

# Arson Detection for the First Responder

ADFR-Student Manual

*1st Edition, 2nd Printing-August 2002*



Homeland  
Security

FEMA/USFA/NFA  
ADFR-IG  
August 2002  
1st Edition, 2nd Printing

*Arson Detection for the First Responder*



**Homeland  
Security**

# Arson Detection for the First Responder

ADFR-Student Manual

*1st Edition, 2nd Printing-August 2002*



Homeland  
Security



U.S. DEPARTMENT OF HOMELAND SECURITY

PREPAREDNESS DIRECTORATE

UNITED STATES FIRE ADMINISTRATION

NATIONAL FIRE ACADEMY

FOREWORD

The U.S. Fire Administration (USFA), an important component of the Department of Homeland Security (DHS) Preparedness Directorate, serves the leadership of this Nation as the DHS's fire protection and emergency response expert. The USFA is located at the National Emergency Training Center (NETC) in Emmitsburg, Maryland, and includes the National Fire Academy (NFA), National Fire Data Center (NFDC), National Fire Programs (NFP), and the National Preparedness Network (PREPnet). The USFA also provides oversight and management of the Noble Training Center in Anniston, Alabama. The mission of the USFA is to save lives and reduce economic losses due to fire and related emergencies through training, research, data collection and analysis, public education, and coordination with other Federal agencies and fire protection and emergency service personnel.

The USFA's National Fire Academy offers a diverse course delivery system, combining resident courses, off-campus deliveries in cooperation with State training organizations, weekend instruction, and online courses. The USFA maintains a blended learning approach to its course selections and course development. Resident courses are delivered at both the Emmitsburg campus and its Noble facility. Off-campus courses are delivered in cooperation with State and local fire training organizations to ensure this Nation's firefighters are prepared for the hazards they face.

The *Arson Detection for the First Responder* two-day training course is designed specifically to provide a clear definition of the role of initial responder organizations and to provide essential knowledge to enable them to recognize the potential of an intentionally set fire, preserve evidence, and properly report the information to appropriate officials.

The training course includes the following basic topics: fire behavior, critical observations of the first responder, fire causes, scene security and evidence preservation, legal considerations, and reporting of findings.

The *Arson Detection for the First Responder* training course is specifically designed for the firefighter who is inexperienced in arson detection and the preservation of evidence at the fire scene. It is **not** designed for the arson-experienced firefighter or inspector.



TABLE OF CONTENTS

|   | PAGE   |
|---|--------|
| Foreword .....  | iii    |
| Table of Contents .....                                   | v      |
| Schedule .....  | vii    |
| <br>  |        |
| UNIT 1: INTRODUCTION .....                                | SM 1-1 |
| UNIT 2: FIRE BEHAVIOR .....                               | SM 2-1 |
| UNIT 3: FIRST RESPONDER OBSERVATIONS .....                | SM 3-1 |
| UNIT 4: FIRE CAUSES .....                                 | SM 4-1 |
| UNIT 5: SCENE SECURITY AND PRESERVATION OF EVIDENCE ..... | SM 5-1 |
| UNIT 6: LEGAL CONSIDERATIONS .....                        | SM 6-1 |
| UNIT 7: REPORTING OF FINDINGS .....                       | SM 7-1 |





**SCHEDULE**

|         |   |
|---------|---|
| UNIT 1: | INTRODUCTION                                |
| UNIT 2: | FIRE BEHAVIOR                               |
| UNIT 3: | FIRST RESPONDER OBSERVATIONS                |
| UNIT 4: | FIRE CAUSES                                 |
| UNIT 5: | SCENE SECURITY AND PRESERVATION OF EVIDENCE |
| UNIT 6: | LEGAL CONSIDERATIONS                        |
| UNIT 7: | REPORTING OF FINDINGS                       |



# ***UNIT 1: INTRODUCTION***

## **COURSE OBJECTIVES**

*The students will be able to:*

- 1. Recognize as first responders the indicators of an intentionally set fire, preserve evidence, and report the information to the appropriate official.*
- 2. Define clearly the role of the first responder, and understand that the first responder's role is not to determine the origin or cause of the fire, and that he/she is not responsible as an investigator.*

## **UNIT OBJECTIVE**

*Students will understand the direct and indirect impact of the crime of arson.*

---



## INTRODUCTION

The first responder is often in the best position to make critical observations regarding a fire. The first responder can compare this fire to a similar fire and draw parallels between them for similar fire-behavior patterns. The observations of the first responder during the various stages of an incident are extremely critical. From the moment of dispatch through the overhaul phase, the first responder's senses are exposed to countless stimuli, many of which can help make a determination of fire origin and cause. Without the first responder's full attention, priceless information could be destroyed.

## OVERVIEW OF COURSE

- Fire Behavior.
- First Responder Observations.
- Fire Causes.
- Scene Security and Preservation of Evidence.
- Legal Considerations.
- Reporting of Findings.

## SOCIAL COST OF FIRE

When fire occurs, the social and economic costs to the community can be devastating: the loss of the tax base, jobs, and injury and deaths both to civilians and firefighters. The impact on public resources can put a burden on the community's tax base, and the loss of the employment base.

The *NFPA Journal* of September/October 1994 reports the number of fires, deaths, and injuries both to firefighters and to civilians for the year 1993. The information in this article will be discussed in this unit. These figures give the overall picture of fire in the United States.

### Fires

Public fire departments responded to 1,952,500 fires in 1993, of which 621,500 were structural fires. Seventy-six percent of all structural fires, or 470,000 fires, occurred in residential properties. Vehicle fires increased by 3.8 percent to 420,500. The remaining number of fires were outside and decreased by 1.2 percent to 910,500. The south and northeast had the highest fire incident rates in the country.

### Civilian Deaths

In 1993, there was a decrease in civilian fire deaths of 2 percent from 1992. However, in 1993, there were 4,635 civilian fire deaths, with about 80 percent of all fire deaths occurring in the home. Of this, 560 civilians lost their lives in incendiary or suspicious fires.

### Civilian Injuries

Injuries to civilians from fire increased to 30,475, a 6.2 percent increase from the previous year. This estimate is low because of the under reporting of injuries to civilians at fires. Of these injuries, 74.1 percent occurred in residential fires, while only 13 percent occurred in nonresidential structures.

### Property Damage

Property damage loss was \$8.546 billion; with structure fires resulting in 87 percent of all property damage, or \$7.406 billion. This figure does not account for the loss of the tax base to the community, or the loss of jobs that cause an additional overall impact on the local community.

### **Incendiary and Suspicious Fires**

It is estimated that 84,500 fires were deliberately set or of suspicious nature. These fires caused \$2.351 billion in property damage alone.

These fires also resulted in the deaths of civilians. In the structures mentioned above, 560 civilians lost their lives, with property damages reaching \$2.351 billion.

Fires of incendiary and suspicious origin in vehicles caused \$137 million in property damage (41,500 fires).

### **Firefighter Injuries and Deaths**

Each year, there are deaths and injuries to firefighters performing their duties. In 1993, there were 77 deaths and 101,500 injuries. These figures emphasize the importance of the firefighter, when responding and on the scene during operations, always to be mindful of the ever-present danger to both firefighters and civilians.

## **FIREFIGHTER SAFETY**

### **Scene Safety**

Scene safety is another major consideration for the first responder. From the receipt of the alarm, the first responder should evaluate response activities from the standpoint of safety. In this light, the first responder should be making decisions about the risks that need to be taken versus the benefits that can be gained.

These same considerations apply to the fire origin and cause determination phase of the incident. The first responder needs to evaluate the status of the structure to determine any unsafe areas. Some of these areas may need attention before anyone can enter them safely.

### **Safety Considerations**

Parts of the structure need careful scrutiny. Floors must be evaluated for their stability, their load-bearing capacity, and the potential effect if something falls on them.

The walls and ceilings also must be evaluated to determine if they are structurally sound. Of particular concern are the bearing walls that are carrying the weight of the floors above. Should the bearing walls weaken, the interior or nonbearing walls often become unduly stressed. These interior walls were not meant to support this weight. The result can be dangerous, if not deadly, to firefighters and any civilians present.

Ceilings should be evaluated for their stability. If there is any inkling that the ceiling is holding trapped water, punch an inspection hole. Ceilings are not designed to support hundreds of pounds of water, even though many ceilings have held the weight of the water for several hours. However, when the plaster or other material finally becomes saturated, the ceiling collapses. Once again, the results can be dangerous, if not deadly, to firefighters and any civilians present.

Roof supports also must be evaluated for stability. Of special interest are those structural members with wide spans or large open spaces. Often, there is nothing to catch the roof should it fall. If a roof collapses in a dwelling, it is generally caught by the interior partitions. If the roof in other types of occupancies collapses, there is nothing to stop it from crashing to the floor. Examples of these types of occupancies are churches, auditoriums, or gyms.

If the roof structure consists of lightweight materials, it should be evaluated very carefully. Some roof covering materials, such as slate or tile, place a tremendous weight on the roof. This weight may be excessive for partially destroyed structural members.

A common construction feature today is roof trusses held together with metal gusset plates. These thin plates actually hold together the truss parts, usually no more than two by four or two by six lumber. The metal ties are either nailed into the wood, or more often, punched so that they adhere to the wood. It does not take much fire exposure to damage the integrity of these trusses.

Basements must be evaluated for safety. If there is water in the basement, it should be pumped out. Even if it is only a foot deep, it should be removed before entering. It is possible that a person could fall into a sump area, open shaft, or other area in the basement where water is deeper. There also is the possibility of electrical shock from sump pumps in the water.

Soaked stock has the potential to collapse; this could block paths of egress. Their stability must be considered for the protection of the first responder during suppression and post-suppression activities.

### **Utility Considerations**

Electric and gas utilities also need to be evaluated prior to making an origin and cause determination. This is necessary to determine if the service has been terminated or must be terminated prior to the inspection. Has the electric service been terminated at the utility pole or somewhere else outside the structure? It is critical to find out if the main breakers have been thrown or the fuses removed from service. If they have, the electrical service should terminate at the panel box. There is always a risk that someone has used a method that is not approved to install wiring and somehow bypassed the normal protection devices.

Portable sources of gas such as propane and butane tanks should be closed at the tank to shut down the gas supply. Small fires, such as a fire in a kitchen range, may require closing only the appliance valve.



## **Fuel Oil Tanks**

Aboveground fuel oil tanks will have a shutoff valve near the tank's fuel filler. If no shutoff is found, control the fuel by crimping or bending the oil line. Caution should be taken to ensure that punctures are not made by crimping or bending the oil line.

Underground tanks may be more difficult to shut down. Many installations will have a shutoff valve inside the building near the heating device's fuel filler. If they do not, consider crimping the oil line. If the power is shut down and the fuel is not leaking, you may not have to do anything to the fuel oil supply. Again, use caution when bending or crimping so that punctures are not made in the line.

## **SUMMARY**

The first responder has simple but very important responsibilities after the suppression efforts end and the overhaul and salvage operation begins. The first responder must determine the stability of the structure to ensure the safety of personnel.

He/She must establish control of the premises and ensure that all unauthorized person(s) are barred from the structure, and that authorized person(s) are escorted into the structure.

The first responder owes it to the fire investigator to give him/her all help possible in the form of observations, evidence, and reports. In order to have a good investigation, the first responder must work with the investigator, not hinder him/her.



## Activity 1.1

### Fire Scene Observations

#### Purpose

To introduce you to the course.

#### Directions

1. Watch the 4-minute video.
2. There are three stopping points within the video. The video will pause for 5 minutes at each of the breaks.
3. What are some of the things you would notice or observe as the first responder arriving at the scene of the fire?

#### Task I

Working independently, make a list of some of your observations.

---

---

---

---

---

---

---

**Task II**

Working in small groups, make a list of some of your observations.

---

---

---

---

---

---

---

**Task III**

Working in small groups, make a list of some of your observations.

---

---

---

---

---

---

---

## BIBLIOGRAPHY

This is a list of materials that may assist you in furthering your knowledge of arson detection.

FEMA-FA-87, *Rural Arson Control*.

*Fire Fighter's Responsibility in Arson Detection*, NFPA.

*Fire Protection In The Wildland/Urban Interface*. A Publication of the National Wildland/Urban Interface Fire Protection Program.

*Fire Storm '91*, Case Study, NFPA.

*Oakland/Berkeley Hills Fire*, NFPA.



## ***UNIT 2: FIRE BEHAVIOR***

### **OBJECTIVES**

*The students will be able to:*

1. *Define fire.*
  2. *List and describe three methods of heat energy transfer.*
  3. *Define flameover/rollover, flashover, and backdraft.*
  4. *Classify the elements of the fire triangle and tetrahedron.*
  5. *Identify basic building construction.*
-





## INTRODUCTION

Since their first days in the fire department, firefighters have heard how important basic skills are for safely and effectively responding to fires. Basic skills are needed for preincident planning, fire suppression, fire prevention, and for fire origin and cause determination.

The goal of this unit is to make initial responders more aware of some of the principles that underlie the origin, cause, and spread of fire. This knowledge will, in turn, help the first responders make a more accurate determination as to the origin and normal or abnormal spread of fire.

## BASIC FIRE CONCEPTS

### Definition of Fire

A good place to start is with the meaning of combustion.

Combustion is an exothermic, self-sustaining reaction involving a solid, liquid, and/or gas-phase fuel. The process is usually (but not necessarily) associated with the oxidation of a fuel by atmospheric oxygen. Some solids can burn directly by glowing combustion or smoldering, but in flaming combustion of solids and liquid fuels, vaporization takes place before burning. It is necessary to distinguish between two types of flaming: 1) premixed, in which gaseous fuel is mixed intimately with air before ignition, and 2) diffusive, in which combustion takes place in the regions where the fuel and oxygen are mixing. If premixed burning takes place in a confined space, a rapid pressure rise will occur, giving rise to an explosion. (NFPA *Fire Protection Handbook*, 17th Ed., p. 1-44.)

Fire is a rapid, self-sustaining oxidation process usually accompanied by the evolution of heat and light in varying intensities.

Of all the terms learned throughout this course, the definition of fire is one of the most important. This is because the process of combustion underlies everything else we need to consider in reaching an accurate fire origin and cause determination.

## **Principles of Combustion**

### **The Fire Triangle**

The first responder must be familiar with basic fire chemistry. First, we will discuss the principles of burning and the elements necessary to produce burning.

The triangle theory is still used for a simple explanation. Until recently it was explained that a triangle of three essential elements is necessary for fire.

These three elements are heat, fuel, and oxygen. Remove any one of these three elements, and the fire goes out.

The fire triangle continues to explain the glowing fire, that is, a glowing fuel mass without flaming combustion. Modern research has expanded the understanding of open or flaming combustion by adding a fourth element.

### **The Fire Tetrahedron**

A new element has been added, and the four elements make up the sides of what is known as the "fire tetrahedron." This fourth element is described as an uninhibited chain reaction. This chain reaction is responsible for the continuous heating of the fuel mass and the continuous production of vapors or flammable gases which the flames ignite.

As defined earlier in this unit, fire is often referred to as a rapid self-sustaining oxidation process usually accompanied by the evolution of heat and light of varying intensities.

Oxidation is an exothermic reaction which releases heat. An endothermic reaction absorbs heat. For an exothermic reaction to occur, combustible fuel and an oxidizing agent must come together. Fuel may be almost any material which has not been fully oxidized. Most materials are composed of carbon and hydrogen (hydrocarbons) which usually can be further oxidized. Most organic materials, flammable gases, and liquid gases contain large amounts of hydrogen and carbon.

Air contains approximately 21 percent oxygen. Other materials may provide oxygen during combustion; these are known as oxidizing agents. Some examples of these oxidizing agents are sodium nitrate and potassium chlorate.

Under certain conditions combustion can take place without oxygen being present, such as during the burning of magnesium. Such cases are somewhat rare and are not included here.

Only gases or vapors burn during open combustion. Solids and liquids do not actually burn. What is actually burning is the flammable gases released by the fuel.

Pyrolysis begins when fuel is heated.

### **Pyrolysis**

Pyrolysis is the chemical decomposition of matter through the action of heat. This process begins when fuel is heated, and continues through specific stages. Let's use wood as a fuel example.

Various gases slowly form during decomposition. The combustibility of these gases increases with the material's decomposition. The decomposition moves deeper into the fuel mass as the fuel surface is attacked and charring occurs.

Evolved gases ignite when they reach their lower flammable limit, assuming an ignition source is available. Ignition may be delayed if ignition energy (source) is not available.

Heat from an open flame starts the secondary pyrolysis reaction. Heat balance and heat feedback are important to continued burning. A positive heat balance occurs when more heat is produced than is lost to heat conduction, convection, or radiation, and the fire continues to burn. A negative heat balance occurs when most of the heat produced is lost to conduction, convection, or radiation and the fire normally goes out.

Flashpoint, flammable and combustible liquids, and ignition temperature have an important bearing in the development of a fire. Knowing their implications will be very helpful to the company officer trying to make a fire origin and cause determination.

## **FLASHPOINT**

Flashpoint is the lowest temperature at which a flammable or combustible liquid produces enough vapors to form a flammable mixture at or near the surface of the liquid. This definition is based on experiments conducted under laboratory conditions.

Knowing the flashpoint of something can be critical in making the proper origin and cause determination. As with so many of the concepts discussed here, the knowledge of flashpoint can be used to support a fire origin and cause determination.

## **FLAMMABLE AND COMBUSTIBLE LIQUIDS**

The flashpoint of a product determines if the product is classified as flammable or combustible. A flammable liquid has a flashpoint below 100°F (38°C). A combustible liquid has a flashpoint of 100°F or above. The ability to discriminate between flammable and combustible liquids is critical to an arson investigation.

## **IGNITION TEMPERATURE**

Ignition temperature is the minimum temperature required to ignite a material. Autoignition occurs at the temperature at which the product will ignite without the presence of an open flame. Some common ignition temperatures follow (listed with Fahrenheit and Celsius temperatures).

Self-ignition, also known as autoignition, occurs at the minimum temperature to which the substance must be heated in air in order to ignite independently of the heated or heating element.

| <b>Material</b> | <b>°F</b>  | <b>°C</b>        |
|-----------------|------------|------------------|
| Soft wood       | 608 to 660 | 320 to 349       |
| Kerosene        | 410        | 210              |
| Polystyrene     | 1,063      | 573              |
| Gasoline        | 853        | 456 (100 octane) |
| PVC             | 945        | 507              |
| Acetone         | 869        | 465              |

Often ignition temperature is confused with flashpoint, but there is no relationship between the two terms. Some fuels which have very low flashpoints may have very high ignition temperatures.

## **FLAMMABLE OR EXPLOSIVE LIMITS**

The next terms we need to examine are flammable or explosive limits. They form a range that includes lower and upper limits.

These are the extreme concentration limits of a combustible or flammable gas in an oxidant through which a flame, once initiated, will continue to burn.

There are upper and lower percentages of an air-gas mixture in which combustion will be supported. A mixture below the lower limit is too lean to burn. A mixture above the upper limit is too rich to burn.

## **SPECIFIC GRAVITY**

Gravity is the weight of something based on the earth's pull. Specific gravity is the weight of something compared to water, which is given a specific gravity of 1. The weight of the product will either cause it to float on top of the water or to sink to the bottom. Gasoline has a specific gravity of .73, making it lighter than water, and causing it to float. The specific gravity of asphalt is 1.4; it will sink in water because it is heavier.

## **VAPOR DENSITY**

Vapor density is the ratio of the weight of a volume of a given gas to an equal volume of dry air, air having the value of 1 (as water did for specific gravity). This is used to determine whether a gas will rise or sink in the atmosphere. This, too, can be very important in determining origin and cause.

If a substance's vapor density is higher than 1, it will tend to sink or to collect in low-lying areas. If it is lower than 1, it will tend to rise. A helium balloon tends to rise because its vapor density is lower than that of air. An example is that of gas vapors settling to the lowest point, such as a basement, and igniting when the vapor reaches the ignition source.

## **SOLUBILITY**

Solubility is the ability of a material to dissolve in water. A common example is alcohol. For certain types of fires, such as those with an alcohol base, a special type of foam must be used.

## **RATE OF HEAT RELEASE (RHR)**

While the fire load determines the amount of heat that would be generated, just as important is the Rate of Heat Release (RHR). The RHR indicates how fast the heat in the fuel is released. The type and form of materials affect the RHR. The higher the RHR, the more rapidly the fire will increase in severity.

Heat is measured in British Thermal Units (BTUs). One BTU is the amount of heat required to raise the temperature of one pound of water one degree Fahrenheit (measured at 60°F [15.5°C]). The total number of BTUs generated from a fire is important in relation to the fire loading and the amount of damage in the structure.

Once again, it is important to emphasize that the knowledge of this technical point is not as critical as the officer's ability to use this knowledge with all of the other pieces of information at the scene.

Having some sense of the number of Btus generated by various combustibles may be important information when related to the damage inflicted on a structure. An example is the amount of combustibles in a structure.

Examples of Btu production:

| <b>Product</b>     | <b>Btu/lb.</b> |
|--------------------|----------------|
| Wood               | 7,000          |
| Polyurethane       | 14,700         |
| Polyvinyl Chloride | 17,900         |
| Polystyrene        | 18,750         |
| Polypropylene      | 20,000         |
| Polyethylene       | 20,100         |

## **REACTION OF FIRE TO WATER APPLICATION**

How a fire reacts to the application of water is an important aspect of fire suppression and a critical point for the first responder to observe. Normal items in today's environment will produce a significant amount of heat. The application of the appropriate amount of water should cause the fire to diminish and go out. If the fire does not react as one has seen at previous similar fires, one should be curious as to the reasons.

A common reason might be the use of an accelerant. Another could be the combustion of a substance that burns hot and fiercely when water is applied. Whatever the case, this fact could be another clue that will help figure out the correct answer.

## **HEAT TRANSFER AND TEMPERATURE FACTORS**

The properties of heat are such that its route of travel and method of transfer can reveal interesting information about fire origin and cause. Therefore, it is a critical evaluation while making a fire cause determination.

As fire travels from room to room or from one portion of a building to another, the methods of travel should be fairly obvious. This observation is critical to determine if the fire was spread intentionally with devices such as accelerants, trailers, or separate fires.

### **Methods of Heat Transfer**

The three methods of heat transfer are conduction, convection, and radiation.

Conduction is heat transferred by direct contact from one body to another, such as through a brick. There are many examples of heat transfer and the spread of fire from involved to uninvolved areas by heating some structural element. Some common examples include

- pipes and other conduits;
- steel structural members; or
- walls, doors, ceilings, or floors.

Convection involves the transfer of heat by a circulating medium, either a gas or liquid. This form of heat transfer is the one most often responsible for fire spread in structures.

An example of heat transfer by convection is the spreading of fire from lower to upper structural areas when the upper areas become heated to their ignition temperatures.

Radiation heat is heat in the form of energy waves that travel from one area to another without direct contact, and without any circulating hot gases, to help "bathe" the area in heat. An example is how the earth is warmed by the sun. An example of heat transfer by radiation is an exposure fire.

Structural fires usually involve all three types of heat transfer or combinations of all three. Being able to differentiate one from another may be critical for the first responder in reporting his/her observations as to how the fire spread.

### **Observing Fire Spread**

Observing fire spread may be vital to reconstructing where the fire started and how it traveled to another location. Certain fire travel predictions also can be made for some classifications of buildings.

Consider the following example. A fire starts in the basement of a wood-frame building of balloon construction. Shortly after, the fire appears in the attic. This may be a result of convected heat traveling up through open wall cavities to the attic level and igniting combustible materials.

## **FLASHOVER**

Flashover is caused when heat produced by the fire collects at the ceiling level and returns to the lower areas by thermal radiation. Combustible materials are heated to their ignition temperatures and fire flashes over large areas.

A more recent term used to describe the rapid spread of flame over one or more surfaces is "flameover." This should not be confused with flashover.

Flameover is defined as the condition where flames propagate through or across the ceiling layer only, and do not involve the surfaces of target fuels.



Flashover may cause the area to appear to have been exposed to a flammable accelerant. However, during the fire scene examination, discovery of the following would indicate flashover rather than the use of an accelerant:

- burning over top surfaces of materials;
- lack of normal fire spread from point of origin;
- lack of accelerant residue; and
- demarcation line around area.

## **BACKDRAFT**

Backdraft is defined as an explosion resulting from the sudden introduction of air (oxygen) into an oxygen-deficient, confined space that contains superheated products of incomplete combustion.

What causes a backdraft? Carbon monoxide is one of the major components of most structural fires and it is highly flammable, with explosive limits of 12.5 to 74 percent. The ignition temperature of carbon monoxide 1,128°F (609°C) is well below the normal temperatures found at ceiling levels of most structural fires. The carbon monoxide usually collects at the upper areas of a fire-involved structure, and the introduction of air (oxygen) from below frequently results in an air-to-carbon monoxide mixture within the flammable range.

Backdraft explosions often cause injuries to firefighters. When a backdraft occurs, some critical information that first responders could provide includes

- What was the extent of smoke at the time of arrival?
- Was there a lack of visible flame or was there the presence of blue flames?
  - What method was used to open or enter the structure?
  - Did entry prior to venting provide oxygen and possibly cause a backdraft?
  - Was there movement of smoke immediately preceding the explosion?

Backdrafts also can occur during the later stages of the fire if pockets of smoke remain after venting.

## **CLASSES OF FIRE**

As part of a fire scene examination, first responders should note the methods of extinguishment. One issue to examine is whether the proper extinguishing agent was used for the type of fire that occurred. There are four classes of fire with which every first responder should be familiar.

**Class A** fires are those fires that involve ordinary combustible materials, or materials which produce an ash or glowing coals. Some common examples are wood, paper, cloth, and rubber.

**Class B** fires are those fires that involve flammable or combustible liquids. Some common examples are gasoline, kerosene, fuel oil, and alcohol.

**Class C** fires are those fires that involve energized electrical equipment.

**Class D** fires are those fires that involve certain combustible metals. Some common examples are magnesium, titanium, sodium, and potassium.

## **NORMAL FIRE BEHAVIOR**

Fires usually will go through at least two stages. If the building is tightly closed and remains closed, it may go through a third stage and eventually self-extinguish. Knowing the stages and being able to distinguish each is another important skill for the first responder.

