Fire Suppression

Fire Fighter I

Knowledge Objectives

After studying this chapter, you will be able to:

- Describe the objectives of an offensive attack. (NFPA 5.3.10, p 680–681)
- Describe the operations performed during an offensive attack. (NFPA 5.3.10, p 680–681)
- Describe the objectives of a defensive attack. (NFPA 5.3.10, p 680–681)
- Describe the operations performed during a defensive attack. (NFPA 5.3.10, p 680–681)
- Describe the characteristics of a fog stream. (NFPA 5.3.8, p 682)
- Describe the characteristics of a straight stream. (NFPA 5.3.8, p 682)
- Describe the characteristics of a solid stream. (NFPA 5.3.8, p 682)
- Describe the objectives of an interior fire attack. (NFPA 5.3.10, p 682–683)
- Describe the objectives of a direct attack. (NFPA 5.3.10, p 683)
- Describe the objectives of an indirect attack. (NFPA 5.3.10, p 683–684)
- Describe the objectives of a combination attack. (NFPA 5.3.10, p 684)
- Describe the techniques used to advance a large handline. (NFPA 5.3.1.A, p 684–687)
- Describe the characteristics of a master stream device. (NFPA 5.3.8.A, p 687–688)
- Describe the characteristics of a deck gun. (NFPA 5.3.8.A, p 688–689)
- Describe the characteristics of a portable monitor. (NFPA 5.3.8.A, p 689)
- Describe the characteristics of elevated master streams. (NFPA 5.3.8.A, p 689–690)
- Describe the tactics used to protect exposures. (NFPA 5.3.10.A, p 690)
- Describe the characteristics of concealed-space fires. (NFPA 5.3.10, p 690–692)
- Describe the characteristics of basement fires. (NFPA 5.3.10, p 692)
- Describe the tactics used to suppress basement fires. (NFPA 5.3.10, 5.3.10.A, 5.3.10.B, p 692)
- Describe the tactics used to suppress fires above ground level. (NFPA 5.3.10, 5.3.10.A, 5.3.10.B, p 692–693)
- Describe the tactics used to suppress fires in large buildings. (NFPA 5.3.10, p 694)
- Describe the tactics used to suppress fires in buildings under construction, renovation, or demolition. (NFPA 5.3.10, p 694)
- Describe the tactics used to suppress fires in lumberyards. (NFPA 5.3.8A, p 694)
- Describe the tactics used to suppress fires in stacked or piled materials. (NFPA 5.3.8, 5.3.8.A, p 694–695)
- Describe the tactics used to suppress fires in trash containers. (NFPA 5.3.8, p 695)
- Describe the tactics used to suppress fires in confined spaces. (NFPA 5.3.8.A, p 695–696)
- Describe the tactics used to suppress fires in vehicles. (NFPA 5.3.7, p 696–697)
- Describe the tactics used to suppress fires in alternative-fuel vehicles. (NPFA 5.3.7.A, p 697)
- Describe the tactics used to suppress fires in the passenger compartment of a vehicle. (NFPA 5.3.7, p 697)
- Describe the tactics used to suppress fires in the engine compartment of a vehicle. (NPFA 5.3.7.A, p 698)
- Describe the tactics used to suppress fires in the trunk of a vehicle. (NPFA 5.3.7.A, p 698)
- Describe how to overhaul a vehicle fire. (NPFA 5.3.7.A, p 698)
- Describe the hazards presented by flammable-liquid fires. (NFPA 5.3.7, p 698–699)
- Describe the tactics used to suppress flammable-liquid fires. (NFPA 5.3.7, p 698–699)
- Discuss when gas service should be shut off. (NFPA 5.3.18, 5.3.18A, p 701)
- Describe when the electrical system should be shut off. (NFPA 5.3.18, 5.3.18A, p 701)
- Describe the hazards posed by electrical fires. (NFPA 5.3.18.A, p 701–702)
- Describe the tactics used to suppress an electrical fire. (p 701–702)

CHAPTER 22

Skills Objectives

After studying this chapter, you will be able to perform the following skills:

- Perform a direct attack. (NFPA 5.3.10.B, p 683)
- Perform an indirect attack. (NFPA 5.3.10.B, p 684)
- Perform a combination attack. (NFPA 5.3.10.B, p 684)
- Perform the one-fire fighter method for operating a large handline. (NFPA 5.3.8.B, p 685–686)
- Perform the two-fire fighter method for operating a large handline. (NFPA 5.3.8.B, p 685–687)
- Operate a deck gun. (NFPA 5.3.8.B, p 688–689)
- Deploy and operate a portable monitor. (NFPA 5.3.8.B, p 689)
- Locate and suppress concealed-space fires. (NFPA 5.3.8.B, p 692)
- Extinguish an outside trash fire or other outside Class A fire. (NFPA 5.3.8.B, p 695)
- Extinguish a vehicle fire. (NFPA 5.3.7.B, p 697)
- Shut off gas utilities. (NFPA 5.3.18.B, p 701)
- Control the electric utility system. (NFPA 5.3.18.B, p 701)

Fire Fighter II — FFII

Knowledge Objectives

After studying this chapter, you will be able to:

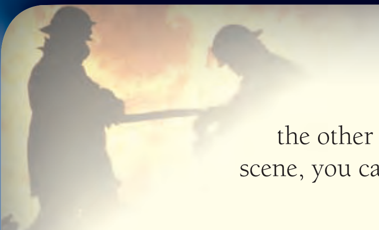
- List the factors that the incident commander evaluates when determining whether to perform a defensive attack or an offensive attack. (NFPA 6.3.2, p 681)
- Describe the characteristics of a fog stream. (NFPA 6.3.2A, p 682)
- Describe the characteristics zof a straight stream. (NFPA 6.3.2A, p 682)
- Describe the characteristics of a solid stream. (NFPA 6.3.2A, p 682)
- Describe the objectives of an interior fire attack. (NFPA 6.3.2B, p 682–683)
- Describe the objectives of a direct attack. (NFPA 6.3.2B, p 683)
- Describe the objectives of an indirect attack. (NFPA 6.3.2B, p 683–684)
- Describe the objectives of a combination attack. (NFPA 6.3.2B, p 684)
- Explain how ventilation is coordinated with fire suppression operations. (NFPA 6.3.2, p 690)
- Describe the characteristics of concealed-space fires. (NFPA 6.3.2, p 690, 692)
- Describe the characteristics of basement fires. (NFPA 6.3.2, p 692)
- Describe the tactics used to suppress basement fires. (NFPA 6.3.2,B, p 692)
- Describe the tactics used to suppress fires above ground level. (NFPA 6.3.2,B, p 692–693)
- Describe the characteristics of flammable-gas cylinders. (NFPA 6.3.3A, p 699–700)
- Describe the hazards presented by flammable-gas fires. (NFPA 6.3.3A, p 699–700)
- Describe a boiling liquid/expanding vapor explosion (BLEVE). (NFPA 6.3.3A, p 700)
- Describe the tactics used to suppress flammable-gas fires. (NFPA 6.3.3, 6.3.3A, p 700–701)

Skills Objectives

After studying this chapter, you will be able to perform the following skills:

- Coordinate an interior attack. (NFPA 6.3.2.B, p 683)
- Suppress a flammable-gas cylinder fire. (NFPA 6.3.3.B, p 700–701)

You Are the Fire Fighter



This is it—your first night at the fire station. You lie in your bed wide awake, just hoping for a call. Just past midnight, the alarm sounds for a fire in a house. You slide down the pole and quickly slip on your turnout gear before climbing into the cab. Your heart is racing as the other crew members mount the apparatus like it is just another day at the office. As you get close to the scene, you can see the orange glow: The incident is a working fire.

1. What is the difference between an offensive attack and a defensive attack?
2. When would you use an indirect attack rather than a direct attack?
3. Which type of nozzle would you use for an indirect attack?

Introduction

The term "fire suppression" refers to all of the tactics and tasks that are performed on the fire scene to achieve the final goal of extinguishing the fire. Fire suppression can be accomplished through a variety of methods that will stop the combustion process. All of these methods involve removal of one of the four components of the fire tetrahedron—that is, a fire can be extinguished by removing the oxygen, the fuel, or the heat from the combustion process; interrupting the chemical chain reactions will also stop the combustion process and extinguish the fire.

This chapter presents the methods that fire fighters most frequently use to extinguish fires. The apparatus and equipment employed by most fire departments are designed to apply large volumes of water to a fire in an attempt to cool the fuel below its ignition temperature. Although fire departments typically deploy a variety of extinguishing agents for different situations, water is used more often than any other agent. Water is a very effective extinguishing agent for many different types of fires, because tremendous quantities of heat energy are required to convert water into steam. When water is applied to a fire, all of the heat that is used to create steam is removed from the combustion process. If a sufficient quantity of water is applied, the fuel is cooled below its ignition temperature and the fire is extinguished.

FIRE FIGHTER Tips

While fire suppression operations are ongoing, a variety of other activities will be occurring simultaneously. All firefighting activities are important because successful firefighting requires a team effort and coordinated attack.

Offensive Versus Defensive Operations

All fire suppression operations are classified as either offensive or defensive. When fire fighters advance hose lines into a building to attack a fire, the strategy is offensive. By contrast, defensive operations are conducted from the exterior, by directing water streams toward the fire from a safe distance.

Offensive operations expose fire fighters to the heat and smoke of the fire inside the building as well as to several other risk factors, such as the possibility of being trapped by a structural collapse. The objective in an offensive operation is for fire fighters to get close enough to the fire to apply extinguishing agents at close range. This allows the extinguishing agent to be applied directly where it is needed to overpower the fire. When an offensive attack is successful, the fire can be controlled with the least amount of property damage.

An offensive strategy is used in situations where the fire is not too large or too dangerous to be extinguished by applying water from interior handlines. Small handlines (1½- or 1¾-inch [38- or 45-mm] lines) are used for most interior fire attack operations. Large handlines (2½-inch [65-mm] lines) are often used to conduct an interior attack on a large fire. Although they are much heavier and more difficult to maneuver inside a building than their smaller-diameter counterparts, the volume of fire may require the use of these larger-diameter hoses.

Large handlines and master streams are more often used in defensive operations. A defensive strategy is used in situations where the fire is too large to be controlled by an offensive attack and in situations where the level of risk to fire fighters conducting an interior attack would be unacceptable. The primary objective in a defensive operation is to prevent the fire from spreading. Thus water is directed into the building through doorways, windows, and openings in roofs, or onto exposures to keep the fire from spreading. During this type of fire suppression operation, fire fighters remain outside the building and operate from safe positions.

The decision whether to conduct offensive or defensive operations must be made by the incident commander (IC) at the beginning of each fire suppression operation and is periodically reevaluated throughout the incident. This decision must be made before operations begin and must be clearly communicated and understood by everyone who is involved in the operation. There is no room for confusion: It would be an extremely dangerous situation if one group of fire fighters initiated defensive operations while another group of fire fighters was conducting an offensive attack inside the building.

If the decision is made to switch from offensive to defensive strategy, or from defensive to offensive strategy, at any point during an operation, this change must be clearly communicated and understood by all fire fighters. A change from offensive to defensive operations could be warranted if an interior attack is unsuccessful or if the risk factors are determined to be too great to justify having fire fighters work inside the building. Sometimes the strategy switches from defensive to offensive after an exterior attack has reduced the volume of fire inside a building to the point at which fire fighters can enter and complete extinguishments with handlines. An offensive fire attack requires well-planned coordination among crews performing different tasks, such as ventilating, operating hose lines, and conducting aggressive search and rescue.

Fire Fighter Safety Tips

One of the most crucial decisions made by the IC is whether to initiate a defensive or offensive fire attack. Mounting an offensive attack on an unsafe building can result in fire fighter deaths or injuries.

A defensive strategy should be implemented when the IC determines that it would be impossible to enter the burning building and control the fire with handlines, as well as in situations where the risk of injury to or death of a fire fighter is excessive. A defensive operation involves the use of large-diameter hoses and master stream devices from the exterior of the structure in an attempt to confine the fire. Exposure protection should be a high priority during a defensive operation.

Fire Fighter Safety Tips

Offensive (interior attack) operations and defensive (exterior attack) operations must never be performed simultaneously.

Fire Fighter Safety Tips

An IC should never risk the lives of fire fighters when there are no lives to save.

FIRE FIGHTER II

Command Considerations

The IC must evaluate a whole range of factors to decide whether an offensive strategy (interior attack) or a defensive strategy (exterior attack) should be used at a particular fire. If the risk factors are too great, an exterior attack is the only acceptable option. If the decision is made to launch an interior attack, the IC must determine where and how to attack, after considering both safety issues and the potential effectiveness of the operation. The factors to be evaluated when considering whether to enter the structure to mount an attack include the following:

- What are the risks versus the potential benefits?
- Is it safe to send fire fighters into the building? Do not risk fire fighters' lives to retrieve the dead or save a building about to be demolished.
- What are the structural concerns?
- Is this building made of lightweight construction?
- Are there any lives at risk?
- Does the size of the fire prohibit entry?
- Are enough fire fighters on the scene to mount an interior attack? (Remember the two-in/two-out rule.)
- Is an adequate water supply available?
- Can proper ventilation be carried out to support offensive operations?

