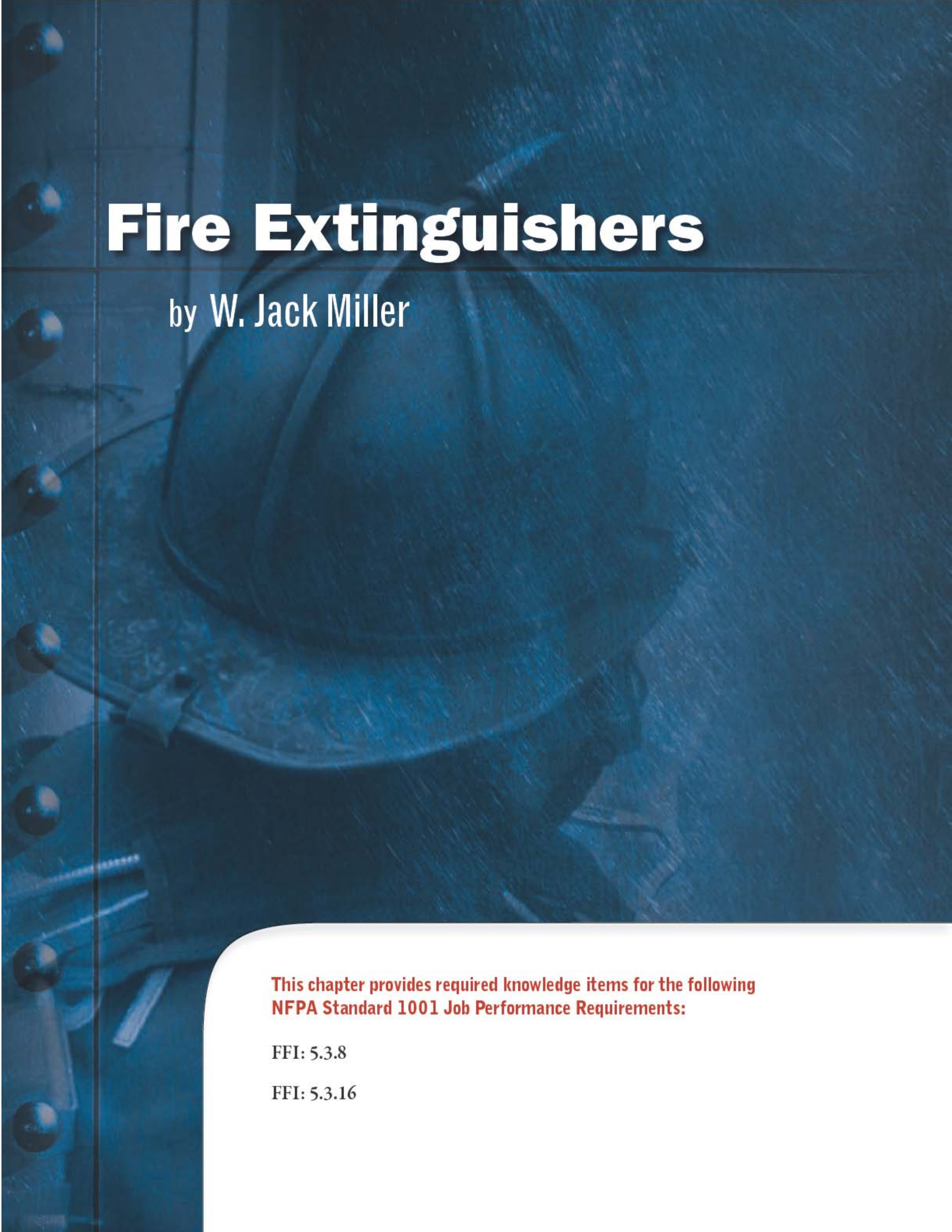

Fire Extinguishers

by W. Jack Miller

This chapter provides required knowledge items for the following NFPA Standard 1001 Job Performance Requirements:

FFI: 5.3.8

FFI: 5.3.16

6

This chapter contains Skill Drills. When you see this icon, refer to your Skill Drill book for step-by-step instructions.

SKILL DRILL

OBJECTIVES

Upon completion of this chapter, you should be able to do the following:

- Define the five classes of fires
- Describe fire extinguisher design and operation
- Describe the different extinguishing agents
- Explain the fire extinguisher rating system
- Have a general knowledge of inspection, maintenance, hydrostatic testing, and recharging of fire extinguishers

INTRODUCTION

Even small fires endanger lives and property. Building owners and managers have a responsibility to protect their tenants and the public by maintaining a fire-safe environment. All public buildings and workplaces need an effective fire protection program that includes strategically-placed portable fire extinguishers.

Portable fire extinguishers, when handled properly by trained and confident personnel, are useful for fighting fires before they spread—provided they are appropriate for the fire being fought and in proper working condition. To choose the right portable fire extinguisher you need to match the extinguisher to the job. This chapter provides the information to help you do just that. It covers the five classes of fire (A, B, C, D, and K) as well as the numbering system that determines the firefighting effectiveness of the different extinguishers. This chapter also reviews the classification of hazards, extinguishing agents, extinguisher design, and operating procedures.

FIRE CLASSIFICATIONS: WHAT IS BURNING?

FFI 5.3.16 The first question to ask is, "What type of fire is most likely to occur?" Fires are classified according to their fuel—that is, what is burning. Some fire extinguishers are more appropriate than others for fighting certain classes of fires. To be effective and safe, the extinguisher being used must match the class of fire to be extinguished. The proper extinguishing agent will put the fire out more efficiently. In some cases, it is dangerous to apply an incorrect extinguishing agent to a fire. The two best examples involve common water extinguishers, which should never be used to fight a fire involving combustible cooking media because water splatters grease and spreads the fire. Also, if you discharge a stream of water on live electrical equipment, you risk electric shock and establishing a short circuit that could damage equipment.