### **Stage One--Incipient Or Beginning Stage**

The incipient stage is the first or beginning stage. All fires start with a single point of ignition and expand from that point. A Class B fire (flammable liquid) expands rapidly, while a Class A fire expands slowly. As a Class A fire starts, the fire gases and heat start to rise upward and outward. This is often referred to as the "V" pattern with the bottom of the "V" pointing to the area of fire origin. The hotter and the faster the fire, the narrower the "V" pattern.

Class A fires can accelerate with the addition of flammable liquids and can have their normal fire patterns altered. As the fire burns, it produces a wide variety of fire gases.

Carbon monoxide (CO) is not the most toxic fire gas, but it is the most abundant. As the oxygen level decreases, the production of CO increases. Carbon dioxide (CO<sub>2</sub>) is produced in every fire.

Two other commonly produced gases are hydrogen sulfide, generated when organic materials containing sulfur, such as hair and wool, burn; and benzene, produced when vinyl materials burn.

### **Stage Two--Free-Burning Stage**

The free-burning stage follows flashover of the area or building, at which time the area appears to be fully involved. Normally, in accidental fires, this stage will occur in about three to five minutes from the time of ignition. However, if certain building contents, such as plastic furniture, are burning, the free-burning stage may occur sooner.

The type of fuel or arrangement of the fuel may affect the time it takes the fire to develop fully. Fire growth accelerated by a flammable liquid or other methods, such as a trailer device of combustible materials arranged to cause the rapid spread of the fire, will alter this normal fire growth.

### **Stage Three--Smoldering Stage**

When a fire has passed through Stages One (incipient) and Two (free burning) it likely will smolder if the area or building is closed. For this to happen, the oxygen level must fall to 16 percent or lower. If the free-burning phase is reduced, the fire may return to its area of origin (most heavily burned part), and will continue to smolder for a long period of time.

Various things happen during Stage Three of burning:

- Carbon monoxide production rises.
- The temperature of the area or building rises.
- Large amounts of heavy black carbon are deposited on the walls and windows.

- Moisture may appear on the inside of the window glass as the outside air cools the glass.
- The building may appear to be "puffing" and "breathing."
- Smoke may appear around windows, through the siding, or through the roofing material.

One can infer that the level of the structure where the smoke stops puffing is probably where the seat of the fire is located. If there is puffing smoke on the second floor but none on the first, the area of fire origin may well be located on the second floor. This is not absolute, but is a good rule of thumb.

As buildings become more tightly constructed and insulated, the potential for Stage Three fires increases.

### Combustion Byproducts

Four categories of combustion byproducts are produced as the result of combustion. They are gases, heat, flames, and smoke. We need to discuss each of these and how they relate to fire behavior.

Fire gases produced in most fires depend on certain variables, including the chemical makeup of the burning materials, the available oxygen during burning, and/or the temperature of the fire and the fire area.

The toxicity of these gases is determined by variables such as the concentration (percent) of gas in the air, the length of exposure, and the physical condition of the victim.

The toxic effects on personnel are greater during the fire because of increased respiration by the victim from exertion, heat, and excess carbon dioxide. What ordinarily appear to be harmless amounts of toxic byproducts may become dangerous during the fire.

### Flame, Heat, and Smoke

Flame results from the burning of most materials in an oxygen-rich atmosphere. This produces luminosity (flame). Therefore, flame is considered to be a "byproduct" of combustion.

Heat is the byproduct which is most responsible for the spread of fire in buildings. The presence of moisture in heated air increases the danger and the damage.

Smoke consists of very fine solid particles and condensed vapor. Gases that are produced by the heating of combustible materials are contained in flammable tar droplets and carried upward within the thermal column. Very little smoke is produced during complete combustion. As combustion diminishes, smoke density increases.

### Oxygen and Fire

Air contains approximately 21 percent oxygen. Without an air supply, insufficient oxygen often results during combustion. Flaming combustion usually ceases when the available oxygen is less than 16 percent.

## **BUILDING CONSTRUCTION AND FIRE SPREAD**

Understanding building construction features will help in determining several factors. These include correctly classifying the code in the Basic Fire Incident Report and determining how heat, smoke, and fire may have traveled through voids and vertical openings in the structure, and how renovations and alterations affect heat, smoke, and fire travel. This also aids in selecting the appropriate suppression tactics.

There are five building construction classifications, each with distinctive spread patterns:

- fire resistive,
- noncombustible,
- heavy timber,
- ordinary, and
- wood frame, which includes
  - post and beam,
  - balloon, and
  - platform.

### **Fire-Resistive Construction**

In fire-resistive construction all structural members, including walls, partitions, columns, floors, and roofs are of noncombustible materials with fire-resistive ratings. Fire-resistive ratings are established by tests

conducted under laboratory conditions. Poured-in-place concrete is a common fire-resistive material.

There usually are two subtypes of fire-resistive construction based on the level of fire protection specified for the structural frame. A building in which no structural steel is exposed and all vertical openings are enclosed with approved fire doors would be fire resistive. The bearing walls may be made of steel with fire-resistive coverings applied. Structural steel often is protected by encasement, sprayed-on protection, or membrane fire-rated ceilings. Exterior walls generally will be nonbearing walls and not structurally supporting. Exterior or interior nonbearing walls will have varying degrees of fire resistance. Stairwells are enclosed in fire-resistive materials. Roof construction may be similar to floor construction.

Fire spread via the exterior of a building is a primary concern in this type of construction. This may occur from window to window or through a gap between the floor and the exterior curtain wall.

Finally, fire-resistive buildings typically are constructed with a center-core design. This allows outside walls to be used for offices, apartments, etc.

### **Noncombustible Construction**

In noncombustible construction, walls, partitions, and structural members are constructed of noncombustible or limited combustible materials which do not qualify as fire resistive. Often noncombustible construction is steel, which provides a totally noncombustible building in which the structural elements are exposed to the effects of the fire. Totally noncombustible refers only to the structural materials, not to interior finish and contents. The building's structural framework is made of steel bolted, riveted, or welded together. This is susceptible to expansion, distortion, or relaxation of steel members resulting in early collapse in as little as 15 to 20 minutes. Wall enclosures may be masonry, steel, aluminum, glass, or other material. Concrete construction also can be considered noncombustible. The floor and roof support system will often be lightweight bar joists, trusses, or other lightweight steel. Like the pre-engineered structure, collapse of this type of roof system can occur in as little as 15 to 20 minutes.

The obvious strengths of this type of construction are the assurance that structural elements will not add to the fire load, and that the means of egress are enclosed in fire-resistive materials. Obvious weaknesses are that steel exposed to heat will expand approximately one inch for every 10

feet at 1,100°F (593°C). Also, steel members are subject to early distortion and relaxation.

### **Heavy-Timber Construction**

In heavy-timber (mill-type) construction, bearing walls and bearing portions of walls are noncombustible construction and have a minimum fire-resistive rating of two hours. Columns, beams, and girders are heavy timbers with wood floor and roof construction.

Heavy-timber structural members (columns, beams, arches, floors, and roofs) are unprotected wood with large cross-sectional areas. These buildings consist of masonry exterior walls and structural members of substantial timber construction. The minimum dimensions of structural wood supports should be eight inches for columns, beams, girders, and arches. All other exposed wood has a minimum dimension of two inches. This type of construction is commonly found in older factories and mills. Wood floors will generally be a minimum thickness of three inches and may be oil soaked from years of supporting heavy machinery on which lubricating oils were used. Roof supports will be wood with minimum dimensions of four by six inches, and a minimum roof decking thickness of 1-1/8 inches.

The main advantage of heavy-timber construction is that the large-mass support timbers burn a long time before being destroyed. On the other hand, when fires in this type of construction defeat initial suppression efforts they will tend to grow to great sizes. Large, open interior areas, unprotected vertical shafts, and laminated timbers may weaken structural members and provide for potential rapid fire development and building collapse.

### **Ordinary Construction**

In ordinary construction exterior bearing walls or bearing portions of exterior walls are of noncombustible materials, and floors, roofs, and interior partitions may be of combustible materials. In this type of construction all or part of the interior structural elements may be combustible. Exterior walls are required to be rated. The building will have masonry exterior walls, wooden structural members, and combustible interior construction. The building generally will not exceed six stories, and will most often be two or three stories in height. Floor and roof supports are usually wood, but may contain steel joists or beams. Floor and roof rafters are inserted in wall sockets, typically cut on an angle

called a "fire cut." This allows structural members to fall out of the wall without toppling the entire wall.

Floor and roof decking will most frequently be wooden boards, tongue-and-groove boards, plywood, or composition board. Common walls between buildings may share wall sockets for floor joists and roof rafters of both buildings.

The main strengths of ordinary construction are the masonry walls, full-dimension lumber, and fire cuts in roof and floors. Critical weaknesses are common walls with wall sockets, common crawl spaces or attics, renovations such as dropped ceilings, and spreader rods.

### **Wood-Frame Construction**

In wood-frame construction, exterior walls, bearing walls and partitions, floors, roofs and their supports are wholly or partly made of wood or other combustible materials. Usually wood frame is subdivided into two types: protected, in which structural elements have limited fire-resistance ratings; and unprotected, in which structural elements have no fire-resistance ratings.

Post-and-beam construction has a frame of substantial dimension wood and is sided with a lightweight covering such as wood boards. This construction is commonly used for barns, sheds, and storage buildings but also may be used in dwellings and other occupancies.

In balloon-frame construction, studs run from the foundation to the attic. This type of construction was used extensively in many parts of the country until the late 1930s for residential and light commercial structures. Floor joists are tied into the wall, allowing for fire extension in any direction. Firestopping was not a common practice.

In platform-frame construction the walls of each successive story are built upon a platform formed by the preceding floor. The joists for the deck may be full dimension lumber or lightweight construction. Once the floor/deck is in place, walls are placed on it with a sill at the bottom of the wall and a plate on top. Platform frame construction provides a natural fire barrier for vertical extension within walls. Openings in walls for water, sewer, ventilation, or heating/air conditioning pipes can create a void for fire extension. Multifamily dwellings frequently have extensive vertical openings and void spaces.



## **Lightweight Construction**

Lightweight construction is not a separate classification but it presents special problems under fire conditions. Lightweight supporting members can be used to span large open areas. These lightweight structural members may be steel bar joists, wood trusses, or laminated wood beams. Lightweight "sandwich beams" or "I joists" are typically of 3/8-inch plywood sandwiched into 2-inch by 3-inch top and bottom chords.

While these types of structural members provide sufficient structural strength to support the building and its contents under normal (nonfire) conditions, these elements fail very rapidly when exposed to fire conditions. Collapse may occur after as little as five minutes of fire exposure. An additional problem associated with wooden trusses is that they create large, combustible concealed spaces in which rapid fire spread can be expected.

## **Structural Loads**

Specific terminology is used to describe the different loads that can be placed on a building. Dead load is defined as the weight of the building itself and any equipment permanently attached or built in. Additional dead loads may be added to a structure during alterations without any strengthening of the structure. Alterations, such as the addition of roof-top air conditioning units, may cause early structural failure under fire conditions. The term live load is used to denote all loads other than dead loads. This includes furniture and occupants. Impact loads are live loads which are delivered in a short period of time. This would include such things as the overturning of a heavy object such as a safe, collapse of heavy, nonstructural, ornamental masonry onto a roof, or a firefighter jumping onto a roof.

## **Building Materials and Fire Spread**

The amount of heat produced by burning is determined almost entirely by the chemical composition of the material. The speed with which heat is produced is determined by the physical form of the material. Hydrocarbon-based materials consume 50 percent more oxygen, and thus produce about 50 percent more heat than equivalent amounts of other materials. Pound for pound, hydrocarbons also produce twice as much heat. A gallon of gasoline will produce 115,000 Btus in comparison to a polyurethane mattress or sofa which will produce 340,000 Btus.

### Fire Loading

Fire loading is the measurement of the maximum heat that would be liberated if all combustibles in the fire area burned. Fuel load is the quantity in pounds per square feet of combustibles in a given area. It normally is expressed in weight of combustibles having a value of 8,000 Btus per pound, given as the equivalent weight of wood.

### Steel

The popularity of steel-frame building construction is due to its high strength, ease of fabrication, and assured uniformity of quality, but exposed structural steel is vulnerable to fire damage and structural collapse. Fire protection generally is provided by encasing the members in concrete, lath and plaster, and/or sprayed fibers, or by installing a fire-rated membrane, such as tiles, in a grid system.

The intensity of stress in a steel member influences the load-carrying capacity. The higher the load stress, the more rapidly a member will fail at elevated temperatures; 1,100°F (593°C) normally is considered to be the critical temperature. At this temperature steel has lost 60 percent of the carrying capacity it had at room temperatures. If the ends of a structural steel member are restrained, when heated uniformly from 721°F to 972°F (383°C to 522°C), the structural member will expand 3.9 inches.

### Concrete

Although collapse of reinforced concrete structures is rare, loss of strength and damage do occur. Factors that influence strength reduction are the type of aggregate, moisture content, type of loading, and level of stress. The greatest problem of prestressed concrete is the elevated temperature of the stressed steel. Elasticity is reduced by 20 percent when the temperature of the steel reaches 600°F (316°C). Prestressed wires are permanently weakened when they reach 800°F (427°C).

### Wood

Depending on its form, wood may or may not provide reasonable structural integrity in a fire. Fire retardant treatment delays ignition and retards combustion; however, all wood will burn eventually. Burning produces charcoal, which initially provides a protective coating that insulates the unburned wood. Thicker members provide much more

structural integrity over the period of fire exposure than do thin ones. Heavy timber has proved to be an excellent form of construction for delaying the spread of fire. Wood frames use structural members smaller than those used in mill construction and, when exposed to fire, they offer relatively little structural integrity.

## **SUMMARY**

First responders do not need to memorize a lot of information to function effectively at the fire scene. What is required is a good grasp of some of the basic fire principles and how these affect an accurate origin and cause determination.

This unit has presented the major fire principles needed to help the first responder avoid making erroneous conclusions as a result of misreading the evidence.

A basic understanding of the characteristics of building construction is a critical element in conducting a proper fire loss analysis. The type of construction, materials used, and any fire protection systems in place will influence fire behavior.



## BIBLIOGRAPHY

DeHaan, John D. *Kirk's Fire Investigation*, 3rd Ed. New Jersey: Brady, 1991.

Egan, David M. *Concepts in Building Fire Safety*. Florida: Robert Krieger Publishing Company, 1986.

*Fire Dynamics*. Emmitsburg MD: National Fire Academy, Open Learning Fire Service Program, 1992.

*Fire Protection Handbook*, 16th Ed. Quincy, MA: National Fire Protection Association, 1991.



# **UNIT 3: FIRST RESPONDER OBSERVATIONS**

## **OBJECTIVES**

*The students will be able to:*

- 1. Obtain and evaluate the appropriate information from the reporter(s) of the fire.*
  - 2. Identify critical observations made while en route to the fire scene and explain their importance.*
  - 3. Identify critical observations made upon arrival at the fire scene and explain their importance.*
  - 4. Identify critical observations made during fire suppression activities and explain their importance.*
  - 5. Identify critical observations made during postsuppression operations and explain their importance.*
-





## **INTRODUCTION**

The first responder is often in the best position to make critical observations regarding a fire. The first responder can compare this fire to other similar fires and draw parallels between them for similar fire-behavior patterns. The observations of a first responder during various stages of an incident are extremely critical. From the moment of dispatch through the overhaul phase the first responder's senses are exposed to countless stimuli, many of which can help in making a determination of fire origin and cause or, if certain indicators are present, to suspect that the fire is incendiary. The scenes observed can never be duplicated in a courtroom, and the first responder may be the critical link in the prosecution of an accused arsonist by convincing the jury that the fire was unusual or unnatural.

During the incident the first responder will see thousands of images and make hundreds of decisions, many of them instantaneous. The many phases of the operation will provide the first responder the opportunity to make particular observations that may be critical to fire cause determination. On the other hand, the first responder may note something casually that later will emerge from memory. This also may be a critical piece of information.

We will consider five phases during which critical observations are possible:

- the initial call;
- en route to the fire scene;
- arrival on the scene;
- fire suppression; and
- postsuppression (overhaul).

## **INITIAL CALL**

The initial report of the fire can be received by various sources:

- a 9-1-1 emergency dispatch center;
- a fire department dispatcher;
- the local police or sheriff's department;
- the home of the fire chief or department dispatcher; or
- a private alarm company.
- neighbor.

The first critical piece of information about the fire usually will come from the person calling in the alarm. This person may be the discoverer of the fire, the occupant of the fire building or vehicle, or a passer-by who observed the fire. In today's world of instantaneous communications, mobile telephones in many cars make it possible for any of these parties to report an incident.

The person receiving the information from a caller should attempt to obtain and record all of the following pieces of information.

**Identification of the person reporting the fire.** It is important to obtain the name, address, and home telephone number, as well as the location from where the call is being made. Personal information that is obtained should be forwarded to the person investigating the fire, as the discoverers and reporters of the fire will need to be interviewed regarding their observations and actions.

**The location from where the call is made** may indicate delay in the reporting of the alarm if the caller had to drive a great distance to find a pay phone, and this may help to establish burn time and the amount of fire spread.

Note any **accents or speech impediments**, the pitch that would distinguish the voice of a child or woman from that of a man, the speed of speech, and any other distinctive traits. Slurred speech may indicate an intoxicated person who may, in fact, be the arsonist. If more than one call is received, the same information should be recorded for each caller.

Remember, arsonists have been known to report their own fires to the appropriate authorities.

**State of the person reporting the fire.** The person receiving the call should note whether the caller sounded calm or appeared excited. If the fire was not planned, one would expect some level of excitement in the caller's voice, especially if it is the owner or occupant of the involved property.

**Indications of background noises.** This is especially important if the background noises are unusual for the location of the fire. If the person is calling from inside a building, one would not expect to hear trucks rumbling by; however, if the call is made from a pay phone, this could be normal. Background sounds also may indicate the call being made from a bar (laughter, glasses clinking, yelling, etc.) or a place of business (typewriters, fax machines, machinery, etc.).

**The exact address of the fire**, or at least specific information about the area, such as street names, landmarks, closest intersections, etc.

## **EN ROUTE TO THE SCENE**

The next critical phase for making observations begins with the response. While en route, the first responder should be aware of anything unusual, especially as he/she nears the fire scene.

### **Weather Conditions**

The first responder should be aware of the weather conditions, including wind speeds and direction, that may affect the fire intensity and spread.

Arsonists have been known to set fires during electrical storms in the belief that the cause will be determined as a lightning strike. Observe the weather conditions while en route and note whether there is any evidence of a recent rain storm, such as wet roads. Interview neighbors regarding their knowledge of lightning strikes in the area. Remember, lightning can cause a fire which may not be discovered for a period of time after the strike.

Do not fail to make note of clear weather conditions versus rain, snow, or ice. If the fire was incendiary, it may have been the intent of the arsonist to set the fire in inclement weather conditions in order to delay the fire department's response, giving the fire a longer burn time.

Temperature and humidity readings should be obtained. In certain climates freezing temperatures may cause fire hydrants to freeze, or cause other hazards that can delay fire suppression. (Climatic conditions and statistics can be obtained by telephone from the nearest office of the National Weather Service.)

Another key point that should be recognized is a change of weather conditions from the time of arrival at the fire to the time of departure, and what effects these weather changes had on fire suppression activities.

### **Time Periods**

The times and methods of alarms probably will be recorded automatically. Time plays an important role in fire origin and cause determination. It allows one to show any abnormalities in the fire spread or growth from the time the fire was first reported, and the amount of fire at the time of arrival

of first-responding emergency personnel. In addition, it also is important to note or record the arrival time of the first-arriving fire company.

If the alarm was received by telephone, most emergency dispatch centers automatically record the location from where the call originated. This allows for possible identification of the caller for later interviews. In the event the alarm was received from a municipal alarm box, a neighborhood canvass should be conducted, as it may turn up a witness that can identify the person responsible for the alarm.

If a private alarm service received the fire alarm, ascertain whether any problems with the alarm system had been reported or recorded, or if the service had received other recent alarm signals from the client. This may indicate an arsonist's tampering with the alarm prior to the fire. The time the alarm was received also can be a crucial piece of information.

When a serial arsonist is working in your fire district, a pattern can be established by recording similarities in time periods, days of the week, or even the months when the fires occur. This information can be very beneficial if surveillance is being considered.

### **Spectators and Vehicles**

Almost any disastrous situation will attract people, and to observe people **leaving** a fire scene prior to the fire department's arrival is unusual. Pedestrians may be leaving the fire scene casually or hurriedly, or, if still present at the scene, may be acting in a strange or suspicious manner.

Vehicles traveling away from the scene (without lights at night) or with occupants attempting to avoid observation may be good indicators that they were linked to the fire.

Attempt to note some identification of vehicles (color, make, size, tag number) or pedestrian(s) (height, build, age, clothes, hair, gender, etc.).

If your department has been experiencing a rash of arson fires, be observant for the same person(s) or vehicle(s) at different fire scenes. The vehicles in the area of the fire may carry some valuable clues. The first responder should pass along any information, either to the Incident Commander/Supervisor or to the investigator regarding vehicles observed, so that witnesses or any other responding emergency personnel (police, EMS, etc.) can be interviewed regarding their observations while en route and upon arrival at the scene. They may have arrived on the scene prior to the fire department and possess valuable information about suspicious vehicles or persons.

Note and identify any vehicles that were damaged by fire, heat, or smoke and attempt to ascertain from the owners why these vehicles were present at the fire scene. Obtain descriptions, vehicle identification numbers, and license plate numbers from these vehicles for later investigation.

### **Delays**

Of particular interest to the first responder are other factors that are not directly associated with the fire itself, but which may have some tie-in. Was the timing of the fire such that your response was slowed because of a train passing through a grade crossing, or a drawbridge raised over water? There may be no link at all; on the other hand, there may be. Road construction or repairs can cause delays, especially on an unsuspected detour. Frequently, radio stations announce road closings or detours, informing the arsonist about possible delays in fire apparatus response.

Also be aware of the intentional placement of obstacles such as tree branches, brush, or plowed snow across driveways, small roads, or private entrances. These obstacles delay the arrival time of the first-arriving equipment, and allow the fire a longer burn time.

Traffic patterns at certain times of the day (morning or evening rush hours) also can cause delays in response. Someone who planned a fire may take advantage of a social event, such as a parade or a sports event, that can create huge traffic bottlenecks. The sharp first responder will note anything that is unusual or unnatural.

### **Smoke and Flames**

The first responder also should be cognizant of the color and amount of smoke, as well as the presence of any flames. The color of smoke and flames may indicate the materials burning.

Heavy black smoke with deep red flames in the early stages of the fire may indicate the presence of an accelerant; however, the kinds of materials burning must be taken into consideration.

## ARRIVAL AT THE SCENE

Without a doubt, the fire scene itself provides the greatest opportunity for observations. There is a whole range of possibilities.

### Spectators

The first set of possibilities rests with the spectators in the area. As already mentioned, large numbers of spectators will gather to observe any type of disaster, and fires are no exception. If a series of arson fires has occurred in your fire protection district, groups of spectators should be videotaped or photographed for later, detailed review.

Things which may prove helpful include

- Familiar faces or individuals seen at other fires.
- The actions of spectators, such as individuals who appear too concerned, or too vocal about the incident, or who voice criticism about fire, and/or police agencies, neighbors, society, and/or government agencies.
- Individuals who appear to be too quiet, or withdrawn, or overly frightened about the fire.
- Individuals who appear to be too excited about the emergency, overly brave, helpful, or curious.

The appearance of spectators may provide helpful information. Construction or repair crews should be noted. Accidental fires often result from repairs crews working within a structure. Repair crews may be reluctant to be interviewed for fear of loss of job or financial liability if their actions were responsible for the cause of the fire.

Spectators may show signs of having been involved in starting the fire. Their clothing may display indications of fire damage or the odor of accelerants. It is perfectly legal for accelerant detection dogs to "sniff" a crowd for accelerants. If you have access to accelerant detection dogs in your jurisdiction, use them. Spectators also may display signs of physical fire injuries, such as singed eyebrows, hair, mustaches, beards, or redness of skin on the face, arms, or back of hands. These injuries may be the result of the vapors "flashing" on the arsonist as he/she attempted to ignite the accelerant.

Not only should these observations be made of the spectators, but also of the owners/occupants of the involved structure. Is their manner of dress consistent to the time of day? Are they in sleeping attire or fully clothed, with shoes tied, at 3:00 o'clock in the morning?

### **Environmental Considerations**

Observations about the immediate vicinity of the fire may provide an insight into circumstances surrounding the fire. Some areas of the community may be more prone to fires than others. Fires may occur more often in areas with transient populations than in areas that have the same owner/occupant for years.

Areas with a high occupancy turnover may not have a fire reported as quickly as in other areas. This may be observed in the heavy fire conditions and deep charring of structural members upon arrival. However, this latter fact may not be known for some time.

Uninhabited properties or properties for sale pose interesting possibilities. The fact that the property is for sale, or has been for sale for a period of time, is not, of itself, cause for suspecting an incendiary fire. The fire cause determination must be conducted just as it would for any other fire. If the fire is determined to be incendiary in cause, this may identify a fraud motive, and an investigator will need to conduct an intensive followup investigation in order to prepare a case against an individual for starting the fire.

However, this activity goes beyond the responsibility of the firefighter, although he/she may assist the fire investigator in a number of ways.

Fires in remote sections of the community, or in a section that may have daytime, but not nighttime occupancy, may burn longer prior to being discovered.

The intent is to start the first responder thinking about what is commonly referred to as "environmental factors" that will help in making a correct origin and cause determination.

### **Fire Conditions**

Another whole set of possibilities rests with the physical aspects of the fire itself. First responders must observe the fire conditions at the time of arrival. They must observe how the fire vented itself, noting natural

ventilation versus fire company venting. Note removal of debris, furnishings, stock, supplies, etc. They should provide security for materials or debris which has been removed, as it may contain evidence of incendiarism or need to be used for reconstruction of the room of origin for identifying point of origin or fire cause.

Other observations that need to be made include the size of the fire, number of rooms involved, unconnected fires, and any outside fires that are burning.

Note both damaged and undamaged areas of the structure. Areas of extensive damage may not always indicate the area of origin.