After sizing up the situation, the IC must determine which type of attack is appropriate. As a new fire fighter, you are not responsible for determining the type of fire attack that will be used. Nevertheless, you should understand the various factors that go into making these decisions and recognize why the IC orders different types of fire attacks for different types of fires.

Operating Hose Lines

Some of the most basic skills that must be mastered by every fire fighter involve the use of hose lines to apply water onto a fire. Put simply, a fire fighter must be able to advance and operate a hose line effectively to extinguish a fire. The proper operation of a hose line is also essential to protect yourself, your crew, and any trapped victims from the fire. Fire attack operations are often conducted under extremely stressful conditions, including high heat conditions, limited or zero visibility, and unfamiliar surroundings. Care should be taken not to have opposing hose lines, such that two crews are working "against" each other.

Fire fighters must learn how to operate both large and small handlines, as well as master stream appliances. Small handlines can be as large as 2 inches (50 mm) in diameter. The most frequently used size for interior fire attack is 1¾-inch (45 mm) handlines. Although one fire fighter can usually operate the nozzle on a small hose line, a second fire fighter will provide valuable assistance when a small hose line must be advanced and maneuvered.

Large handlines are defined as hoses that are at least 2½ inches (65 mm) in diameter. Because water can flow through these hoses at a rate of more than 250 gallons per minute (gpm) (1136 liters per minute [lpm]), large handlines are heavier and less maneuverable than smaller lines. At least two fire fighters are required to advance and control a large handline, although one fire fighter can control a large handline if it is firmly anchored. This task can be accomplished by utilizing a webbing strap or by looping the line and sitting down on it FIGURE 22-1.

Master streams are used when large quantities of water are needed to control a large fire. Such a stream can deliver water at a rate of at least 350 gpm (1591 lpm), and some master stream devices can flow more than 2000 gpm (9092 lpm). The most commonly used master stream devices deliver flows between 350 (1591) and 1500 (6819) gpm/lpm. Master stream devices are operated from a fixed position—either on the ground, on top of a piece of fire apparatus, or on an aerial ladder or elevated platform. They are typically used for defensive operations, although master streams can also be used to "blitz" a fire before beginning an offensive attack. This fire suppression method knocks the main body of fire down with a heavy stream; crews can then stretch handlines into the site and extinguish the remaining fire.

FIGURE 22-1 One fire fighter can control a large handline if it is firmly anchored. This task can be accomplished by utilizing a webbing strap or by looping the line and sitting down on it.

Fire Streams

Different types of fire streams are produced by using different types of nozzles. As described in the Fire Attack and Foam chapter, the nozzle defines the pattern and form of the water that is discharged onto the fire. A fire stream can be produced with a smooth-bore nozzle or an adjustable nozzle. Fire department policies and standard operating procedures (SOPs) usually dictate the types of nozzles that are used with different types of hose lines. The nozzle operator must know which type of nozzle should be used in the specific situation at hand. When an adjustable nozzle is used, the nozzle operator must know how to set the discharge pattern to produce different kinds of streams.

The first major distinction in nozzle discharge patterns is between a fog stream and a straight stream FIGURE 22-2. A fog stream divides water into droplets, which have a very large surface area and can absorb heat efficiently. When heat levels in a building need to be lowered quickly, a combination of ventilation and a fog stream may be the fire suppression method of choice. A fog stream can also be used to protect fire fighters from the heat of a large fire. Most adjustable nozzles can be adjusted from a straight stream, to a narrow fog pattern, to a wide fog pattern, depending on the reach that is required and how the stream will be used.

A straight stream has a greater reach than a fog stream, so it can hit the fire from farther away. A straight stream also keeps the water concentrated in a small area, so it can penetrate through a hot atmosphere to reach and cool the burning materials. To produce a straight stream, the fire fighter sets the adjustable nozzle to the narrowest pattern it can discharge. This type of stream is made up of a highly concentrated pattern of droplets that are all discharged in the same direction.

A solid stream is produced by a smooth-bore nozzle FIGURE 22-3. A solid stream has a greater reach and penetrating power than a straight stream, because it is discharged as a continuous column of water.

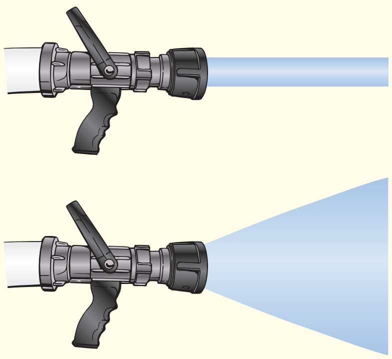


FIGURE 22-2 A straight stream and a fog stream are both produced using a fog nozzle.

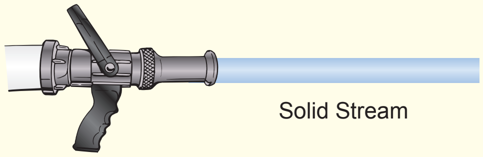


FIGURE 22-3 A solid stream is produced by a smooth-bore nozzle.

One consideration when selecting and operating nozzles is the amount of air that is moved along with the water. A fog stream naturally moves a large quantity of air along with the mass of water droplets. This air flows into the fire area along with the water. When this air movement is combined with steam production as the water droplets encounter a heated atmosphere, the thermal balance is likely to be disrupted quickly. In such a case, the hot fire gases and steam may be displaced back toward the nozzle operator. Straight and solid streams move little air in comparison with a fog stream, so fewer concerns with displacement and disruption of the thermal balance arise when these types of streams are used for fire suppression.

When applied correctly, the air movement created by a fog stream can be used for ventilation. Discharging a fog stream out through a window or doorway, for example, will draw smoke and heat out in the same manner as an exhaust fan. This operation must be performed carefully to prevent accidentally drawing hidden fire toward the nozzle operator. The use of a water stream to provide ventilation is called hydraulic ventilation and is discussed further in the Ventilation chapter.

Interior Fire Attack

An interior fire attack is an offensive operation that requires fire fighters to enter a building and discharge an extinguishing agent (usually water) onto the fire. An interior structure fire is a fire that occurs inside a building or structure. Its fuel could be the contents of the building, or the structure itself might be burning. The larger the fire, the greater the challenge in suppressing it, and the more ominous the risks that are involved in interior fire suppression.

Interior fire attack can be conducted on many different scales. In many cases, such an attack is geared toward a fire that is burning in only one room; this kind of fire may be controlled quickly by one attack hose line. Larger fires require more water, which could be provided by two or more small handlines working together or by one or more larger handlines. Fires that involve multiple rooms, large spaces, or concealed spaces are more complicated and require more extensive coordination; nevertheless, the basic techniques for attacking these fires are similar to the techniques used when extinguishing smaller fires.

FIRE FIGHTER II

As a trained Fire Fighter II, you should be able to understand and coordinate an interior fire attack. To coordinate an interior attack, follow the steps in SKILL DRILL 22-1 (Fire Fighter II, NFPA 6.3.2):

1. Don full personal protective equipment (PPE), including self-contained breathing apparatus (SCBA). Enter the personnel accountability system, and proceed to work as a team.
2. Perform size-up and give an arrival report. Call for additional resources if needed.
3. Ensure that an adequate water supply and backup resources are available.
4. Select the appropriate attack technique.
5. Communicate the attack technique to the team.
6. Maintain constant team coordination.
7. Evaluate conditions on an ongoing basis.
8. Communicate and manage search, rescue, and ventilation requirements.
9. Report hazards.
10. Inform incident command of changing conditions.
11. Assess burn patterns to determine the fire's origin.
12. Preserve signs of the fire's origin, cause, and arson.
13. Ensure complete extinguishment of fire during overhaul.
14. Exit the hazard area, account for all members of the team, and report to incident command.

Direct attack and indirect attack are two different methods of discharging water onto a fire. A combination attack is performed in two stages, beginning with an indirect attack and then continuing with a direct attack.

Fire Fighter Safety Tips

It is imperative to extinguish all fire as you proceed to the seat of the fire. Failure to do so may allow the fire to grow behind you, entrapping you by cutting off your escape route.

Direct Attack

The most effective means of fire suppression in most situations is a direct attack. This kind of attack uses a straight or solid hose stream to deliver water directly onto the base of the fire FIGURE 22-4. The water cools the fuel until it is below its ignition temperature. Water should be applied until flame is no longer visible. To perform a direct attack, follow the steps in SKILL DRILL 22-2 (Fire Fighter I, NFPA 5.3.10):

1. Exit the fire apparatus wearing full PPE, including SCBA.
2. Select the proper hose line to fight the fire based on the fire's size, location, and type.
3. Advance the hose line from the apparatus to the entry point of the structure. Flake out excess hose in front of the door.
4. Don a face piece and activate the SCBA and personal alert safety system (PASS) device prior to entering the building.
5. Signal the pump operator/driver that you are ready for water.
6. Open the nozzle to purge air from the system and make sure water is flowing.
7. Make sure that ventilation is completed or in progress.
8. Enter into the structure and locate the seat of the fire.
9. Apply water in either a straight or solid stream onto the base of the fire until all visible flame has been extinguished.
10. Watch for changes in fire conditions.
11. Shut down the nozzle and listen.
12. Locate and extinguish hot spots.

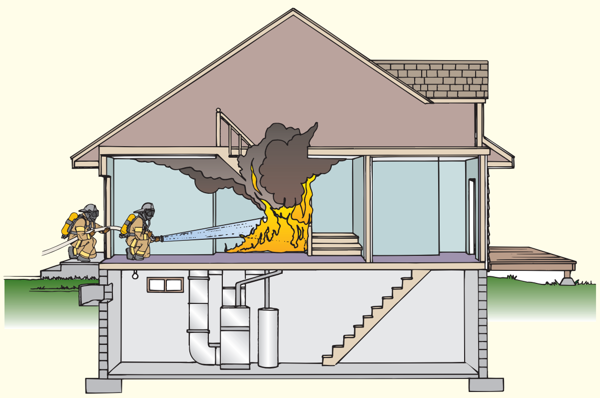


FIGURE 22-4 In a direct attack, a straight or solid hose stream is used to deliver water directly onto the base of the fire.

Indirect Attack

Indirect application of water is used in situations where the temperature is increasing and it appears that the room or space is ready to flash over. With this fire suppression method, the fire fighter aims a short burst of water at the ceiling to cool the superheated gases in the upper levels of the room or space. This action can prevent or delay flashover long enough for fire fighters to apply water directly to the seat of the fire or to make a safe exit. Follow your department's SOPs regarding the application of water.

The objective of an indirect attack is to quickly remove as much heat as possible from the fire atmosphere. An indirect attack is particularly effective at preventing flashover from occurring. This method of fire suppression should be used when a fire has produced a layer of hot gases at the ceiling level. When water is injected into the hot fire gases, it is converted to steam, absorbing tremendous quantities of heat in the process. The atmosphere cools quickly down to 212°F (100°C), the boiling point of water. In this way, heat—which is used to convert the water to steam—is removed from the combustion process.

Fire fighters can make an indirect attack by using a straight stream, a solid stream, or a narrow fog stream. With this strategy, they direct their water toward the ceiling of the intensely heated area where the hot gases are layered, so as to create steam FIGURE 22-5. This practice is often referred to as "painting the ceiling" with the water stream. The water is distributed over a large surface area so that it will absorb heat as quickly as possible. Once the temperature has been reduced and the area has been properly ventilated, fire fighters can switch to a direct attack to complete extinguishment.

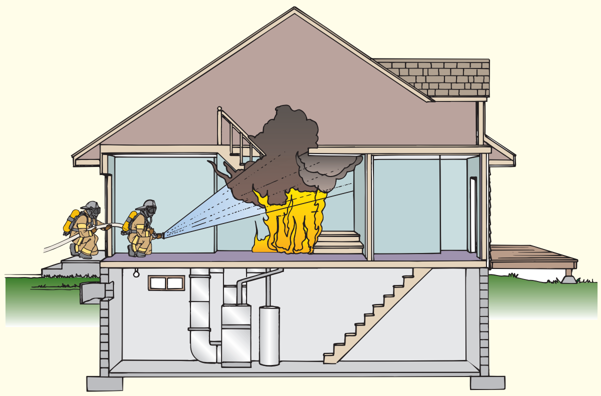


FIGURE 22-5 In an indirect attack, fire fighters direct a fog stream at the ceiling of the intensely heated area so as to create steam.

As soon as enough steam has been produced to reduce the fire, the fire stream should be shut down so that the thermal layering of the superheated gases is disturbed as little as possible. When water is converted to gaseous steam, it expands to occupy a volume 1700 times greater than the volume of an equivalent amount of liquid water. This expansion tends to displace the hot gases that were near the ceiling and push them down toward the floor. The resulting mixture of steam and hot gases is capable of causing serious steam burns to fire fighters, even those who are wearing PPE. Serious injuries can occur if fire fighters put too much water into the upper atmosphere and the hot gases are forced down on top of them.

