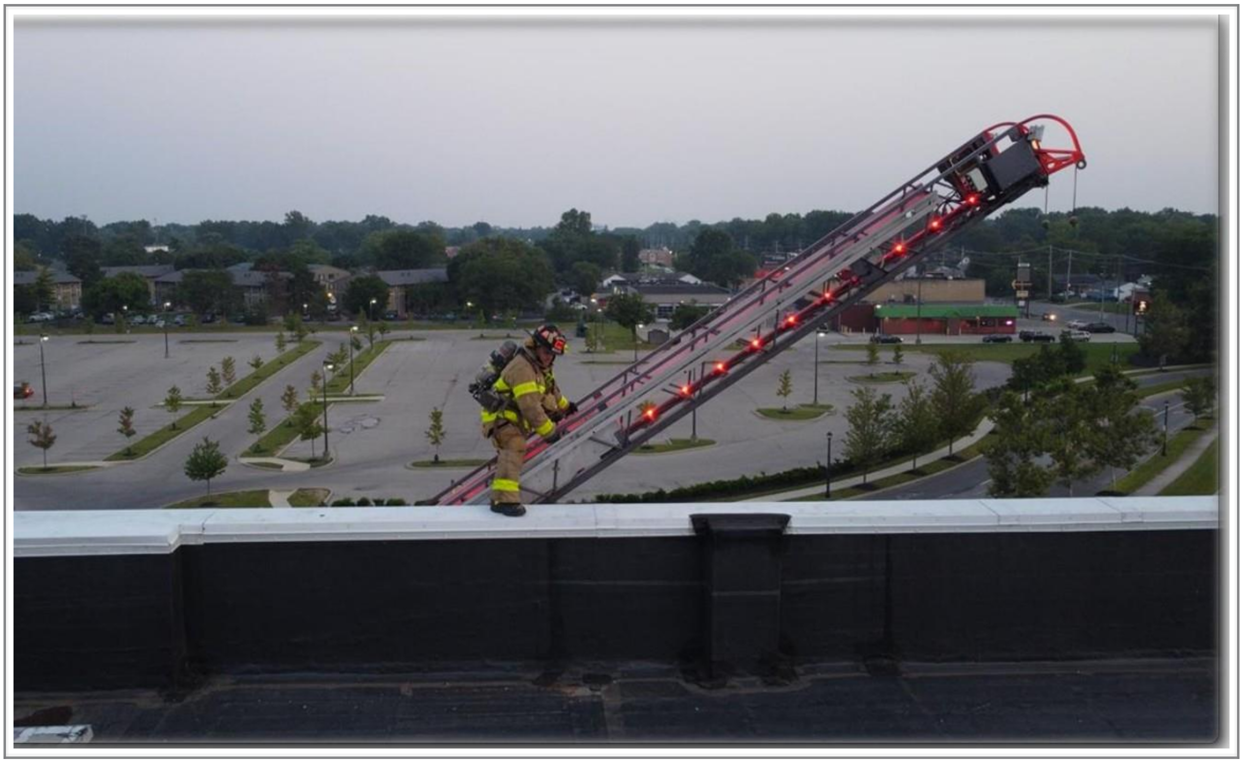
Requires significant skill to position the turntable in the correct spot to have the aerial in the right position.

Pros -

Allows the aerial to be seen easily by members working topside Can hit multiple roofs with a single aerial.

Easy transition from the aerial to the roof.