Ascertain whether there was complete or partial collapse of the structure. Was there ignition or exposure of flammable/ combustible or hazardous materials? Were there reports of any explosions? Were firefighters forced to fall back for any reason, or was there a fast fire spread overtaking the fire streams? Did fire keep reigniting after initial extinguishment, or were there flames floating on top of water? These conditions could indicate the presence of flammable liquids.

### **Flame and Smoke Characteristics**

The color of the smoke may indicate the type of materials burning in the fire. Complete combustion often produces little or no smoke, while dense smoke often indicates incomplete combustion.

Flame color also may indicate the type of materials being burned. As the amount of hydrocarbons increases, the flames will become darker or more orange in color. A lack of sufficient oxygen (air) usually causes flames to be darker than when the same fuel is burned in a well-ventilated area.

Use extreme caution. During the later stages of the fire, smoke colors from materials burning may give false indications. Also, most structures contain fuels with hydrocarbon bases which, when burning, may produce smoke and/or flames that could give misleading signs. In addition, heavy black smoke in the early stages of a fire no longer indicates the presence of accelerants due to the materials now used in the manufacture of common household furnishings, such as plastic tables and chairs and polyfoam-filled cushions on sofas and easy chairs.



The following chart shows examples of smoke and flame colors as indicators of the types of materials being burned:

| <b>Fuel</b>     | <b>Color of Smoke</b> | <b>Color of Flame</b> |
|-----------------|-----------------------|-----------------------|
| Wood            | Gray to brown         | Yellow to red         |
| Paper           | Gray to brown         | Yellow to red         |
| Cloth           | Gray to brown         | Yellow to red         |
| Gasoline        | Black                 | Yellow to white       |
| Naphtha         | Black to brown        | Straw to white        |
| Benzene         | White to gray         | Yellow to white       |
| Lubrication oil | Black                 | Yellow to white       |
| Lacquer         | Brownish to black     | Yellow to red         |
| Turpentine      | Brown to black        | Yellow to white       |
| Acetone         | Black                 | Blue                  |
| Cooking oil     | Brown                 | Yellow                |
| Kerosene        | Black                 | Yellow                |

## **Condition of Doors and Windows**

### **Doors**

Among the many other things to be noted are the doors. Was forcible entry necessary or were the doors already open or unlocked? Doors may have been left open by the occupants in their attempt to escape, or in an attempt to remove the smoke from the structure. Neighbors or police officers who arrive prior to the fire department may have forced entry into the structure to ascertain occupancy or conduct rescues. If the occupants claim to have closed doors during egress, attempts should be made to ascertain who opened them. Remember, discovery of open doors or forced entries prior to fire department's arrival do not prove incendiarism, but should be investigated.

Identification of the firefighters who forced entry must be made, along with the methods used to force entry.

### Windows

Broken windows at the time of arrival may indicate that a burglary occurred prior to the fire, and the fire was set as an attempt to cover the burglary. However, broken windows and open doors also may have been caused by witnesses, occupants, or first-arriving emergency personnel (other than firefighters), who because of their lack of fire behavior knowledge, attempted to let the smoke out of the structure. Broken windows are also the result of explosions, but if this was the cause, the shards of glass should be on the exterior and at a distance from the involved structure.

### **Observations During Sizeup**

The next important time for making observations is during the sizeup period. Upon arrival, first-responding firefighters seek out available occupants to ascertain the rescue needs of residents who are unaccounted for. This task does not negate the need for a primary search, but does narrow down the responsibilities for search.

During this activity the first responder should take note of several items:

- Is the clothing worn normal for that time of day or night at that time of the year?
- Did the occupants have time to retrieve special items, such as a child's favorite toy, a pet, the insurance policy, sports equipment such as guns, fishing poles, photos or photo albums, jewelry, or other items of value?
- Are there any signs that the occupants have burns, lacerations, contusions, or singed hair that may indicate they were close to the fire?
- Is there any sign of soot around their mouths or noses to indicate they were inhaling smoke?
- Do any of the occupants require medical attention?
- Are there any spectators who have been observed at other fires, especially fires of a similar nature in the same general area?
- Is anyone acting strangely, hiding in shadowed areas, standing out for some reason, or trying too hard to blend into the crowd?

Persons who intentionally start fires often will stay at the fire scene to watch the results of their efforts. Many fire investigations reveal that the same person was present at several fires, and when arrested, these persons state that they remained at the scene to watch the firefighter activities.

Unfortunately, this frame of mind also extends to members of the fire service. Arson fires are set by members of both volunteer and paid fire companies for various reasons that include thrill seeking, boredom, lack of firefighting activity, or any of the six basic motives: vanity, spite and revenge, fraud, pyromania, to conceal a crime, or civil disorder.

### **Actions of Occupants**

Any unusual signs of the occupants' escape need to be noted. Things like ladders to windows, escape chain ladders from windows, bedsheets tied together, or reports from a neighbor that a parent dropped her children from a window are strong indications that the occupant did not plan the fire.

On the other hand, occupants' stories should be verified. Examine the window from which they claim to have escaped to ascertain that the window is, in fact, broken or open, or that the screen is no longer intact. Ensure that the escape door was not locked or blocked at the time of the "escape."

## **FIRE SUPPRESSION**

### **Obstacles**

Note any obstructions in entryways. Arsonists will barricade doors from the inside to delay entry by firefighters, and they also have been known to cut out sections of the floor at entrances, knowing that if a firefighter falls through, rescue efforts will take precedence over fire suppression.

Also be observant of any other entry obstructions, such as doors with an interior security crossbar, chained panic bars, or stock piled in front of exits. These situations may be normal for that particular occupancy and not a setup. Were any fire doors propped open to allow better fire spread?

## **Location and Extent of the Fire**

During sizeup and suppression operations you can make many observations about the location of the fire, the extent of the fire, and the path of the fire travel. These observations may be critical during the fire scene examination to assist in determining if fire behavior was normal or if it was aided in its path of destruction.

It is critical to determine if the location of the fire upon arrival corresponds with information obtained from the discoverer. A fire that is initially reported in the basement, but has progressed to a fully involved attic fire upon arrival may be explained because of the type of building construction, or it may have been intentionally started in one location, and trailers used to spread the fire from one point to the other.

It is also important to establish if the fire spread as anticipated for the type of building and occupancy. The spread of the fire may be very typical or normal, or the spread may indicate it had some assistance.

## **Fire Behavior**

During fire suppression efforts, the first-in firefighters will probably be in the best position to observe the fire and its behavior. Physical aspects of the fire, such as materials burning, appearance of more than one area of origin, and color of smoke and flames are critical observations. It is also essential to note the current stage of burning and the intensity with which the fire is burning.

Based on prior experience, did the fire spread appear normal or could it have been the result of accelerants poured throughout the structure? Determine whether ventilation procedures used by the fire department (positive pressure versus ventilation) could have created irregular fire spread, or could they have been the result of natural ventilation, such as heating or air conditioning systems.

Attempt to determine if the fire was extinguished as expected, or if difficulties were encountered with fire suppression. Fires that are difficult to extinguish and do not react normally with the application of water may indicate a fuel load greater than expected. This condition should be noted and examined after the fire is extinguished in an attempt to determine the possible fuel load that caused difficulty during suppression activities.

Was there anything unusual found during suppression, such as windows covered to delay the fire's discovery? Although it is common for vacant businesses to cover their front windows with paper or glass cleaner, it also may be an attempt by the arsonist to delay the fire's discovery.

### **Alarm/Detection/Suppression Systems**

Were fire detection or extinguishing systems intentionally disabled? If the structure was protected by smoke detectors, did any firefighters hear the alarms operating? Did automatic fire suppression systems, such as sprinklers, perform properly in fire control and suppression? Was there any evidence of tampering with the hydrant or standpipe? Obstructions can be placed in hydrant and standpipe connections, so that when water flows, the obstructions plug the hoselines. Also make note of the condition of the Post Indicator Valve (PIV). This should always be in the "OPEN" position; if not, ask why. Has there been any tampering with the tamper alarm on the PIV? An examination of the OS&Y valve for the sprinkler system will reveal if it was opened or closed at the time of the fire. If the valve stem extends from the wheel, the valve is open.

### **Unusual Observations**

Unusual observations during this phase of operations includes problems encountered with suppression, such as "flashbacks" of fire, where flames reignite after extinguishment. This is caused by the reignition of flammable vapors from the heat generated in the room. Did firefighters observe fire floating on water? Were any unusual odors detected prior to donning self-contained breathing apparatus?

Be aware of any indications of intentionally set fires, such as trailers or remains of incendiary devices. These will be discussed in Unit 4: Fire Causes. Again, watch for anything that is unusual or unnatural, such as candles or lamps in unnatural locations, unusual storage of flammable/combustible liquids, unusual placement of combustible materials near heat-producing appliances, or cooking fires in use at unusual times.

It is impossible, and really not necessary, to list everything the first responder needs to observe. The items mentioned here are the more important ones, and experience will reveal many others. Spending time with your colleagues in discussion is a way of generating a list of many more items. Remember, note and report anything unusual or unnatural.

## **POSTSUPPRESSION**

The last critical phase in which observations can be made is during overhaul. In many respects, it is an ideal time because you do not have to worry about the fire and you have plenty of time to carry out a careful and detailed examination. The overhaul phase is the first real opportunity to start making critical, first-hand observations about the structure, its contents, and the circumstances that caused the fire.

### **Delay of Overhaul**

If it is necessary that a fire investigator be requested to respond to the fire scene, it is imperative that overhaul procedures cease at this point, so as not to further destroy the scene. Removal of wall, ceiling, and floor coverings, as well as room contents will destroy burn patterns and also may result in the discarding and/or destruction of valuable evidence. If room contents are removed, reconstruction of the room will need to take place. This makes the job of the investigator more difficult, and delays the return of fire apparatus into service.

### **Removal of Items**

The first thing to establish is whether any items appear to be missing (such as wedding albums, wall hangings, family portraits, etc.). On the other hand, are there any items present that shouldn't be there? Do items such as furniture or appliances appear to have been switched or replaced prior to the fire? Have room contents been stacked in one location to increase the fire load? Are contents of closets and/or drawers normal for the occupancy?

A person planning a fire may remove irreplaceable items prior to the fire. The firefighter who makes these observations needs to ask appropriate questions of the owner or occupant regarding the absent items.

### **Crime Concealment**

Be observant of indications of unusual prefire activity. In some situations fire is used to cover up a burglary. The evidence of the burglary may be very apparent after fire suppression. In commercial structures, vending machines or cash registers that were pried open will still display evidence of prying after the fire. File drawers forced or left open are another indicator.

Doors that have been forced, broken windows, or other structural damage not created by the fire may go unnoticed unless the firefighter is observant during overhaul. It is critical that overhaul crews disrupt items as little as possible. As discussed previously, firefighters often alter or remove critical evidence that can result in incorrect determinations or the inability to successfully prosecute an accused arsonist, in their haste to perform overhaul procedures.

### **Utilities**

Finally, utilities need to be evaluated to determine if they were operational at the time of the fire, or shut down by, or at the request of, fire suppression personnel. Fire personnel should attempt to determine if there were any signs of malfunctions or improper use of the utilities that could have caused or contributed to the fire. Tool marks on gas pipe fittings or electric service panel boxes may indicate tampering. Examination of the circuit breakers or fuses also may reveal evidence of tampering or bypassing of the current protection devices. These indicators do not necessarily mean the fire was intentional, but may reveal recent repairs or attempts to overcome a preexisting electrical problem.

### **Fire Patterns**

It is important that the first responder note the features of the structure that allowed the fire, heat, and smoke to travel. Open stairways, plumbing or electric shafts, laundry chutes, or heating ducts are some of the more common paths of fire travel. Building renovations often result in dropped ceilings, covered walls, or new voids, and these can be responsible for hidden fire and fire travel. Frequently fire is hidden in these voids and may burn undetected for a considerable amount of time before discovery.

Do the remaining burn patterns explain the normal fire spread? There are basic fire patterns with which the first responder should be familiar.

- "V"-shaped patterns are common fire patterns displayed on vertical surfaces. The lateral spread of the sides of this pattern is caused by radiated heat from above and by the upward and outward movement of flames and hot fire gases when they encounter a horizontal surface such as a ceiling, eaves, a tabletop, or a shelf.

The angled lines that produce the "V" often can be traced back toward the point of origin. As a general rule, the wider the angle of the "V" the longer the burned material has been subjected to heating. The angle produced on a vertical combustible surface will be wider than on a noncombustible surface for a comparable heat source and burn time.

It was long believed that a narrow-angle "V" pattern was produced by a fast-burning fire, while a wide-angle "V" was produced by a slow-burning fire. This is incorrect, since angles of the lines of the "V" pattern are actually the result of the size of the fire, burning rate, ventilation, and combustibility of the walls, rather than the rate of heat release (RHR) alone. These patterns are valuable because they indicate the direction of fire spread, not what caused them.

- Inverted cone patterns, also called inverted "V" patterns, are triangular patterns, wider at the bottom than at the top. Inverted cone patterns are the result of relatively short-lived fires that do not fully evolve into floor-to-ceiling flame plumes, and that are not restricted by ceilings. Since they often appear on noncombustible surfaces, it was thought that they were caused by fast-burning fires. However, such patterns indicate that the burning was of short duration and there is no relationship to RHR. Inverted cone patterns have been interpreted as proof of a liquid accelerant fire, but any fuel that produces flame zones that do not become vertically restricted can produce such patterns.

Leaking natural gas can cause inverted cone patterns, especially if the leakage occurs below floor level and escapes above the intersection of the floor and wall. The resulting burning will not reach the ceiling, and thus will result in the characteristic inverted cone pattern shape.

- Hourglass patterns result from the combination of the plume of hot gases and the flame zone. The plume of hot gases is shaped like a "V," while the flame zone is shaped like an inverted "V." If the fire itself is very close to, or in contact with the vertical surface, this may result in a pattern displaying the effects of both the hot gas plume and the flame zone. This results in a pattern with the general shape of an hourglass.



- Truncated cone patterns (also called truncated plumes) are three-dimensional fire patterns, created on both horizontal and vertical surfaces. This pattern occurs at the intersection of two vertical surfaces (the corner of a room). The cone-shaped pattern is the result of the effects of the natural expansion of the fire plume as it rises and the horizontal spread of the heat energy when the plume encounters a horizontal surface, such as a ceiling.

Other patterns that you may observe, but are uncommon and will not be discussed are

- "U" patterns;
- pointer-and-arrow patterns;
- circular patterns;
- irregular, curved, or pool-shaped patterns; and
- doughnut patterns.

The "saddle burn" is another unusual pattern. This occurs when flammable liquids run down through floor boards and onto the joists. As the accelerant burns, it leaves a char pattern on the joist that resembles the shape of a saddle. It is unusual, but not always improbable, for fire to burn in a downward direction. However, when this type pattern is observed it should be reported to the investigator.

### **Security Cameras**

In addition to the above observations, search for security video cameras. These methods of security are becoming increasingly popular and are of great value in determining the origin and cause of fires. Recently, security cameras have "eyewitnessed" the inception of accidental fires, and also have proved the innocence of a person in an incendiary fire.

Even though the cameras or film may appear damaged from the fire, there are methods to enhance the film and produce an acceptable image. During overhaul, preserve and protect the cameras and tapes and notify the investigator of their existence.

### **SUMMARY**

The first responder's methodical and careful observations will assist in making a proper determination of fire origin and cause. Information gathered at the time of the fire alarm, and the observations made during response, arrival, suppression, and postsuppression, will contribute a vast

amount of useful information. Later, this information will be sorted out and evaluated to make a valid determination of the cause of the fire.

This early part of the process cannot be underestimated and cannot be performed too carefully.

## ***UNIT 4: FIRE CAUSES***

### **OBJECTIVES**

*The students will be able to:*

1. *List and describe numerous causes of accidental fires.*
  2. *Identify the most common incendiary methods used by firesetters.*
  3. *List and explain the most common types of incendiary devices.*
-



## INTRODUCTION

There are many causes of accidental fires, and the first responder should be familiar with them. Many accidental fires are the result of appliance or equipment malfunctions that are beyond the control of the fire victim. Carelessness on the part of the owner/occupant also results in accidental fires, but does not make the cause incendiary. The first responder must realize that for a fire to be incendiary in cause, the intent or recklessness must be proved on the part of the firesetter.

Fires of incendiarism usually leave behind some type of indicators that are indicative only to this type of fire cause. Most arsonists lack knowledge of chemistry, electronics, or mechanics and use the most commonly available materials to initiate the fire. Experience tells us that because of its easy availability, gasoline is the most widely used accelerant in incendiary fires. Most arsonists leave behind telltale indicators and evidence that the first responder should be able to identify.

On the other hand, some firesetters are quite clever and will construct elaborate devices to initiate the fire. These devices include electrical, mechanical, and chemical components, and the device is only as elaborate as the imagination of the arsonist. Most devices leave some type of evidence behind in the fire debris, and the first responder must be aware of these while performing fire suppression and overhaul activities.

## ELEMENTS OF FIRE CAUSE

A fire will not occur unless three elements or factors are present: the heat, the fuel, and the event which brings together the heat source and the fuel.

Heat sources are divided into four basic forms.

### Chemical Heat Sources

**Heat of combustion** is the amount of heat released during complete oxidation. It is the heat given off by a burning object, also referred to as the caloric fuel value.

**Spontaneous heating** is an increase in temperature without drawing heat from the surroundings. This also has several forms.

**Heat of decomposition** comes from an organic substance decomposing. Wet lawn clippings in a trash can, or compost piles are good examples.

**Heat of solution** is another type of spontaneous heating. Heat is released when a substance is dissolved in liquid. Examples of this are slaked lime and water.

## **Electrical Energy**

The next form of heat is from electrical energy. The most common form is resistance heating. The heat is produced by the flow of electrons through a conductor that impedes the flow. This impediment (resistance) produces heat. Electric space heaters, ranges, and clothes dryers are a few examples of this form of electrical heat.

Induction heating is another type of electric energy producing heat. The heat is produced by the electrons' movement. This type of heat is produced by passing electrons through the object to be heated.

Microwave ovens are the most common example. The electrons are in the form of an alternating magnetic field that are fluctuating at such a high rate that they are no longer contained within a conductor. This is called radio frequency (RF), and is also the basis of radio and television transmission.

In a microwave oven, this RF energy is contained within the oven and passes through the object to be heated. You also can receive microwave burns from a powerful radio transmitter. (Never touch a 100-watt fire department radio antenna while transmitting.)

Dielectric heating is a form of uncontrolled electrical heat. Have you ever seen a high voltage transmission system on a dark night? The long insulators may sometimes show a light blue/white light from the dirt, dust, and moisture allowing a flow of electrons over the surface of the insulation. This is a ground fault leak of electrical energy.

Electrical heat also is produced by arcing. An arc is produced when the flow of electrons is interrupted by separating the conductors. This can be as simple as opening a switch or breaking a wire.

Static electricity also can produce arcs and heat. Ungrounded moving objects will produce static electricity. A shock and arc can be produced by walking across a carpet, a moving belt, or a hovering helicopter.

Lightning is also a form of static electricity. Because of the power transmitted by lightning, it is considered a separate form of heat in this course.

### **Mechanical Heat Energy**

Mechanical heat energy takes four basic forms. First is friction heat, which is the heat from direct mechanical contact between moving objects, such as rubbing sticks together to make fire.

The second form of mechanical heat energy is friction sparks. The best example of this type is a grinding wheel or the brakes on a railroad train.

The third form is the heat of compression. When a gas is compressed, the molecules are forced closer together and heat is produced. One example of this heat form is filling a SCBA air tank. A diesel engine is dependent on this form of heat for operation. The spark plugs are replaced with a very high compression ratio (over 20 to 1). The compression of the air in the cylinders increases its temperature above the ignition point of the diesel fuel. When the fuel is injected into the cylinders, it ignites and the engine runs.

The fourth form is nuclear heat energy. However, it is not a major fire cause in this country. It is used for illustration only and will not be discussed in the course.

### **Fuel**

The fuel portion of a fire can be anything combustible. The ease of ignition of a fuel depends on three variable factors.

The first factor is the mass of the fuel. Is the fuel light grass or heavy lumber? The greater the mass of the fuel, the more energy is required to bring it to its ignition temperature.

The second factor is the state of the fuel. A fuel can be found in a solid state, a liquid state, or a gaseous state. Solids cannot burn. They must be pyrolyzed to form a gas in order to burn. A liquid must be vaporized to gas in order to burn. Both these processes require energy, but less is needed to burn a liquid than is needed to burn a solid.

The third factor is the gaseous state of the fuel. If a substance is in its gaseous state, it will be more readily ignited when its ignition temperature is reached.

### **Event**

The event is the joining of heat source and fuel. This may take the form of an action or may be an inaction. The decision not to take some action to prevent a fire starting is the same as taking a action to start a fire. These decisions may cause the heat source and fuel to come together completing the cycle and starting a fire.

## **TWO CAUSES**

There are two causes of fire, accidental and incendiary.

### **Accidental**

Accidental fire causes include all providential acts or "Acts of God." These may take the form of natural disasters, such as earthquakes, lightning-caused fires, hurricanes, tornadoes, floods, and volcanic eruptions.

Accidental acts of individuals are those actions, or inaction, not intended or designed to cause a fire to start. Fires may be caused by carelessness. In our society carelessness is not criminal, therefore the cause is considered accidental.

### **Incendiary**

Incendiary fires are all fires caused intentionally or allowed to start intentionally. Arson (which is a legal term used to define a specific crime involving fire) is always an incendiary fire, while all incendiary fires are not necessarily arson. In some states it is not an arson to burn junked cars or wildlands, where in other states, this type of fire would fall under the arson statutes. The crime of arson usually requires intent or a reckless act before it can be classified as a crime.



## ACCIDENTAL FIRE CAUSES

The accidental fire causes discussed in this unit are not all-inclusive. It would be impossible to cover each and every fire cause you will come into contact with during your career. Almost any article we use can be a fire cause if handled improperly. This course will cover the major accidental fire causes that you or your department are most likely to face.

### Heating Equipment

A major cause of accidental fires is defective, misused, and overheated heating equipment. This equipment may be installed too close to combustibles such as newspapers, clothing, or furniture and cause a fire to start.

Oil- and gas-burning equipment are designed to provide safe, reliable heat. They are manufactured to current industry standards and should be installed according to the manufacturer's directions. However, people are the unpredictable factor. When these units are misused, incorrectly installed, or not properly maintained, they can start fires.

If you suspect that heating equipment is the source of the fire, check the firebox, pipes, and flue for excess soot. The presence of excess soot and carbon may indicate that incomplete combustion has been taking place over a period of time. In addition, look for signs of malfunctions, improper adjustments, or poor maintenance.

Examine the controls and fuel lines for indications of prior trouble with the equipment. Look for home repairs that have been attempted or the presence of fresh tool marks which may indicate that the owner attempted to repair the appliance.

Check for indications of fuel leakage in the area of the unit. These units use combustible liquids for fuel, and when these fuels leak, they soak into the floor and leave stains or liquid burn patterns.

### Electrical Heating Equipment (Portable)

Portable electrical heating equipment is found in most areas of the country. These units are designed to provide safe, reliable heat. They are manufactured to current industry standards and should be used as required by the manufacturer's directions. Because of their portability, they are a common fire cause when misused and/or abused. These units are

commonly placed too close to combustibles. If this is the suspected cause of the fire, first check to see if the unit was operational at the time of the fire by checking the controls for function and position. In addition, make sure the appliance was plugged in. It may be embarrassing to determine a portable heating unit was the cause of the fire when further examination reveals that it was not even energized.

Most of these heat-producing appliances are manufactured with tilt or overturn switches designed to cause the unit to turn off if toppled. These switches are mechanical and subject to malfunction; some have been bypassed in older units.

Check the location of the appliance. Is the unit in a location where it normally would be found? Is the unit in the proper location for heating?

Check the appliance for an electrical short circuit or improper functioning. This may require the assistance of a certified repair person.

### Solid-Fuel Heating Systems

Coal, wood, or other solid-fuel heating systems have become more common with the increase in the price of petroleum fuel. These systems, like other heating systems, are subject to misuse and abuse. If this is a suspected fire cause, examine the unit fuel supply. Is it oversupplied with fuel, or is improper fuel being used? Wood-burning equipment will fail rapidly if coal is used; likewise, solid pellet units are sensitive to improper fuel use and loading.

Fires may occur in nearby combustibles, including the fuel stored nearby. Examine the combustion chambers and the flue areas for carbon deposits or soot. The proper installation of the flue and pipe is critical for the unit to function safely. Examine the flue at the thimble, where it passes through walls or ceilings. Remember to consider the distance from the equipment and the time of exposure of the material to the heat source.

Creosote buildup on seams of a flue pipe may indicate a lack of cleaning and maintenance of equipment. Stove pipes, flues, or chimneys which appear extremely clean inside may have been involved in a chimney fire.

A chimney fire will produce extreme temperatures and may ignite nearby combustible fuels improperly stored.

The improper conversion of an old solid fuel unit to burn fuel oil is another dangerous condition. Some older units are not suitable for this type of conversion. They were not designed for liquid fuel and a positive-pressure firebox. They can overheat and allow combustion products to escape from the combustion area of the unit.

With the increase in the price of petroleum fuel, the use of solid-fuel wood stoves is on the increase. If one of these units is suspect, check with the manufacturer and with your code enforcement agency for proper installation. In addition, check the required distance from combustibles and structural members.

### Chimney or Flue Fires

Chimney or flue fires are caused by a lack of maintenance. Soot and creosote buildup may occur over a period of time and, if not removed, may ignite from sparks of combustion, or from overheating of the unit.

Chimney or flue fires can cause roof fires when the burning soot and debris are drawn out of the flue during combustion. The point of origin may be near the area where the flue passes through the roof or other combustible structural members.

Ask the owner when the chimney last was cleaned or serviced. Chimney or flue fires are often accompanied by extreme heat and a roaring sound, such as a jet engine or locomotive.

Flames are very abrasive and a chimney or flue fire will produce the appearance of a clean, soot-free chimney. Due to the extreme heat they also can overcome the safety design limits and allow the ignition of the structural members of the building.

### Hot Ashes and Coals

The improper disposal of hot ashes and coals is also a common accidental fire cause. If this is suspected, check the ash disposal habits of the occupants. Remember to use caution as this is a possible occupant coverup situation.