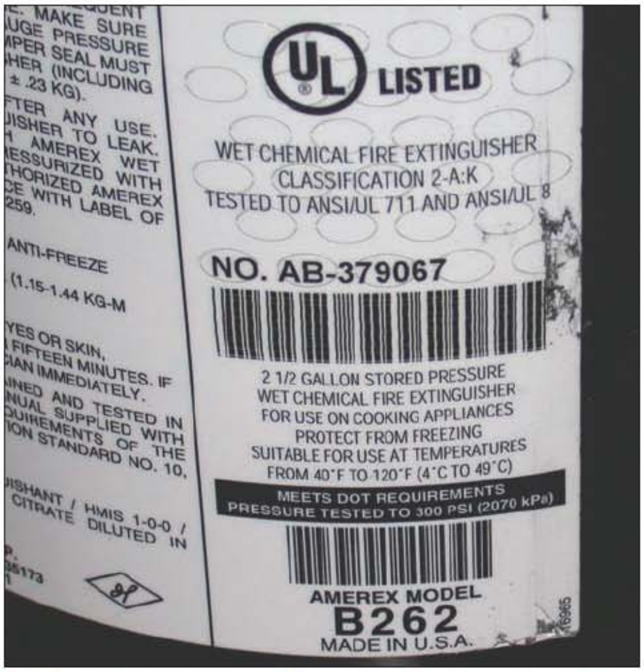

Fig. 6–1. This label from Underwriters Laboratories (UL) certifies that this fire extinguisher has been tested to their rigid standards.

Underwriter Laboratories Inc. or other independent testing laboratories rate fire extinguishers according to the type of fires they can extinguish safely. All fire tests are conducted by trained and experienced personnel in a controlled environment. Extinguishers that are tested and have been found to meet test standards are said to be listed and bear a label from the lab that conducted the testing (fig. 6–1).

Classes of fires

Class A: Ordinary combustibles such as wood, paper, rubber, fabrics, and many plastics.

Class B: Flammable liquids and gases such as gasoline, oils, paint, lacquer, and tar.

Class C: Fires involving live electrical equipment.

Class D: Combustible metals or metal alloys.

Class K: Fires in cooking appliances that involve combustible cooking media such as vegetable or animal oils and fats.

Figure 6–2 lists the classes of fire and their picture symbols.

CLASSES OF FIRES	TYPES OF FIRES	PICTURE SYMBOL
A	Wood, paper, cloth, trash, & other ordinary materials.	
B	Gasoline, oil, paint, and other flammable liquids.	
C	May be used on fires involving live electrical equipment without danger to the operator.	
D	Combustible metals and cumbustible metal alloys	
K	Cooking media (Vegetable or Animal Oils and Fats)	

Fig. 6–2. The five major classes of fire are represented with pictures so that inexperienced users can quickly identify the correct fire extinguisher to use.

TYPES OF EXTINGUISHERS

SKILL DRILL

Fire extinguishers are rated for, among other things, the classes of fire they can extinguish. Note that in the following list of extinguisher types, some extinguishers can be used on more than one class of fire. Do not attempt to use an extinguisher on a class of fire that it is not rated for.

Class A (fig. 6–3)

Class A:B

Class A:B:C (fig. 6–4)

Class A:C

Class B:C (fig. 6–5)

Class D

Class K (fig. 6–6)

Fig. 6–3. A pressured water extinguisher can be used on Class A fires only.

Fig. 6–5. A carbon dioxide extinguisher is common for use against Class B and C fires.

Fig. 6–4. Some dry chemical extinguishers are rated for fire classes A, B, and C. These extinguishers are commonly found in homes and commercial properties.

Fig. 6–6. A Class K fire extinguisher can resemble a Class A pressurized water extinguisher, however, has a special nozzle and water solution designed for cooking oils and greases.

Fire extinguisher design and types

All portable fire extinguishers use pressure to expel their extinguishing agents, but there are a few different designs (fig. 6–7). Many extinguishers rely on a pressurizing gas to expel their agents. Some models store the pressurizing gas with the agent in the cylinder and others store the pressurizing gas externally in a separate cartridge. Some extinguishing agents, such as carbon dioxide, create their own pressure and do not require the addition of a pressurizing gas to expel. Other extinguishers rely on pressure from a hand-operated pump.

The majority of extinguishers in use consist of six basic parts: cylinder, handle, lever, nozzle or horn, locking mechanism, and a pressure indicator (gauge).

The **cylinder** contains the extinguishing agent. Stored-pressure extinguishers store their extinguishing agent in a cylinder with a gas that provides the pressure to operate the unit. Cartridge- and cylinder-operated extinguishers use an external cartridge of a pressurizing gas that feeds pressure into the agent cylinder to expel the extinguishing agent.

Fig. 6–7. Pressure can be generated for fire extinguishers through storing the pressure in the main cylinder, having an outside cartridge, or through a manual pump.

The **handle** is the means by which an extinguisher is carried. The actual design of the handle varies from model to model. In most cases, the handle is located just below the lever that you squeeze for discharge.

The **lever** is what is squeezed or depressed to discharge the fire extinguisher's agent. In cartridge-operated extinguishers, the discharge is accomplished by releasing the pressurizing gas into the cylinder. On most extinguishers, the lever is located above the handle.

The **nozzle** or **hose/horn** is the device through which the agent is expelled.

The **locking mechanism** is a simple, quick-release device that secures an extinguisher's lever to prevent accidental discharge.

The **pressure indicator**, more commonly known as the **gauge**, indicates whether the extinguisher has adequate pressure to operate properly.

TYPES OF EXTINGUISHING AGENTS

FFI 5.3.8 The following extinguishing agents are the most often used in firefighting operations.

Water

Water is an excellent extinguishing agent suitable for use only on Class A (ordinary combustibles) fires. It extinguishes a fire by cooling fuel to below its kindling temperature. Never use water-type extinguishers on fires involving live electrical equipment or for fires in cooking media. The water could flash to steam as a result of high temperatures and cause serious burns.

Foam

Aqueous film-forming foam (AFFF) is made mostly of fluorochemical **surfactants**. As the bubbles break, drain, and lose their water, they form a film on the surface of the fuel that moves easily across the surface and prevents vapors from escaping.