Info from Columbus FD Truck Manual



Pictures from Columbus FD Truck Manual

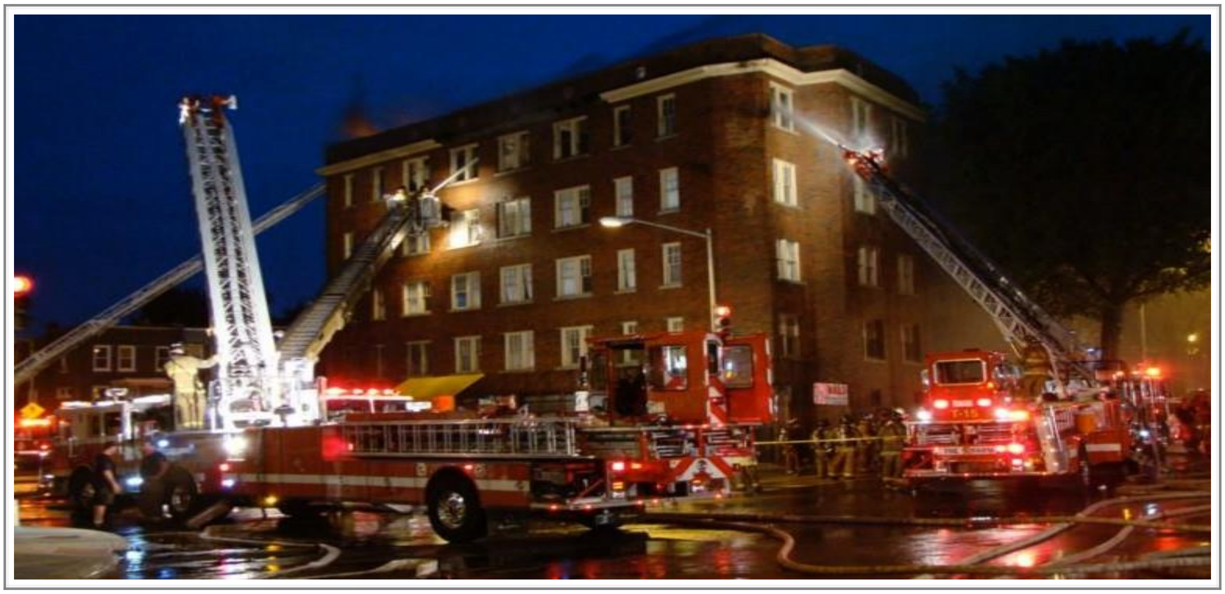
HEAVY-DUTY MASTER STREAM

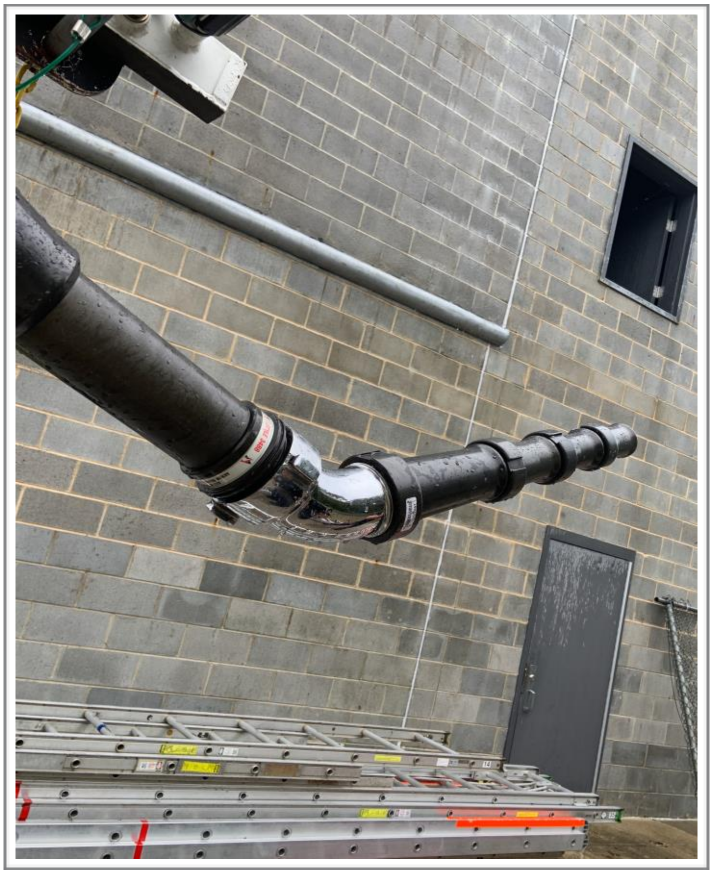
If good driver operators positioned the aerial correctly, transitioning from offensive to defensive should not be an issue. They should be in a relatively decent spot to flow water.