Compare the disposal point with point of origin of the fire. The time elements may seem extreme, as the ash can hold burning embers for several days. You should consider the insulating effects of ashes, and the storage container construction. You may locate the remains of the

container used to hold the ashes and coals when the heating unit was cleaned out.

### **Cooking Equipment**

Like heating units, cooking equipment is designed to provide safe, reliable service. They are manufactured to current industry standards, and should be installed according to the manufacturer's directions. Again, people are the unpredictable factor. When cooking equipment is misused, incorrectly installed, or not properly maintained, it can start fires.

You should consider the point of origin in respect to cooking equipment. If cooking equipment is the cause of the fire, most of the burn damage usually will be found directly above the equipment.

Check the positions of the burner and oven temperature controls. They usually will survive even a major fire. These controls can display what position they were in at the time of the fire. Check the contact points of controls, switches, and thermostats for malfunction, and signs of pitting and arcing.

Check the location of the kitchen's trash container in relation to the point of origin. It is not unusual for occupants to place the trash container between the cooking equipment and a cabinet or wall. This proximity frequently allows the ignition of trash and its container to occur. This can be caused by splattering grease or conduction of heat from a cooking unit.

Housekeeping can be a factor in this type of fire. Sloppy or poor housekeeping habits can cause an accumulation of trash, dirt, and even pet hair to cause a fire. Check for accumulation of these materials behind the suspected appliance.

Occupants frequently attempt to remove burning pans from cooking equipment. The burning pan and liquid contents may be dropped or thrown. The point of origin may appear to be located at floor level, and the burn patterns may indicate burning fuel at the floor level. This may have the appearance of a flammable accelerant pattern on the floor area. The point of origin may be located in or near the sink or exit door. Owners or occupants may suffer burn injuries from attempts to extinguish the fire.

Several facts need to be examined in an accidental cooking fire. Check the time factors involved. Did the fire occur during normal meal preparation time? What is normal meal preparation time for the occupant (do they work nights, etc.)? What other evidence of meal preparation is present?

Check the number of cooking elements being used in the food preparation. How many normally would be used? Is one or all set on high?

If the cooking equipment is the source of the fire, check for signs of repair or adjustment to the appliance and/or fuel supply. Look for tool marks or missing cover plates and screws.

Portable cooking equipment is another item that is frequently misused or abused. If portable cooking equipment is present at the point of origin, check the time factors, the type of occupancy, and the location where the equipment was found. It is not unusual to find cooking equipment in boarding houses, hotels, and college dormitories stored under the bed, in drawers, or closets.

### **Smoking and Related Fires**

The heat generated by burning cigarettes varies from 550°F (287°C), measured on the outside surface of a glowing ash, to 1,350°F (732°C) measured in the center of a glowing ash. Some researchers have recorded even higher temperatures for burning cigarettes.

It should be noted that cigarettes that come in contact with most common combustibles will usually produce local char or damage due to the small contact area of the heat. This type of incident often will be self-extinguishing.

Generally, fire departments and investigators too often cite cigarettes as the fire cause. It is used as a catchall, thought to be difficult to contradict, when, in fact, cigarettes usually must be insulated to ignite combustibles.

The insulation allows buildup of heat from the glowing ash and increases the surface contact of the cigarette, allowing the heat to build to the ignition temperature of the combustibles. The most common form of this insulation effect occurs when a cigarette or burning ash falls between cushions on a sofa or chair.

An exception to the general rule of insulation is when a cigarette is in open contact with cotton bed coverings, sheets, or mattress covers. The insulation effect may not be necessary in these instances because the

cotton fibers will allow the buildup of heat, and the sheet or mattress padding may begin smoldering.

Smoldering fires in furniture such as sofas, beds, or chairs, usually require long periods of time to produce open burning. Although it is difficult to identify the absolute minimum time period for the slow, smoldering fire to reach open flaming combustion, experience indicates that 1 to 1-1/2 hours is the common timeframe. The first responder should remember that this timeframe can vary widely in either direction. It is not an absolute.

A smoldering fire inside padded furniture eventually may produce temperatures of 1,400°F (760°C) to 1,600°F (871°C). This will produce several indicators of cigarette-caused fires in furniture. One indicator is the collapse of coil springs. This occurs as fire temperatures exceed 1,300°F (704°C) to 1,400°F (760°C) and the temper of furniture's coil springs is removed. The coil springs then may collapse into themselves. When examined they will display little, if any, spring tension. Like all indicators, the collapse of coil springs should be used in conjunction with other indicators. Do not use a sole indicator as the basis for your conclusion.

Smoldering fires in furniture usually produce large quantities of heavy smoke. Check for heavy smoke staining on windows near the point of origin. Remember that if fire vents through a nearby window the fire may burn off carbon on that window, and the window could appear clean.

Heavy floor damage (charring) may result from smoldering furniture fires. Many items of furniture are now made with polyfoam padding. This padding is made from a hydrocarbon base; when involved in a fire the foam will melt and run, and may resemble a flammable liquid pattern on the floor. This pattern may mislead the first responder.

However, the burn pattern found beneath such furniture fires will usually lack the "fingers" or splash-and-run pattern normally associated with a flammable liquid pattern. This is due to the heavy viscosity of the melted foam. In cigarette fires there frequently is more extensive fire damage on the inside of the furniture frame than on the outside, indicating that the fire came from within the item. It is possible that almost total destruction of an involved article of furniture may result from the fire.

Exceptions should be considered when investigating fires thought to have been caused from contact of furniture with a cigarette. The use of large quantities of flammable liquids on or under furniture can cause spring collapse. Remember that spring collapse is an indicator of high heat. A small quantity of flammable liquid accelerant usually causes only

localized damage to the furniture, and top or surface burning. Also, extensive building damage may produce sufficient heat to anneal and collapse furniture springs.

Foamed plastics, foam rubber, and polyfoam furniture padding will produce more heat than older, cotton-padded furniture. Depending upon several factors such as age, chemical composition of the material, and the actual circumstances of ash placement, the foam may or may not ignite easily upon contact with a lighted cigarette.

While foam padded furniture may be difficult to ignite, when burning it may produce melted, napalm-like materials that will produce extreme heat, extreme smoke, very rapid burning, and very deep char patterns.

Cigarettes that come into contact with flammable gases or vapors do not usually start fires. The cooler ash around the burning coal may act as a flame or flash screen similar to those used on flammable liquid safety cans. The fires that occur from smoking around flammable gases and vapors may result in the explosion of flammable gases or vapors when an individual attempts to light a cigarette with a match or lighter.

## **Energized Electrical Equipment**

### **Basic Electricity**

Various terms must be understood in order to discuss electricity. The following terms are provided so that a first responder has a basic knowledge of how electricity could cause a fire.

Electricity--the flow of electrons due to a difference in energy potential between two points on a conductor.

Electricity and magnetism are closely related. Like charges repel while unlike charges attract. Electricity can produce magnetism and, conversely, magnetism can produce electricity.

Two terms you want to be familiar with are

- Conductor--material that allows free flow of electricity (gold, silver, copper, carbon).
- Insulator--material that restricts or inhibits the flow of electricity (rubber, plastic, glass, porcelain).

### Units of Electricity

- Voltage--unit of force or pressure that causes electrons to flow in a conductor (Electromotive Force). Expressed in volts.
- Current--the number of electrons which flow past one point in a circuit in one second. Expressed in amperes or amps.
- Resistance--the opposition of a conductor to the flow of current. Expressed in ohms. Every circuit offers some resistance to the flow of current and this resistance creates heat.
- Wattage--amount of electrical power. Expressed in watts.

### Ohm's Law

"The strength of a direct current is directly proportional to the potential difference and inversely proportional to the resistance of the circuit." Ohm's Law is a basic law of electricity useful for making circuit load calculations.

$E = \text{Voltage (Volts)}$

$I = \text{Current (Amps)}$

$R = \text{Resistance (Ohms)}$

$W = \text{Wattage (Watts)}$

To find the voltage on a given circuit, multiply the known current by the known resistance (found by using an Ohm meter). If the current and voltage are known, divide the current into the voltage and you will have the resistance. If the current needs to be identified, divide the known resistance into the known voltage.

$E = I R$  to find Volts

$I = E / R$  to find Amps

$R = E / I$  to find Ohms

The same formula can be rewritten in another way to calculate for wattage. This is beneficial to the investigator when the circuit demand at the time of the fire is needed. What we have done is remove the resistance variable



and introduce wattage. Normally, the wattage can be identified by adding the wattage ratings of all the appliances on the affected circuit.

Next, we know that normal household voltage in North America is 120 volts. So, we divide the voltage into the total wattage, and we have the current capacity on that given circuit.

$W = E I$  to find Watts

$E = W/I$  to find Volts

$I = W/E$  to find Current

Example: A fire that involved a 15-amp circuit had the following appliances in use at the time of the fire.

|                   |                    |
|-------------------|--------------------|
| TV                | 300 watts          |
| Hair dryer        | 1,000 watts        |
| Radio             | 100 watts          |
| Incandescent lamp | 10 watts           |
| Air conditioner   | <u>1,000 watts</u> |
|                   | 2,410 watts        |

To find the total load on a circuit, plug the known variables into the formula:

$I = W/E$

$I = 2,410 \text{ watts}/120 \text{ volts}$

$I = 20 \text{ amps}$

The overcurrent protection device for this 15-amp circuit should have activated. If it did not, the reason for the failure should be determined.

The following is a list of some common electrical items with the approximate watts that each uses.

| <b>Item</b>                              | <b>Watts</b> |
|--|--------------|
| Lamps, incandescent                      | 10 Upward    |
| Lamps, fluorescent, residential          | 15-60        |
| Lights, Christmas tree                   | 30-150       |
| Clock                                    | 2-3          |
| Radio                                    | 40-150       |
| Television                               | 200-350      |
| Sun lamp (ultraviolet)                   | 275-400      |
| Heating pad                              | 50-75        |
| Blanket, electric                        | 150-200      |
| Razor                                    | 8-12         |
| Heater, portable, household              | 500-1,500    |
| Heater, wall-type, permanently installed | 1,000-2,500  |
| Fan, portable                            | 50-200       |
| Air conditioner, room type               | 800-1,500    |
| Hair dryer                               | 350-1,000    |
| Projector, slide or movie                | 300-1,000    |
| Sewing machine                           | 60-90        |
| Vacuum cleaner                           | 500-1,500    |
| Refrigerator, household                  | 150-300      |
| Freezer, household                       | 300-500      |
| Iron, hand (steam or dry)                | 660-1,200    |
| Hot plate, per burner                    | 600-1,000    |
| Range (all burners and oven "on")        | 8,000-14,000 |
| Range top (separate)                     | 4,000-6,000  |
| Range oven (separate)                    | 4,000-5,000  |
| Toaster                                  | 500-1,200    |
| Coffeemaker (percolator)                 | 500-1,200    |
| Waffle iron                              | 600-1,000    |
| Roaster                                  | 1,000-1,650  |
| Fryer, deep fat                          | 1,000-1,650  |
| Frying pan                               | 1,000-1,200  |
| Blender, food                            | 500-1,000    |
| Knife, electric                          | 100          |
| Food mixer                               | 120-250      |
| Dishwasher                               | 1,200-1,800  |
| Garbage disposal unit                    | 500-800      |
| Washing machine                          | 350-550      |
| Washer, automatic                        | 600-800      |
| Dryer, clothes                           | 4,000-5,000  |
| Water heaters                            | 2,000-5,000  |
| Motors 1/4 hp                            | 300-400      |
| Motors 1/2 hp                            | 450-600      |
| Motors over 12 hp (per hp)               | 950-1,000    |

Electrical protective devices are designed in accordance with the National Electric Code (NFPA) with basic safety features designed into the electrical system.

The service entrance is the point where the utility companies connect service to the customer. This service entrance usually contains an electric meter, a means of disconnecting, and overcurrent protection devices

The fuse or circuit breaker is an overcurrent protection device that will be rated to correspond to power (current) demands of the system (amperes).

The normal voltage is 120 or 240 volts for residential occupancies and the usual incoming service is 240 volts. This is known as a two-phase system. Commercial and industrial services generally demand much higher voltages, with 440 volts, and is referred to as a 3-phase system. The distribution panel, which contains the overcurrent protection devices, is usually located within the structure. This is where the incoming 240 volt service is divided into secondary circuits to service the needs of the customers.

These secondary circuits usually feed 120-volt electric power to the wall outlets and light switches. Water heaters, range stoves, heating systems, electric dryers, and air conditioning units are usually on 240-volt circuits and connected to individual circuit breakers because of the heavier power requirements of these appliances.

Secondary circuits are referred to as "branch circuits." A branch circuit is one which extends beyond the overcurrent device (fuse or circuit breaker). The wiring found in branch circuits is usually #14 gauge copper wire and will accommodate up to 15 amperes. These circuits are generally protected by a 15-amp fuse or a circuit breaker.

Appliance circuits usually found in kitchens, dining rooms, laundry rooms, and garage areas are wired with #12 gauge copper wire and accommodate current loads up to 20 amperes. These circuits are protected by a 20-amp fuse or a circuit breaker. Special purpose, or individual branch circuits, supply a limited number of appliances (usually only one). The wire size and overcurrent protection device will be installed as required by the current load of the appliance.

### Grounding

Grounding is required for all electrical circuits. Improper grounding conditions and situations that occur can cause either a shock hazard or a fire hazard within an electrical wiring system.

These situations occur when an energized conductor, or hot wire, makes contact with some other conductive object which is capable of supporting current flow. This uncontrolled electrical energy is the chief danger inherent in electricity. The typical situations that would allow uncontrolled electrical energy to escape are:

- loose connections;
- failed connections;
- lightning;
- deterioration or physical damage of insulation;
- introduction of electrical current from some other source; and
- current leakage from dust or moisture at connections.

A system malfunction or failure of this type can energize appliance cabinets, piping, control valves, or handles, and pose severe shock hazards to people as well as fire hazards to the structure.

To avoid such situations, and to reduce the likelihood of such occurrences, most codes require that one conductor within the electrical system be a grounded circuit.

Most metal cabinets, enclosures, and raceways used in electrical service are required to be grounded to earth. With proper grounding, a system malfunction will permit current flow through the ungrounded wire of sufficient flow (current) to cause the overcurrent protection device to operate and thereby open the circuit, stopping the flow of current.

Many modern circuit breakers will also have a "ground fault interrupter" (GFI) device which activates the breaker device in cases of low-resistance ground faults. These GFIs are located either in the distribution service panel or the wall receptacle itself.

### Overcurrent Protection

Overcurrent protection devices are the "safety valves" of the electrical system.

Current flow will generate heat. The amount of heat generated depends upon the type of conductor and its inherent resistance. Often, excessive heating is caused by excess current demand, too many appliances, or a heavy load on a given circuit.

### Short Circuits

Short circuits on a given circuit will develop when two elements of different electrical potential contact.

Short circuits are of several types. Ground faults are a type of short circuit that occur when a hot wire comes in contact with a ground or ground potential. This can be a life-threatening situation, as some ground faults will not cause a current flow sufficient to trip the circuit breaker, but will carry enough current to injure or kill.

A true short circuit will occur when a "hot" wire is allowed to come in contact with a neutral wire. Ground faults or true short circuits can produce very large surges of current. If a circuit breaker is properly designed and operating correctly, it should activate, or the fuse elements melt, and open the circuit when subjected to excess heating or current surge. This acts as a switch in the off position and stops the flow of current.

Fuses and circuit breakers are manufactured to withstand the temporary surge of current associated with the startup of heavy equipment without tripping.

### Typical Overcurrent Protection Devices

A fuse is an intentional weak link in the circuit designed to self-destruct when excess current flow melts the fusible element. Fuses come in several types with different applications. The ordinary fuse has an Edison base and comes in 6- to 30-amp sizes.

The type "S" fuse is similar, but with a permanent-mounting Edison base that stays in the fuse socket and a special element that is removable. Each element is a different screwbase size dependent on the amperage rating.

This is the best fuse design because it helps to eliminate substitution and tampering with the fuse.

As a general practice, fuses of 15 amperes or less are manufactured with a hexagonal window. A fuse rated at 15 to 30 amperes will have a round window. Fuses rated above 30 amperes are usually cartridge, ferule, or blade type and require special sockets in the fuse box.

Circuit breakers are mechanical devices that open a circuit at a predetermined level of current flow. They are normally reusable and can be reset manually after tripping and opening the circuit. Most circuit breakers are a thermal-magnetic type. A magnetic element provides short circuit and ground fault protection, while a thermal element provides overload protection. The thermal element is usually a bimetal device that deforms when heated by the excess current flow.

Circuit breakers cannot be placed manually in a tripped position and the protection will continue to operate even if the switch handle is held in the "on" position by mechanical means.

### Examining Fires of Electrical Origin

The examination of fires of suspected electrical origin should begin with the service entrance and distribution panel. The area in and around the utility company entrance and distribution panel also should be examined. The first question to ask would be whether the electric service was connected and energized at the time of the fire. If there was no electricity at that time, an electrical fire can be ruled out.

Examine the exterior areas of the structure for indications of electrical arcing and malfunctioning equipment. The utility company connection, weatherhead, meter, and cabinet should be examined for electrical arcing or other malfunctions. Always ensure that the system is not energized prior to starting your examination.

Examine the distribution panel inside the structure, along with the fuses or circuit breakers, for indications of arcing or overheating. When overheating occurs due to excess current flow, the fuse element will melt, leaving the glass and fuse housing relatively clean. When a short circuit occurs, the fuse glass and housing area often will blacken, or in some cases, the glass itself will be damaged physically. Small "globs" of the melted fusible link may adhere to the interior of the glass.

Examine the circuit breakers for indications of malfunctions or activation. Extreme short circuits can cause evidence of arcing or pitting on the circuit breaker contact points. Carefully examine the circuit breakers for evidence of arcing between circuit breakers or arcing across circuit breaker wire connections.

Next, examine the wire connections in the distribution panel. Look for evidence of recent repairs. This evidence includes tool marks, loose wire or terminal connections, or a missing cover plate.

Examine the distribution panel for evidence of electrical system problems such as blown or discarded fuses. Also look for indicators of efforts to bypass fuses or circuit breakers. These efforts can be as simple as pennies placed under the fuse in fuse sockets, or the more sophisticated altering of the actual fuses. Fuses may have been replaced by other devices in an attempt to continue electrical service. There are many cases where the fuses were wrapped in foil and placed in the sockets. Fuses have been replaced by a metal bar or copper tubing and in some cases the fuses have been physically wired around. This creates an unfused circuit without the "safety valve" for short circuit or overload conditions.

The entire distribution panel should be removed and an examination made of the back of the panel and wall surface for indications of heating or electrical arcing. Extreme current surges or short circuits may cause physical damage inside the panel. It also is possible for lightning actually to blow out the rear of an electrical panel.

Examine all undamaged areas of the structure for indicators such as unsound mechanical work, missing cover plates, loose connections, and loose splices

Evaluate the overall condition of the electrical system. Is there an adequate number of receptacles? Is their placement appropriate for the structure? Does the wiring display excessive or unsafe use of drop cords, cube plugs, or octopus adapters in the receptacles?

Calculate the total electrical load present in the structure for indications of misuse of the system. (See earlier discussion of system evaluation in this unit.)

Examine the wiring and equipment at or near the point of origin and note whether the system is using aluminum wiring. Aluminum wire usually melts at approximately 1,220°F (660°C). Often it will melt and run in the area of origin. Aluminum wire may leave very little evidence for examination after the fire.

You may have to check nearby undamaged areas in order to evaluate the probable conditions which existed at the point of origin.

### Aluminum Wiring

General facts concerning aluminum wiring should be understood by the first responder before attempting to evaluate a fire suspected to have been caused by a malfunction involving this type of wiring.

Aluminum wire was used in residences and commercial occupancies during the late 1950s. Millions of structures were wired with aluminum wiring before problems were identified. The main problem was that aluminum wire expands and contracts approximately 38 percent more than copper wire. This expansion may loosen connections which, in turn, increase the amount of resistance heat that is generated.

Aluminum wire also will oxidize more than copper wire. Connections that have oxidized develop resistance heating, thereby causing additional oxidation. Another problem is that aluminum and copper may react through electrolysis and cause an increase in aluminum oxidation.

The oxidation of the aluminum wire reduces the actual cross-section diameter of the wire. This reduces its capacity to carry the necessary current safely, and increases the resistance heating of the wire and connections.

Proper connectors also must be used for aluminum-to-copper connections. Refer to the manufacturer's instructions for markings on approved connectors and devices. Older connectors are marked "AL/CU." After 1972 approved connectors were marked "CU-AL."

The majority of aluminum wiring fires are caused by the mechanical connection at the screw terminals. Loose connections can develop, and the heated connector can, over time, cause ignition of structural members. Check for evidence of long-duration heating of the wire at the point of origin.

### Copper Wiring

If the system is wired with copper wiring, the following general information is useful.



An indicator of an electrical malfunction is not sufficient to classify a fire as electrical in origin. The indicator must be validated by proving that the necessary physical cause and conditions for an electrical fire were present. If the indicators cannot be validated, the fire cause should not be classified as electrical in origin.

Copper wire melts at 1,980°F (1,082°C). Most ordinary structure fires do not reach temperatures high enough to melt copper wire.

The physical conditions which serve as clues in a fire scene may be created by a hostile fire of other than electrical origin. Although not absolutely necessary, there should be some circumstantial evidence to indicate that the fire occurred as a result of age or deterioration of the electrical system; the system or its component parts were misused or misapplied; the system or its components were improperly installed; an accident occurred; or a defective product was involved.

The following discussion of clues will be separated into the categories of the basic electrical fire ignition mechanisms. The basic mechanisms are arcs and sparks, overheated connections, and overheated wires.

### Arcs and Sparks

Arcs and sparks are produced in several ways. Some arcs are an unavoidable result of operating electrical equipment and switches. For example, an arc is sometimes observed when a switch is operated. Some arcs are the result of breakdown, malfunction, or damage in electrical systems or equipment.

Naturally occurring arcs take place when an individual touches a grounded object after crossing a carpet. Lightning is another form of a natural arc. The temperatures developed by arcs typically range from 2,000°F (1,093°C) to over 7,000°F (3,871°C). An arc may scatter hot particles of metal (sparks) over a wide area.

### Normally Occurring Arcs

The fire itself can, and usually does, produce arcing when it attacks energized conductors and equipment. The presence of arc damage alone is not proof that the fire was started by that arcing.

Certain conditions are necessary for normal arcing to cause the ignition of a fire. It must be determined that ignitable mixtures of air and flammable gases, vapors, or dust were present, and that the electrical system or equipment was not designed for this type of atmosphere. Also, it must be determined that the electrical equipment was known to be energized and operating at the time of ignition.

The first responder also must determine if the fire scene has signs of a flash fire or explosion typical of the specific material ignited, and that other sources of ignition have been ruled out.

### Abnormal Arcing

Arcs may be produced by abnormal operations, failure, or damage to the electrical systems or the equipment. The following are clues to a fire possibly caused by abnormal arcing:

- Holes melted in metal enclosures for electrical equipment and wiring.
- Portions of electrical insulators in equipment destroyed or damaged in areas adjacent to normally energized parts while other similar insulators are not damaged in the same manner.
- Electrical cabinets bulged or distorted from internal pressure.
- Electrical equipment dislodged or deformed in a manner not consistent with damage caused by the fire. This is an indication of heavy current flow.
- Melted or beaded wiring not consistent with temperatures developed by the fire.

The following conditions are necessary for abnormal arcing and ignition to occur:

- Some outside influence must be present to initiate the arcing process, such as physical damage, water on live parts, conductive objects coming in contact with live parts, etc. The voltages present in normal residential and small commercial electrical systems will not begin arcing spontaneously.

- The suspected circuit or equipment must be energized. One should determine whether the switch was on and the equipment was plugged in.
- Low-level or intermittent faults may not cause a fuse or circuit breaker to open. Under these conditions, sufficient heat may be generated to cause ignition.
- The arcing must occur in the area of origin of the fire with suitable combustibles present.

Example: The hot particles scattered by an arc could ignite newspaper, but are less likely to ignite framing lumber or a wood floor.

- Arcing must have been of sufficient duration to ignite the suspected combustibles, and all other sources of ignition must be eliminated.

### Overheating Connections

Any time a wire or other conductor is connected to another wire or the terminal on a piece of equipment, the possibility for excessive heat has been created.

When a connection is properly made, the materials involved will be compatible, clean, and held in firm contact with sufficient area of contact to provide a low resistance to the flow of electricity. The amount of heat generated in a proper connection will be very small. In a deteriorated connection, normally safe and acceptable current flow over a long period of time can cause the connection to become hot enough to ignite common combustibles.

NFPA 70, *National Electrical Code*, in general, requires all connections to be enclosed in an approved junction box, cabinet, or terminal box with covers in place and unused openings effectively closed. The enclosure requirement serves several purposes: physical protection for the connections, separation of the connections from combustibles, limitation of oxygen, containment of overheated materials should a breakdown occur, and protection for live parts from accidental contact.

**Note 1:** An overheated connection may continue to deteriorate and become an arcing fault before it is noticed or a fire is caused.

**Note 2:** The contacting surfaces in a switch or fuse holder, when they are loose, are a potential source of heating in the same manner as an overheated connection.

The following are clues to a fire caused by overheated electrical connections:

- The suspected electrical parts show signs of localized heating.
- Surfaces of the wires, terminals, or connectors are discolored, pitted, or eroded. In a good installation these surfaces are protected from fire damage by the enclosure.
- Charring is deeper where the electrical enclosure was in contact with combustible supporting surfaces. Normally an electrical box or piece of equipment will provide a degree of protection from an external fire to the surface on which it is mounted.
- Some or all of a connection has deteriorated while other connections in the same enclosure are intact or exhibit exposure damage only.
- Localized pitting, erosion, or deterioration is observed at the point of origin in normally nonenergized metal parts of the electrical systems.

The following conditions are necessary for ignition to occur from overheated electrical connections:

- Electrically powered equipment or lighting fixtures, which depend on the suspected connection, must be drawing current at the time of the fire. This is not always obvious, as an unused receptacle may serve as a connecting point for a downstream load.
- The connection can be energized but will not heat until current flows are used to operate an appliance or fixture.
- Susceptible combustibles are exposed to the suspected connections or enclosure.