To perform an indirect attack, follow the steps in SKILL DRILL 22-3 (Fire Fighter I, NFPA 5.3.10):

1. Exit the fire apparatus wearing full PPE, including SCBA.
2. Select the correct hose line to be used to attack the fire depending on the type of fire, its location, and its size.
3. Advance the hose line from the apparatus to the opening in the structure where the indirect attack will be made.
4. Don a face piece, and activate the SCBA and PASS device.
5. Notify the operator/driver that you are ready for water.
6. Open the nozzle and make sure that air is purged from the hose line and that water is flowing. If using a fog nozzle, ensure that it is set to the proper nozzle pattern for entry. Shut down the nozzle until you are in a position to apply water.
7. Advance with a charged hose line to the location where you will apply water.
8. Direct the water stream toward the upper levels of the room and ceiling into the heated area overhead, and move the stream back and forth. Flow water until the room begins to darken. Shut the nozzle off, and reassess the fire conditions.
9. Watch for changes and a reduction in the amount of fire. Once the fire is reduced, shut down the nozzle.
10. Confirm that ventilation has been completed.
11. Attack any remaining fire and hot spots until the fire is completely extinguished.

Combination Attack

A combination attack employs both indirect attack and direct attack methods in a sequential manner. This strategy should be used when a room's interior has been heated to the point that it is nearing a flashover condition. Fire fighters should first use an indirect attack method to cool the fire gases down to safer temperatures and prevent flashover from occurring. This operation is followed with a direct attack on the main body of fire.

In a combination attack, the fire fighter who is operating the nozzle should be given plenty of space to maneuver. Only enough water as is needed to control the fire should be used, so as to avoid unnecessary water damage.

To perform a combination attack, follow the steps in SKILL DRILL 22-4 (Fire Fighter I, NFPA 5.3.10):

1. Don full PPE and SCBA. Select the correct hose line to accomplish the suppression task at hand.
2. Stretch the hose line to the entry point of the structure, and signal the operator/driver that you are ready to receive water.
3. Open the nozzle to get the air out and make sure that water is flowing.
4. Enter the structure, and locate the room or area where the fire originated.
5. Aim the nozzle at the upper-left corner of the fire and make either a "T," "O," or "Z" pattern with the nozzle. Start high and then work the pattern down to the fire level.
6. Use only enough water to darken down the fire without upsetting the thermal layering.
7. Once the fire has been reduced, find the remaining hot spots and complete fire extinguishment using a direct attack.

Large Handlines

Large handlines can be used either for offensive fire attacks or for defensive operations. In an offensive attack situation, a 2½-inch (65 mm) attack line can be advanced into a building to apply a heavy stream of water onto a large volume of fire. The same direct and indirect attack techniques that were described for small hose lines can also be used with large handlines.

Fire Fighter Safety Tips

Indicators of possible building collapse include the following signs:

- Leaning walls
- Free-standing walls
- Smoke emitting from cracks
- Creaking sounds
- Sagging roofs or floors

Considerations for possible building collapse include the following factors:

- Exposure to serious fire
- Water loading from use of master streams
- Lightweight construction or trusses

FIRE FIGHTER Tips

When using an indirect or combination attack, watch for droplets of water raining down; they indicate lowered ceiling temperatures. If no droplets fall, the ceiling is still too hot.

A 2½-inch (65 mm) handline can overwhelm a substantial interior fire if it can be discharged directly into the involved area. The extra reach of the stream can also prove valuable when making an interior attack in a large building.

It is more difficult for fire fighters to advance and maneuver a large handline inside a building, particularly in tight quarters or around corners. At least three team members are usually needed to advance and maneuver a 2½-inch (65 mm) handline inside a building. These fire fighters must contend with the nozzle reaction force as well as the combined weight of the hose and the water. In situations where the hose line must be advanced over a considerable distance into a building, additional fire fighters will be required to move the line. The extra effort required to deploy such a line, however, is balanced by the powerful fire suppression capabilities of a large handline.

Large handlines are often used in defensive situations to direct a heavy stream of water onto a fire from an exterior position. In these cases, the nozzle is usually positioned so that it can be operated from a single location by one or two fire fighters. The stream can be used to attack a large exterior fire or to protect exposures. It can also be directed into a building through a doorway or window opening to knock down a large volume of fire inside. If the exterior attack is successful in reducing the volume of fire, the IC might decide to switch to an offensive (interior) attack to complete extinguishment of the fire.

One-Fire Fighter Method

One fire fighter can control a large attack hose by forming a large loop of hose about 2 feet (0.6 m) behind the nozzle. When the loop is placed over the top of the nozzle, the weight of the hose stabilizes the nozzle and reduces the nozzle reaction. To add more stability, lash the hose loop to the hose behind the nozzle where they cross. This technique reduces the energy needed to control the line if it is necessary to maintain the water stream for a long period of time. Although this method does not allow the hose to be moved while water is flowing, it is a good choice for protecting exposures when fire fighters are operating in a defensive attack mode.

To perform the one-fire fighter method for operating a large handline, follow the steps in SKILL DRILL 22-5:

1. Select the correct size of fire hose for the task to be performed.
2. While wearing full PPE and SCBA, advance the hose into the position from which you plan to attack the fire
3. Signal the pump operator that you are ready for water.
4. Open the nozzle to allow air to escape the hose and to ensure that water is flowing.
5. Close the nozzle and then make a loop with the hose, ensuring that the nozzle is under the hose line that is coming from the fire apparatus. (STEP 1)
6. Lash the hose sections together where they cross, or use your body weight to kneel or sit on the hose line at the point where the hose crosses itself. (STEP 2)
7. Allow enough hose to extend past the section where the line crosses itself for maneuverability. (STEP 3)
8. Open the nozzle and direct water onto the designated area. (STEP 4)

Two-Fire Fighter Method

When two fire fighters are available to operate a large handline, one should act as the nozzle operator, while the other serves as a backup. The nozzle operator grasps the nozzle with one hand and holds the hose behind the nozzle with the other hand. The hose should be cradled across the fire fighter's hip for added stability. The backup fire fighter should be positioned approximately 3 feet (0.9 m) behind the nozzle operator. This person grasps the hose with both hands and holds the hose against a leg or hip. The backup fire fighter can also use a hose strap to maintain a better hand grip on a large handline. When the line is operated from a fixed position, the second fire fighter can kneel on the hose with one knee to stabilize it against the ground.

To perform the two-fire fighter method for operating a large handline, follow the steps in SKILL DRILL 22-6:

1. Don all PPE and SCBA.
2. Select the correct hose line for the task at hand.
3. Stretch the hose line from the fire apparatus into position. (STEP 1)
4. Signal the pump operator that you are ready for water.
5. Open the nozzle a small amount to allow air to escape and to ensure that water is flowing.
6. Advance the hose line as needed. (STEP 2)
7. Before attacking the fire, the fire fighter on the nozzle should cradle the hose on his or her hip while grasping the nozzle with one hand and supporting the hose with the other hand.
8. The second fire fighter should stay approximately 3 feet behind the fire fighter who is on the nozzle. The second fire fighter should grasp the hose with two hands and, if necessary, use a knee to stabilize the hose against the ground.

SKILL DRILL 22-5 Performing the One-Fire Fighter Method for Operating a Large Handline

(Fire Fighter I, NFPA 5.3.8)

1 Select the correct size of fire hose. Advance the hose into position. Signal that you are ready for water and open the nozzle to allow air to escape and to ensure that water is flowing. Close the nozzle and then make a loop with the hose, ensuring that the nozzle is under the hose line that is coming from the fire apparatus.

2 Lash the hose sections together where they cross, or use your body weight to kneel or sit on the hose line at the point where the hose crosses itself.

3 Allow enough hose to extend past the section where the line crosses itself for maneuverability.

4 Open the nozzle and direct water onto the designated area.

9. Use a hose strap to maintain a better grip on the hose. (**STEP 3**)
10. Open the nozzle in a controlled fashion and direct water onto the fire or designated exposure. (**STEP 4**)

If it is necessary to advance a flowing 2½-inch (65 mm) handline over a short distance and only two fire fighters are available, be aware of the large reaction force exerted by the flowing water. It is much easier to shut down the nozzle momentarily and move it to the new position than to relocate a flowing line. If the line must be moved while water is flowing, both fire fighters must brace the hose against their bodies to keep it under control. Three fire fighters can stabilize and advance a large handline more comfortably and safely than can two fire fighters.

SKILL DRILL 22-6 Performing the Two-Fire Fighter Method for Operating a Large Handline

(Fire Fighter I, NFPA 5.3.8)

1. Stretch the hose line from the fire apparatus into position.

2. Signal that you are ready for water and open the nozzle to allow air to escape and to ensure water is flowing. Advance the hose line as needed.

3. Before attacking the fire, the fire fighter on the nozzle should cradle the hose on his or her hip while grasping the nozzle with one hand and supporting the hose with the other hand. The second fire fighter should stay approximately 3 feet behind the fire fighter who is on the nozzle. The second fire fighter should grasp the hose with two hands and may use a knee to stabilize the hose against the ground if necessary.

4. Open the nozzle in a controlled fashion and direct water onto the fire or designated exposure.

Master Stream Devices

Master stream devices are used to produce high-volume water streams for large fires. Several types of master stream devices exist, including portable monitors, deck guns, ladder pipes, and other elevated stream devices. Most master streams discharge between 350 and 1500 gallons (1591 to 6819 lpm) of water per minute, although much larger capacities are available for special applications. In addition, the stream that is discharged from a master stream device has a greater range than the stream from a handline, so it can be effective from a greater distance.

A master stream device can be either manually operated or directed by remote control. Many of these devices can be set up and then left to operate unattended. This capability may prove extremely valuable in a high-risk situation, because it eliminates the need to leave a fire fighter in an unsafe location or a hazardous environment to operate the device.

Master streams are used mainly during defensive operations. They should never be directed into a building while fire fighters are operating inside the structure, because these streams can push heat, smoke, or fire onto the fire fighters.

Fire Fighter Safety Tips

A nozzle flowing 1000 gallons (4546 lpm) of water per minute is adding 4.2 tons (8345 pounds) (3785 kg) of weight to the building every minute. Be aware of the increasing risk of building collapse in such a scenario.

Fire Fighter Safety Tips

Master streams should never be directed into a building while fire fighters are operating inside the structure. The force of the stream can push heat, smoke, or fire onto the fire fighters.

The force and impact of the stream can also dislodge loose materials or cause a structural collapse.

Deck Guns

A deck gun is permanently mounted on a vehicle and equipped with a piping system that delivers water to the device. These devices are sometimes called turret pipes or wagon pipes FIGURE 22-6. If the vehicle is equipped with a pump, the pump operator can usually open a valve to start the flow of water.

Sometimes, however, a hose must be connected to a special inlet to deliver water to the deck gun. If your fire apparatus is equipped with a deck gun, you need to learn your role when placing it in operation.

To operate a deck gun, follow the steps in SKILL DRILL 22-7:

1. Make sure that all firefighting personnel are out of a structure before using a deck gun.

SKILL DRILL 22-7 Operating a Deck Gun

(Fire Fighter I, NFPA 5.3.8)

1. Make sure that all firefighting personnel are out of a structure before using a deck gun. Place the deck gun in the correct position.

2. Aim the deck gun at the fire or at the target exposure. Signal the pump operator that you are ready for water.

3. Once water is flowing, adjust the angle, aim, or water flow as necessary.

FIGURE 22-6 A deck gun is permanently mounted on a vehicle and equipped with a piping system that delivers water to the device.

FIGURE 22-7 A portable monitor is placed on the ground and supplied with water from one or more hose lines.

2. Place the deck gun in the correct position. (STEP 1)
3. Aim the deck gun at the fire or at the target exposure.
4. Signal the pump operator that you are ready for water. (STEP 2)
5. Once water is flowing, adjust the angle, aim, or water flow as necessary. (STEP 3)

FIRE FIGHTER Tips

Remote-controlled wildland monitors can be mounted on the front bumper of wildland apparatus. These devices operate through an electrically operated remote control and are built to flow anywhere between 15 gpm (68 lpm) and 350 gpm (1591 lpm). They can be used to mount an attack while the operator remains in the vehicle.

Portable Monitor

A portable monitor is a master stream device that can be positioned wherever a master stream is needed FIGURE 22-7. It is placed on the ground, and hose lines are then connected to the portable monitor to supply the water. Most of these devices come equipped with either one, two, or three inlets. Portable monitors can be built with 2½-inch (65 mm) inlets or with a large-diameter hose inlet. Smaller portable monitors are sometimes set up attached to a preconnected hose. This arrangement enables one fire fighter to step away from the engine with the portable monitor and attached hose, walk to an assigned area, and quickly place the portable monitor in operation. Some master stream devices can be used as deck guns or taken off the fire apparatus and used as portable monitors.

To deploy a portable monitor, remove it from the apparatus and carry it to the location where it will be used. Advance an adequate number of hose lines from the engine to the monitor. The number of hose lines needed depends on the volume of water to be delivered and the size of the hose lines. Form a large loop in the end of each hose line in front of the monitor, and then attach the male coupling to the inlets of the monitor. The loops serve to counteract the force created by the flow of the water through the nozzle.