Alcohol type AFFF is similar in base to AFFF with the addition of a **copolymer**. The copolymer reacts with **water miscible** fuels (**polar solvents** and hydrocarbon/polar-solvent mixtures containing 10% or more polar solvents) and reacts with the polar solvents to create a polymeric membrane.

Film-forming fluoroprotein foam forms a film over a flammable liquid surface much like AFFFs. (See fig. 6–8.)

Wet chemical

Wet chemical agents are solutions of water mixed with potassium acetate, potassium carbonate, potassium citrate, or combinations thereof. They are specifically designed for Class K fires, but they have demonstrated superior effectiveness on Class A fires when compared with plain water. They have limited capabilities on Class B fires and can be used in extinguishers with special wand applicators that achieve a Class C listing, verifying that electricity cannot be conducted back to the operator.

Fig. 6–8. A foam extinguisher

Wet chemical extinguishers work on Class K fires through two methods. The solution is alkaline in nature and therefore reacts with the fatty acids in the cooking medium to form a soapy foam on top of the burning material. This secures the vapors and cools the cooking medium as the foam drains and converts to steam. This reaction is known as **saponification**. In addition to saponification, the agent is discharged as a fine mist that does not submerge below the surface of the cooking medium (preventing a steam explosion), but rather it converts to steam on the surface pulling heat out of the material. Cooking-medium fires must be cooled below their **autoignition temperature** to be successfully extinguished.

Water mist

The **water mist extinguisher** uses deionized water that is discharged as a fine spray onto the burning material. It is designed as an alternative to halon in areas where contamination must be kept to a minimum without the expense of halon substitutes. Using deionized water causes little damage to most electronic circuits and is the safest agent available for use on humans (such as in operating rooms). The wand and wide spray with fine droplets gives a soft and controlled discharge pattern. This extinguisher has passed the Underwriters Laboratories Inc. test for electrical conductivity, allowing it to be listed for Class C applications (fig. 6–9).

Fig. 6–9. Water mist extinguisher

Dry chemical

Dry chemical extinguishing agents have been used since the early 1900s. Early in the development of these agents, sodium bicarbonate was found to have greater effectiveness on flammable liquid fires compared to other chemicals being used at the time. They are still widely used. In the 1960s, major developments in dry chemical agents led to the introduction of potassium bicarbonate (Purple K), monoammonium phosphate (ABC), potassium chloride (Super K), and urea potassium (Monnex). Potassium chloride and urea potassium-based dry chemicals are not common in the U.S. market. Dry chemicals are nonpoisonous, but either the acidic-based (ABC) or alkaline-based (Regular or Purple K) chemicals could be an irritant if inhaled. Dry chemical is not recommended for fires in delicate electrical equipment or aircraft because use of these agents may extinguish the fire but damage the equipment beyond repair.

Sodium bicarbonate

Sodium bicarbonate, or **BC**, is also known as regular dry chemical. In addition to its effectiveness on Class B and C fires, it has some effect on the flaming stages of a Class A fire but no effect on the embers or deep-seated Class A fire. When used on common cooking greases, it reacts with hot grease to form a thick foam through the saponification process. The foam created by saponification acts much like other firefighting foams and extinguishes the fire through vapor securement, flame separation, and generation of steam. Sodium bicarbonate is alkaline in nature and will not cause corrosion during normal use.

Potassium bicarbonate

Potassium bicarbonate, or **Purple K** dry chemical, was developed by the U.S. Naval Research Lab precluding the use of the term "Purple K" as a trade name. It was discovered that potassium salts are far more effective on flammable liquid fires compared to sodium salts. Potassium bicarbonate is also alkaline in nature, has similar abilities to saponify when used on hot cooking grease, and does not cause corrosion in most cases.

Monoammonium phosphate

Monoammonium phosphate, **ABC**, or multi-purpose dry chemical differs from potassium bicarbonate and sodium bicarbonate in its acidic nature. In addition to similar effectiveness on Class B and C fires when compared to sodium bicarbonate, monoammonium phosphate has unique effectiveness on Class A fires. When it contacts the burning surface of an ordinary combustible, a molten residue (metaphosphoric acid) is formed. This residue coats the burning ember and excludes oxygen. Monammonium phosphate does not saponify when used on hot cooking grease and causes corrosion if not thoroughly removed from most hot surfaces.

Dry chemicals are nonpoisonous, but either the acidic-based (ABC) or alkaline-based (Regular or Purple K) chemicals could be an irritant if inhaled. If any physical discomfort is experienced, contact a physician immediately.

Dry powders for Class D fires

Combustible metal fires represent a special hazard unlike Class A, B, and C fires. Extinguishing agents used on all other classes of fires have no success when used on Class D fires. In fact, some agents, such as water, react violently with the burning metal. Most agents used in extinguishers for these fires are proprietary in nature and are classified according to the manufacturer of the dry powder or the brand name of the agent. Each agent has different limitations regarding the type of metal (magnesium, titanium, lithium, etc.,) that it may be used on and the form the metal is in (molten, casting, turnings, or fines). The following NFPA codes, standards, and recommended practices should be consulted:

1. NFPA 49: *Hazardous Chemicals Data*
2. NFPA 48: *Storage and Handling of Magnesium*
3. NFPA 481: *Production, Processing, Handling and Storage of Titanium*
4. NFPA 482: *Production, Processing, Handling and Storage of Zirconium*
5. NFPA Hazardous Materials Handbook

Most Class D agents are applied generously to the burning material, often requiring up to 15 pounds of agent per pound of burning material. The extinguishing agent usually excludes oxygen and performs as a "heat sink" to absorb the thermal energy and cool the material. Caution must always be used when applying special agents to combustible metal fires because these fires react with any moisture in the ground and surrounding materials.

Class D agents

Graphite (carbon) is a finely divided powder that must be applied with a dry scoop or shovel. The powder conducts heat away from the material, reducing its temperature below the point that combustion may be sustained.