### Overheated Wire

Whenever electric current is flowing through a wire, heat is generated. The allowable current-carrying capacity of a wire is based upon several factors:

- temperature rating and type of insulation;
- type of metal;
- wire diameter;
- number of conductors; and
- whether the wires are enclosed or open to the air.

If the overcurrent protective devices are improperly sized for the circuit, malfunctioning, or defeated, excessive current can be delivered to the wire and cause sufficient heat to ignite nearby combustibles.

The following are clues to a fire caused by overheated wires:

- Damage to the insulation from internal heating throughout the length of the circuit from the point of overload or fault to the point where the circuit receives its current. This condition must be present on the suspected circuit even in areas outside the area of fire damage. Signs of internal heating are loose, sagging, or swollen insulation, and insulation which is charred inside and not outside.
- Defeated, tampered, improper fuses or circuit breakers serving the suspected circuit.
- Multiple points of origin, all of which occur along the suspected circuit.
- Charring inside the holes where the suspected circuit passes through wood structural members.

The following conditions are necessary for overheated wire ignition:

- A complete energized electrical circuit.
- An overload or fault condition which would allow excessive current to flow.
- Defeated, malfunctioning, or improper overcurrent protection on the suspected circuit.

### Effect on Wires

Whenever arcing occurs in wiring, there will be characteristic marks left at the point of arcing. Arc marks usually can be distinguished from mechanical marks and from fire melting. An arc mark is a distinct spot, but there might be multiple arc marks close together. The mark is an area where the metal has been melted. It might be a smooth cavity or a cavity with a projection. Sometimes the cavity will be rough with numerous small projections. Next to the arc mark the surface of the wire is not melted. However, there might be some spattering of melted metal onto the nearby surface if the wire was bare at the time of the arc.

Arcs can leave cavities in wires or they can sever wires. The ends of severed wires might be smoothly melted or might be beaded. Arc marks are generally similar whether in copper or aluminum wires.

Arcing in stranded lamp and extension cords commonly causes beading rather than cavities. Arcing that occurs within a junction box or other metal enclosure will usually leave small droplets of metal spattered around the inside of the box.

### Fire Melting

Fire melting usually can be distinguished from arc marks because with fire melting the fire affects a wider area. Fire melting of copper wire exhibits a graduation from light oxidation to distortion of the surface, to blistering, to flow of metal. Under some conditions the flow of melted copper leaves a smooth surface with thin necks, beads, and a pointed end. It is characteristic of copper wire to melt on the surface and have an unmelted core.

Fire melting of copper wire will be a function of the duration of the fire, the location of the wire, and the protection of the wire. In a normal building fire, the temperature in the upper part of a room or building will be higher than in lower parts. Under normal fire conditions, melting of wire in the upper parts of a room or building will be unusual and, in the lower parts, almost nonexistent. Caution should be used, as fire can cause arcing of building electrical wiring. This arcing in the fire can continue to destroy electrical wire from the original point of the fire-induced arc back toward the power supply. This arcing may not trip the circuit protective devices. Caution needs to be used here as this arcing or melting mistakenly can be taken as the cause of the fire, rather than a consequence of the fire.

Aluminum wire behaves differently than does copper wire during fire melting. Sometimes aluminum wire will drop off sharply because it melts throughout, instead of having an unmelted core. Most of the time there will be some kind of indication of the melted aluminum or other evidence of the presence of aluminum wiring.

When a wire is melted by greatly excessive current (over-current) it tends to melt all through and along the wire at the same time. When the wire finally falls apart, current stops and the wire cools. Often there will be offsets where the wire started to disintegrate. This effect can be found in copper, aluminum, or any other kind of wire.

When evidence of overcurrent is found (offsets, sleeving, heated insulation in nonfire areas), fuses or circuit breakers should be checked. Arc marks indicate whether the circuit was energized. Small isolated arcs are not likely to start fires unless a very easily ignitable fuel is present. Massive arcs, such as are found with service equipment, can start a fire fairly easily.

Fire melting can obliterate arc marks or any other characteristic effects that were present at the start of the fire. Thus, failure to find characteristic marks in fire-melted wires does not necessarily mean that there had not been arcs. This is especially a problem with aluminum wiring because it melts at a relatively low temperature.

Mechanical marks or gouges in wires usually can be distinguished by shape or by lines of scraping. A wire that is gouged by a nail, saw, or other means, but is not severed will not cause enough heating to start a fire at allowable amperage, assuming that a short or ground fault is not created.

## **Electrical Equipment and Appliances**

### **Light Bulbs**

Electrical equipment and appliances can, and do, cause accidental fires. Light bulbs often are used as a probable cause in accidental fires. Light bulbs can cause the ignition of combustible materials; however, this does not occur as often as some investigators believe. The temperatures generated by light bulbs depend on the several factors. The size of the bulb is measured by wattage, not physical size. The size can be used as a measure of the heat-producing capability of the bulb. The shape or design of the bulb and color of the envelope are also factors. The color or lack of color will affect the amount of heat radiated from the bulb. The position or angle at which the bulb is mounted is the final factor. Although they do

create considerable heat, light bulbs which come in contact with thin combustibles often produce only localized scorching.

The most common indicators of light bulbs as a fire cause are

- heavy staining of bulb fragments and filaments;
- combustible ash stuck to the bulb, fragments, or filament;
- a short circuit which developed near the bulb or socket;
- bulb found very near the point of origin; and
- long periods of time with no occupants in area of origin.

If the occupants had been in the immediate area prior to the fire it is likely that they would have noticed the odors associated with a slow, smoldering ignition.

### Lighting Fixtures

Improperly installed lighting fixtures may cause fires in nearby combustible building members, joists, studs, or insulation. This type of fire may be very slow starting and may show the characteristics of low-temperature ignition. The slow buildup of pyrophoric carbon in low-temperature ignition will be discussed later in this unit.

The point of origin may show very deep charring in and around the lighting fixture. Recessed lighting may have a light bulb(s) of excessive wattage. This will produce an excess of charring within the unit and can cause ignition of nearby combustibles. Check for insulation packed on top of this type of fixture. The insulation does not allow heat to dissipate, and also can ignite.

Fluorescent fixtures may develop a malfunction or breakdown of ballast transformer(s). Ballast transformers may contain filler materials which will melt and run at higher temperatures. This occurs more often in older transformers. Improperly operating ballast transformers may develop extreme temperatures and self-ignite or ignite other nearby combustibles.

### Small Electrical Appliances

Most small appliances are required by code to have thermal controls, thermostats, and current overload protective devices. These controls usually are constructed of bimetal strips. In older or frequently used appliances the contacts or control points may be pitted or fused together, thus allowing overheating.



Contact points which were closed during the fire are usually clean and unstained (protected area).

### Electric Motors

Electric motors offer numerous possibilities for the ignition of fires. These possibilities include defective windings and excessive load which can affect proper operating speed of the motor and can produce sparks from centrifugal switches or brushes. Bronze bearings usually do not freeze, stick, or lock up from external fire damage. A frozen shaft may indicate internal heating by electrical overload or friction on the rotor bearings.

Motors with a small size or mass are not reliable, and frozen bearings, or the lack of frozen bearings, should not be considered an indication with respect to fire cause.

Motor overload fuses should be examined for activation or damage. Low voltage from the electrical service will also cause severe internal heating. The contact points should be examined for fusing or pitting. Any damage to the inside surface of drive belts at the point of contact with pulleys should be documented, as it may indicate friction heat buildup.

Electric motor wiring insulation normally has a clear, varnish-like appearance. The insulation is usually burned away only when the motor burns out. External fire damage usually does not destroy motor wiring insulation or cause the bearings to seize.

Motors which retain high temperatures after other metal objects in the same area have cooled may indicate internal heating. The mass of each object must be taken into consideration.

### Electric Blankets

Electric blankets and heating pads also can be the cause of accidental fires. The fires caused by electric blankets are most frequently caused by misuse by the owner. The manufacturer's instructions and the safe use of the electric blanket require that blankets are not to be covered by other bed coverings, folded, or tucked under mattresses.

Accidental electric blanket fires have developed from misuse such as:

- individuals sleeping on top of blankets;
- pets sleeping on top of blankets;
- blankets being left on for a long period of time; and
- blankets left folded on the bed while the controls are on.

Contact points of the thermostat controls should be examined for damage. It is often difficult to distinguish between a fire caused by electric blankets and a fire caused by a cigarette in or on a mattress.

### Televisions, Radios, Stereos, and Home Entertainment Systems

Accidental fires involving televisions, radios, stereos, and home entertainment systems also can occur. The installation of systems into cabinets or corners may produce excessive heat buildup. Electronic appliances are designed to operate in areas with adequate ventilation. These appliances are temperature sensitive and may fail if subjected to excessive heat.

Dust buildup inside these appliances may produce arcing, and cause ignition of plastic components or of the enclosure.

Most television components operate at voltages of up to 32,000 volts in some areas within the appliance. The failure of these high-voltage components may cause extreme heat and provide ignition possibilities.

Television failure also may occur due to the failure of the set's power switch. Some manufactures are thought to use switches of light or less than heavy-duty design.

Prior trouble with the appliance may indicate possible investigative leads. Burning appliances may increase the amount of fire damage and may produce floor charring similar to furniture fires. The plastic cabinets may melt, run, and burn.

Questions to be answered in any fire suspected to have been caused from electrical sources:

- Was the electricity on before the fire?
- Was the electricity on at the time of the fire?
- Did the local utility company respond to the fire?

- Have there been any recent problems of an electrical nature in the building?
- Have there been any blackouts or brownouts?
- Have there been blown fuses?
- Have the circuit breakers been tripped?
- Has the local utility company been called, or have service people been seen on the premises recently?
- Do the lights seem to dim, or do they get dim at peak hours of electrical usage?
- Do the lights flicker or dim when appliances are turned on?
- Do appliances start or operate slowly?
- Does the television picture shrink or fade when appliances are turned on?
- Does the radio sound scratchy or fade when appliances are turned on?
- If there have been any electrical problems, what, if anything, has been done to alleviate them?
- Has a repair person or janitor been working on the electrical system?
- Has the owner or manager been working on the electrical system?
- Has any other authorized or unauthorized person been working on the electrical system?
- Has an electrical contractor been working on the electrical system?
- Why was the electrical contractor called?
- Was the electrical contractor called to alleviate a problem?
- Was the electrical contractor called for an addition, remodeling, or for new electrical work?

- Is the contractor licensed?
- Is there a permit for the job? Is so, where is it?
- Has the job been completed?

### **Flammable and Combustible Liquids**

A detailed discussion of the indicators of the presence of flammable and combustible liquids will take place in the Incendiary Structure Fire section of this unit. This section will focus on accidental fire situations such as spills, leaks, etc., which involve flammable and combustible liquid fuels.

#### **Improper Storage of Flammable Liquids**

The improper storage of flammable liquids is a major cause of accidental fires. Flammable liquids can be found in almost any storage area. These areas can be found in residential occupancies with locations such as utility rooms, kitchen cabinets, bathrooms, garages, and carports.

Commercial and industrial occupancies frequently will have flammable liquids stored in places such as offices, plant areas, work areas, storage closets, and warehouse areas. Fires involving flammable liquids can occur either inside or outside of the structures.

#### **Improper Storage Containers**

Improper selection and use of storage containers is a major reason for accidental flammable liquid fires. These lightweight plastic containers may become brittle with age and develop cracks or leaks. They also may be punctured by almost any sharp object, edge, or corner. The flammable liquid may act as a solvent and cause the deterioration of the plastic container.

Lightweight metal containers also are dangerous, as they can rust or deteriorate along the crimped seams. This will cause slow leaks to develop and flammable vapors will be present.

Another common cause of accidental flammable liquid fires is improper use of flammable liquids as cleaning fluids. The most common flammable liquids used in this manner are gasoline, kerosene, alcohol, and lighter fluid. These liquids may be spread over large floor areas and their vapors ignited.

### Flammable Liquid Ignition Sources

Flammable liquid vapors are heavier than air and will usually settle to the lowest level in the involved area. These vapors may contact an ignition source and flash back over long distances. The most readily available ignition sources are

- gas appliances;
- hot water heaters;
- gas stoves and ranges;
- gas heating appliances;
- sparking of electrical equipment;
- sparking of light switches;
- telephones;
- motors; and
- static electricity.

The flammable vapors may explode or spread flame to all areas of the structure. Gas explosions will be discussed in detail in the section entitled Gas Fires and Explosions later in this unit.

The indicators of the presence of flammable liquids in accidental fires are rapid flame spread, very heavy charring, and low burning. Another indicator available to assist in the identification of accidental fires involving flammable liquids is the presence of cleaning equipment containing residue of flammable liquids. These indicators can be used to confirm the stories of the occupants. Another indicator is the report of children playing in areas containing the stored flammable liquids. One should also consider injuries to persons in the area. Accidental fires caused by flammable liquids are very deadly and often result in people being injured or killed. The "staging" of accidental flammable liquid fires to cover incendiarism is discussed in the Incendiary Fire Causes unit.

## **Open Flames and Sparks**

### **Welding and Cutting**

Welding and cutting operations are often conducted in areas of combustible storage. A fire may smolder for long periods after completion of the welding and/or cutting operations. The fire may result from the effects of heat conduction or convection from the welding when welding or cutting objects are connected to, or pass through, combustible construction. The welder may ignite combustibles through careless flame contact.

The indicators of a fire caused by welding or cutting are slag in the area of origin, spot burning, or welding or cutting equipment left in the area. Other indicators are the recent welding or cutting of metal objects, and metal objects passing through combustible construction near the point of origin.

### **Friction and Sparks**

Friction and sparks from machinery is another often-seen cause of accidental fires. Friction from the high-speed rotation of objects may result in extreme heat generation if the machinery is improperly lubricated. This may cause a fire if the heated material comes into contact with combustible materials. This also may cause a fire by convection of heat to combustible objects.

The indicators of a fire caused by friction may include the report of trouble or noise from the equipment involved, or a point of origin near or inside the suspected equipment or machinery.

Localized damage to metal parts may be present and the intensity of the fire may produce the actual melting of metal.

Sparks from machinery also may serve as an ignition source. (See Energized Electrical Equipment in this unit.) Sparks from grinding will produce indicators that are similar to open-flame cutting. Examine the equipment present in relation to the fire cause and other investigative indicators. The thawing of pipes in cold weather and the soldering of pipes with open flames will exhibit indicators similar to open-flame cutting in relation to the investigative indicators.

Often, electrical welding equipment is used in cold climates to thaw water pipes. This electrical welding equipment can be grounded improperly, and cause fires.

### **Spontaneous Heating Leading to Ignition**

Sometimes spontaneous heating is used as a catchall fire cause by investigators. While it is a cause of accidental fires it is probably somewhat rare except in rural or farm areas.

Many organic materials and some metals are subject to oxidation or fermentation which will result in spontaneous heating. This spontaneous heating is produced in three ways:

- chemical action (example--unslaked lime and water);
- fermentation or microbial thermogenesis; and
- oxidation.

In the remainder of this section we will discuss fermentation, the most frequently encountered fire situation involving spontaneous heating. For fires suspected to have started by chemical action or oxidation, refer to the chemical references.

#### **Fermentation**

Moisture is a prime factor in the fermentation process. In grasses and hay, the drying time prior to storage is critical. If the susceptible material is fresh cut and has been stored longer than six weeks, the odds of spontaneous heating are greatly decreased, as the product has been allowed to dry. Storage while wet or while "green" is an invitation to spontaneous heating.

Spontaneous heating may be accelerated by outside heat sources such as sunshine and storage near steam pipes or heaters. Other sources of heat also should be considered: hot-air ducts or heat from friction, vibration of the mass, or vibration of the storage container.

Available air movement is important to spontaneous heating because too much air or air movement may dissipate the heat and keep the mass below ignition temperature. Too little air may retard the heating of the mass.

For example, a rag soaked in organic-based oil may produce spontaneous heating when wadded at the bottom of a trash can, while the same rag laid open on the ground or floor simply may dry.

The mass of the material also is important because it usually requires several inches of depth to allow for spontaneous heating.

Spontaneous heating may occur in a matter of hours, days, or even months before reaching its ignition temperature. Bacteriological preheating may initiate the process. The bacteria may die as the mass reaches temperatures of 175°F (79°C). The spontaneous heating may continue or halt, depending on all other factors present.

Indicators of fires caused by spontaneous heating include charring inside the mass or more than one area of charring inside the mass. It is also important that the suspected material is composed of a living source or base. This is a general rule with some exceptions.

Some of the common materials that are susceptible to spontaneous heating are

- linseed oil;
- charcoal;
- fish meal;
- wool waste; and
- foam rubber.

(For a complete listing refer to NFPA *Fire Protection Handbook*.)

## **Gas Fires and Explosions**

### **Gas Fires**

The destruction of home fuel lines during a fire may increase burning, and the resulting charring and burn patterns may appear unnatural. The discovery of the point of origin in the area of a gas appliance requires confirmation of appliance malfunction.

Gas explosions can result in massive structural damage. This structural damage may indicate the type of explosive fuel involved. Natural gas (or manufactured natural gas) is lighter than air and will rise to upper levels of the structure. Explosions involving this gas usually produce damage centered at the upper levels of the area involved.



Liquefied petroleum (LP) gases such as butane or propane are heavier than air and normally will settle to lower levels of the structure. Explosions involving LP gas usually produce damage centered at the lower levels of the area involved.

This also holds true for flammable liquid explosions. All flammable liquid vapors are heavier than air and normally will settle to lower levels of the structure. Explosions involving flammable vapors usually produce damage centered at the lower levels of the area involved.

Gas explosions may occur during attempted suicides. Many people incorrectly believe LP and natural gases are poisonous and they may attempt to use gas-fueled cooking equipment to commit suicide. The fuel eventually finds an ignition source and the "poison gas" suicide results in an explosion. If this is suspected, be sure and check for extinguished pilot lights and range controls set to "high."

### **Fireworks and Explosives**

Fireworks may be difficult to detect as a fire cause. Often children are involved in this type of fire. Children or adults may attempt to conceal the presence of fireworks if possession and use of them is illegal. Also be aware of the time of year. Is it likely that fireworks were being used in celebration of a holiday?

### **Dust Explosions**

Many common materials may explode when in dust form. Common examples are dust from wood, grain, malt, flour, starch, metals, and resins. It is important to note that fires may not necessarily result from a dust explosion.

There are several important factors influencing the possibility of a dust explosion:

- size of the dust particles;
- concentration of dust in the air;
- impurities present in the dust;
- oxygen concentration; and
- strength of ignition source.

The involved area may appear to have suffered a "flash fire" with no single point of origin. As with spontaneous ignition, the material involved must be identified.

### **Low-Temperature Ignition**

When heat as low as 250°F (121°C) is applied to cellulose materials (wood) for a long period of time, pyrophoric carbon is formed. In this process the character of the material is changed. The exposed material becomes almost pure carbon and is subject to spontaneous heating.

Although the minimum temperature of 250°F (121°C) is the generally accepted limit, there is some indication that lower temperatures could actually initiate low-temperature ignition. Temperatures of 212°F (100°C), 200°F (93°C), and 180°F (82°C) have been known to initiate low-temperature ignition.

Low-temperature ignition may develop in areas where combustibles are located near light bulbs, steam pipes, or other low-temperature heat-producing appliances.

Low mass or low density (small or thin) materials may not be affected by the low-temperature heat. Low-temperature pyrolysis usually occurs in heavier timbers. This is a result of the density of material acting as an insulator of the heat.

Low-temperature heating may occur over a long period before a fire develops. This time period can extend over several weeks or even months, and cases have been recorded where the time period was up to several years.

The following are examples of common objects which can provide the necessary heat for low-temperature ignition:

- Electric lamps (approximate temperatures on or near surface of bulb).

| <b>Watts</b> | <b>F</b> | <b>C</b> |
|--------------|----------|----------|
| 40 to 100    | 200°     | 93°      |
| 150 to 200   | 295°     | 146°     |
| 300 to 500   | 380°     | 193°     |

- Saturated steam pipes (approximate temperatures on or near surface).

| <b>Pressure</b> | <b>F</b> | <b>C</b> |
|-----------------|----------|----------|
| 10 lb.          | 240°     | 115°     |
| 15 lb.          | 250°     | 121°     |
| 20 lb.          | 259°     | 126°     |

One indicator of low-temperature ignition is a large charred section of combustible material combined with the presence of a low-temperature heat source. Another indicator is the discoloration or baking of the affected material.

Generally, even though a very large charred area can be expected, the charring will appear baked and will have few (if any) deep cracks along the charred surface. A smooth surface with hairline dehydration cracks is more common.

Caution should be used, because frequently the effects of conduction and convection are misinterpreted as pyrophoric carbon. The fire could be the result of a combination of various types of heating. Remember that the pyrophoric carbon is the result of heating, and that the heating may be due to one (or more) of the three basic types of heat transfer: convection, conduction, and radiation.

### **Lightning**

Evidence of physical damage is not always present in lightning fires. Lightning fires may, however, produce unnatural burn patterns.

Confirm the weather conditions in the fire area prior to and during the time of the fire. A smoldering fire may be hidden for a long period of time after lightning strikes.

### **Rural Area Fires**

This section addresses situations common to rural areas. However, it is not intended to be exclusive of such areas. These situations include barns and storage sheds, grain elevators and silos, and mobile homes, and are sometimes found within urban areas as well.

Rural areas may face an increased possibility of accidental fires because of the lack of fire code enforcement combined with the fact that many fire codes exempt farms from the scope of their coverage.

Many jurisdictions consider farm buildings to be part of the residential curtilage, and therefore no periodic inspections are conducted. This lack of coverage and lack of enforcement may result in failure to correct fire and life safety violations. There is no guidance provided to property owners and little or no "first aid" fire suppression equipment present.

The local fire service response may be delayed due to long distances to the incident scene.

Electrical hazards are an additional accidental fire cause in rural areas. Many property owners extend or modify their electrical service. (These modifications may be done by unqualified repairmen.) They also may result in unqualified electrical repair or alterations.

The improper choice of conductors and/or electrical equipment, or the use of old electrical connectors and appliances result in a mix-and-match service. This can cause overloaded circuits and resistance heating from long wiring runs. It also is possible to have improper grounding or lack of grounding in the circuits.

The system may have unsound mechanical support or unsound electrical components and wiring and a lack of anchoring or bracing. Also present may be worn or damaged insulation on wiring which has been used several times. The wiring may have improper circuit overload protection or lack of circuit protection. Wiring also may be exposed to the travel of humans, animals, or equipment.

### Spontaneous Heating

Detection of spontaneous heating as an accidental fire cause in rural areas follows the same guidelines that were covered earlier in this unit. The prime consideration when spontaneous heating is suspected is to ask whether or not the stored material is susceptible to spontaneous heating.

Examples of typical farm materials that may cause burning due to spontaneous heating:

- various feeds;
- various fertilizers;
- hay;
- manure; and
- sawdust.

(For a complete listing refer to NFPA 902M, *Fire Reporting Field Incident Manual, Basic Incident Reporting*. Quincy, MA: National Fire Protection Association, 1988.)

### Animals

Presence of animals at accidental fires should be noted. Animals can cause accidental fires when they are housed in areas containing electrical wiring or appliances, or areas containing open flames or heating equipment.

### Age and Condition

The age and condition of the rural structure may increase the spread of and the damage caused by a fire. The age and condition of a structure may not increase the chances of a fire starting, but these factors may increase the spread and damage of a fire due to the rough finish of materials and the extreme dryness of the combustible structural elements.

### Storage in the Structure

Storage in the structure may affect the start and severity of accidental fires. The improper storage of combustible materials and poor housekeeping in the structure all increase the risk of fire. Frequently flammable liquids are stored in nonapproved containers, such as lightweight plastic, glass, or metal. The problem caused by these types of containers is compounded by the dispensing of the fuel without proper static electrical bonding into open containers.

Leakage from these improper containers may be due to age or condition. This leakage is likely to go unnoticed for long periods of time, and can result in combustible building components absorbing large quantities of the flammable liquids.

### Low-Temperature Ignition

Low-temperature ignition most likely will occur in remote areas of the structure near heating equipment or other sources of heat such as lighting equipment.

Friction from equipment that is exposed frequently to the extremes of weather may produce excessive heat. This may be caused by insufficient lubrication, or drive belts and drive mechanisms in contact with combustible materials.

### Lightning

Rural structures may not be protected from lightning with lightning rods. When lightning is suspected, consider the height of the structure in relation to the surrounding area.

### Grass and Woods Fires

The exposure of rural buildings to grass or woods fires is frequent and may be an increased risk. The reason for this is that farm buildings frequently do not have a cleared area around the outside of the structure.

### Barn and Shed Fires

Often barn and shed fires have numerous accidental causes. If electrical malfunctions are suspected, retrace electrical circuits and check circuit protective devices.

If flammable liquids are suspected, search for storage containers and identify possible ignition sources. Also examine the spill or leak area.

If spontaneous heating is suspected, check for materials charred throughout their mass or for deep-seated fire. Also confirm that the suspected material is likely to heat spontaneously. Determine the time the material has been stored and the drying time prior to storage.

If friction is suspected, check for frozen motor shafts or drive belts that are burned on the inside surface.

If lightning is suspected, check for physical damage and check weather records for lightning.

Incendiary barn fires often are set using available fuels and materials. They may be set inside or outside the barn or shed.

### Manufactured Housing (MH) Fires

Between 12,000 and 15,000 MH fires occur each year, and many of these mobile homes are located in rural areas. MH fires present significant problems for the first responder. There may be a lack of first-aid fire suppression, or a long response time.

The building components used in older MH aid in the spread of fire. Fire deaths in MH occur at twice the rate of fire deaths in one- or two-family homes of ordinary construction. The very young (1 to 4 years old) account for more than 25 percent of all MH deaths.

An indepth investigation is required in MH fires to find the fire origin and cause, the development of the fire, and the spread of the fire.

### Grain Elevators and Silos

These types of structures burn for the same reasons as other rural structures. (See sections of this unit on barn and shed fires for flammable liquids, lightning, spontaneous heating, friction, and electrical malfunctions.)