To set up and operate a portable monitor, follow the steps in SKILL DRILL 22-8 (Fire Fighter I, 5.3.8):

1. Remove the portable monitor from the fire apparatus and move it into the desired position.
2. Attach the necessary hose lines to the monitor as per SOPs or the manufacturer's instructions.
3. Loop the hose lines in front of the monitor to counteract the force created by water flowing out of the nozzle.
4. Signal the pump operator that you are ready for water.
5. Aim the water stream at the fire or onto the designated exposure, and adjust the stream as necessary.

If the portable monitor is not adequately secured, the nozzle reaction force can cause it to move from the position where it was originally placed. A moving portable monitor poses a danger to anyone in its path. Many of these master stream devices are equipped with a strap or chain that may be secured to a fixed object to prevent the monitor from moving. Pointed feet on the base also help to keep a portable monitor from moving. If the stream is operated at a low angle, the reaction force will tend to make the monitor unstable. For this reason, a safety lock is usually provided to prevent the monitor from being lowered beyond a safe angle of 35 degrees. When setting up any portable monitor, always follow the manufacturer's instructions and your department's SOPs to ensure its safe and effective operation.

Elevated Master Streams

Elevated master stream devices are mounted on aerial ladders, aerial platforms, or special hydraulically operated booms FIGURE 22-8. A ladder pipe is an elevated master stream device that is mounted at the tip of an aerial ladder or tower ladder. On many aerial ladders, the ladder pipe is attached to the top of the ladder only when it is actually needed, and a hose is run up the ladder to deliver water to the device. Most newer aerial ladders and tower ladders are equipped with a fixed piping system to deliver water to a permanently mounted master stream device at the top. This arrangement saves valuable

FIGURE 22-8 Elevated master stream devices can be mounted on aerial apparatus.

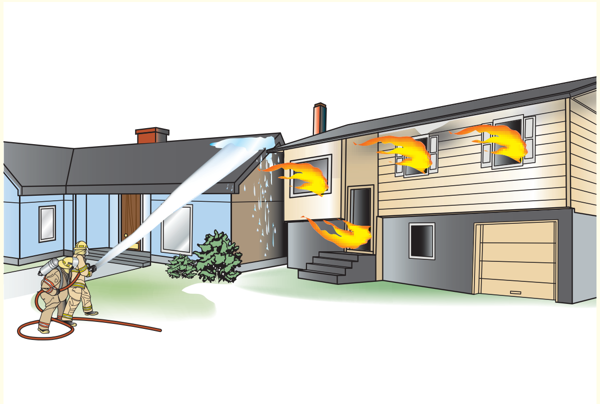


FIGURE 22-9 Protecting an exposure from radiant heat.

setup time at a fire scene. If your apparatus is equipped with a ladder pipe, you need to learn how to assist in its setup.

Protecting Exposures

Protecting exposures refers to actions that are taken to prevent the spread of a fire to areas that are not already burning. Exposure protection is a consideration at every fire; it becomes even more important with a large fire. If the fire is relatively small and contained within a limited area, the best way to protect exposures is usually to extinguish the fire; when the fire is extinguished, the exposure problem ceases to exist. In cases where the fire is too large to be controlled by an initial attack, exposure protection becomes a priority. In some cases, the best outcome that fire fighters can hope to obtain is to stop the fire from spreading.

The IC must consider the size of the fire and the risk to exposures in relation to how much firefighting capability is available and how quickly those resources can be assembled. In some cases, the IC will direct the first-arriving companies to protect exposures while a second group of companies prepares to attack the fire. At other times, the IC must identify a point where the progress of the fire can be stopped and direct all firefighting efforts toward that objective.

Protecting exposures involves very different tactics from offensive fire attacks. At a large free-burning fire, the first priority is to protect exposed buildings and property from a combination of radiant heat, convective heat, and burning embers FIGURE 22-9. The best option in these circumstances is usually to direct the first hose streams at the exposures rather than at the fire itself. Wetting the exposures will keep the fuel from reaching its ignition temperature. Because radiant heat can travel through a water stream, directing water onto the exposed surface is more effective than aiming a stream between the fire and the exposure. Master stream devices such as deck guns, portable monitors, and elevated master streams are excellent tools for protecting exposures. They also ensure that large volumes of water can be directed onto the exposures from a safe distance without putting fire fighters in the path of excess heat or in danger of building collapse. Fog streams can sometimes be used to absorb some of the heat coming from the main body of fire.

FIRE FIGHTER II

Ventilation

Ventilation must be coordinated with the suppression efforts to ensure that both events occur simultaneously and in a manner that supports the attack plan. Proper ventilation is designed to allow hot gases and smoke to be removed from the building, thereby improving visibility and tenability in the building for any trapped victims and fire fighters. Conversely, improper ventilation can create conditions that allow a fire to burn more aggressively and make it more difficult for fire fighters to enter the structure and attack the fire.

Coordination is essential to ensure that the hose lines will be ready to attack when the ventilation openings are made. These openings must be located so that the hot smoke and gases will be drawn away from the attack crews.

Fire Fighter Safety Tips

With modern lightweight construction and highly flammable contents, many fires today are likely to be underventilated when you arrive. Remember that even the act of opening the front door can introduce additional oxygen to the fire, contributing to a violent flashover in as little as 100 seconds!

Specific Fire-Ground Operations

Concealed-Space Fires

Fires in ordinary and wood-frame construction can burn in combustible void spaces behind walls and under subfloors and ceilings. To prevent the fire from spreading, these fires must be found and suppressed FIGURE 22-10. To locate and suppress

VOICES OF EXPERIENCE

It was 0400 hours and I was the company officer on duty. We had just returned from an EMS call. I went into the kitchen to start a pot of coffee and then headed into the Captain's office to start my report. That's when the tone went off and the dispatcher reported a structure fire. As I looked at the run book, I noticed that address given was on the right side of the street and there was a hydrant near the house. Knowing that we had a secure water supply, my next concern was, were all the occupants out of the structure?

As we rolled down the street, my focus was on the right side of the street, looking for the house involved. A flicker out of my left eye caught my attention. The house involved was across the street from the reported address. The house was a two-story balloon frame structure from the turn of the century. The front windows on the first floor were blown out, with fire lapping up the front and heading toward the second floor windows. I had my operator stop just past the house, providing him easy access to the hydrant.

As I exited the engine, I heard people yelling from the rear of the structure that there was a victim inside needing rescue. I directed my crew to grab the 24' ladder and meet me in the back of the house. When I got to the rear of the structure, I found a woman out on the roof of a first floor addition. She had escaped through a window on the second floor onto the roof over the kitchen.

I noticed that the fire was now spreading into the kitchen rapidly. There was no time to wait for a ladder to arrive. I made the decision to assist the victim from the roof before the ladder arrived. I was able to reach the edge of the roof and direct her to roll over onto her stomach and slide off of the roof as I assisted her to the ground. She was able to escape the roof safely.

Then I asked her if there were any other people in the house. She stated that she had assisted her daughter out of the same window and that her son was already out of the house. Thinking that all occupants were out of the house and with the growing intensity of the fire, my next priority was extinguishing the fire. I redirected my crew to pull two 1¾" hose lines to the front of the house. The fire on the first floor was extinguished quickly.

Accompanied by a crew member, I made entrance with a hose line through the front door, turned the corner, and started extinguishing the fire on the second floor. As we made our way through the second floor, the radio crackled to life and I heard the message that no fire fighter wants to hear, "Grandma is unaccounted for."

We initiated an immediate search of the second floor, but were hampered by piles of junk jamming the hallway. Additional units arrived to assist in the search, but it took over 50 minutes to uncover the location of the bedroom where the victim was found.

During the investigation, it was discovered that the room that the victim was in had an open grate to the first floor. When she stood up to exit the room, she inhaled super-heated air and was rendered unconscious immediately. She never had a chance.

Three people survived but one lost her life. As I reflected back on the incident days later, I asked myself, was there anything else I could have done to save the one we lost? The realization is that sometimes there is nothing we can do, fires kill.

Mark Romer
Division Chief, Retired
Lincoln, California

FIGURE 22-10 Fire may be hidden behind walls.

fires behind walls and under subfloors, follow the steps in SKILL DRILL 22-9 (Fire Fighter I, 5.3.8):

1. Locate the area of the building where a hidden fire is believed to exist.
2. Look for signs of fire such as smoke coming from cracks or openings in walls, charred areas with no outward evidence of fire, and peeling or bubbled paint or wallpaper. Listen for cracks and pops or hissing steam.
3. Use a thermal imaging camera to look for areas of heat that may indicate a hidden fire.
4. Use the back of your hand to feel for heat coming from a wall or floor.
5. If a hidden fire is suspected, use a tool such as an axe or Halligan tool to remove the building material over the area.
6. If fire is found, expose the area as much as possible without causing unnecessary damage and extinguish the fire using conventional firefighting methods.

Basement Fires

Fires in basements or below grade level present several different challenges. First and foremost, they are difficult to recognize. Basement fires can damage the floor above the fire. If fire fighters do not identify a basement fire and enter the building above the basement fire, they are at risk of falling through the damaged floor and ending up in the burning basement.

Basements are difficult and dangerous spaces to enter, and they have limited routes of egress. They are also usually

FIRE FIGHTER Tips

Floors that are built using lightweight materials such as prefabricated wood I-joists or trusses may fail faster than floors built with more solid lumber.

difficult to ventilate, which means that an interior attack must often be made in conditions of high heat and low visibility. Likewise, it will be difficult to remove the fire gases and steam produced by the attack lines. As a consequence, fire fighters may find it hard to see in a basement even after ventilation has been performed. Basements are often used for storage, so fire fighters may find it challenging to keep their sense of orientation in the narrow, disorganized cluttered spaces.

Fire fighters should identify the safest means of entry and exit into the area where firefighting operations will be conducted. An exterior access point allows them to enter a basement without passing through the hot gas layers at the basement ceiling level. If the only point of entry is an interior stairway, fire fighters must protect that opening to keep the fire from extending to the upper floors of the building FIGURE 22-11. Ventilation must be planned and conducted early. If this operation is not managed properly, the interior stairwell will act as a chimney and bring heat and smoke up from the basement.

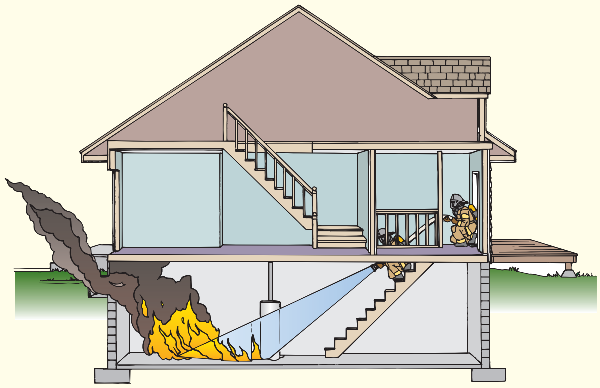


FIGURE 22-11 A fire below grade level is often not recognized. These fires can quickly weaken the floor above them.

Cellar fires can also spread to upper floors in houses with balloon-frame construction. Thermal imaging cameras are especially useful in identifying fires below the floor.

Fires Above Ground Level

Advancing charged hose lines up stairs and along narrow hallways requires much more physical effort than advancing a charged hose line on a level surface. It is important to protect stairways and other vertical openings between floors when fighting a fire in a multiple-level structure. Specifically, hose lines must be placed to keep the fire from extending vertically and to ensure that exit paths remain available.

When working with a hose above the ground floor, fire fighters should advance the line uncharged until they reach the fire floor and have extra hose available. This approach allows for easier advancement of attack lines.

Interior fire crews must always look for a secondary exit path in case their entry route becomes blocked by the fire or by a structural collapse. This secondary exit could be a second interior stairway, an outside fire escape, a ground ladder placed to a window, or an aerial device.

In high-rise buildings, the standpipe system is typically used to supply water for hose lines. Fire fighters must practice connecting hose lines to standpipe outlets and extending lines from stairways into remote floor areas. Additional hose lines, tools, air cylinders, and Emergency Medical Services equipment should be staged one or two floors below the fire.

Fire Fighter Safety Tips

Be alert to the risk of structural instability and collapse. Remember that modern lightweight construction does not provide clear signs of weakness before collapse. Modern construction fails quickly, suddenly, and without warning signs, and there are no effective ways to check the floor for stability.

FIRE FIGHTER Tips

Do not use more water than is needed to extinguish the fire, because retained water adds weight to the structure and may lead to structural collapse.

Near Miss REPORT

Report Number: 06-0000533

Synopsis: Aerial master stream hits second-floor attack crew.

Event Description: On the afternoon of July 4, 2006, our department was dispatched to a residential structure fire. We responded with three engine companies, one truck company, and two squads. The responding units were staffed with two people, and there were two battalion chiefs responding. One of the battalion chiefs was on duty, and the other responded from his house less than a block away. All other units were staffed with three people, and another engine was requested later in the incident.