Sodium chloride-based powder forms a crust on the burning material, excluding oxygen is available in a 30-pound extinguisher. It also helps dissipate heat from the burning material.

Pure copper powder was specifically developed for use on lithium fires.

Halogenated agents

Halogenated agents have been used for firefighting since the early 1900s. Of the 10 halogenated agents that have been used, two have been the most common since the early 1970s: Halon 1211 and Halon 1301. Halogenated agents suppress fire by interrupting the chemical chain reaction in the combustion process, working in the fire chemically instead of physically. Exactly how this chain-breaking process works is not completely understood. It is generally agreed that bromine is released from the agent as it decomposes in the fire, carrying away the free radicals that cause the combustion and releasing more bromine to continue the chain-breaking process. Halon 1211 and Halon 1301 are ozone-depleting agents subject to control under the *Montreal Protocol on Substances That Deplete the Ozone Layer* and other federal requirements. The primary advantage of halogenated agents has been the lack of cleanup required after using the agent. In some environments (such as electronics, data processing, jet engines, and high-tech equipment), discharging other extinguishing agents such as water or dry chemical could damage more property than the fire itself.

Halon alternatives

Since the ratification of the Montreal Protocol, alternatives to Halon 1211 have been sought. Various proprietary blends of gases are available. For streaming agents (those used in portable fire extinguishers), there are two popular agents in use: FE-36 and Halotron I. Both agents extinguish fires primarily through cooling.

Neither Halotron I nor Halon 1211 should be used in confined areas smaller than indicated on the extinguisher nameplate, food-preparation areas, or the presence of people with cardiac problems. If problems occur, quickly remove the person from the area where the gas is present, apply artificial respiration, and transport to a medical facility.

Carbon dioxide

Carbon dioxide, also known as **CO_2**, is an odorless and colorless gas that does not conduct electricity. It is stored in extinguishers as a liquid under pressure and when expelled turns into a snow (dry ice) on contact with atmospheric moisture. Carbon dioxide displaces oxygen and care should be exercised in confined spaces. Avoid skin contact, which can cause cold burns.

Things to remember

Never discharge a fire extinguisher into anyone's face. Never throw an extinguisher into a fire or leave it unattended if the fire is not out. (Pressure build-up from even a partially full extinguisher can cause an explosion.)

UNDERWRITERS LABORATORIES FIRE-EXTINGUISHING RATING SYSTEM

FFI 5.3.16 The numerical portion of Class A ratings of extinguishers is based on comparative fire tests using various sizes of wood-crib, wood-panel, and excelsior fires (table 6–1).

The numerical portion of Class B ratings of extinguishers is based on fire tests using square steel pans in specific size increments and a flammable, liquid test fuel similar to unleaded gasoline. The fire extinguisher classification is equivalent to 40% of the area of fire extinguished twice by an expert operator.

Class A fire tests

For ratings Class 1A through 6A, the extinguisher shall be tested on the appropriate wood-panel, wood-crib, and excelsior fires. For a 10A rating, the extinguisher shall successfully extinguish the 6A wood-panel fire plus the appropriate 10A wood-crib fire test. For a 20A rating or higher, only the appropriate size wood-crib fire is required (fig. 6–10).

The minimum allowable discharge time for extinguishers rated 2A and higher is 13 seconds. During the test, the extinguisher must be in the full open position under continuous discharge.

Fig. 6–10. Establishing the rating of an extinguisher often involves the use of wood crib test fires. (**Courtesy of Tom Jenkins**)

A pan containing commercial-grade heptane is placed beneath the wood crib and is used to ignite the wood members. The heptane is allowed to burn between 2 and 4 minutes, after which it is removed and the crib is allowed to burn an additional 8 to 10 minutes. After the pre-burn period, the operator attacks the fire from the front at a distance of at least 6 ft (2 m). The operator may then shorten the distance and attack the fire from all sides except the back of the crib.

For wood-panel test fires, the panel is first placed in a horizontal position, and a pre-determined volume of No. 2 fuel oil is applied to the panel, which is then mounted vertically on a steel frame. A row of excelsior is placed at the base of the panel. Three additional rows of excelsior are placed at the base of the panel. Three additional rows of excelsior are strategically spaced on the floor of the test room. Using heptane, the first row of excelsior at the foot of the panel is ignited. At 45-second intervals, the three remaining rows are pushed to the base of the panel. At 3 minutes and 20 seconds after ignition, all remaining excelsior is cleared from the base of the panel. The fire then burns vigorously for 4 to 5 minutes, at which time the horizontal furring strips located between 6 and 30 in. (150 and 760 mm) above the floor, burn through and begin to fall away from the panel. Within 5 seconds of this observation, the initial

Table 6–1. Class A Fire Tests

CLASS A FIRES Ordinary Combustible: Wood, Paper, Textiles					
Numerical rating	Excelsior fire test	Wood-panel fire test	Wood-crib fire test Overall dimension, quantity, and size		
1A	6 lb/34×68 in. (2.7 kg/86×172 cm)	8×8 ft (2.4×2.4 m)	20×20×15 in. (51×51×38 cm)	50 pcs	2×2×20 in. (5×5×51 cm)
2A	12 lb/48×96 in. (5.4 kg/122×244 cm)	10×10 ft (3×3 m)	25⅝×25⅝×19½ in. (65×65×50 cm)	78 pcs	2×2×25⅝ in. (5×5×65 cm)
3A	18 lb/59×117½ in. (8.2 kg/150×298 cm)	12×12 ft (3.7×3.7 m)	30¾×30¾×21 in. (78×78×53 cm)	98 pcs	2×2×25⅝ in. (5×5×65 cm)
4A	24 lb/72×128 in. (10.9 kg/183×325 cm)	14×14 ft (4.3×4.3 m)	33⅜×33⅜×22½ in. (85×85×57 cm)	120 pcs	2×2×33⅛ in. (5×5×84 cm)
6A	36 lb/83×167 in. (16.3 kg/211×424 cm)	17×17 ft (5.2×5.2 m)	33⅜×33 ⅜×25½ in. (85×85×57 cm)	153 pcs	2×2×33⅜ in. (5×5×121 cm)
10A	N/A	17×17 ft (5.2×5.2 m)	47½×47½×28½ in. (121×121×72 cm)	209 pcs	2×2×47½ in. (5×5×121 cm)
20A	N/A	N/A	62¼×62¼×36½ in. (158×158×93 cm)	160 pcs	2×4×62¼ in. (5×5×158 cm)
30A	N/A	N/A	74⅝×74⅝×36½ in. (190×190×93 cm)	192 pcs	2×4×75⅝ in. (5×5×192 cm)
40A	N/A	N/A	87⅛×87⅛ in. (221×221 cm)	224 pcs	2×4×87⅛ in. (5×5×221 cm)