Grain elevators usually contain conveyor or belt-driven equipment. One should check for signs of frozen motors, shafts, and drives. Examine the inside surface of belts for signs of heat damage, and check maintenance records and the last date of lubrication.

Dust explosions can cause significant damage without fire. Check for possible ignition sources such as motors or other electrical equipment. Also check for reports of excessive dust prior to the explosion.

The primary motive for incendiary commercial grain elevator and silo fires is fraud. They are frequently used to conceal shortages or improper records and receipts.

### Outside Storage

Outside storage of flammable and combustible liquids does cause accidental fires. Always check the circumstances of the use and storage of the liquids. Also check for improper grounding or lack of grounding as well as leakage of the product.

## **Wildland Fires**

Wildland and open land fires are not restricted to rural and remote areas. Many large cities have open wooded areas subject to wildland fires of both accidental and incendiary origin.

The most common accidental causes of wildland fires are listed below.

### Lightning

In some areas lightning is a major cause of wildland fires. Lightning usually is violent, and causes obvious physical damage such as the splitting of trees and poles.

Often this damage is due to an electrical charge converting the internal moisture in the object to steam. The resulting pressure buildup then causes splitting of the object. Lightning may strike power or phone lines and cause overloading of protective devices.

Lightning may also "run" along fences and cause fires a long distance from the point of the lightning strike. Lightning also may strike the ground directly, leaving little physical damage as evidence of the strike.

### Spontaneous Heating

Spontaneous heating in wildland fires requires special conditions and is considered rare as a wildland fire cause.

### Other Causes

Sunlight can cause wildland fires, but special conditions are required. It is possible for magnifying glasses, mirrors, and liquid-filled containers to concentrate rays of sunlight. The spherical concave bottom of aerosol cans can produce concentration of sunlight, as well.

Falling rocks have caused sparks and fires, but this is extremely rare.

Campfires left unextinguished or unattended may smolder for long periods of time. This occurs even when they have been covered with dirt. The fire may travel through underground combustibles and then break into flames at a point somewhat remote from the original fire site.



Improperly discarded cigarettes or other forms of burning or smoking materials can cause fires, but too often they are used as probable cause when the actual cause cannot be identified.

Burning carbon particles thrown from the exhaust of vehicles, heated vehicle parts, broken brake shoes from trains and large trucks, and broken clutch and drive parts have been documented as the cause of wildland fires.

Wildland fires also have started accidentally when fire spreads from nearby structures or vehicles. This has occurred during vehicle accidents and train wrecks. Fires have started from contact of combustibles with an overheated vehicle engine, drive train, or catalytic converter.

Controlled burning of trash and the burning or "greening" of farmlands is also a cause of fire. People have used fire in an attempt to destroy pests; however, this usually does not work.

Embers and sparks escaping from residential structures along with wildland activities like lumber cutting and land clearing also have been identified as wildland fire sources.

Downed or damaged power lines cause electrical shorts and sparks with temperatures ranging from 2,000°F (1,093°C) to 7,000°F (3,871°C). This may occur overhead or at ground level and cause fires during high wind conditions.

Sparks, shells, or projectiles from firearms also can cause fires.

### Incendiarism

Incendiary wildland fires are very common. Many devices used to set structure fires also are employed to start wildland fires. Matches, lighters, and cigarettes are frequently used, singularly or in combination, as an incendiary device.

A cigarette in a matchbook is a simple but effective incendiary device, and can create a time delay of 5 to 15 minutes.

Motives in incendiary wildland fires may be difficult to identify since many wildland fires are started out of boredom or vandalism.

### Wildland Fire Characteristics

Wildland fire characteristics follow the normal rules of wildland fire growth and travel. A wildland fire uninfluenced by strong wind will burn uphill in a fan-shaped pattern.

On level ground, in the absence of wind, the fire will spread from the center in all directions, but its spread will be inhibited by the wind it creates, blowing into the base of the fire from all directions. Such a fire will spread very slowly.

Ambient winds will modify the pattern by adding an additional spreading component, so that the fan-shaped pattern on the hillside will deflect to one direction or the other, and the predominant direction of travel will be created on level ground.

In the uncommon circumstance of a strong downhill wind, the fire will burn down the hill only to the degree that the ambient wind can overcome the fire's own tendency to burn uphill.

In a fire having an extended perimeter, the direction of burning may vary locally in almost any direction, depending on the interdependence of the terrain, the air currents created by the fire itself, and the ambient wind.

Wildland fire travel is controlled by weather, fuels, and topography.

In the investigation of wildland fires, no one item will indicate a point of origin. Several areas must be traced back to find the point of origin.

### Indications of Path of Fire Travel

- Flames will wrap around trees and posts.
- Fire moves faster uphill than when on level ground or when burning downhill. If the fire burns uphill, the bottom of the char pattern is usually steeper than on the uphill ground slope. If the fire is burning downhill, the bottom of the char pattern is usually parallel to the slope.
- More crown fires burn when the fire travels uphill in a wooded area.

- More grass stubble will remain if the fire travels uphill. Grass will be burned closer to the ground if the fire travels downhill, or burns on level ground.
- Pine cones and other loose fuel may ignite and roll downhill, starting new fires in the unburned fuel. These fires will then burn uphill.

### Wind-Driven Fires

Wind-driven fires may rush through smaller fuels and the flames may wrap around trees. Wind-driven fires also may leave more stubble in the grass. To determine the direction of travel in a grass fire, rub your bare hand over grass stubble. The grass will feel smooth in one direction and feel sharp and pointed in the opposite direction. The sharp side points in the direction of fire spread. Points will be felt when moving your hand toward the direction from which the fire originated.

Fire backing into a wind will produce the same indicators as a fire burning downhill. The char patterns will be parallel to the ground and there will be short grass stubble.

Burned objects in the path of the fire are charred and weakened on the side that the fire came from. Unburned grass stems will fall toward the weakened side, which will be toward the point of origin of the fire. Remember, you must allow for the effect of wind on the fire. Other indicators to remember include

- Noncombustible objects will char or discolor (rocks, etc.).
- Grass or twigs may not burn when protected from the fire's advance by rocks or other objects.

Trees and brush near the point of origin may not develop crown fires or extensive fire damage. This is because the fire usually does not produce sufficient heat during its early stages. The crowns may burn only in part and leave the unburned portion on the side nearest the point of origin.

### Effects of Wind and Terrain

Effects of wind and terrain vary with the wind direction and speed. Smoke, heat, and flying brands may change direction when rising through different levels of air movement causing fire travel to appear unnatural. Check the local weather bureau records and the general aviation weather records for information.

Effects of terrain also must be considered. Fire moving up a canyon may change direction at the ridge line. Canyon winds will change speed and direction as the fire temperatures change.

To determine the fire origin and cause, the first responder must look for the following evidence:

- human or animal travel in the area;
- haste in leaving the area:
  - articles left at the scene,
  - trash,
  - personal items, or
  - "scratch marks" or spinning of vehicles' tires when leaving the area;
- humans using the area:
  - campfires,
  - cleared areas for tents or camping equipment,
  - discarded cigarette and/or matches,
  - food, or
  - human waste;
- accidental fire cause:
  - remains of cigarettes or matches, or
  - campfires very near the point of origin.

Consider exceptions such as high winds or underground fire spread.
- damage from lightning:

Lightning may have contacted a fence or rail at a location remote from the point of origin and then caused the fire when the electric charge left the rail or fence; and
- burning materials thrown a long distance or spread over a wide area.

### Sparks from Vehicles or Power Equipment

Carbon particles sometimes can be located by using a strong magnet. Particles of heated brake shoes or clutch assemblies may be discovered.

### Evidence of Attempts to Extinguish the Fire

- dirt or sand poured over burned materials;
- discharged fire extinguisher compounds;
- pull ring from extinguisher handle; or
- evidence of firearms:
  - spent shell casings or shell wadding, or
  - recovered projectiles.

### Electrical Shorts

- May be at ground level or in crowns of trees.
- Overhead wires do not have to break to cause fires.
- Strong winds can cause wires to come in close proximity or touch, causing sparks to scatter over a large area.

### Evidence of Incendiarism

The remains of incendiary devices in wildland fires may be the same as those used in structural fires. Common flame producers are the most often used device. The incendiarism is based on the intent of the suspect. The device may be as simple as a match, which may be dropped away from the point of origin.

A cigarette also may be used as a device. The evidence of incendiarism may be based on the arrangement of fuel, indicating preparations for burning, or multiple points of origin which can be proved to be different fires.

Evidence of accelerants also can be used in proving incendiarism.

The first responder must be able to prove that the fire could not have started from accidental causes. This is similar to the investigation of structural fires of incendiary cause.

A followup investigation in wildland area fires usually does not have as many people present (witnesses) as do structure fires. The fire crews should be trained to make special notes or records of their observations.

They should record the make of vehicles and tag numbers, if possible, of vehicles passed while en route to the scene of the fire. Also, a record should be made of the make and tag numbers of vehicles parked in the area. The people present in the fire area, bystanders and volunteers, all should be noted.

Open, closed, locked, or unlocked gates, along with tire tracks should be recorded. Use care to avoid destroying tire tracks. Also record the people known to have been in the area, and businesses such as timber company crews.

Campers and hikers may be identified from records and guest registers at park entrances, motels, hotels, area service stations, or visitor supply stores.

### **Sunlight**

The sun's rays can be concentrated by various methods to produce the ignition temperatures of common combustible materials. Many items and articles have been reported to have been involved in such fires.

For example, common articles such as fish bowls, shaving mirrors, makeup mirrors, the rounded bottom of aerosol cans, defective window glass, magnifying glasses, eye glasses, and even decorative prisms have caused accidental fires.

### **Chemical Spills**

Accidental chemical spills also have been reported as fire causes. Oxidizing agents that come into contact with reducing agents may produce heat and fire. Swimming pool chlorine contaminated with brake fluid has caused several garage fires. The contamination of chemicals may produce sufficient heat to cause autoignition or ignition of nearby combustibles.

### **Christmas Trees**

Christmas trees are another deadly type of fire. They are often left in the home until they have almost completely dried out. When ignited, they produce very intense burning. The trees often are ignited by faulty Christmas tree lights. Many times it is difficult to determine the actual heat source involved in ignition, but the area of origin around the tree will be very distinctive in appearance.

Candles are another leading cause of fires, especially during holiday seasons. Candles are used as part of many holiday observances, and often they are used near trees and plants, or left to burn on tables.

In addition, candles appear to be more prevalent at social gatherings during this time of the year, and are often left unextinguished when the host or hostess retire for the night. As the candles burn down, they may ignite combustibles or the furniture on which the candles are placed.

## **INCENDIARY STRUCTURE FIRES**

### **Multiple Fires**

If, during the course of conducting fire suppression and overhaul activities, the first responder discovers more than one point of origin, it must be proved that each fire is independent of the other. The first responder must be able to show that a single fire did not transmit heat through any of the three methods of heat transfer: convection, conduction, or radiation.

The accused may claim that the fire was accidental, and the appearance of multiple points of origin was due to:

- normal heat transfer;
- flashover of the involved area; or
- burning fuels dropping down to start additional fires.

### **Trailers**

The working definition of a trailer is, "Any combustible or flammable material used to spread fire from one point or area to another."

Trailers usually leave char or burn pattern on surfaces where used:

- floors;
- carpets;
- steps; or
- through doors, windows, or wall openings (may be existing openings or openings made for fire spread).

Some of the more common materials used to make trailers are:

- newspapers that can be flat, rolled, or bunched;
- rope, string, twine, etc;
- fuse cord, which may produce a skip char pattern or may leave an asphalt-like residue;
- clothing, bedclothes, drapes, other household materials;
- waxed paper or tissue paper;
- Bounce™ fabric softener; or
- flammable accelerants, such as:
  - gasoline,
  - kerosene,
  - alcohol, which can be either scented or unscented (alcohol can be difficult to detect because of the speed at which it evaporates and its almost total consumption in the fire),
  - charcoal or cigarette lighter fluid, or
  - any other common and/or readily available flammable liquid fuel.

Building contents may be arranged to form a trailer, and although this is rare in residences, it may be prevalent in warehouses and storage areas. Often this type of trailer is used in conjunction with incendiary devices such as candles.

### **Presence of Flammable Liquids**

When accelerants are found in areas where they would not normally be in a given occupancy, the firefighter/officer must determine the reason that the accelerants are present. Once it can be established that the presence of these accelerants was not caused by the actions of the owner/occupant, the firefighter can proceed with the investigation, using this information as an indicator that the accelerants were introduced by another person, and that this fire may be incendiary in cause.



Remember, flammable liquids may be common to some occupancies or to certain areas within the occupancy, such as garages, basements, storerooms, or storage sheds.

### Probable Cause

When the presence of accelerants is detected in a fire, some indicators of incendiarism are

- When the accelerant is found throughout an area, and is not caused by explosion or due to container leakage.
- When the accelerant is found above the floor area, and is not caused by an explosion.
- When the accelerant is found on or in furniture, drawers, cabinets, boxes, files, desks, books, etc.

### Indicators

Common indicators which may assist the first responder in determining the presence or use of some flammable/combustible liquid accelerants (fuel) include the charring of floor surfaces. Normally, most accidental structural fires produce very little floor charring. Temperatures at floor level are usually below ignition temperature in most fires.

"V" burns or grooves between floor boards may indicate the presence of a liquid fuel. Flammable liquids may soak between floor boards, burn, and develop small, sharp "V" patterns between the edges of floor boards.

Flammable liquids may run through the flooring. When this occurs, it can produce burning under the floor. The firefighter must be able to show that the charring did not come from below the floor, but rather from above.

Evidence (residue) may be recovered from between the floor and the subfloor. Examine the area beneath the floor for accelerant residue. The flammable liquids will drip down and be absorbed into these areas and become excellent sources for undisturbed accelerant samples.

Flammable liquids will settle to the lowest parts of the floor area. These areas will include corners of rooms, along the base of walls, and areas of heavy occupant travel, such as doorways. Also, look in areas of heavy occupant use, such as in front of the kitchen sink, stove, or refrigerator.

Accelerants will produce charring in puddles or running patterns. They may also splash on doors and walls, giving the appearance of small black spots.

Flammable liquids may soak into any absorbent material. One good example of this is carpeting, where the liquid may leave a distinct pattern. Accelerant residue may be located in the carpet and/or pad, on the edge of the burned area, or in the remaining charred pad.

Floor-length drapes act like wicks, absorbing poured or spilled flammable liquids. These may be excellent sources for samples of accelerant residue.

Any other absorbent material, such as plaster walls or dry wall, also may contain accelerant residue.

An area may require cleaning away of debris before a flammable accelerant pattern is discovered. Sweep and rinse the floor, being careful that you do not destroy the evidence that may have collected underneath.

Pouring water onto the floor may indicate the direction of running or settling of the accelerant.

### **Spalling of Concrete or Masonry**

The spalling of concrete or masonry floors may indicate the presence of a flammable accelerant.

Spalling is the result of concrete or masonry being heated and rapidly cooled by water. Spalling also can result from the heating of moisture trapped within the concrete or masonry. This causes the surface to crack and loosen, and can produce a pitted appearance or large craters.

Spalling may indicate the possible use of accelerants; however, this is not a sole indicator. Other factors that may cause spalling include

- the age of the concrete and/or the concrete mixture;
- chemical reaction;
- mechanical breaks; and
- extreme hot or cold temperatures.

## Floor Coverings

Flammable accelerants also will cause blistering and/or destruction of floor tiles or linoleum floor coverings. This type of floor covering may indicate flow patterns and should be examined closely.

Residue samples may be difficult to obtain due to the adhesive back of the tiles. When taking samples of asphalt, vinyl, or linoleum flooring be aware that the cleansing agents used to clean the floor may be identified in laboratory analysis.

## Building Contents

Flammable liquids may produce unusual burning of contents and/or building components. Burning of the bottom surface of doors is often an indicator of the presence of flammable liquids at floor level.

Burning of the floor surface along its edge, or at points of contact with walls, may be due to the presence of flammable accelerants. Corners and wall-to-floor edges may be dead air spaces, which suffer little, if any, fire damage unless flammable accelerants are present. These flammable liquids may carry flames behind baseboards or molding. Moldings should be removed and their backs be examined. If fire damage is observed on the protected area of the wall, or the backside of the baseboard or molding, there is a strong possibility that a flammable accelerant was present.

The charring of the undersides of furniture usually indicates that the fire burned at some level below the surface being examined (i.e., the fire was burning below the furniture). This may be due to a flammable accelerant used in the area, but it can be misleading because of the various types of foam padding.

## Flashbacks

Firefighters may have witnessed "flashbacks" in areas saturated with flammable accelerants. This occurrence may be the result of vapors from the flammable accelerant reigniting from accelerated temperatures resulting from the fire.

## Char Pattern

Misconceptions about char. The appearance of the char and cracks has been given meaning by the fire investigation community beyond what has been substantiated by controlled experimentation. It has been widely stated that the presence of large shiny blisters (alligator char) is proof that a liquid accelerant was present during the fire. This is a misconception. These types of blisters can be found in many different types of fires. There is no justification that the appearance of large, curved blisters is an exclusive indicator of an accelerated fire.

It is sometimes claimed that the surface appearance of the char, such as dullness, shininess, or colors, has some relation to the use of a hydrocarbon accelerant. There is no scientific evidence of such a correlation, and the investigator is advised not to claim indications of accelerant on the basis of the appearance of the char alone.

Burning in a downward direction is considered unnatural, and may have been caused when flammable liquids ran and carried flames downward. Flammable liquids may soak into floors and cause holes to be burned through the flooring. Holes produced by flammable accelerants on floor surfaces are often irregularly shaped and may even follow the direction of flooring joints.

Flammable liquid accelerants may produce a "flashover" appearance to the involved area; however, the floor surface usually is burned unevenly when a flammable accelerant is used, and usually burned evenly if the damage is due to flashover.

## Containers

The discovery of flammable liquid containers in or around the fire may be a good indicator that a flammable accelerant is present. Liquid containers should be retained as evidence for laboratory analysis. In addition, it is possible that qualified persons may be able to obtain latent fingerprints from the container. If plastic containers (e.g., milk containers) were used to carry the accelerant into the scene, they may be totally consumed in the ensuing fire.

## Odors

Prior to the donning of SCBAs, firefighters may have detected flammable liquid odors, so make sure fire personnel are interviewed. Odors often remain after extinguishment, and these odors may be detected during an overhaul operation.

## Residue

Residue (evidence) should be collected as soon as possible. Many flammable accelerants evaporate rapidly, and any delay may result in the loss of opportunity for collecting positive samples.

Flammable liquids may leave an oily surface on water or other contents. One should look for this and obtain samples from the oily surface on the water.

Residue of flammable liquids may be detected by the use of ultraviolet light and may aid in identifying the possible location of samples.

A flammable vapor detector (hydrocarbon detector, snifter, etc.) may assist the firefighter in detecting residue of flammable accelerants. This instrument measures vapors of accelerant residue in parts-per-million, and is used as an aid to the firefighter to assist in determining the presence and/or location of an accelerant. A vapor detector will not identify the flammable accelerant, and its findings should never be testified to in a court of law. This instrument is merely a "tool of the trade."

Indicators of flammable liquids which may have been involved during the early stages of a fire are the color of smoke and the color of flame. But, caution must be exercised, as the contents of the fire area can also give what appear to be flammable liquid presence indicators.

## **Eliminate All Accidental Causes**

Prior to the determination that a fire was incendiary in cause, all possible accidental causes for that fire must be eliminated. Even though the fire may be remote from such appliances as the electric distribution panel, water heater, or furnace, each of these appliances must be examined and eliminated as a possible fire cause. (Photographs will help verify this in later court proceedings.) Very detailed notes are required indicating that all internal systems were examined and eliminated as a fire cause. This also will help to support evidence of incendiarism. Due to a lack of

understanding on the part of both the judge and jury, it may be difficult to prove incendiarism to the satisfaction of the court unless you can show you have eliminated all accidental causes.

### **Structural Damage Prior to Fire**

Holes may have been cut into walls, floors, or ceilings to allow the fire to spread into structural areas or from one area to another. (Damage could be accidental or due to poor upkeep of the building.) Make sure the damage was not the result of overhaul or fire suppression activity.

## **EQUIPMENT AND APPLIANCES**

Common household, commercial, and/or industrial equipment or appliances are frequently used as incendiary devices:

- Heating equipment--space heaters, wood burning stoves, fireplaces, furnaces, water heaters, etc. Investigative examination should include checking the control settings. Make sure the appliance was turned on, plugged in, or operating at the time of the fire. Look for tool marks on the fuel lines or evidence of tampering with fuel supply lines, wiring, etc.
- Cooking equipment--toasters, coffeemakers, toaster ovens, etc. Many fires have been caused when a pan of oil/grease was left on the stove. Were they accidental? Examine the appliances for evidence of tampering.
- Lighting equipment--clothes draped over lamps or high-intensity lamps. Check for tampering with the lamps. Be sure to examine the entire branch circuit. Look for evidence of lighting equipment in unnatural places, and check for evidence of combustible fuel having been arranged nearby.
- Small appliances or equipment--irons, hair dryers, curling irons, etc. Determine whether the appliance or equipment is being used in an unnatural location or during an unusual time. Examine the appliance or equipment for tampering or modifications.
- Cigarettes--may be used as a time-delay device. (This will be discussed later in this unit of study.) When cigarettes are used as an ignition device, it is often difficult to prove intent.

## **REMOVAL OR SUBSTITUTION OF CONTENTS**

Expensive or antique objects, or objects of sentimental value may be removed prior to an arsonist setting a fire.

Some examples of items to look for are:

- wedding or family photo albums;
- coin or stamp collections;
- jewelry;
- rifles and/or handguns;
- paintings or other pieces of art;
- tools;
- sports memorabilia (baseball cards, hockey sticks, etc.); and
- televisions, VCRs, CD players, etc.

Neighbors also may be able to identify whether objects are missing.

### **Substitution of Contents**

Prior to a fire the owner may remove usable contents and replace them with junk furnishings. An arsonist hopes the firefighter will not be able to identify the quality of contents, or thinks that they will be totally destroyed by the fire. Again, neighbors may have witnessed the exchange of contents or the presence of a truck or trailer. The source of junk contents may be identified by checking used furniture stores, Goodwill stores, and Salvation Army stores.

### **Contents Out of Place or Not Assembled**

The owner/occupant may stack or pile combustible contents to provide fuel for the fire. Used or junk furniture may be brought into the structure, but left unassembled.

Locking plates from beds should show locking surfaces clear of smoke stains and/or heat damage if the units were assembled at the time of fire. Drawers, when in the closed position, usually burn late in the fire.

Evidence of empty storage containers, such as boxes, drawers, etc., are unusual and suspicious.

Again, the arsonist believes evidence will be destroyed in the fire. However, if the first responder is observant enough, the evidence usually can be located.

### **Removal of Major Appliances**

Major cost items may be removed and substituted items may or may not be used.

- Substitute appliances may not be connected to power outlets or fuel lines.
- Substitute appliances may be empty, in bad repair, or in bad physical condition.
- Substitute appliances may not fit the area of installation.

Examine the floor or cabinet cut-out area for indications that the unit does not fit. Check for indentations of the leveling screws of leg buttons in the floor covering.

### **ABSENCE OF PERSONAL ITEMS OR IMPORTANT PAPERS**

Most homes and businesses contain personal items. Absence of personal items may indicate that only basic contents were left to burn.

Examples of personal items frequently removed prior to a set fire in business, commercial, or industrial occupancies include handtools, portable power tools, work clothing (uniforms), business machines (typewriter, checkwriter, calculators, computer equipment, etc.), guns, or petty cash.

In residential occupancies, items that may be removed will include expensive clothing, jewelry, family photographs, family records (birth certificates, family Bible, etc.), hobby equipment, guns, fishing or other sports equipment, tools, etc.

Important papers frequently removed prior to a set fire are checking and/or savings account books, titles and deeds, school records, wills, marriage and church records, and insurance policies. Some people continue to believe that it is necessary to have their copy of an insurance policy in order to collect on that policy.



## **LOCATION OF FIRE**

Unusual locations of where the fire occurred should arouse suspicions with the firefighter. Unusual locations are listed as areas with no identifiable heat source, such as bathrooms, closets, crawl spaces, or under porches.

## **EVIDENCE OF CRIMES**

Fire may have been set to cover up other crimes. Frequently, fires are set to cover such crimes as murder, burglary, embezzlement, tax fraud, etc. Keep in mind that another crime could have been staged to help explain the set fire. This is a situation where the owner/occupant will need to be thoroughly investigated.

There are also times when a fire is made to look accidental, when in fact, it was intentionally set. This may be the case when suicide is involved.

## **UNNATURAL FIRE SPREAD**

Unnatural fire spread may be caused by the presence of some accelerant. What appears to be unnatural fire spread by itself proves nothing.

Questions that the first responder should ask are

- Was the fire damage increased due to the presence of an accelerant?
- Was the fire damage excessive compared to similar fires in similar occupancies? The answer to this question is based upon your prior experiences, and will require extensive scene examination.

Evidence of extreme heat may be unnatural and may be due to the presence of an accelerant.

Structural fires may produce extreme temperatures (up to or above 1,900°F (1,037°C)). These temperatures are usually attained during the later stages of the fire or when the structure is fully involved.

During the earlier stages of the fire, and at the lower levels within the structure, temperatures may not exceed 1,400°F (760°C) to 1,600°F (871°C).

The melting of metals within the structure may indicate an extremely hot fire. Below is a list of common metals and their approximate melting temperatures.

| <b>Approximate Melting Temperatures<br/>NFPA 921</b> |                    |          |
|--|--------------------|----------|
| <b>Metal</b>   | <b>Temperature</b> |          |
|  | <b>F</b>           | <b>C</b> |
| Solder   | 361°               | 183°     |
| Tin  | 449°               | 232°     |
| Lead   | 618°               | 326°     |
| Zinc   | 878°               | 470°     |
| Magnesium  | 1,202°             | 650°     |
| Aluminum   | 1,220°             | 660°     |
| Silver   | 1,761°             | 960°     |
| Gold   | 1,945°             | 1,063°   |
| Copper   | 1,981°             | 1,082°   |
| Iron   | 2,781°             | 1,527°   |
| Chromium   | 3,407°             | 1,875°   |

The melting of aluminum in a structure may indicate several things:

- The discovery of an aluminum storm window frame which melted during the fire might not indicate excessive heat if the fire vented through that window opening. Additionally, since the upper portion of the window frame extends into the upper portion of the involved room, one could expect the aluminum frame to melt.
- Finding the aluminum threshold of a doorway melted could indicate excessive heat, since the floor surface generally stays much cooler than the upper portions of an involved room. This also may indicate the possible use of an accelerant. Samples should be taken.