The first engine arrived on the scene of an approximately 3500-square-foot (1066 m), two-story, wood-frame dwelling. Heavy smoke and fire were showing from the first floor, and heavy smoke was showing from the second floor. This engine company began setting up for fire attack using one 1¾-inch (45 mm) handline, and the second engine company laid a supply line and assumed rapid intervention team (RIT) duties. The third engine and truck company responded from the same station and arrived at the same time. The truck company was assigned ventilation duties, the third engine company was assigned to the second fire attack, and one of the squad companies was assigned search and rescue responsibility. The on-duty battalion chief (A) established command, and the other battalion chief (B) was assigned to operations.

The first-arriving engine company attacked the fire in division 1, while the third-arriving engine company went to division 2. They encountered heavy fire and high heat conditions. The fire was growing in size and intensity, so command ordered a defensive attack. No evacuation warnings were given (air horns). I saw division 1 fire attack search crews coming out of the house. As they exited, the battalion chief in charge of operations called for an aerial master stream. The stream was directed to the second story through a side window. The master stream hit the division 2 fire attack team, knocking them down the stairs and injuring two firefighters. After command contacted the crew, the RIT was sent in to assist them with egress.

During the RIT operation, all other operations were stopped. This allowed the fire to continue to grow.

Lessons Learned:

- Accountability is priceless.
- Know the crew assignments and number of personnel in the crew.
- When evacuating a structure, use evacuation tones (air horns).
- Big fire calls for big water. Do not be afraid to use something bigger than 1¾-inch handlines.
- Engine companies and truck companies should be staffed with more than three people.
- When going to a defensive attack, slow down, take time to make time, and make sure your people are where they are supposed to be.

FIRE FIGHTER Tips

If the structure is a residential building, fire personnel should conduct a thorough primary search as soon as possible, unless the fire conditions are incompatible with life. Do not risk your life to save a building that will be torn down next week.

Fires in Large Buildings

Large buildings, such as "big box" stores or office buildings, contain one very large open space surrounded by smaller rooms and storage areas. When these structures experience fires, the fire load varies greatly depending on the building contents. "Big box" stores and home improvement centers contain large amounts of flammable materials (contents), ranging from lumber to flammable fuels.

Many large buildings have floor plans that can cause fire fighters to become lost or disoriented while working inside, particularly in low-visibility or zero-visibility conditions. In such a setting, guide lines may be necessary to keep fire fighters from becoming lost and running out of air. A well-organized preincident plan of the structure can be essential when fighting this type of fire. Knowing the occupancy and the other hazards beforehand will help in determining the best strategy and tactics.

FIRE FIGHTER II Tips FFII

Consider the need for long hose lays when fighting a fire in a large building if an adequate number of standpipe connections are not available.

FIRE FIGHTER II Tips FFII

In large buildings that are equipped with automatic sprinkler systems, it is important to augment the water supply by connecting to the fire department connection to increase the water volume and pressure in the sprinkler system. The Fire Detection, Protection, and Suppression Systems chapter discusses this procedure in detail.

Fires in Buildings During Construction, Renovation, or Demolition

Buildings that are under construction, renovation, or demolition are all at increased risk for destruction by fire. These buildings often have large quantities of combustible materials exposed, while lacking the fire-resistant features of a finished building. If the building lacks windows and doors, an almost unlimited supply of oxygen is available to fuel a fire. Fire detection, fire alarm, and automatic fire suppression systems are often not installed or are inoperable. In addition, construction workers using torches and other flame-producing devices pose a notable fire risk. Moreover, these buildings are often unoccupied and can be easy targets for arsonists.

Under these conditions, a fire in a large building can be impossible to extinguish. If no life-safety hazards are involved, fire fighters may need to use a defensive strategy for this type of fire. In such a case, no fire fighters should enter the building, and a collapse zone should be established. A defensive exterior operation should be conducted using master streams, aerial streams, and large handlines to protect exposures.

Fire Fighter Safety Tips

It is important to maintain safety precautions during overhaul. Large unsupported or fire-damaged walls may collapse hours after the main body of fire has been knocked down.

Fires in Lumberyards

Lumberyard fires are often prime candidates for a defensive firefighting strategy. A typical lumberyard contains large quantities of highly combustible materials that are stored in the open or in sheds where plenty of air is available to support combustion. Given this rich fuel supply, a lumberyard fire will usually produce tremendous quantities of radiant heat and release burning embers that will cause the fire to spread quickly from stack to stack. Lumberyards may be sited in locations where there is an inadequate water supply. Such fires may quickly extend to nearby buildings and other structures. Large buildings at lumberyards are often constructed using trusses and other lightweight building techniques, so you must be aware of the potential for rapid building collapse at these incidents.

Protecting exposures is often the primary objective at lumberyard fires, as there may be little life-safety risk. Exposure protection should be dealt with early in the operation by placing large handlines and master stream devices where they can be most effective. A collapse zone must be established around any stacks of burning material and buildings to keep fire fighters out of dangerous positions.

Fires in Stacked or Piled Materials

Fires occurring in stacked or piled materials can present a variety of hazards. The greatest danger to fire fighters is the possibility that a stack of heavy material, such as rolled paper or baled rags, will collapse without warning. Such an event might occur, for example, if a fire has damaged the stacked materials or if water has soaked into them. Absorbed water can increase the weight of many materials and weaken cardboard and paper products. In fact, the water discharged by automatic sprinklers alone can be sufficient to make some stacked materials unstable. A tall stack of material that falls on top of a team of fire fighters can cause injury or death.

Given these risks, fires in stacked materials should be approached cautiously. All fire fighters must remain outside potential collapse zones. Mechanical equipment should be used to move material that has been partially burned or water soaked.

Conventional methods of fire attack can often be used to gain control of the fire; however, water must penetrate into the stacked material to fully extinguish the residual combustion. Class A foam and wetting agents can be applied to extinguish smoldering fires in tightly packed combustible materials. Overhaul will require fire fighters to separate the materials to expose any remaining deep-seated fire. This operation can be a labor-intensive process unless mechanical equipment can be used to dig through the material.

Trash Container and Rubbish Fires

Trash container (dumpster) fires usually occur outside of any structure and appear to present fewer challenges than fires inside buildings. Even so, fire fighters must be vigilant in wearing full PPE and using SCBA when fighting trash container fires or trash pile fires, because there is no way of knowing what might be included in a collection of trash. Some trash containers may contain hazardous materials or materials that are highly flammable or explosive.

If the fire is deep seated, fire fighters will have to overhaul the trash to make sure that the fire is completely extinguished. Manual overhaul involves pulling the contents of a trash container apart with pike poles and other hand tools so that water can reach the burning material. This process can be labor intensive and involves considerable risk to fire fighters. The fire fighters are exposed to any contaminants in the container as well as to the risks of injury from burns, smoke, or other causes. Considering the low value of the contents of a trash container, it is difficult to justify any risk to fire fighters' safety.

Class A foam is useful for extinguishing many trash container fires, because it allows water to soak into the materials and, therefore, can eliminate the need for manual overhaul. Some fire departments use the deck gun on the top of an engine to extinguish large trash container fires and then complete extinguishment by filling the container with water. This is done by pointing the deck gun at the dumpster and slowly opening the discharge gate to lob water into the container FIGURE 22-12.

Trash containers are often placed behind large buildings and businesses. If the container is close to the structure, be sure to check for fire extension. Also look around the container for the presence of telephone, cable, and power lines that might have been damaged by the fire.

FIGURE 22-12 Some fire departments use a deck gun on top to extinguish large trash container fires.

To extinguish an outside trash fire or other outside class A fire, follow the steps in SKILL DRILL 22-10 (Fire Fighter I, 5.3.8):

1. Don full PPE, including SCBA; enter the accountability system; and work as a team.
2. Perform size-up and give an arrival report. Call for additional resources if needed.
3. Ensure that apparatus is positioned uphill and upwind of the fire and that it protects the scene from traffic.
4. Develop and implement a fire suppression strategy.
5. Protect the crew from hazards.
6. Deploy an appropriate attack line (at least 1½ inches (38 mm) in diameter).
7. Direct the crew to attack the fire in a safe manner—specifically, uphill and upwind from the fire.
8. Break up compact materials with hand tools or hose streams.
9. Evaluate and modify the water application technique if necessary.
10. Maintain good body mechanics during the fire attack.
11. Notify command when the fire is under control.
12. Investigate the origin and cause of the fire. Preserve any evidence of arson.
13. Return the equipment and crew to service.

Confined Spaces

Both fires and other types of emergencies can occur in confined spaces. Fires in underground vaults and utility rooms such as transformer vaults are too dangerous to enter. In such cases, fire fighters should summon the utility company and keep the area around manhole covers and other openings clear while awaiting the arrival of utility company personnel. To deal with emergencies in these areas, the Occupational Safety and Health Administration (OSHA) requires specially trained entry teams. Learn your fire department's operational procedures for handling such incidents.

It is also important that fire fighters know about confined spaces that exist in the industries within their individual response areas. Fire fighters should visit these areas with plant personnel so that preincident plans can be developed.

Unique hazards may arise in confined spaces, including oxygen deficiencies, toxic gases, and standing water. Although conditions might appear to be safe, the confined space might not have enough oxygen to sustain life. It is common for a victim to enter these spaces and pass out, only to be followed by another victim—an individual who comes in to assist the first person and also passes out. When entering confined spaces to attempt rescue, fire fighters should wear full SCBA gear and be attached to a life line. An additional life line should be lowered or brought with the fire fighter to tie the victim in a bowline on a bight (rescue knot), which allows surface personnel to raise the victim out of the hole.

Owing to the lack of ventilation in most confined spaces, fire fighters may notice an intense amount of heat once they have entered the space. Fire fighters will tire quickly in this environment, so they must recognize the signs of heat exhaustion and heat stroke.

Because confined spaces commonly have low oxygen levels and high levels of combustible gases, such as methane, fire fighters without breathing apparatus can quickly be overcome in confined spaces with these conditions. For this reason, fire fighters who must enter a confined space should carry a monitoring device. Air quality must be checked constantly, looking for the build-up of explosive gases as well as any decline in oxygen levels.

Fire fighters must adhere to a strict accountability system when they enter into a confined space. This procedure ensures that only those personnel with proper training and equipment enter the space. It is important for a safety officer to track the movement of personnel and the amount of time that they remain in the confined space.

Fire suppression in confined spaces must not begin until all utilities and industrial processes have been turned off. Potential suppression agents include hose streams, high- and low-expansion foams, carbon dioxide (CO_2) flooding systems, and built-in sprinkler systems.

Vehicle Fires

Vehicle fires are one of the most common types of fires handled by fire departments. In 2012, the NFPA reported that approximately 184,000 highway vehicle fires occurred in the United States. These fires may result from a variety of causes. For example, discarded smoking materials can cause fires in upholstery. Electrical short-circuits may cause fires in many different parts of a vehicle. Friction caused by dragging brakes or defective wheel bearings may cause fires. Collisions may lead to ruptured fuel lines, resulting in fires.

Fire fighters save few cars. In fact, when active flames are seen at a vehicle fire, the vehicle will likely be classified as "totaled" by the insurance company. Given this fact, it is important to understand the hazards involved in fighting vehicle fires and to mount a safe attack on the fire. Only when a viable victim is trapped in a burning vehicle does the scenario become a life-or-death situation.

Many hazards are associated with vehicle fires—traffic hazards, fuel, pressurized cylinders and containers that can explode, fire, and toxic smoke. Because vehicle fires usually occur on streets and highways, one of the biggest hazards faced by fire fighters is the danger posed by traffic. Drivers are easily distracted by the sight of a burning vehicle, which may lead to subsequent collisions. To counteract this risk, you should use your apparatus to block traffic. Do not be afraid to shut down traffic flow if necessary to ensure safety for fire fighters. Fire apparatus operators often place their vehicles 100 feet behind the burning vehicle to stop traffic and to position the apparatus a safe distance from the burning vehicle. Follow the steps outlined by your department for guarding against traffic hazards.

Modern vehicles contain a variety of gas-filled, pressurized cylinders and containers containing explosive materials. Hydraulic pistons are used to support hatch backs, trunks, tailgates, and automobile hoods. Energy-absorbing bumper systems contain hydraulic pistons. In addition, many modern vehicles use a MacPherson strut suspension system to absorb road shocks. When these gas-filled components are quickly heated to high temperatures in a fire, they can release pressure explosively, sending metal parts hurtling away from the vehicle. In addition, the supplemental restraint systems (SRS) found in most vehicles consist of air bags and air curtains containing chemicals that can ignite explosively during a fire.

Modern automobiles are constructed from hundreds of pounds of plastics, which give off large quantities of toxic smoke and heat when they burn. They also contain a variety of petroleum products, including gasoline or diesel fuel, motor oil, brake fluid, and automatic transmission fluid. These products ignite easily, burn with high intensity, and produce large quantities of toxic gases. For this reason, it is important to always wear full PPE, including SCBA, when fighting a vehicle fire.