attack with the fire extinguisher is made from at least 10 ft (3 m) from the face of panel. The operator must attack this fire using two horizontal sweeps across the bottom of the panel and then may use the technique of his or her choice, provided the extinguisher remains under continuous discharge in the full open position until emptied.

Class B fire tests

Class B fire tests are conducted using a square steel pan at least 8 inches in depth. The test fuel is to consist of at least a 2-in. (51-mm) layer of Heptane, the surface of which is to be located 6 in. (152 mm) below the top edge of the pan. Water may be added to establish the required 6-in. (152-mm) freeboard (table 6–2).

For B ratings up to and including 20B, the fire test is conducted indoors in a large–volume, draft-free room. For B ratings in excess of 20B, outdoor fire tests are conducted under conditions of essentially still air: steady between 3 to 8 miles (4.8 to 12.9 km) per hour with gusts not greater than 10 miles (16 km) per hour and no precipitation. After a 1-minute pre-burn, the operator attacks the fire but is permitted to do so only from one side. The operator is prohibited from extending any part of his or her body past the edge of the test pan while fighting the fire.

FIREGROUND NOTE

Never use ABC dry chemical, Halon 1211, or Halotron I fire extinguishers on fires involving oxidizers (pool chemicals). A violent explosive reaction could occur with the mixture of chemicals.

Table 6–2. Class B Fire Tests

CLASS B FIRES Flammable Liquids: Oils - Greases - Paints			
Flammable liquids and gas rating	Minimum effective discharge time (seconds)	Pan size (inside) sq ft	Heptane used (approximate) U.S. gallons
Indoor Tests:			
1B	8	2½	3¼
2B	8	5	6¼
5B	8	12½	15½
10B	8	25	31
20B	8	50	65
Outdoor Tests:			
30B	11	75	95
40B	13	100	125
60B	17	150	190
80B	20	200	250
120B	26	300	375
160B	31	400	500
240B	40	600	750
320B	48	800	1,000
480B	63	1,200	1,500
640B	75	1,600	2,000

CLASS C FIRES Electrical Equipment	
No fire test	Extinguishing agent is tested for electrical non-conductivity. If acceptable, "C" Symbol is added.

FLOW RATES/APPLICATION RATES

Every agent, regardless of the mechanism it uses to extinguish a fire, has a critical application rate. The **critical application rate** is the minimum rate at which the agent must be applied to the fire and is usually expressed as a ratio of quantity of agent (in pounds or gallons) per area unit (usually square foot) per time unit (either seconds or minutes).

Under most circumstances, particularly when using equipment that does not involve a fixed system (hand hose lines or extinguishers), a rate of application in excess of the critical rate must be used. Other factors involving the fire and extinguishment may cause problems. Wind direction and speed, weather conditions, length of pre-burn, application technique, and fuel sources all affect the critical application rate. Using a higher application rate will help negate some of these factors and decrease the time required for extinguishment. There is a point at which a further increase in the application rate will not result in a further decrease of the time to extinguishment.

Application rates for dry chemicals are theoretical and often expressed in pounds of chemical per square foot per second. Tests done in the 1960s involving flammable liquid in depth and spill fires using a variety of fuels established an average critical application rate of less than 0.01 lb of chemical per second per sq ft. These tests used fixed systems, thus eliminating any operator error. They are not intended for use in the designing systems or choosing hand-operated equipment.

Flammable liquid fires involving fuel escaping under pressure, **three-dimensional**, running, or gravity-fed fuel generally require higher application rates than spill or fuel-in-depth fires. Listed hand-portable dry chemical fire extinguishers may have a flow rate ranging from 0.31 lb (0.14 kg) per second to 2.5 lb (1.13 kg) per second. The flow rate of different fire extinguishers may be established as a requirement for a higher UL listing (to meet minimum discharge times) or to meet a special purpose.

In practical applications using hand-portable or wheeled fire extinguishers, it is not possible to determine the critical application of the dry chemical for every set of circumstances. The advantages in using higher application rates (extinguishers with faster flow rates or multiple extinguishers in unison) are faster knockdown, greater protection from radiant heat (heat shield), faster extinguishment on fuel in depth fires, and greater chances of extinguishing pressure, obstacle, and three-dimensional fires. Disadvantages of using higher flow rates are wasting chemical and having less discharge time.

Personnel trained during live-fire exercises with dry chemical extinguishers are often able to put out larger and more complex fires with extinguishers that have a faster flow rate (and a lower UL rating). This is partly because their application technique wastes less chemical (negating the need for a longer discharge time), has better protection against radiant heat, and allows firefighters to use the faster knockdown to their best advantage. A 20-lb (9 kg) fire extinguisher with a rating of 40 B:C and a flow rate of 1.33 lb (0.6 kg) per second is likely to have far greater extinguishing capabilities in the hands of even a moderately trained operator than a 20-lb (9 kg) fire extinguisher with a rating of 120 B:C and a flow rate of 0.69 lb (0.31kg) per second. The faster–flow, 20-lb (9 kg) extinguisher can easily extinguish a larger UL test fire than its rating implies, but the required discharge time is insufficient to meet the UL standard.