Occasionally chromium or other shiny metal surfaces may become discolored due to exposure to extreme heat. After the fire, these surfaces may retain this discoloration as an indicator of the presence of extreme heat.

Take into consideration the extent to which an object has been affected and the level (height) at which the object was located.

The following list contains the approximate temperatures needed to cause metals to change color. This list should be used only as a guide, and not to determine actual temperatures.

| <b>NFPA 921</b> |          |          |
|-----------------|----------|----------|
|                 | <b>F</b> | <b>C</b> |
| Yellow          | 450°     | 232°     |
| Brown to purple | 550°     | 287°     |
| Blue            | 600°     | 315°     |
| Faint red       | 900°     | 482°     |
| Dark cherry     | 1,100°   | 593°     |
| Full cherry     | 1,400°   | 760°     |
| Salmon          | 1,600°   | 871°     |
| Lemon           | 1,800°   | 982°     |
| White           | 2,000°   | 1,093°   |
| Sparkling white | 2,400°   | 1,315°   |

### **LIMITED ENTRY OR VIEW**

Firefighters have been known to encounter attempts by arsonists to block access to the fire scene, or block entry to a structure. (The firefighter must be able to prove that the blocking was done prior to the fire in order to slow entry or extinguishment.) A few of the more common methods used by arsonists to block access to the fire scene include:

- trees, limbs, or brush across the roadway or driveway;
- piling of snow across access roads or driveways;
- setting the fire during inclement weather, such as snow or ice storms, so as to delay the fire department's arrival;
- damaging threads on fire hydrants, standpipe connections, and sprinkler connections;
- inserting objects into fire hydrants, standpipe connections, or sprinkler connections;
- removing door hardware (handles or knobs);
- doors and/or windows nailed, bolted, or wired shut; and
- moving contents to block doors or windows.

Occasionally the view into the structure will be blocked or obscured to delay detection of the fire. Windows can be covered with paper or window-cleaning wax, or boxes can be stacked in front of windows.

## **OTHER CONSIDERATIONS**

### **Occupant Injury**

Sometimes the flash of flammable vapors from accelerants, while being spread throughout a structure, may cause burn injury to the arsonist. These injuries may involve only the arms, hands, and/or face; at times they may be severe. If you converse with the owners/occupants, examine them for indications of singed eyebrows, facial hair, hair on their head, arms, and hands. Look for reddening of the face, arms, or hands, similar to first-degree burns. Be sure to verify their story of how they sustained the injury.

### **Time Periods**

As part of the investigation, ascertain the time period between the discovery of the fire and when the last occupant was present in the structure or at the scene. One question that should be addressed during the examination of any fire scene is whether the time factors in this incident are reasonable, appropriate, or believable.

### **Previous Fires**

A second fire in the same structure over a short period of time may indicate incendiarism. This is not an absolute, as people may experience more than one accidental fire in their lifetime. However, the circumstances of each previous fire should become a part of the investigation. The first fire may have been an unsuccessful arson attempt, or even may not have been reported.

The second fire may involve large quantities of flammable accelerants; it also could result in injuries to the firesetter.

The occupant may have obtained junk furnishings to fill the structure. Such furnishings may be damaged, obsolete, or even fire damaged. The occupant believes the fire will destroy such furnishings.

### **Fuel Near the Point of Origin**

Readily available kindling fuels, such as newspapers, may be placed at or near the points of origin. Questioning the owner/occupant should address the reasons for such fuel placement.

Interviews with other family members or neighbors may assist in confirming that these fuels were always in that location, or whether this was an isolated incident.

## **TIMING OF INCENDIARY FIRES**

### **Fires on Holidays or Weekends**

Commercial or industrial complex fires that occur during holidays, weekends, or annual vacation periods may be an indicator of incendiarism. Holiday and/or weekend fires provide the arsonist with the necessary setup time while the workers are away. This also reduces the chance of injury to any employees. In addition, fires during these times help provide an alibi for the arsonist, who may claim he/she was out of town. Also, there will be fewer witnesses in the area, which allows a delayed detection and a longer burn time. Ascertain whether a security guard was on duty, and interview this person.

### **Time of Day**

Determine if the fire cause and/or the occupant's explanation of the fire fit with the time of the fire.

Time-dependant types of fires include

- Kitchen fires (e.g., food on the stove) at odd times may or may not be an indication of incendiarism.
- Sofa fires (cigarette dropped into a sofa) during daytime hours. Sofa or furniture fires caused by cigarettes are often discovered early in the fire's progress if occupants are in the area.

### **Convenient Ignition Source**

Many appliances, which at one time may have had a history of causing fires, are often used as "invented" fire causes in an attempt to cover incendiarism.

Remember, the possibility of an accidental fire does exist. Examine the appliance for evidence of tampering; also check for indicators of a flammable liquid having been introduced to the area.

### **Fires During Renovations and Remodeling**

Accidental fires do occur due to various situations associated with renovations and/or remodeling.

Indicators of an accidental fire during renovation or remodeling are poor housekeeping, temporary electrical wiring, or the presence of flammable liquids

Incendiary fires occur when the owner of the structure may decide to sell the property to the insurance company because the structure was in worse condition than originally believed, the would-be renovator found the job to be too much for him/her, or money ran out before the job was completed.

### **Weather**

The arsonist may believe lightning is a convenient "cover" for the set fire. A telephone call to the local weather bureau can confirm--or eliminate--this possibility. Talk with other residents of the area to verify that an electrical storm occurred.

Snow or ice storms will delay fire department response, allowing longer burn time for the fire and causing increased damage or total destruction.

### **Activities of the Owner/Occupant**

Witnesses or neighbors may report conditions or activities by the owner/occupant which may indicate possible incendiarism.

Conversations may bring forth information on fights or arguments in the neighborhood or between members of the occupant family. A truck or other vehicle may have been seen at the involved property, and the owner/occupant observed removing items prior to the fire.

### **Statements of Owner/Occupant**

When conversing with the owner/occupant, be aware of complaints about the economic conditions, or the neighborhood declining.

Be cognizant of remarks about domestic or marital problems or pending separation/divorce proceedings. One spouse may not want the other to gain possession of the house.

Problems with neighbors may be a motive for the fire. It is possible that the property will not sell, but the owner/occupant feels he/she no longer can reside by the "bickering" neighbor.

## **INCENDIARY DEVICES**

An incendiary device is any mechanical, electrical, or chemical device used to initiate combustion intentionally.

A delay mechanism is comprised of chemical, electrical, or mechanical elements that provide a time delay. These elements may be used singly or in combinations.

Incendiary materials are materials that burn with a hot flame for a period of time. Their usual purpose is to set fire to other materials or structures.

Incendiary devices often are constructed from readily available materials. When used separately, individual materials may be harmless. These materials may be found in everyday use or be normal to a given occupancy. Remember, an incendiary device is only as effective as the individual constructing it.

### **Electrical Incendiary Devices**

Almost any electrical equipment or appliance may be used as part of an incendiary device. The intent of using electrical devices is to:

- produce a spark;
- produce heat; or
- activate some other device, such as a timer mechanism.

Electrical incendiary devices also may be classified by the action of another device. A dry-cell battery could be used to heat a coil which would ignite nearby chemicals. This device could be classified as both an electrical device and a chemical device.

Some examples of common electrical devices:

- Light bulbs placed in or on combustibles. (Heat produced by light bulbs depends on design, wattage, position, and color of the bulb.) Remaining evidence that the first responder should look for are light bulbs found in unusual or unnatural locations and charred, combustible fragments adhering to the remains of the bulb.
- Electrical appliances also are used for incendiarism. Heating devices are used commonly. Heating coils or soldering irons placed in or on combustibles will cause ignition. Portable heaters placed near or in combustibles also will initiate combustion.
- Electric clocks, watches, and timers can be connected to blasting caps, which may have an additional electrical power supply. These items also can act as time-delay mechanisms, affording the arsonist an alibi for not being in the area at the time of the fire's inception.

Remaining evidence that can be found includes electric appliances in unusual or unnatural locations or electric appliances used at improper times (e.g., electric heater being used during hot weather).

### **Radio-Controlled Devices**

These devices are designed to operate other incendiary devices, usually from an area remote from the fire. Again, this affords the arsonist the alibi of not being in the area, and also eliminates the possibility of eyewitnesses. Common radio-controlled devices include an electric garage door opener or a controller for model toys.



### Telephone Devices

This is a fairly simple technique where a device may be attached to bell terminals. When a phone call is received, the bell system is activated, which in turn activates the incendiary device. Another method is to attach a piece of sandpaper and/or emery cloth to the bells and a match head to the striker. When the phone rings, the striker rubs the sandpaper igniting the match head.

Discovery of remaining evidence may require detailed examination of the remains of the telephone by an expert or by the telephone company.

### **Mechanical Incendiary Devices**

A clock is probably the most common mechanical incendiary device used by the arsonist. Depending on the type of clock, this device can cause a delay in ignition of up to 24 hours. A string attached to the wind-up key on mechanical clocks can be used to pull over flammable accelerant containers, strike matchheads against an igniter, pull insulating material from between two reactive chemicals, or trip an electric device

Some mechanical devices are designed to activate upon some action by an individual, such as devices wired to doors, etc.

Remaining evidence should include burned clocks with evidence of modifications. Examine the wind-up key for traces of string or twine.

A simple item such as a mousetrap can become a creative incendiary device. This can create ignition by striking, breaking, or making an electrical connection.

### **Chemical Incendiary Devices**

The following is a list of chemical combinations frequently used as incendiary devices:

- granulated sugar and potassium chlorate (ignited by concentrated sulfuric acid);
- granulated sugar and sodium peroxide (ignited by water or sulfuric acid);
- aluminum powder and sodium peroxide (ignited by water or sulfuric acid);
- potassium permanganate (ignited by glycerin);

- silver nitrate and magnesium powder (ignited by water or sulfuric acid);
- white phosphorus (ignited by contact with air); and
- magnesium powder and barium peroxide (ignited by fuse cord or open flame).

### **Common Incendiary Devices**

Many of these devices also can be listed as electrical, chemical, or mechanical incendiary devices.

**Cigarette and match delay.** This device can delay ignition time for 5 to 15 minutes. The delay depends on the length of cigarette, tightness of tobacco, and whether or not the match is fully inserted into the cigarette. Filter-tip cigarettes limit the delay to approximately seven minutes. Matches bundled around the cigarette provide additional fire intensity.

**Highway flares.** The ignition of flares may be delayed by the use of cigarettes, matches, or Jetex™ fuses. (Jetex™ fuses are available at most hobby shops for approximately a dollar.)

Flares may produce temperatures of up to 1,200°F (649°C). They usually will burn for 15 to 30 minutes, and are easily obtainable in most auto parts stores. Flares also are available in various colors, shapes, and sizes.

### **Cocktails and Other Ignition Devices**

**Molotov cocktails.** A standard Molotov cocktail is comprised of a thin-walled bottle filled with gasoline and wicked with a sanitary napkin, rag, or paper towel. The arsonist (bomber) lights the wick and throws the "cocktail" against a hard surface, normally a wall.

Cocktails often fail to operate or function properly because thick glass bottles are used (soda bottles), and do not break on contact; the bottle does not strike a solid target; or the cocktail is thrown too soon and self-extinguishes in flight.

If the wick is not properly secured to the bottle and falls away during flight, small fires may result over a long flight path.

**Highway flares as a cocktail fuse.** With this adaptation of the Molotov cocktail, a standard highway safety flare is taped to a bottle filled with accelerant, the flare is ignited, and the cocktail is thrown.

**Tampon Molotov cocktail.** This device is constructed with a thin-walled glass bottle containing a flammable liquid. The wick is made of a tampon with several wooden strike-anywhere matches wrapped around it and inserted into the neck of the bottle. The bottleneck is scraped across a rough surface and the tampon wick is ignited. This device provides easy wick ignition.

### Thickened Accelerants

**Gasoline and motor oil Molotov cocktail.** Various materials frequently are added to the accelerants to produce a limited spread of the accelerant, and to cause the accelerant to stick to the target.

An example of one type of assembly is mixing an accelerant with heavyweight oil (a 50/50 mixture of heavy oil and gasoline) in a thin-walled bottle. The bottle is shaken prior to wick ignition in order to produce necessary mixing. Any type fuse or wick can be used.

In addition to the increased adhering capability of this mixture, it also produces longer burning time.

**British Molotov cocktails** (sometimes called a chemical Molotov). The bottle is filled with a mix of gasoline and concentrated sulfuric acid. The bottle is capped and may be stored for long periods. (The liquid will turn dark when aged.) A 50/50 mixture of sugar and potassium chlorate is combined with water to form a paste, and a rag is soaked in the paste. The rag is tied around the bottle of the gasoline/acid mixture and allowed to dry. (Note: the potassium chlorate and sugar mixture **does not** go inside the bottle.) The bottle is thrown, and ignition occurs. However, ignition may be delayed after impact while the heat of ignition is produced. This type of cocktail may fail to operate in subfreezing temperatures.

A substitute design for the British Molotov can be made by attaching a mixture of dry sugar and potassium chlorate to the outside of a bottle with a label, and carrying the device in a bag or under a newspaper.

Examine the target area for bottle fragments that may be covered with brown, wet, oily beads of decomposed sulfuric acid. A brown track may be left on the wall; however, if the wall is concrete, there may be a black track.

### **Availability of Plans**

Several publications, such as *The Poor Man's James Bond* and *The Anarchist's Cookbook*, are available which provide details of how to construct these and other various incendiary or explosive devices. Several EOD manuals from the military are also available. Other sources of information are the various mercenary magazines. These books can be obtained easily in college campus bookstores, mail-order companies, and through underground organizations.

## **INCENDIARY VEHICLE FIRES**

### **Probability of Accidental Vehicle Fires**

Vehicle fires can, and do, occur accidentally. Fire causes that can accidentally destroy a vehicle include

- The improper or careless use of smoking materials.
- Leaking flammable/combustible liquids in combination with an ignition source.

Most accidental vehicle fires cause only localized damage, and most total-loss vehicle fires are thought to be of incendiary cause.

Uncertain economic periods affect the number of vehicle fires. When inflation rises, unemployment is high, or variable interest rates soar, the number of incendiary vehicle fires rises.

The ownership of the vehicle also has an effect on the burning of the vehicle. Company-owned (fleet, public, etc.) vehicles seldom are destroyed by fire, while privately owned vehicles do suffer total destruction by fire.

Financed vehicles will fall victim to more incendiary fires than those owned outright. If a person owns two vehicles where one is paid for and one still has payments, the latter is more likely to be the target of an incendiary fire.

Insured vehicles burn, while uninsured vehicles seldom suffer total fire loss. The most common motive for incendiary vehicle fires is insurance fraud. If there is no fire insurance on the vehicle, it makes no sense to burn it.

Fire injuries to the owners/operators may indicate incendiarism. Injuries may have resulted from the splashing back of accelerants as they were being poured into the vehicle, and flashing as the arsonist lit the fire. Stories often are developed by the injured party to cover the incendiarism.

Another indicator that may point to incendiarism is the time of the fire. Most incendiary fires occur at night so the arsonist's actions will be protected by the cover of darkness.

The location of the vehicle can be another indicator of incendiary vehicle fires. Most arson vehicle fires occur in remote areas void of witnesses, such as remote roads, utility company or railroad right-of-ways, vacant lots, or back alleys.

The area of the country may affect the number of total-loss vehicle fires; however, this may be related to the regional standard of living. For example, economic standards may be more important to a person in a highly populated area than that of a person in a farm or rural environment, where status may be less important.

One conclusion to be drawn is that some total-loss vehicle fires do occur from accidental causes, but most total-loss vehicle fires are thought to be of incendiary cause.

## **Indicators of Incendiarism**

### **Incident Scene Examination**

Here we discuss the examination of the scene surrounding the vehicle, and not the vehicle itself. This is an important part of the first responder's initial observations, as indicators of incendiarism may be discovered that soon will be obliterated by fire suppression activities.

### Shoeprints

Shoeprints can place the owner at the incident scene. Identifying the shoeprints as those of the owner/operator may contradict a story that the vehicle was stolen and then burned.

Shoeprints may help to identify accomplices and may indicate direction of departure from the incident scene. This type of evidence is rarely found right around the vehicle, as most shoeprints are destroyed or obliterated by firefighters or fire apparatus.

### Skid Marks

Skid marks or the absence of skid marks are indicators for the first responder. Sudden fire will normally cause panic stops and usually produce skid marks. The lack of skid marks may contradict the driver's story.

### Gas Cap

Search for the gas cap if it missing from the vehicle. If found, note and photograph the location. Examine the cap for evidence of explosion damage if the operator claims the gas cap was "blown off." The discovery of the gas cap may destroy the owner/operator's story or cover.

### Residue

Accelerant residue may be recovered from the soil under or near the vehicle. The floor of the vehicle contains seams and drain plugs, and if an accelerant is poured onto the floor of a vehicle, it often will leak out onto the ground. Spillage from the container also may occur as the arsonist pours or splashes the accelerant in or on the vehicle. Also, an accelerant may be used as a trailer, allowing the arsonist to start the fire some distance away from the vehicle.

### Damage to Area

Damage to the surrounding area should be noted. It may be caused by flammable accelerants on the ground, or by the intense burning of the vehicle.

### Containers

Accelerant containers often are recovered at the incident scene. These containers may be discarded by the arsonist throwing them into nearby cover. Check both sides of the road for several hundreds yards in each direction from the scene. An accelerant container may be thrown from the vehicle used to transport the arsonist after the fire was set. If found, and if the container is not in jeopardy of being destroyed or contaminated, leave the container alone, and protect the area until it can be removed by the appropriate personnel.

### **Examination of Vehicle Interior**

A majority of incendiary vehicle fires are started in the interior, and because of this the first responder must be aware of what indicators to look for. Numerous indicators or pieces of evidence may be discovered when this part of the investigation is conducted properly.

### Containers

Frequently, accelerant container(s) are left inside the vehicle. The arsonist often believes the container will be totally consumed; in some instances, especially if a plastic milk container is used, this may be the case.

Discovery of an accelerant container may help to discredit the alibi or story of the owner/operator. Most accelerant containers will leave some type of evidence.

- If glass jugs are used, search for the neck and/or carrying ring. These are made of thick glass and usually will withstand the high temperatures of a fire.
- If plastic jugs are used, search for melted plastic.
- The accelerant may have been transported in metal cans. If the can was left in the car, it still will be present after fire extinguishment. The container may still contain some accelerant for comparison samples.
- A glass or metal container also may be an excellent source of latent fingerprints that later can help the investigator to identify the firesetter.

A check of local gas stations in the area or near the residence of the owner/ operator may help to identify who purchased the gasoline just prior to the fire, and the attendant may be able to identify the container used.

### Combustibles

Combustibles inside the vehicle often leave little evidence. However, combustibles under seats may survive fire streams, and valuable evidence can be recovered.

### Residue

Accelerant residue may be recovered from a vehicle's interior. Usually it will settle to the lowest level, and may be recovered from floor carpets, in or under floor mats, in metal floor indentations, or around rubber grommets.

The first responder's sense of smell may not be effective in locating flammable accelerant residue. For example, in addition to firefighters wearing SCBAs, gasoline is an integral part of a vehicle and its odor normally will be present around the burned vehicle.

### Ashtrays

Ashtrays should be examined for possible accelerant or other evidence. Evidence of heavy smoking, heavy drinking, or drug usage may be discovered. Poor housekeeping may be evidenced by tissues, candy and/or gum wrappers, etc., being discarded in the ashtray.

The ashtray may contain flammable accelerants as a result of the accelerant being poured or splashed around prior to the fire. It may provide a good source for comparison samples.

An examination of the ashtray may help to disprove the owner/operator's story of a discarded cigarette as the fire cause. An unused ashtray may indicate that the owner does not smoke or allow smoking in the vehicle.



### Seat Cushions

Vehicle seat cushions are made of many types of foam rubber or synthetic materials. These materials often are difficult to ignite without an open flame.

Certain types of foam rubber, polyfoam, or foamed plastics may be ignited readily by an open flame (age and/or cleaning fluids may affect the foam). Once ignited, these materials often produce large amounts of smoke and high heat.

### Springs

Extreme heat is required for loss of spring temper in seats. High temperatures attained may be the result of burning of foam, synthetic cushions, or padding materials. However, these extreme temperatures also may be due to the presence of a flammable accelerant.

Loss of spring temper indicates a hot fire, but does not prove the fire was incendiary. The weight of an individual normally occupying that seat, or the amount of usage of the seat, as in police cars or taxi cabs, can have an influence on the spring temper.

### Windows

Position and/or condition of the vehicle's windows has an influence on the type of interior fire.

Open windows during very cold weather is not normal; nor are closed windows in very hot weather. However, consider the use of air conditioning in hot weather.

The fire may self-extinguish if windows are left closed. Therefore, an arsonist may open vehicle windows to allow an influx of oxygen to feed the fire.

If glass is melted, check the window lift arms to determine the position of the windows at the time of the fire. If the arm is at the bottom of the door, the window was open, and vice versa.

Melted window glass indicates a hot fire, but does not prove the fire was incendiary.

### Doors

The position of the vehicle's doors may be an indicator of incendiarism. Vehicle doors often are left open when the vehicle is intentionally burned to allow oxygen to feed the fire. It also is possible that the fire progression was so rapid the arsonist had no time to close the door.

### Steering Lock

An examination of the steering lock assembly may discredit the owner's story of a stolen vehicle. This may require an expert examination by a locksmith to determine whether the assembly was damaged.

### Extinguishment

Evidence of attempts to extinguish the fire should be noted. Sand, dirt, or extinguishing agents often can be found in the vehicle's interior. This may help to confirm or contradict the owner/operator's story.

### Ignition Key

Examination of debris in the vehicle's interior should include looking for the ignition key. If the key was in the ignition at the time of the fire, it may fall to the floor when the ignition switch melts, and remain embedded in the white metal of the ignition assembly. Even if the key melts from the ignition, a portion of the key still should remain inside the assembly.

Finding a single key is usually not normal, since most people carry more than one key. Quite often, keys are on a metal ring that normally remains intact after a fire.

Always check the floor below the ignition assembly for the remainder of the assembly or the car keys.

### Personal Items

All passengers should be questioned to determine what items, if any, were in the vehicle at the time of the fire. Most items leave some type of evidence of their presence, such as buttons, zippers, or the soles of shoes. Mechanics' tools are never consumed in a vehicle fire and are readily identifiable.

Inventory of the remains of personal items may help to identify a fraud attempt, and evidence (remains) of incendiary devices may be recovered from the vehicle's interior.

### Glove Compartment

Most vehicle owners keep such items as the Owner's Manual, maps, vehicle registration, insurance card, etc., in the glove compartment. An empty glove compartment is usually considered suspicious.

Glove compartments also may contain records of the vehicle's repair history and may help to identify prior mechanical problems as a motive.

### Accessories

When an incendiary vehicle fire occurs, the owner often removes accessories for later use. The owner may wish to give or sell these accessories to accomplices, friends, or relatives at a later time.

Most vehicle accessories do not burn or melt totally, and will leave melted metal in mount holes or brackets. Empty mounting brackets or holes should be considered suspicious.

## **Examination of the Vehicle Exterior**

As with the interior examination, an exterior examination will identify several indicators of incendiarism.

### Roof

At one time, the sagging of the vehicle's roof as a result of an intense fire was thought to indicate an incendiary fire. On newer vehicles, a sagged roof can be the result of the burning of certain types of seat padding. The sagging of the roof should be noted; however, it does not prove the fire was incendiary.

### Multiple Fires

When a vehicle is involved in a fire, it often is difficult to prove that multiple fires occurred. In order to make this determination, the first responder must prove noncommunication among the fires.

### Underside of Vehicle

An arsonist may spray or pour an accelerant on the underside of a vehicle. This usually can be detected by the presence of soot on the undercarriage. However, it must be determined that this soot was not caused by liquids from a leaking fuel line or transmission.

### Collision Damage

Evidence of collision damage to the vehicle may be a strong indicator of incendiarism. The owner/operator may have been involved in a hit-and-run accident, or it may be a teenager attempting to cover up an accident he/she was involved in with the family car.

### Exterior Fire Damage

Flammable accelerants on the exterior of a vehicle may show evidence of running or dripping down the sides of the vehicle.

### Tires

Tires almost never are consumed totally in a vehicle fire. The portion of the tire that is resting on the ground usually will remain after the fire. This remaining portion of the tire is called the "pad." These pads should be collected as evidence.

Check tires or pads for odd treads, uneven wear, or treads that do not match, which may indicate a change of tires prior to the fire.

### Wheels (Rims)

As with tires, the wheel rims should be examined closely. Remember, these are usually made of steel and will not suffer extensive damage in a fire. Frequently, the owner of a vehicle will replace new tires with old ones just prior to the fire.

Look for jack impressions in the ground around the vehicle. Check for missing lugs or lug nuts, indicating haste in the fire preparations. Also check to see if all four rims are the same color, and if they match the rim of the spare tire. If not, this may indicate changing of tires prior to the fire, and will have to be explained by the owner/operator.

### Fuel System

The fuel system of the vehicle gives the arsonist an excellent supply source for his/her accelerant. Examine the fuel tank drain plug. (However, newer model cars have eliminated the use of drain plugs.) The arsonist may have removed the drain plug to allow the fuel to drain under the vehicle.

The owner may claim the drain plug was blown out by an explosion of the fuel tank, but this should be easily eliminated by an examination of the threads. If the plug was blown out, the threads usually show signs of damage.

If the drain plug can be located, check for recent tool marks on it. This may indicate the plug was removed and then replaced after the fuel (accelerant) was obtained.

Examine the fuel tank for evidence of intentional damage (puncture holes, etc.) for the purpose of obtaining fuel.