If the owner or driver of the burning vehicle is present, ask about any specific hazards that may be present in the vehicle, such as portable propane cylinders, propane torches, medical oxygen equipment, cans of spray paint, and other hazardous materials. If no driver or occupant is present, do not assume that the vehicle is safe; always be cautious as you approach a vehicle fire. Perform a risk–analysis assessment—that is, look at the big picture and weigh the options. Do not risk injuring fire fighters in a vehicle fire.

Attacking Vehicle Fires

As you prepare to approach a vehicle fire, make sure that you have created a safe area around the vehicle. The only people closer than 50 feet (15 m) to the vehicle should be fire fighters in full PPE and SCBA who are extinguishing the fire. Use a hose line at least 1½ inches (38 mm) in diameter; such a hose will provide sufficient cooling power to overwhelm the fire and provide protection from a sudden flare-up. The use of compressed air foam or Class B foam aids in fire suppression. Charge the hose line while you are at least 50 feet (15 m) from the fire. Bleed all the air from the hose line. Set the nozzle to initially deliver a straight stream or a fog pattern that is no wider than a 30-degree angle. Approach the vehicle from an uphill and upwind position, moving in from the side and at a 45-degree angle FIGURE 22-13. This path will help you avoid debris in case of an exploding bumper.

From a point approximately 30 feet (9 m) away from the vehicle, open the nozzle and sweep the bottom part of the vehicle using a horizontal motion. Extinguish all visible fire while advancing toward the vehicle. Sweeping along the undercarriage helps to cool the bumper pistons, shock absorbers, and hydraulic struts; cool the tires before they explode; and cool the fuel tank before it fails. By applying a sufficient quantity of water to the lower part of the vehicle, you reduce the chance of an explosive event. Observe the area under the car during the approach for any sign of leaking flammable liquids. If burning flammable liquids are present, widen the spray pattern on the nozzle. Foam can be used to extinguish the burning liquid and provide a vapor barrier to prevent reignition. Once this sweep is complete, fire fighters can begin to attack any fire in the passenger compartment, the engine compartment, and the cargo compartment.

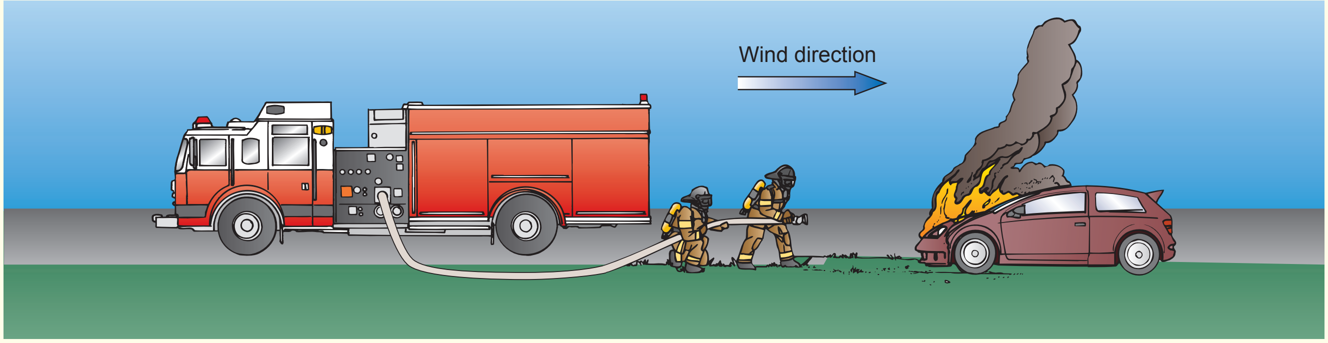


FIGURE 22-13 When possible, approach vehicle fires in the hood or engine area from the upwind side.

To extinguish a vehicle fire, follow the steps in SKILL DRILL 22-11 (Fire Fighter I, 5.3.7):

1. Don full PPE, including SCBA; enter the accountability system; and work as a team.
2. Perform size-up and give an arrival report. Call for additional resources if needed.
3. Ensure that the fire apparatus is positioned uphill and upwind, and that it protects the scene from traffic.
4. Ensure that the crew is protected from any hazards.
5. Identify the type of fuel used in the burning vehicle and look for fuel leaks.
6. Advance a fire attack line of at least 1½-inch (38 mm) diameter using water or foam.
7. Attack from uphill and upwind of the fire, and at a 45-degree angle to the side of the vehicle.
8. Suppress the fire.
9. Overhaul all areas of the vehicle, passenger compartment, engine compartment, and trunk.
10. Notify command when the fire is under control.
11. Investigate the origin and cause of the fire. Preserve any evidence of arson.
12. Return the equipment and crew to service.

Alternative-Fuel Vehicles

Always be alert for signs that a burning vehicle could be powered by an alternative fuel, such as compressed natural gas (CNG) or liquefied petroleum gas (LPG). Fully involved fires in vehicles powered by either type of fuel should be fought with an unmanned master stream to prevent injuries from exploding gas cylinders.

Automobiles powered by CNG contain storage cylinders that are very similar to SCBA cylinders. These cylinders are usually located in the trunk and contain CNG at high pressures. When a fire occurs, they must be cooled and protected just like any gas cylinder. CNG is a nontoxic, lighter-than-air gas that will rise and dissipate if it is released into the atmosphere.

Propane is stored in the same types of cylinders as are used for heating or cooking purposes. Propane is heavier than air, so its vapors will pool or collect in low areas.

Hybrid automobiles have small gasoline-powered engines and large battery banks. The batteries power electric motors that drive the wheels, much like a train locomotive. Two noteworthy hazards are associated with these vehicles:

- The nickel metal hydride batteries are hazardous when burning.
- High-voltage, direct-current cables connect the batteries to the electric motors that power the wheels. The power to these cables can usually be disconnected by activating the power shut-off switch that is built into these vehicles. Cutting these orange cables can be dangerous. These cables usually run from the battery bank to the front of the car via the undercarriage; they typically pass directly under the center of the driver's seat. Given this setup, fire fighters must use extra care when using hydraulic metal cutters or spreaders on these types of vehicles.

Follow the manufacturer's instructions for disconnecting the power to alternative-powered vehicles. More information on alternative-powered vehicles is presented in the Vehicle Rescue and Extrication chapter.

Fire in the Passenger Area

Fires in the passenger area of a vehicle are more visible and accessible than fires in the engine compartment or the cargo area. Usually it is logical to extinguish the fire in the passenger compartment before moving on to extinguish any fire in the engine and cargo compartments. Often the windows are broken or a door is ajar, presenting an opening through which fire fighters can direct a stream of water. If the doors will not open, stand upwind from the window and use a striking tool to break out one or more windows. Be cautious, because a backdraft may occur.

As you get closer to the vehicle, change the nozzle to produce a wider pattern that will cool a wider area and give you some protection from the heat of the fire. Pay special attention to cooling areas such as the steering column and the dashboard on the passenger side. Cool areas that contain side-curtain air bags; cooling will greatly reduce the chance for accidental deployment of the SRS. Once the fire in the passenger compartment has been knocked down, attack any fire in the engine compartment or in the cargo compartment.

Fire in the Engine Compartment

The engine compartment of a vehicle is filled with a variety of devices that use petroleum products to power or lubricate them. They also contain components made of plastics and rubber. As a consequence, these devices produce a large amount of smoke when they burn. Other hazards present in the engine compartment include suspension struts and hydraulic lift cylinders for the hood. Vehicle batteries contain sulfuric acid, which can cause serious burns. Some vehicles have magnesium parts within the engine compartment; when magnesium is present, you must use a Class D extinguishing agent.

A challenging part of extinguishing a fire in the engine compartment is gaining access to the fire. An initial attack can be made through the wheel well. The plastic liner between the engine compartment and the wheel well is often consumed during such a fire, so it may be possible to spray water into the engine compartment through this opening. An alternative initial approach is to spray water through the grille after thoroughly cooling the area around the bumper. When using this tactic, avoid standing directly in front of the bumper until this area is thoroughly cooled. Although neither of these two methods is effective at totally extinguishing the fire, they will help to diminish the volume of fire while fire fighters are gaining access to the engine compartment.

The fastest way to gain access to the engine compartment is to pull the hood-release lever inside the passenger compartment to open the hood. Unfortunately, this method rarely works during a vehicle fire, so other methods usually need to be tried. A quick means of gaining access to the engine compartment is to insert a pry bar along the side of the hood between the edge of the hood and the fender. Pry the side of the hood away from the fender to produce an opening big enough to apply a stream of water into the engine compartment.

A second method of gaining access to the engine compartment is to open the hood of the vehicle. In most fires, the cable that normally opens the hood is damaged and will not release from the inside of the vehicle. To open the hood of a burning vehicle, break out the plastic grille and find the hood-release cable. With a gloved hand, pull on the cable to release the hood or use the forked end of a Halligan tool to twist the cable until the hood releases. Fire fighters can also use vise grip pliers to grasp the cable and pull it.

Once the hood is raised, fire fighters should have good access to any remaining fire and hot spots. Use plenty of water or foam to cool this area. Once the vehicle's hood has been opened and any fire in the engine compartment extinguished, disconnect the power to the vehicle by cutting the battery cables if the battery is not under the hood, check the wheel wells or trunk. First, remove a section of the negative cable at least 6 inches (152 mm) long by making two cuts with wire cutters. Then, remove a similar section of the positive cable. This excision will disrupt the flow of power to the vehicle and ensure that nothing is powered accidentally.

Fire in the Trunk

A fire in the trunk of a vehicle may present unknown hazards because it is not possible to know what the trunk contains. In addition, fires in this area are challenging to access. Initial access can sometimes be made by knocking out the tail light assembly on one side, which enables fire fighters to direct a hose stream into the trunk to cool down and partially extinguish fire in this area. A fire in the trunk area of an automobile can also be accessed by first using the pike of a Halligan tool to force the lock into the trunk, and then using a screwdriver or key tool (K-tool lock puller) to turn the lock cylinder in a clockwise direction. A charged hose line must be ready when the trunk lid is raised.

Fires in the rear of light trucks and vans must always be approached cautiously. In addition, vehicles using alternative fuels (discussed earlier in this chapter) may contain compressed natural gas or propane cylinders in the trunk. Vans are often used by couriers and could contain medical waste, laboratory specimens, and radioactive material.

Overhauling Vehicle Fires

Overhaul of vehicle fires is just as important as overhaul of structure fires. As soon as it is safe to approach the vehicle, chock the wheels to prevent the vehicle from moving. If a vehicle fire erupts quickly, the driver may not have time to set the brake and parking gear. Also, fire can damage cables and wires that control the operation of parking and braking mechanisms. After all visible fire has been knocked down, allow a few minutes for the steam and smoke to dissipate before starting overhaul. This delay will allow visibility to improve so that overhaul can be completed safely.

During overhaul of interior fires, remember that air bags can deploy without warning in a burning automobile. Never place any part of your body in the path of a front or side air bag.

As you overhaul the vehicle, be systematic and thorough. Do not miss areas that may contain lingering sparks. Direct the hose stream under the dashboard, and soak and remove smoldering upholstery. Apply water over and under all parts of the engine compartment. Confirm that no fluids are leaking from the vehicle. If contents in the car might potentially be salvaged, treat them with respect. Continue to use your SCBA as long as smoke or fumes are present.

Fire Fighter Safety Tips

Some vehicle components (engines or body) may be constructed from magnesium or other flammable or explosive metals that can react violently when water is applied during fire suppression. A Class D extinguishing agent should be used in these cases instead of water.

Flammable-Liquid Fires

Flammable-liquid fires can be encountered in almost any type of occupancy. Most fires involving a vehicle (e.g., airplane, train, ship, car, truck) will involve a combustible or flammable liquid. Special tactics must be used when attempting to extinguish a flammable-liquid fire, and special extinguishing agents such as foam or dry chemicals may be needed.

Hazards

Fires involving flammable liquids such as gasoline require special extinguishing agents. Most flammable liquids can be extinguished using either foam or dry chemicals. Class B extinguishing agents are approved for use on Class B (flammable liquids) fires. Flammable-liquid fires can be classified as either two-dimensional or three-dimensional. A two-dimensional fire refers to a spill, pool, or open container of liquid that is burning only on the top surface. A three-dimensional fire refers to a situation in which the burning liquid is dripping, spraying, or flowing over the edges of a container.

A two-dimensional flammable-liquid fire can usually be controlled by applying the appropriate Class B foam to the burning surface. Several different formulations of Class B foams are suitable for a variety of liquids and situations. The foam will flow across the surface of the liquid and create a seal that stops the fuel from vaporizing; this separates the fuel from the oxygen and extinguishes the fire. Foam will also cool the liquid and reduce the possibility of reignition.

When dealing with flammable-liquid fires, fire fighters should look for hot surfaces or open flames that could cause the vapors to reignite after a fire has been extinguished. It is important to determine the identity of the liquid that is involved so as to select the appropriate extinguishing agent and to determine whether the vapors are lighter or heavier than air.