Two operators applying dry chemical to the fire at the same time can theoretically double the flow rate of each of their extinguishers, thereby decreasing the time to extinguishment and providing better safety to the operators and greater chances of success. These are reasons to train personnel to fight fires as a team rather than as individuals.

When conducting training sessions, it is important that the same flow rates are used in training that are available "on line" in the facility. If personnel are trained with extinguishers flowing chemical at 1.77 lb (0.8 kg) per second, and the extinguishers in the facility have a flow rate of 0.68 lb (0.31 kg) per second, then training will not help personnel learn application techniques for their equipment. Application techniques for fast-flow equipment are different from those used with extinguishers having low flow rates and long discharge times. Using old extinguishers for training may have the same result. Many older fire extinguishers have much lower ratings (and faster flow rates) than newer extinguishers of the same agent capacity. For example, a 20-lb (9 kg) extinguisher made in 1972 may have a UL rating of 60B:C, while the same model made in 1992 has a UL rating of 120B:C.

Higher UL ratings do not equate to greater firefighting capability. Many factors, including training, type of fire incident, fuel, and application technique affect any attempt to extinguish a fire. NFPA 10, *Standard for Portable Fire Extinguishers* recognizes this issue and provides the local agency having jurisdiction (AHJ) with the flexibility to use fast-flow equipment based on customers' needs and sound fire protection practices.

FIRE EXTINGUISHER OPERATION

SKILL DRILL

FFI 5.3.16 These general instructions are intended to familiarize you with the basic operating techniques of a stored-pressure, hand-portable fire extinguisher. Because there are a variety of extinguishers, the nameplate must be consulted for specific procedures and starting distances.

1. Hold the extinguisher upright and pull the safety pin to break the plastic seal.
2. Stand back from the fire (minimum distance is stated on the nameplate) and aim at the base of the fire.
3. Keeping the extinguisher upright, squeeze the handle and lever together to discharge and sweep from side to side. Move closer as the fire is extinguished, but not so close as to scatter the burning material or liquid.
4. When the fire is out, back away while checking for possible re-ignition.
5. Evacuate and ventilate the area immediately after use. The smoke and fumes from any fire may be hazardous and deadly.

Remember the acronym **PASS** (fig. 6–11):

- **P**ull
- **A**im
- **S**queeze
- **S**weep

Any firefighting effort, first and initial response, or organized attack should minimize risk of injury and death. Once a decision has been made to fight a fire, it is important to remain calm and keep a clear perspective concerning safety. All things of a material nature can be replaced or rebuilt, but human life and health cannot.

Humans, like other animals, will react with either "fight" or "flight" when scared. Fire will cause one of these reactions to occur, sometimes involuntarily. No two people react exactly the same way, and no person is consistent from one fire to the next. Even the most experienced and trained firefighter makes bad decisions regarding safety in the heat of the battle.

Fig. 6–11. The acronym PASS is used to remind untrained users of fire extinguishers to pull, aim, squeeze, and sweep the hose back and forth.

Application techniques

SKILL DRILL

The most important aspect of any fire extinguisher application technique is operator safety. Techniques that needlessly jeopardize the safety of the operator are unnecessary and should never be taught or demonstrated.

It is advisable that all fires should be fought from the upwind side in order to stay out of the smoke, flames, and radiant heat. While this is preferable, it is not always practical. Regardless of wind direction, fires should only be fought from a side that allows a clear path of escape. Never place yourself on the opposite side of a fire from the path of escape in order to take advantage of the wind direction.

Foam application techniques. When applying foam to a fire, it is important to stay back during the initial attack. Unlike dry chemical or water fog patterns, foam streams do not give good protection against radiant heat. Once control of the fire starts to be established, the operator can safely move closer.

Care should always be taken to ensure that the foam is not submerged into the fuel and is applied gently with minimal disturbance to the fuel surface. Methods to do this include deflecting the stream off the back edge, bouncing the stream off of the front edge, deflecting it off an object in the center, or allowing the foam to gently fall down on the surface (known as the "rain down" or "snowfall" technique).

Faster extinguishment can be accomplished if the stream is moved about the surface rather than holding at one application point and waiting for the foam to move across the fuel surface. Once control has been established, shut down the nozzle and see if the foam will seal up, completing extinguishment. As long as the stream is disturbing the fuel surface, the foam cannot seal across the surface and complete extinguishment.

If water-miscible (polar solvent) fuels are involved, even in a small percentage, an alcohol-type foam must be used. When using an alcohol-type foam, it is important that the fuel surface not be disturbed so that the polymeric membrane can form on the surface.

No firefighting foam will secure a fuel surface indefinitely. Reapplication is necessary over a period of time to prevent reignition. Firefighters should never drag hoses through a **foam blanket** or step into a fuel source with a foam blanket on it without having specific equipment and protection on to do so. Water-miscible (polar solvent) fuels such as alcohol are particularly dangerous since they burn so cleanly that the flames may not be visible.

Dry chemical application. Unlike foam on a Class B fire, dry chemical has no securement capabilities. All of the fire must be extinguished or none of it will be extinguished. Because dry chemical uses a chain-breaking action to extinguish a Class B fire, no physical properties of the fire are affected. Oxygen is not displaced, little cooling is accomplished, and the fuel is not removed. Depending on the type of materials exposed to the fire (such as steel, gravel, combustibles), the chances for a reflash usually are present. The operator should anticipate the possibility of a reflash and never turn his or her back on a fire. There is never a reason to step into a flammable liquid source when using only fire extinguishers.

With the exception of fighting fires inside structures or underground mining operations, the operator should remain upright for the best and safest mobility. Bending over or running may cause the operator to trip.

Always start the approach at a safe distance. Humans were made to walk forward well, but running backwards is never safe.

Be aware of what is on the side of the fire opposite the operator discharging. The flare-up phenomenon can catch other fuels or combustibles on fire at a great distance from the dry chemical discharge.

Whether one operator is involved or several, keep alert, communicate loudly, and always have an open escape route in case you are not successful.