The most important task of flowing water from a master stream, is NOT to flow from above if the roof in intact. Having the roof intact only prevents and wastes time and water. A roof system is designed to keep the elements out. It will do so until the fire breaks though.

In order for aerial master streams to be EFFECTIVE, you must use the term "Low and below".

Position the aerial as low as you can, below the fire, and work it "like a handline". Flow into the fire room and up into the ceiling/void space to knock down and extinguish the fire.





Remember, that when using Aerial Tower and/or straight stick master streams, it is highly recommended to use a smooth bore nozzle. Smooth bore nozzles flow more water and are able to reach farther than combination/fog nozzles.

LCFS Aerial ladders, when they were at the same height, angle, and GPM provided the following information:

Nozzle	Break-Away Distance	Total Distance	GPM
Smooth Bore	71 ft	231 feet	500
Fog Nozzle	18 ft	161 feet	500

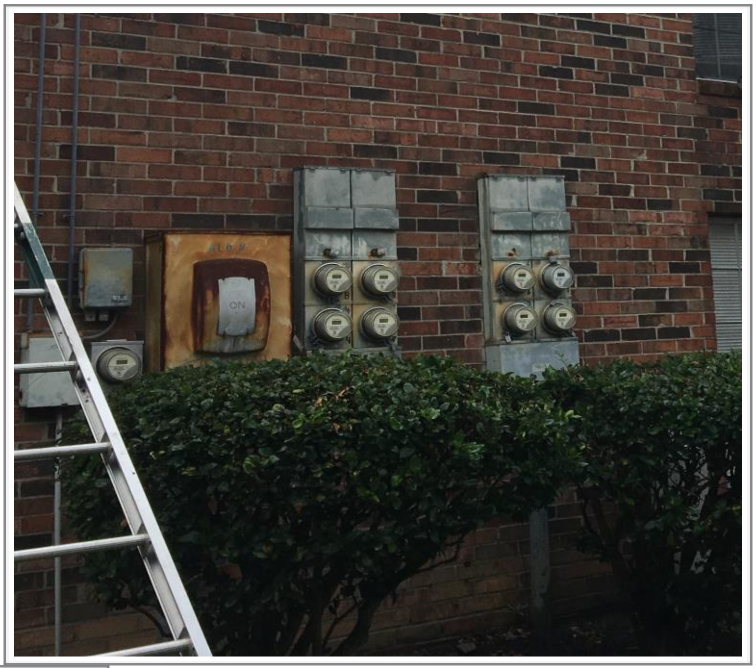
CHAPTER ELEVEN

UTILITIES AND SUMMARY

CHAPTER: 11 Utilities and Summary

Almost all occupied structures are serviced by one or more utilities (natural or L/ P gas, electricity, water, phone, cable, etc). When operating at a working fire, outside ladder crews should secure the utilities when performing a 360 size-up.

As the fire conditions can worsen, these hidden dangers can increase and/or provide the fire with fuel.



Some considerations should be followed when addressing utilities

- What utilities are involved in the structure?
- What company is responsible?
- Are there solar panels on the roof?

On newer construction homes, there are now requirements for a main service shut off, next to the electrical meter.

This should be quickly secured safety when performing a 360 size up.

The gas meter is another utility that can be quickly and safely secured during the size-up. Use the forks of your halligan or a pair of pliers to turn the shut off attached to the gas meter. This will secure the gas and hopefully prevent a gas-fed fire.

Some tasks to consider -

- Shut off gas meter

- Locate electrical meter (communicate the meter location as this will often help the inside crews locate the electrical panel inside).
- Advise the incident commanders of a utility company name.

SUMMARY

In summary, this book is to serve as a reference and guide to understanding the fundamentals of ladder company operations. You must not only understand and perform all tasks in the book at a proficient level, you must be in the mindset of being a "student of the craft". New information and technology are developed everyday. Always take the opportunity to learn, train, and pass on the information to younger members.

The purpose of this book is to inform and train newer members of the LCFS who want to become Truckmen.

We owe it to those before us, who taught us what we now know, to pass on this information to anyone who wants to grow.

Stay Safe.