A three-dimensional flammable-liquid fire is much more difficult to extinguish with foam, because the foam cannot establish an effective seal between the fuel and the oxygen. Either dry-chemical or gaseous extinguishing agents are usually more effective than foam in controlling these kinds of fires. These agents can also be used to extinguish two-dimensional fires, although they do not provide a long-lasting seal between the fuel and the oxygen. In some cases, a fire can be extinguished with a dry chemical, and then the surface can be covered with foam to prevent reignition.

Fire fighters should avoid standing in pools of flammable liquids or contaminated runoff from them, because their PPE will absorb the flammable product and become contaminated. In cases of serious contamination, the PPE itself can become flammable.

Suppression

The skills used in suppressing small flammable-liquid fires are presented in the Portable Fire Extinguishers chapter. Larger flammable liquid fires may require the use of Class B foam. The equipment and methods used to apply Class B foam are described in the Fire Attack and Foam chapter.

FIRE FIGHTER II

Flammable-Gas Cylinders

Flammable-gas cylinders can be found in many places. Many types of flammable gases are stored in many different types and sizes of containers. A variety of flammable gases can be found in industrial occupancies.

Propane Gas

The popularity of propane gas for heating and cooking has meant that these cylinders have become commonplace in residential areas and many industrial and commercial locations. In addition, propane is used as an alternative fuel for vehicles and is often stored to power emergency electrical generators. Fire fighters should be familiar with the basic hazards and characteristics of propane as well as with procedures for fighting propane fires.

Propane (LPG) exists as a gas in its natural state at temperatures higher than –44°F (–42.2°C). When the gas is placed into a storage cylinder under pressure, it is changed into a liquid. Storing propane as a liquid is very efficient, because it has an expansion ratio of 270:1 (i.e., 1 cubic foot (0.02 cubic meters) of liquid propane is converted to 270 cubic feet (7.64 cubic meters) of gaseous propane when it is released into the atmosphere). Put simply, a large quantity of propane fuel can be stored in a small container.

Inside a propane container, there is a space filled with propane gas above the level of the liquid propane. As the contents of the cylinder are used, the liquid level becomes lower and the vapor space increases. The internal piping is arranged so as to draw product from the vapor space.

Propane gas containers come in a variety of sizes and shapes, with capacities ranging from a few ounces to thousands of gallons. The cylinder itself is usually made of steel or aluminum. A discharge valve keeps the gas inside the cylinder from escaping into the atmosphere and controls the flow of gas into the system where it is used. This valve should be easily visible and accessible. In the event of a fire, closing the valve should stop the flow of the product and extinguish the fire. The valve should be clearly marked to indicate the direction in which it should be turned or moved to reach the closed position.

A connection to a hose, tubing, or piping allows the propane gas to flow from the cylinder to its destination. In the case of portable tanks, this connection is often the most likely place for a leak to occur. If the gas is ignited, this area could become involved in fire.

A propane cylinder is always equipped with a relief valve to allow excess pressure to escape, thereby preventing an explosion if the tank becomes overheated. Propane cylinders must be stored in an upright position so that the relief valve remains within the vapor space. If the cylinder is placed on its side, the relief valve could fall below the liquid level. If a fire were then to heat the tank and cause an increase in pressure, the relief valve would release liquid propane, which would expand by the 270:1 ratio and create a huge cloud of potentially explosive propane gas.

Propane Hazards

Propane is highly flammable. Although it is nontoxic, this gas can displace oxygen and cause asphyxiation. By itself, propane is odorless, so leaks of pure propane cannot be detected by a human sense of smell. For this reason, mercaptan is added to propane to give it a distinctive odor.

Propane gas is heavier than air, so it will flow along the ground and accumulate in low areas. When using meters to check for LPG, be sure to check storm drains, basements, and other low-lying areas for concentrations of the gas.

When responding to a reported LPG leak, fire fighters and their apparatus should be staged uphill and upwind of

FIRE FIGHTER II

the scene. Because an explosion can happen at any time, fire fighters should wear full PPE and SCBA at this type of incident. Life safety should be the highest priority; depending on the type and size of the leak, an evacuation might be necessary.

The greatest danger with propane and similar products is a BLEVE. If an LPG tank is exposed to heat from a fire, the temperature of the liquid inside the container will increase. The fire could then be fueled by propane escaping from the tank or from an external source. As the temperature of the product increases, the vapor pressure will also increase. The increasing pressure creates added stress on the container. If this pressure exceeds the strength of the cylinder, the cylinder can rupture catastrophically. An exploding LPG cylinder can produce the same explosive power as dynamite.

To protect the container from rupture, the relief valve will open to release some of the pressure. This relief valve is designed to exhaust the vapor until the pressure drops to a preset level. When the pressure returns to a safe level, the valve will close. If the heating continues, however, the liquid will begin to boil within the container. If the flame impinges directly on the tank, the container can weaken and fail somewhere above the liquid line. When this happens, the container will rupture and release its contents with explosive speed. The boiling liquid will expand, vaporize, and ignite in a giant fireball, accompanied by flying fragments of the ruptured container. Fire fighters have been killed in these explosions.

The best method to prevent a BLEVE is to direct heavy streams of water onto the tank from a safe distance. The water should be directed at the area where the tank is being heated. Cool the upper part of the tank to cool the gas vapors. The fire fighters operating these streams should work from shielded positions or use remote-controlled or unmanned monitors. Horizontal tanks are designed to fail at the ends if a catastrophic failure occurs, so fire fighters should operate only from the sides of the tank.

Flammable-Gas Fire Suppression

Fighting fires involving LPG or other flammable-gas cylinders requires careful analysis and logical procedures. If the gas itself is burning because of a pipe or regulator failure, the best way to extinguish the fire is to shut off the main discharge valve at the cylinder. If the fire is extinguished and the fuel continues to leak, there is a high probability that it will reignite explosively. Do not attempt to extinguish the flames unless the source of the fuel has been shut off or all of the fuel has been consumed. If the fire is heating the storage tank, use hose streams to cool the cylinder, being careful not to extinguish the fire.

Unless a remote shut-off valve is available, the flow of propane can be stopped only if it is safe to approach the cylinder. Fire fighters should inspect the integrity of the cylinder from a distance before they make any attempt to approach and shut off the valve. If the container is damaged or the valve is missing, the fuel should be allowed to burn off, while hose streams continue to cool the tank from a safe distance.

Approach a flammable-gas fire with two 1¾-inch (45 mm) hose lines working together. When approaching a horizontal LPG tank, always approach it from the sides. The nozzles should be set on a wide fog pattern, with the discharge streams interlocked to create a protective curtain. The team leader should be located between the two nozzle operators. On the command of the leader, the crew should move forward, remaining together and never turning their backs to the burning product. Upon reaching the valve, the fire fighter in the center can turn off the valve, stopping the flow of gas. Any remaining fire may then be extinguished by normal means. Continue the flow of water as a protective curtain and to reduce sources of ignition.

If the fire is extinguished prematurely, the valve should still be turned off as soon as the team reaches it. Always approach and retreat from these types of fires while facing the objective with water flowing, in case of reignition.

Unmanned master streams should be used to protect flammable-gas containers that are exposed to a severe fire. Direct the stream so that it is one-third of the way down the container. This technique will allow half of the water to roll up and over the container, while the remainder projects downward **FIGURE 22-14**. The objective is to cover as much of the exposed tank as possible.

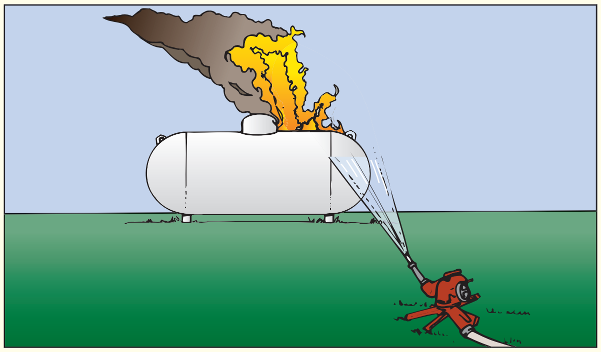


FIGURE 22-14 Using a master stream to protect a flammable-gas container that is exposed to fire.

If the LPG container is located next to a fully involved building or a fire that is too large to control, evacuate the area and do not fight the fire. If there is nothing to save, risk nothing.

Keep in mind that if the relief valve is open, the flammable-gas container is under stress. Exercise extreme caution in this scenario. As the gas pressure is relieved, it will sound like the whistle on a teakettle; if the sound is rising in frequency, an explosion could be imminent and evacuation should be ordered.

To suppress a flammable-gas cylinder fire, follow the steps in **SKILL DRILL 22-12** (Fire Fighter II, 6.3.3):

1. Cool the tank from a distance until the relief valve resets.
2. Wearing full PPE, two teams of fire fighters using a minimum of two 1¾-inch (45 mm) hose lines advance using an interlocking 90-degree-wide fog pattern for protection. Do not approach the cylinder from the ends. The team leader should be located between the two nozzle persons. The leader coordinates the advance toward the cylinder.

FIRE FIGHTER II

3. When the cylinder is reached, the two nozzle teams isolate the shut-off valve from the fire with their fog streams while the leader closes the tank valve, eliminating the fuel source.
4. After the burning gas is extinguished, the fire fighters continue to apply water to the cylinder to cool the metal, with the goal of preventing tank failure and a subsequent BLEVE.
5. As cooling continues, fire fighters slowly back away from the cylinder, never turning their backs to it.

Shutting Off Gas Service

Many structures use either natural gas or propane gas for heat or cooking. In addition, these two energy sources have many industrial applications. If a gas line inside a structure becomes compromised during a fire, the escaping gas can add fuel to the fire. The means by which the gas is supplied to the structure must be located to stop the flow.

Most residential gas supplies are delivered through a gas meter connected to an underground utility network or from a storage tank located outside the building. If the gas is supplied by an underground distribution system, the flow can be stopped by closing a quarter-turn valve on the gas meter. If the gas is supplied from an outside LPG storage cylinder, closing the cylinder valve will stop the flow.

After the gas service has been shut off, use a lockout tag to ensure that it is not turned back on. Only a professional can reestablish the flow of gas to a structure.

To shut off gas utilities, follow the steps in SKILL DRILL 22-13 (Fire Fighter I, NFPA 5.3.18) FIGURE 22-15:

1. Don PPE, including SCBA; enter the personnel accountability system.
2. Acknowledge the assignment.
3. Locate the exterior gas shut-off valve.
4. Shut off the gas valve.
5. Attach a shut-off tag and lock if required.
6. Notify command that the gas is shut off.

FIGURE 22-15 Shutting off gas line.

Fires Involving Electricity

The greatest danger with most fires involving electrical equipment is electrocution. For this reason, only Class C extinguishing agents should be used when energized equipment is involved in a fire. All electrical equipment should be considered as potentially energized until the power company or a qualified electrical professional confirms that the power is off. Once the electrical service has been disconnected, most fires in electrical equipment can be controlled using the same tactics and procedures as are used for a Class A fire.

When a fire occurs in a building, the electrical service should be turned off quickly to reduce the risks of injury or death to fire fighters, even if there is no involvement of electrical equipment in the fire. If possible, this shut-off should take place at the main circuit breaker box, with a lockout tag being used to prevent someone from accidentally turning the electrical current back on.

If it is not possible to turn the electricity off at the breaker box, fire fighters must notify the electrical utility company to send a representative to the fire scene to disconnect the service from a location outside the building. In many cases, the local utility company is automatically notified of any working fire.

To control the electric utility system, follow the steps in SKILL DRILL 22-14 (Fire Fighter I, 5.3.18):

1. Don PPE, including SCBA; enter the personnel accountability system.
2. Acknowledge the assignment
3. Locate the exterior shut-off.
4. Shut off the power.
5. Attach a lockout tag and lock.
6. Notify command that the electricity is shut off.

Electrical Fire Suppression

Fire suppression methods for fires involving electrical equipment vary according to the type of equipment and the power supply. In many cases, the best approach is to wait until the power is disconnected and then use the appropriate extinguishing agents to control the fire. If the power cannot be disconnected or the situation requires immediate action, only Class C extinguishing agents—such as halon agents, CO_2, or dry chemicals—should be used.

When delicate electronic equipment is involved in a fire, either halons or CO_2 should be used to limit the damage as much as possible. These agents cause less damage to computers and sensitive equipment than do water or dry chemical agents.

When power distribution lines or transformers are involved in a fire, special care must be taken to ensure the safety of both emergency personnel and the public. No attempt should be made to attack these fires until the power has been disconnected. In some cases, fire fighters may need to protect exposures or extinguish a fire that has spread to other combustible materials, if this can be accomplished without coming in contact with the electrically energized equipment. If a hose stream comes in contact with the energized equipment, the current can flow back through the water to the nozzle and electrocute fire fighters who are in contact with the hose line.