Dry chemical and fuel in depth. Class B fires involving fuel in depth present unique problems for the application of dry chemical. **Fuel in depth** implies that the flammable liquid is confined to a certain area either by a vessel, berm, or dike. Only the surface is of concern. It does not make a difference from an application standpoint whether the surface area encloses 5 gal or 500 gal of fuel. Because the fuel is contained to a specific surface area, it is important that the operator does not get too close and splash fuel, causing the area to increase.

Ideally, this fire should be fought upwind, but if the upwind approach would cut off a safe escape route, it can be fought with a crosswind or diagonal wind. The operator should start discharging the extinguisher from a comfortable distance using the dry chemical stream to "lay down" the fire and push it back before stepping closer.

If the fire surface is rectangular in shape, a slow, deliberate cut across the leading edge will get chemical into the **freeboard** area between the lip of the containment and the fuel surface. This is best accomplished by splitting the stream of dry chemical on the lead edge. Generally, the stream should be placed at least 6 in. (152 mm) in front of the lead edge and the sweep or cut should begin at least 6 in. (152 mm) beyond the side of the fire and continue past 6 in. (152 mm) beyond the other side of the fire.

If, after the initial cut has been made, fire is seen rising immediately on the lead edge right after the dry chemical stream moves away, the aim is too high, or in the case of a deep freeboard area, the angle is too flat. If fire immediately reappears on one side or the other, the cut or sweep is not being extended far enough to that side.

If the fire surface is in the shape of a circle, as in a round pan, start the discharge at the closest point, splitting the stream on the lead edge. Hold for a count of one to two, then begin sweeping side to side. As with a rectangular pan, each sweep must extend beyond the edges on both sides.

Once the fire is moving backwards, the operator can take slow steps forward, sweeping side to side until the fire is completely out. During these sweeps side to side, each sweep must extend at least 6 in. (152 mm) past each side. Unless it is necessary because of nozzle range, it is advisable to always back away from the fuel source. Should a sudden wind shift occur, the attempt at extinguishment fail, or a new source of ignition be introduced, the entire surface area of fuel will quickly ignite.

If for any reason it is necessary to be close to the fuel source, the speed of the sweep action must be increased in order to keep from splashing fuel.

Do not chase the flare-up. Keep the stream down on the surface of the fuel. The flare-up will burn out quickly.

Once extinguishment has been accomplished, stand by waiting for reflash, and then back carefully towards the escape route.

Spill fires. Spill fires by themselves are most likely the easiest of all flammable liquid fires to extinguish with dry chemical. There is no "lead edge" or freeboard area to conceal burning vapors. The same basic technique that is used for fuel in depth applies to spill fires, with one extra caution. With a lot of dry chemical flying about, the exact spill area may be hard to define, so it is important that the operator must stay back as far as possible to avoid inadvertently stepping into the fuel source.

Three-dimensional fire (gravity fed). This type of fire involves flammable liquids in motion, usually running from a source through several levels and pooling on the ground and other areas. Often, obstacles are involved, and, at the least, areas where fuel will flow around structures are involved. For these reasons, more than one dry chemical extinguisher operator should be present at the same time.

Initial approach and application are the same as for a spill fire. The operator(s) should open up the stream(s) at a safe distance, keep a clear exit path, and then, once the fire is moving, move forward and take care to stay out of the fuel spill.

Application must begin with the ground fire and then systematically continue extinguishment up to the source. Everywhere that fuel is flowing over hot metal surfaces or wrapping around an obstacle, the dry chemical stream should be held briefly to allow chemical to build up at that spot before continuing.

If ground fire re-ignites at any point during the application, the dry chemical stream must be brought back to the ground fire in order to be successful.

Applications with more than one operator. Using extinguishers in teams can be the safest and most successful way of extinguishing fires in their incipient or early stages. Communication is the key to having a safe, coordinated effort. All other basic rules apply regarding safe exit, distance, staying clear of the fuel source, and individual application technique. Each operator must speak loudly and clearly to each other. Dry chemical streams must be opened at the same time, and each operator should know what the other's plan is going to be prior to the attack.

At no time should the operators be at direct opposite sides of the fire. This will obscure vision and spray fuel and dry chemical on each other. Each operator should be able to see the other at all times and know where each team member is located.

If one operator runs out of dry chemical before the other, that person should say loudly and clearly, "I'm out," and then back away to safety along the predetermined path. This will let the other operator know that it is time to back away and cover both of their exits by discharging dry chemical between them and the fire and creating a heat barrier.

If one operator spots fire that is being missed by the other operator, that person must point it out immediately to the other. While each person may have a specific task to do, or a specific part of the fire to handle, it is important for each person to keep looking at all aspects of the fire. Other operators may be unable to see fire lingering in a small area because their vision is obscured by the dry chemical discharge.

If the fire is successfully extinguished, one of the operators must call the fire out. Both operators should then stop discharging, stand by, look for a reflash, and then back away to safety following the same route used to advance on the fire.

Spill or fuel in depth with an obstacle. An obstacle inside a fuel in depth or spill fire will shield the dry chemical stream from covering the entire liquid surface. At least two operators must be used when obstacles are present.

First, operators must agree on a plan of attack. (Who goes which way and covers what part?) Standing side-by-side, start discharging dry chemical together with each covering two-thirds of the surface area. Once the fire is moving, they then advance and split to each side until they can reach the back of the obstacle from an approximate 45-degree angle. When the fire is out behind the obstacle, they sweep the rest of the surface fire out. Once extinguishment is accomplished, they stand by looking for reflash, and then back away along the same path used to advance.

Fires with flammable liquids under pressure. Generally, the best way to extinguish flammable liquids under pressure is to shut off the source of supply. This is not always practical and dry chemical can be very effective on these types of fires. Usually it is necessary to place the dry chemical stream right at the point of escape and hold at that spot until the fire goes out. Then, continue to put out any ground fire that is burning. Fast-flow equipment with high flow rates must be used on this type of fire since the dry chemical flow rate must match the flow of fuel escaping.