Many electrical transformers contain a cooling liquid that includes polychlorinated biphenyls, a cancer-causing material. Do not apply water to a burning transformer. Water can cause the transformer's cooling liquid to spill or splash, contaminating both fire fighters and the environment. If the transformer is located on a pole, it should be allowed to burn until electrical utility professionals arrive and disconnect the power. Dry-chemical extinguishers can then be used to control the fire. Fires in ground-mounted transformers can also be extinguished with dry chemical agents after the power has been disconnected. Fire fighters should stay out of the smoke and away from any liquids that are discharged from a transformer, and they must wear full PPE and SCBA to attack the fire.

Some very large transformers contain large quantities of cooling oil and require foam for fire extinguishment. This foam can be applied only after the power has been disconnected. Until the power is off, fire fighters can still protect exposures while taking care to avoid contamination.

Underground power lines and transformers are often located in vaults beneath the ground's surface. Explosive gases can build up within these vaults. If a spark then ignites the gases, the resulting explosion can lift a manhole cover from a vault and hurl it for a considerable distance. Products of combustion can also leak into buildings through the underground conduits. Fire fighters should never enter an underground electrical vault while the equipment is energized. Even after the power has been disconnected, these vaults should be considered to be confined spaces containing potentially toxic gases, explosive atmospheres, or oxygen-deficient atmospheres. Special precautions are required to enter this type of confined space.

Large commercial and residential structures often have high-voltage electrical service connections and interior rooms containing transformers and distribution equipment. These areas should be clearly marked with electrical hazard signs, and fire fighters should not enter them unless there is a rescue to be made. Until the power has been disconnected, fire suppression efforts should be limited to protecting exposures. Fire fighters must wear full PPE and SCBA owing to the inhalation hazards presented by the burning of the plastics and cooling liquids that are often used with equipment of this size.

Wrap-Up

Chief Concepts

- Fire suppression refers to all of the tactics and tasks performed on the fire scene to extinguish a fire.
- All fire suppression operations are either offensive or defensive:
  - Offensive—Tasks performed inside. Used when the fire is not too large or dangerous to be extinguished using interior handlines.
  - Defensive—Tasks performed outside. Used when the fire is too large to be controlled by an offensive attack or when the level of risk is too high.
- The IC evaluates conditions constantly to determine the type of attack that should be used. An interior attack may be switched to a defensive attack if necessary, and vice versa.
- A fire fighter must be able to advance and operate a hose line effectively to extinguish a fire.
- Care should be taken not to have opposing hose lines, such that two crews work "against" each other.
- The most frequently used hose line size for interior fire attack is 1¾-inch (45 mm) handlines. Although one fire fighter can usually operate the nozzle on a small hose line, a second fire fighter will provide valuable assistance when a small hose line must be advanced and maneuvered.
- Different types of fire streams are produced by different types of nozzles. A fog stream divides water into droplets, which can absorb heat efficiently. Fog streams can be used to protect fire fighters from the intense heat of the fire and to assist in ventilation. A straight stream can hit a fire from a longer distance away; it also keeps the water concentrated in a small area. A solid stream has an even greater reach and penetrating power than a straight stream and is charged as a continuous column of water.
- An interior fire attack is an offensive operation that requires fire fighters to enter a building and discharge an extinguishing agent onto the fire. Interior fire attack can be conducted on many different scales. In many cases, an interior attack is conducted on a fire that is burning in only one room and may be controlled quickly by one

attack hose line. Larger fires require more water, which could be provided by two or more small handlines working together or by one or more larger handlines.

- The most effective means of fire suppression in most situations is a direct attack. This kind of attack uses a straight or solid hose stream to deliver water directly onto the base of the fire. The water cools the fuel until it is below its ignition temperature.
- The objective of an indirect attack is to quickly remove as much heat as possible from the fire atmosphere. Such an approach is particularly effective at preventing flashover from occurring. This method of fire suppression should be used when a fire has produced a layer of hot gases at the ceiling level.
- A combination attack employs both indirect attack and direct attack methods in a sequential manner. This strategy should be used when a room's interior has been heated to the point that it is nearing a flashover condition. Fire fighters first use an indirect attack method to cool the fire gases, then make a direct attack on the main body of fire.
- Large handlines can be used either for offensive fire attacks or for defensive operations.
- Master stream devices are used to produce high-volume water streams for large fires. Several types of master stream devices exist, including portable monitors, deck guns, ladder pipes, and other elevated stream devices. Most master streams discharge between 350 (1591 lpm) and 1500 (6819 lpm) gallons of water per minute.
- Fires in ordinary and wood-frame construction can burn in combustible void spaces behind walls and under subfloors and ceilings.
- Fires in basements or below grade level may cause the floor on the ground level to collapse.
- Protect stairways and other vertical openings between floors when fighting a fire in a multiple-level structure. Hose lines must be placed to keep the fire from extending vertically and to ensure that exit paths remain available to fire fighters and victims.
- Many large buildings have floor plans that can cause fire fighters to become lost or disoriented while working inside, particularly in low-visibility or zero-visibility conditions.
- Buildings that are under construction, renovation, or demolition are all at increased risk for destruction by fire. These buildings often have large quantities of combustible materials exposed, while lacking the fire-resistant features of a finished building.
- A lumberyard fire will usually produce tremendous quantities of radiant heat and release burning embers that can cause the fire to spread quickly from stack to stack.
- Fires in stacked materials should be approached cautiously. All fire fighters must remain outside potential collapse zones. Mechanical equipment should be used to move material that has been partially burned or water soaked.
- Fires in trash containers may be fought with foam or a deck gun.
- Some unique hazards exist with fires in confined spaces, including oxygen deficiencies, toxic gases, and standing water.
- Vehicle fires are one of the most common types of fires handled by fire departments. These fires may result from a variety of causes, including discarded smoking materials, electrical short-circuits, friction caused by dragging brakes or defective wheel bearings, and ruptured fuel lines due to a collision.
- Many hazards related to vehicle fires are possible—traffic hazards, fuel, pressurized cylinders and containers that can explode, fire, and toxic smoke.
- Overhaul of vehicle fires is just as important as overhaul of structure fires. As soon as it is safe to approach the vehicle, chock the wheels to prevent the vehicle from moving. After all visible fire has been knocked down, allow a few minutes for the steam and smoke to dissipate before starting overhaul. As you overhaul the vehicle, be systematic and thorough.
- Always be alert for signs that a burning vehicle could be powered by an alternative fuel, such as compressed natural gas (CNG) or liquefied petroleum gas (LPG). Fully involved fires in vehicles powered by either type of fuel should be fought with an unmanned master stream to prevent injuries from exploding gas cylinders.
- Flammable-liquid fires can be encountered in almost any type of occupancy. Most fires involving a vehicle (e.g., airplane, train, ship, car, truck) will involve a combustible or flammable liquid. Special tactics must be used when attempting to extinguish a flammable-liquid fire, and special extinguishing agents such as foam or dry chemicals may be needed.
- Flammable-gas cylinders can be found in many places. Many types of flammable gases are stored in many different types and sizes of containers. A variety of flammable gases can be found in industrial occupancies.
- The greatest danger with propane and similar flammable-gas products is a BLEVE. If an LPG tank is exposed to heat from a fire, the temperature of the liquid inside the container will increase. The fire itself could be fueled by propane escaping from the tank or from an external source. As the temperature of the product increases, the vapor pressure will increase in tandem. The increasing pressure creates added stress on the container. If this pressure exceeds the strength of the cylinder, the cylinder can rupture catastrophically.
- The greatest danger with most fires involving electrical equipment is electrocution. Only Class C extinguishing agents should be used when energized equipment is involved in a fire. All electrical equipment should be considered as potentially energized until the power

company or a qualified electrical professional confirms that the power is off.

- Once the electrical service has been disconnected, most fires in electrical equipment can be controlled using the same tactics and procedures as are used for Class A fires.

Hot Terms

Combination attack A type of attack employing both direct attack and indirect attack methods.

Deck gun An apparatus-mounted master stream device that is intended to flow large amounts of water directly onto a fire or exposed building.

Direct attack (structural fire) Firefighting operations involving the application of extinguishing agents directly onto the burning fuel. (NFPA 1145)

Elevated master stream device A nozzle mounted on the end of an aerial device that is capable of delivering large amounts of water onto a fire or exposed building from an elevated position.

Indirect application of water The use of a solid object such as a wall or ceiling to break apart a stream of water, creating more surface area on the water droplets and thereby causing the water to absorb more heat.

Indirect attack (structural fire) Firefighting operations involving the application of extinguishing agents to reduce the build-up of heat released from a fire without applying the agent directly onto the burning fuel. (NFPA 1145)

Ladder pipe A monitor that is fed by a hose and that holds and directs a nozzle while attached to the rungs of a vehicle-mounted aerial ladder. (NFPA 1965)

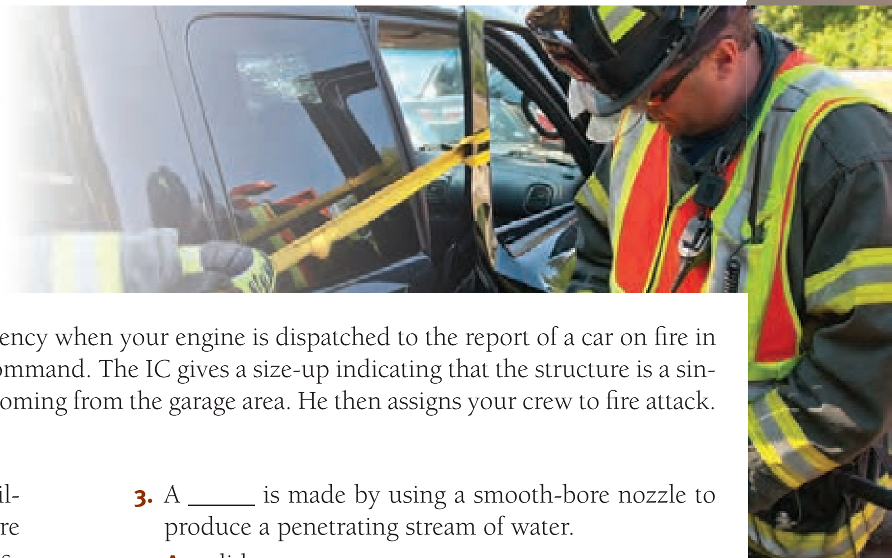
Master stream device A large-capacity nozzle that can be supplied by two or more hose lines or fixed piping. Such devices include deck guns, portable ground monitors, and elevated streams, and commonly flow between 350 (1591 lpm) and 1500 (6819 lpm) gallons per minute.

Portable monitor A monitor that can be lifted from a vehicle-mounted bracket and moved to an operating position on the ground by not more than two people. (NFPA 1965)

Solid stream A stream made by using a smooth-bore nozzle to produce a penetrating stream of water.

Straight stream A stream made by using an adjustable nozzle to provide a straight stream of water.

FIRE FIGHTER *in action*



You are just returning to the station from a medical emergency when your engine is dispatched to the report of a car on fire in a garage. The battalion chief arrives first and establishes command. The IC gives a size-up indicating that the structure is a single-story, wood-frame house with dark, turbulent smoke coming from the garage area. He then assigns your crew to fire attack.

1. A(n) _____ uses a solid object such as a wall or ceiling to break apart a stream of water, creating more surface area on the water droplets and thereby causing the water to absorb more heat.
  - **A.** interior attack
  - **B.** indirect attack
  - **C.** direct attack
  - **D.** combination attack

2. Which of the following is not a master stream device?
  - **A.** Deck guns
  - **B.** Portable ground monitors
  - **C.** Elevated streams
  - **D.** Solid stream

3. A _____ is made by using a smooth-bore nozzle to produce a penetrating stream of water.
  - **A.** solid stream
  - **B.** fog stream
  - **C.** straight stream
  - **D.** master stream

4. What is the expansion ratio of propane?
  - **A.** 5:1
  - **B.** 17:1
  - **C.** 70:1
  - **D.** 270:1

FIRE FIGHTER *in action* (continued)

5. What should be done once the gas has been shut off to a building?
   - **A.** Attach a shut-off tag
   - **B.** Report to staging
   - **C.** Report to rehabilitation
   - **D.** Notify the gas company
6. Large handlines will flow at least ____ gpm/lpm.
   - **A.** 150 (681)
   - **B.** 200 (909)
   - **C.** 250 (1136)
   - **D.** 300 (1363)
7. Which challenge do fire fighters frequently face when extinguishing an engine compartment fire?
   - **A.** Confining the fire
   - **B.** Vehicle movement
   - **C.** Gaining access
   - **D.** Locating the seat of the fire

FIRE FIGHTER II *in action*

It is a beautiful Saturday morning, and you are out washing the engine on the front apron of your fire station. A car pulls in and the driver walks over and begins to chat with you. He says he is a fire fighter from a neighboring jurisdiction, so he decided to stop and visit when he saw you out washing the engine. It is evident that he has been a fire fighter for only a short period of time, but he is very enthusiastic about learning and seems to be a very likeable individual. You know that his department has very limited financial resources, so you engage him in an informative discussion about fire attack.

1. Which factors would you tell him affect the incident commander's decision on whether to make an interior attack rather than an exterior attack?
2. How would you describe to him the characteristics of the various types of nozzles?
3. Which other activities would you tell him need to be coordinated with fire attack?