Using dry chemical with handlines. Dry chemical can be applied to fires from behind fog patterns with great success. The fog pattern protects the fire fighters and aids in cooling the fire. The dry chemical can be directed from behind through the pattern without allowing the fire to come back on the operator. When using this technique, it is still necessary to apply the dry chemical using the same application techniques that are used without a fog pattern. Common mistakes with a combined water and dry chemical attack involve just directing the dry chemical into the water stream (this will have little effect on the fire) or sticking the dry chemical nozzle into the fog pattern (thus breaking the pattern and allowing flame to come back onto the hose team).

Dry powder on Class D fires. Applying dry powder to class D fires generally involves a soft discharge pattern that will completely cover the burning material under a mound of dry powder. The operator should be careful that no moisture is present in the surrounding area that may contact the burning metal. Once the material is completely covered, the operator should stand by and watch for "hot spots" that start to burn through the powder and reapply as necessary (fig. 6–12).

Fig. 6–12. Applying dry powder to a Class D fire is risky and requires the fire extinguisher operator to monitor the situation for "hot spots" that might flare up.

Inspection, maintenance, recharge, hydrostatic testing, and obsolete extinguishers.

Fire extinguishers are to be inspected at a minimum of 30-day intervals. They should be inspected more frequently when circumstances require. Per NFPA 10, 7.2.2 Procedures, the following shall be checked:

1. Pressure gauge reading or indicator in the operable range or position
2. Fullness determined by weighing or hefting for self-expelling extinguishers, cartridge-operated extinguishers, and pump tanks
3. The discharge outlet is not blocked
4. The seal is not broken
5. The operating instructions are clearly visible

When an extinguisher reveals a deficiency, it shall be subjected to applicable maintenance procedures.

- **Annual Maintenance.** A more complete inspection of the extinguisher that shall be done by trained, certified persons having the appropriate service manuals, tools, manufacturer replacement parts, and recharge agents specifically listed for use in the extinguisher.
- **6-Year Maintenance.** Every six years, extinguishers requiring a 12-year hydrostatic test shall be emptied and subject to thorough examination of mechanical parts, extinguishing agent, and expelling means. When applicable maintenance procedures are being done during periodic recharging or hydrostatic testing, the six-year requirement will begin from that date.
- **Hydrostatic Testing.** This involves subjecting the cylinder (known as the pressure vessel) to water pressure or pressure applied by some other noncompressible fluid, usually through the cylinder's valve opening, using a specially designed test coupling. This testing should not be performed using compressed air or any compressed gas, and all air and other gases must be vented from the cylinder before you apply any fluid pressure. Hydrostatic testing should be done by trained, certified

personnel using suitably equipped testing facilities. How often hyrdotesting should be conducted depends on the type of extinguishing agent used. Examples are water, foam, wet chemical, and carbon dioxide, which require a 5-year test. Dry chemical, whether stored-pressure or cartridge-operated with mild steel cylinders, require 12-year testing.

- **Recharge.** Recharge shall be done by trained, certified personnel immediately after use. The extinguisher must be recharged with the extinguishing agent listed on the nameplate. Substitutions could cause damage or injury. ***WARNING:*** *Always use a regulated pressurizing source set to no more than 25 psi above extinguisher operating pressure.*
- **Obsolete Fire Extinguishers.** Per NFPA 10 section 4.4, the following types of extinguishers are considered obsolete and shall be removed from service:

    1. Soda acid
    2. Chemical foam (excluding film-forming agents)
    3. Vaporizing liquid (e.g., carbon tetrachloride)
    4. Cartridge-operated water
    5. Cartridge-operated loaded stream
    6. Copper or brass shell (excluding pump tanks) joined by soft solder or rivets
    7. Carbon dioxide extinguishers with metal horns
    8. Solid charge-type AFFF extinguishers (paper cartridge)
    9. Pressurized-water fire extinguishers manufactured prior to 1971
    10. Any extinguisher that needs to be inverted to operate
    11. Any stored-pressure extinguisher manufactured prior to 1955
    12. Any extinguishers with 4B, 6B, 8B, 12B, or 16B fire ratings
    13. Stored-pressure water extinguishers with fiberglass shells (pre-1976)

Further, 4.4.1 states: Dry chemical, stored-pressure extinguishers manufactured prior to October 1984 shall be removed from service at the next six-year maintenance interval or the next hydrotest interval, whichever comes first.

Section 4.4.2 adds: Any fire extinguisher that can no longer be serviced in accordance with the manufacturer's maintenance manual is considered obsolete and shall be removed from service.

NOTES

NFPA 10 *Standard for Portable Fire Extinguishers*

LESSON FROM THE FIREGROUND

On arrival the fire in the basement of the 2½-story single family colonial style house was lapping up the wall and starting to spread across the ceiling to the stairway. A firefighter in full personal protective equipment and wearing self-contained breathing apparatus positioned himself at the exterior doorway on the side of the house by the stairway. There he used a 2½-gal (9.5-L) water extinguisher from a fire chief's car to hold the fire in check by placing a fingertip over the discharge point of the nozzle and spraying intermittent bursts of water. The judicious application of water prevented the fire from extending up the stairway and into the house. Shortly thereafter, the attack hoseline was in place and quickly extinguished the fire in the basement. The deployment of the 2½-gal (9.5-L) water extinguisher was a crucial factor in minimizing the damage to the house.

QUESTIONS

1. Explain the differences between applying an extinguisher to a fuel-in-depth fire in a rectangular and a circular container.
2. The rating system for a Class A fire extinguisher is based on what?
3. Explain the difference between dry chemical and dry powder extinguishers.
4. Describe the two ways that wet chemical fire extinguishers work on Class K fires.
5. List examples of the types of fires that halogenated extinguishing agents would be more beneficial than other agents.
6. List the criteria for selecting the proper fire extinguisher.
7. What is the best way to extinguish a fire involving a flammable liquid under pressure?
8. List four fire extinguisher types that are considered obsolete by NFPA 10.