### Tank Fill Cap and Spout

The fill cap often is removed to allow the siphoning of fuel from the gas tank. The cap may be discarded by throwing it. Be sure to check nearby ground cover, alongside the road, or inside the vehicle for the missing cap. Also, check in both directions along the road, as the arsonist may have discarded the cap upon departing the scene.

The owner may claim that a fuel tank explosion blew off the cap. Check for damage to cap flanges or the filler spout.

### Fuel Lines

Check for loosened fuel lines or evidence of tool marks. This may show recent tampering or repair work done to the fuel system. Arsonists have been known to loosen fuel lines in an attempt to make the fire appear accidental.

### Trunk

An empty trunk usually is considered suspicious. Most people always have something in their trunk. Standard items found in the trunk will include

**Spare tire.** New vehicles normally will have a new spare tire. Compare the wheel color with the other rims on the vehicle, or check the local dealer to determine proper wheel color. Newer models may have a "temporary" spare tire; the color may not match.

**Jack (tools).** This accessory should be present, as most people do not want to be caught with a flat tire and no jack with which to change it. However, a missing jack is not conclusive evidence that a fire may have been incendiary.

### Engine Compartment

A thorough examination must be conducted of the vehicle's engine compartment. As most accidental vehicle fires originate in this compartment, the first responder must eliminate all possible accidental causes. A clever arsonist will attempt to disguise an incendiary fire by making it appear that there was an engine malfunction, such as backfiring through the carburetor, or a fuel leak. Attempting to disguise incendiarism as an electrical malfunction can be difficult, but it is possible.

Look for evidence of attempts to extinguish the fire. Check for dirt, sand, or extinguishing agents on the engine or in the engine compartment. It would be unusual for an owner/operator not to attempt to extinguish his/her own fire. Compare your findings to the owner's story.

### Motor Supports

Motor supports seldom receive extensive fire damage during accidental fires. If the supports show evidence of damage, it may indicate the presence of an accelerant.

Broken motor supports may indicate a costly repair, and show the reason for the intentional fire.

### **Radiator**

Solder in radiator joints usually does not melt out during an accidental fire. An exception to this is when a fuel line leaks and creates an unusually hot fire. If a fuel leak can be eliminated, the radiator damage may indicate the presence of an accelerant.

### **Belts**

Fan, generator/alternator, power steering, or air conditioner belts are seldom destroyed in accidental vehicle fires. Damage to these belts may be localized in the area of an accidental fire, but if they are totally consumed, you may find evidence of an accelerant.

### **Missing Accessories**

The battery, carburetor, generator or alternator, starter, etc., are not totally destroyed in a fire. These accessories may receive heavy damage as a result of the fire, but some portion of them will remain. If these items are missing, it may indicate removal prior to the fire, or extensive engine repairs that the owner/operator could not afford.

### **Carburetor**

Accidental carburetor fires may self-extinguish without damage to the entire vehicle. Engine backfires can cause some damage to the carburetor and the surrounding area. If the fire is accidental, caused by backfire or ignition of fuel inside the carburetor, there usually will be internal damage to the carburetor, and possible meltdown of the alloy metal walls of the carburetor. It may be difficult to prove an arsonist poured gasoline into and over the carburetor.

### **Fuel Pump and Lines**

Total-loss vehicle fires can occur if a fuel line connection disconnects and the vehicle's motor is running, causing the fuel pump to continue to operate, or if the fuel pump is electrically operated and it continues to run.

Examine the fuel pump and the fuel filter, especially if it is an in-line filter, for tight connections.

Steel fuel lines do not burn, especially if there is fuel in the lines. On the other hand, neoprene gasoline lines will burn and expel small amounts of gasoline onto the fire. Examine remaining fuel line hoses to make sure they are not rubber. Frequently, the do-it-yourself mechanic will replace these lines with improper hoses. A new, improper rubber hose replacement can begin to leak in a very short period of time.

### **Motor and Drive Train**

Check for missing or loose head bolts around the motor. Examine the engine for damage such as cracked heads or a hole in the block. Look under the vehicle for missing or loose oil pan bolts or missing parts of the drive train. Make sure the drive train is connected.

If any of these problems exist, it will indicate a major, costly engine repair, and a possible motive for an incendiary fire.

### **Electrical System**

Examine all fuses and fusible links. Modern vehicles are well protected from electrical short circuits and current overloads. The local dealership may provide assistance as to the location of fusible links.

Examine all wiring. Most electrical wiring in a vehicle is small-gauge, copper-strand conductor, and several circuits will run through a wiring harness. It may be difficult to trace the circuit to its origin, as several circuits may sever and fall to the ground. Look for evidence of direct short circuits.

Most accidental vehicle fires that result from an electrical malfunction will cause only localized damage.

### **Voltage Regulator**

Dismantle and examine the voltage regulator. Short circuits may cause burning or welding of the regulator points.



## **Battery**

The battery may drain rapidly when a short circuit occurs. Batteries which remain fully charged probably were not involved in a short-circuit malfunction.

Check the battery with a tester. Be extremely cautious of explosion potential.

Extensive fire damage to a battery usually is not found in most accidental fires. The areas not facing the fire usually are not extensively damaged.

Always be cautious when working with or around the battery. Make sure the battery has been disconnected prior to any examination. Battery acid is extremely caustic and can burn skin or clothing.

## **Vehicle Identification Number (VIN)**

Prior to 1969, the VIN was found in various locations on the vehicle. On models built since 1969, the VIN is located at the left side of the dashboard by the windshield. Other "hidden" VIN plates are located throughout the vehicle.

Altered or missing VIN plates may indicate the vehicle was stolen. Look for evidence of filing, grinding, or sanding of the numbers on the VIN plate.

## **SUMMARY**

This unit has discussed numerous indicators of incendiarism in both structure and vehicle fires. At any time during your presence at a fire scene, do not overlook these indicators. Report them to the proper authority who will make a request for an arson investigator to conduct a thorough and professional examination of the fire scene.

Remember, anything that is unusual or unnatural should be reported. Based on your information, the investigator's job will be a little easier and your information probably will aid him/her in bringing the arson case to a successful conclusion.

The observations and reporting of findings by the first responder plays a very important role in arson detection, and the arrest and conviction of an accused firesetter.



## BIBLIOGRAPHY

- Bates, Edward B. *Elements of Fire and Arson Investigation*. Santa Cruz, CA: Davis Publishing Co., 1975.
- Kirk, Paul L. *Fire Investigation*. New York: John Wiley & Sons, Inc., 1969, p. 84.
- NFPA 921, *Guide for Fire & Explosion Investigations*. Quincy, MA: National Fire Protection Association, 1992.
- Ricketts, John. *Electricity and Fire: The Role of the Investigator*. Private publication by John Ricketts, 1977.
- Stickney, C.W. "Recognizing Where Arson Exists," *Selected Articles for Fire and Arson Investigators*. International Association of Arson Investigators, 1976.
- Vliet, H.R. "What to Look For in T.V. Fires," *Selected Articles for Fire and Arson Investigators*. International Association of Arson Investigators, 1976.



# ***UNIT 5: SCENE SECURITY AND PRESERVATION OF EVIDENCE***

## **OBJECTIVES**

*The students will be able to:*

1. *Describe the proper procedures for securing the fire scene.*
  2. *Describe the procedure for allowing the owner, occupant, or building manager to re-enter the burned structure.*
  3. *Explain the importance of evidence preservation at the fire scene.*
  4. *Identify proper evidence collection techniques.*
-



## INTRODUCTION

Up to this point the course has focused on observations to be made at fire scenes and the indicators of incendiaryism at both structure and vehicle fires. Another important factor in obtaining arson arrests and convictions is properly securing the incident scene against contamination by owners, occupants, building managers, concerned family members, politicians, or even the arsonist.

The only people who should be allowed to enter the fire scene prior to its release to the appropriate person(s) are the firefighters, the fire investigator(s), or evidence technician(s). Any other entry into the structure can be construed as scene contamination. This could result in crucial evidence being ruled inadmissible in court proceedings. There have been documented incidents of arsonists re-entering the fire scene during overhaul activities and walking off with incendiary devices.

If the fire is large or newsworthy, local politicians, clergy, news media, neighbors, and sightseers all will attempt to gain entry to the structure, mainly out of curiosity. Scene security is a crucial part of the first responder's responsibility, and all efforts should be made to maintain scene security.

The second section of this unit will deal with the preservation of evidence and the proper methods for handling that evidence. An important and critical point that must be considered is the "chain of custody," which, when broken, can cause the evidence to be ruled inadmissible in court. To have an arsonist acquitted because a first responder mishandles evidence is totally unacceptable.

## RESTRICTING ENTRY INTO THE SCENE

### Postsuppression Reasons to Enter a Scene

Many people, including the owner, occupants, building manager, and others may have justifiable reasons to re-enter the burned building. These reasons may include

- assessing fire damage;
- retrieving personal items such as jewelry or other valuables, medicines, eye glasses, false teeth, or prosthetic devices;
- collecting insurance documents;

- gathering items that may help children feel secure (e.g., favorite toys, books, blankets, or stuffed animals); and
- retrieving clothing.

The owner or occupant also may want to re-enter and examine the fire scene for any appliances they may have left on. They may question themselves as to whether any of their actions were responsible for the fire. Stoves, irons, soldering guns, curling irons, and the use of candles, especially around holiday times, have been the causes for many accidental fires.

Entry into the fire scene by anyone, except essential emergency personnel, should be restricted. The first responder has a responsibility to determine the cause of the fire. If a fire investigator has been requested, under no circumstances should any unauthorized persons be allowed entry into the scene. The scene should be designated as a crime scene until a final determination of the cause has been established.

## **Restrict Entry**

### **Suggested Methods of Securing the Fire Scene**

- Placing barrier tape or rope around the perimeter of the scene.
- Securing access and egress areas by posting a guard at each door.
- Posting a guard at each door to restrict entry.
- Firefighters often assist the investigator for safety purposes by lifting, or shoveling, or providing lights. If firefighters are at the scene to assist the fire investigator, other interested parties should be kept in a staging area until needed.

### **Procedures for Allowing Authorized Entry**

First, verify that the person(s) have a right to gain access to the building or fire area. Unauthorized persons have been known to enter a burned structure and loot.

Determine the person's need for entering the building. If immediate entry is not necessary, advise the person that the fire department is still engaged in fire suppression or overhaul activities, or that the fire investigator is still



conducting his/her investigation, and that upon completion of these tasks entry will be allowed.

After entry is allowed, advise the person(s) that he/she will be escorted for his/her own safety. Explain that there may be holes in the floor, falling ceiling, dripping water, protruding nails, etc.

Instruct those who enter that they are not to tamper with anything, not to move controls, change positions of switches, or remove articles that may be critical to the origin and cause examination.

Record the name of each person who enters the structure, as well as any property that he/she removes from the scene.

A display of compassion by the firefighter goes a long way. You may have fought numerous fires, many worse than the one you are presently attending, but this may be the first fire that these people have experienced, and it is a very traumatic time for them.

If you are escorting the victims through the scene, assist them as much as possible in locating what they need. No matter how insignificant a certain item may seem to you, it may be of great value to the victim.

## **RELEASE OF FIRE SCENE**

### **Accidental Fires**

The fire scene should be released to the owner or occupant only after the fire origin and cause examination has been completed and a determination made. The fire investigator should discourage the owner/occupant from looking over his/her shoulder and listening to his/her initial commands or remarks. However, it sometimes is necessary for the owner or occupant to be present during the investigator's examination.

#### **Escort the Owner or Occupant**

Escort the owner or occupant through the structure and explain the safety considerations relative to the stability of the building. In some cases, if the fire damage is extensive, local building officials may condemn the building. Explain the extent of the fire damage.

### Explain Suppression Efforts and Cause Determination

Explain the fire suppression efforts performed by the firefighters. Most fire victims are not aware of proper firefighting tactics and question the reason for the breaking of windows, cutting of holes in the roof for ventilation, cutting of holes in the floor for water drainage, or the opening of floors, walls and ceilings to check for fire extension. Often, they view this as unnecessary damage caused by the fire department. Taking the time to explain these tactics can create better relations between fire personnel and the public.

An explanation of the fire investigator's determination, if available, also can help to put the victim's mind at ease. It is preferable to have the investigator explain his/her findings, pointing out the indicators, such as burn patterns, smoke travel, cracking of glass, etc., used to establish his/her determination.

### Official Reports

Advise the fire victims that an official report will be completed and available to them and to the insurance company.

### Victim Assistance

Inform the victims of procedures that should be followed to contact their insurance company. Many insurance companies have brochures available that explain the steps to be followed after the loss of property due to fire. If the brochure is given to the victims at the scene, it may give them something to do while the fire department is still performing its duties, and it also may help to ease their anxieties.

Advise the victims of assistance that is available from outside agencies such as the Red Cross or Salvation Army.

Suggest to the victims that they keep all expense receipts acquired from lodging, meals, purchase of clothing, laundry services, etc., that resulted from the fire, as most insurance companies will reimburse these expenses.

## **Undetermined Fires**

Fires that are classified as undetermined or appear unusual in origin need to be evaluated with a degree of certainty. These include fires which have unusual burn patterns, no logical explanation, or those which do not appear accidental.

### **Request for Investigator and Scene Security**

A fire investigator should be requested for the purpose of conducting a thorough scene examination whenever circumstances of a fire appear suspicious.

The fire scene must be secured until the investigator arrives. If there will be a delay in the investigator's arrival, and the fire department cannot remain on the scene, barrier tape should be left in place and arrangements made with the local law enforcement agency for scene security to ensure that no one enters. If the scene is left unsecured for any length of time, it cannot be proved that someone did not enter the scene and contaminate evidence. This renders any evidence obtained by the fire investigator inadmissible for presentation in court proceedings.

Inform the owners and/or occupants of actions taking place and advise them that they should refrain from entering the fire scene until the fire investigator completes his/her examination and releases the scene to them.

### **Statements to the Press**

Prior to the investigator's final determination, any information regarding the cause of the fire should be released only by the Incident Commander or Information Officer. Do not offer any opinions about the fire cause to anybody. If, for some reason, you must give statements in regard to the status of the fire, state only that the fire is still under investigation and that additional assistance has been requested for determining the origin and cause of the fire. Most news media personnel will accept "under investigation" as an acceptable answer.

### **Arrival of the Investigator**

Brief the fire investigator on all facts collected at the scene. Explain the first responder's observations beginning with the initial call through the overhaul operations. Explain any fire suppression efforts that may have

changed normal burn or smoke patterns, as well as any unusual fire suppression tactics such as ventilation, initial attack, or defensive/offensive operations that were performed. Also, make the investigator aware of any structural problems or hazards that may be encountered during his/her scene examination.

Allow the fire investigator to perform his/her job without interference from owner/occupants or curious firefighters. Remember the old adage that "too many cooks spoil the pot." This holds true in a fire scene examination, as too many firefighters in the room of origin create problems of overcrowding, destruction of evidence, and possible loss of concentration by the investigator. Allow him/her to do his/her job.

## **EVIDENCE PRESERVATION**

The successful presentation of evidence of incendiarism from a fire scene is dependent upon the ability to properly identify such evidence at the scene. Evidence that is collected or handled improperly, or is not documented, will severely compromise any investigation.

Evidence preservation and collection is one of the most important tasks associated with fire investigation. Everything needed to confirm the origin, cause, or contributing factors associated with a particular fire must be preserved, collected, and recorded.

The fire investigator will use photographs, in conjunction with sketches, to present both selective and detailed illustration of the evidence to a jury.

The first responder could be the first official to discover or observe a crucial piece of evidence, and must understand the proper care and handling of evidence.

Proper evidence preservation and collection, as well as the "chain of custody," are the responsibility not only of the fire investigator, but of the first responder as well.

### **Protect Found Evidence**

When evidence discovered by the first responder will not be destroyed by the ensuing fire, building collapse, or firefighter activities, it should be left in place for the fire investigator or evidence technician. A guard should be placed by the evidence and it should be covered by a box or tarp to protect it from fire streams, falling debris, weather, or other firefighters. On the

other hand, if it is determined that the evidence is in danger of being destroyed, it should be removed from the scene.

### Proper Handling

There are technical and legal aspects to consider regarding the proper handling of evidence. If these procedures are not followed, the evidence may be ruled inadmissible in a court of law. If possible, prior to its removal, photograph the evidence where it was discovered. A second photograph should be taken of the area from where the piece of evidence was removed. Record the date, time, discoverer, location where found, and reporter of the evidence. It is strongly recommended that the discoverer of the evidence be the only person to handle the evidence until it is transferred to the investigator or technician.

### If the First Responder Must Collect Evidence

Evidence should be placed in a proper container for safekeeping. The recommended fire scene evidence container is a clean, unused, unlined, airtight metal container (paint can). If one is not available, a glass jar is acceptable; however, caution must be exercised not to break the jar. If broken, the evidence may be contaminated, thus making it ineligible for laboratory analysis. Certain approved plastic bags also are acceptable. Caution must be used when using improper plastic bags as they may have a reaction with the accelerants in the evidence and destroy any chance for a positive lab analysis.

Once the evidence is properly documented, placed in its proper container, and removed from the scene, it should be transported directly to a secure location. It is recommended that the evidence be locked in the trunk of the Incident Commander's vehicle. Once the investigator arrives on the scene, the evidence should be transferred from the Incident Commander's vehicle directly to the investigator by the discoverer.

### **Chain of Custody**

The procedures outlined above should be followed closely since they may come under close scrutiny at a later date.

Chain of evidence problems are one of the prosecutor's greatest areas of concern in preparing and trying an arson case. The prosecuting attorney usually is not involved in the investigative stages of the case, and the chain

of custody will have been preserved or violated by the time he/she receives the case. Therefore, the fewer the people who have handled the evidence, the easier it will be to prove the chain of custody.

When evidence is expected to be subject to analysis, as in an arson investigation, it is necessary to be able to establish that the item seized is the same item that was analyzed. Consider the following advice from Melville, *Manual of Criminal Evidence*, 2nd Ed., Denver D.A.'s Office.

Whenever any piece of evidence must be passed from hand to hand to set up the chain of evidence in a case, it is essential that every person who has anything to do with the matter must be prepared to testify as to 1) when and how such piece of evidence came to him, 2) what he did with it while it was in his possession, and 3) when, why, how and to whom he delivered it.

Frequently, important evidence is rejected because the prosecution is unable to prove continuity of possession from collection to the time it is being offered into evidence. A police officer, firefighter, or investigator should always take the precaution of initialing or otherwise marking every piece of physical evidence coming into his/her hands in the course of a criminal investigation. By doing so, he/she can give persuasive evidence of his/her one-time possession of the item by identifying initials or other marks on it.

### **Contamination of Evidence**

Evidence can be contaminated even before it is discovered and collected, either by fire personnel during extinguishment and overhaul, or by returning occupants who wish to view the damage and salvage their belongings. Occupants who want to return to retrieve documents, medications, valuables, etc., should be accompanied by fire department personnel to ensure that they do not contaminate the scene.

Evidence also may be contaminated and/or lost by exposure to the atmosphere; thus, it must be sealed in an airtight container. It also may be contaminated by an improper evidence container. Flammable vapors may deteriorate portions of the container such as the seam of metal containers, or the rubber seals on lids of glass containers.

## **Cross-Contamination**

Cross-contamination is the transfer of liquid or solid accelerant residue from one fire scene or location to another evidence collection site.

There are four potential sources of cross-contamination at a fire scene: tools, turnout gear, evidence containers, and portable generators or power tools. Certain "housekeeping" procedures should be performed after every fire to preclude possible accelerant cross-contamination from previous scenes.

### Tools

All fire investigation units, and some fire departments, have a special tool kit to process fire scenes. These tools should be kept separate from other fire department equipment and must never be coated with any rust preventative material. After a fire scene examination is completed, tools should be rinsed clean with a strong stream of flushing water. Before bringing any excavation or cutting tools into a fire scene, it is a good practice to cleanse each tool with isopropyl alcohol and clean paper wipes or cloth, then flush it with fresh water in the presence of a witness. Note that accelerant liquids derived from crude oil generally are not soluble with water alone. Check with your local lab on recommended cleaning procedures.

### Turnout Gear

Boots should be cleaned with fresh water after each fire scene. Accelerants from previous incendiary fires may adhere to the soles and be tracked into the fresh scene, thus contaminating the new scene and possibly giving false indicators.

Fire gloves should never be worn when collecting accelerant samples, as samples from previous scenes may have been absorbed into the gloves. Disposable latex gloves eliminate this problem; any gloves used should be submitted to the lab with the accelerant sample.

### Evidence Containers

Fire investigators and fire departments should carry a supply of various evidence containers, including both one-quart and one-gallon size, clean, unused metal containers (paint cans). The cans should remain sealed until

ready for use; this prevents contamination in the interior of the can. Once a can is used to collect an evidence sample, it should be discarded and not used a second time.

### Portable Generators and Power Tools

Gasoline-powered equipment should be placed outside the scene in order to eliminate the possibility of vapor contamination from exhaust. Firefighters should work closely with investigators to limit potential contamination whenever possible. Be aware of where such tools were used or fueled, as spilled fuel may give a false indicator.

## **SUMMARY**

The need for proper scene security cannot be emphasized strongly enough. Unauthorized persons in a fire scene can create problems of scene contamination such as altering the scene, destroying evidence, or even removing a critical piece of evidence that could establish the crime of arson.

A security perimeter must be established, and guards should be placed at each entry point to the structure. Only persons who have been authorized by the appropriate personnel may enter the fire building, and they always must be escorted.

Records must be kept to identify these people and any items they remove from the scene. These procedures are necessary both for legal purposes and for the protection of the fire department.

The preservation and proper handling of evidence is probably the most important factor involved with an incendiary fire. Proper documentation, noncontamination, and an unbroken chain of custody all are critical to the successful prosecution of an arson case.



## ***UNIT 6:***

# ***LEGAL CONSIDERATIONS***

### **OBJECTIVES**

*The students will be able to:*

- 1. Explain the United State's Supreme Court's Michigan v. Tyler decision that grants fire departments the right to enter property forcibly under exigent circumstances.*
  - 2. Describe the applicability of the Fourth Amendment that allows for search and seizure of property.*
  - 3. Describe proper courtroom demeanor when called upon to testify.*
-



## INTRODUCTION

On occasion, a first responder may be required to testify in court regarding the observations he/she made at the scene of a fire.

This unit will cover some of the basic principles a first responder should be aware of before giving testimony in a court of law.

The intent of this unit is not to provide first responders with a complete understanding of the law, but to familiarize them with the general principles and procedures related to court proceedings of arson investigations. Whenever the first responder has any doubt or confusion concerning a legal matter, the district attorney should be consulted.

## ARSON LAWS IN THE UNITED STATES

"Arson at Common Law" was originally the offense of "The burning of the dwelling of another." In recent years, the arson laws have been codified and changed by Congress and the individual states. At least one state still has arson at common law; however, most states have revised laws dealing with arson to reflect the current standards.

## CONSTITUTIONAL LAW

The Constitution of the United States limits the power of government and defines the rights of its citizens. The Amendments to the Constitution further define the rights of individuals. The following amendments are pertinent to the subject of arson investigation. Therefore, the first responder should be familiar with their content.

### Fourth Amendment

"The right of the people to be secure in their persons, houses, papers, and effects, against unreasonable searches and seizures, shall not be violated, and no Warrants shall issue, but upon probable cause, supported by Oath, or affirmation, and particularly describing the place to be searched, and the persons or things to be seized."

### **Fifth Amendment**

"No persons shall be held to answer for a capital, or otherwise infamous crime, unless on a presentment or indictment of a Grand Jury.... nor shall any person be subject for the same offense to be twice put in jeopardy of life or limb; nor shall be compelled in any Criminal Case to be witness against himself; nor be deprived of life, liberty, or property, without due process of law; nor shall private property be taken for public use, without just compensation."

### **Sixth Amendment**

"In all criminal prosecutions, the accused shall enjoy the right to a speedy and public trial, by an impartial jury of the State and district wherein the crime shall have been committed, which district shall have been previously ascertained by law, and to be informed of the nature and cause of the accusation; to be confronted with the witnesses against him; to have compulsory process for obtaining Witnesses in his favor, and to have the Assistance of Counsel for his defense."

## **LEGAL REQUIREMENTS RELATED TO ARREST, SEARCH, AND SEIZURE**

### **Constitutional Provisions**

The Fourth Amendment governs searches and seizures (arrests) of persons and of property. To be lawful under the Constitution, any search or seizure must be reasonable under the circumstances.

- They must be based on probable cause.
- They must be supported by oath or affirmation and must, with particularity, name any and all persons, places, or things to be searched and seized.

The warrant application itself must state the what, whom, where, when, how, and why of the investigation. The warrant must stand the scrutiny of the court; and not what the investigator knew about, but did not write into the warrant application.

Fire personnel should not forget that the basic requirements of the Constitution are the minimum requirements, and the Constitution only prohibits **unreasonable** searches and seizures. Many state statutes differ greatly and are more restrictive. It is important to obtain guidance from

your prosecuting attorney with regard to the applicability of materials presented in this unit.

### **Search and Seizure of Property**

Search and seizure of property now is governed by the minimum requirements of the Constitution. In 1914, the U.S. Supreme Court held that evidence obtained unlawfully could not be used against the accused. Supreme Court rulings in 1961 required that all state courts observe the same rules of evidence in criminal proceedings.

This is known as the "exclusionary rule." It states that evidence gained unlawfully shall be excluded from court. The rule applies not only to evidence directly found by the unlawful search, but also to that which flows from the excluded evidence. This is called "The Fruits of the Poisonous Tree."

### **MICHIGAN v. TYLER**

In 1978, the U.S. Supreme Court laid down minimum constitutional requirements for postfire searches in a case known as *Michigan v. Tyler*. (436 U.S. 499, 98 S. Ct. 1842 56L. Ed. 2d 486.)

In summary, the U.S. Supreme Court ruled that the fire department has the right to enter property under exigent (emergency) circumstances and to remain until the emergency is over. The Court also ruled that once inside, firefighters may seize evidence of arson that is in plain view.

The U.S. Supreme Court further ruled that no search warrant was necessary for a fire investigator to remain on or enter the scene for the purpose of conducting an origin and cause determination, as long as the origin and cause examination was conducted within a **reasonable time** after extinguishment. If the time period exceeds the standard of reasonableness, the investigator may apply for an administrative search warrant which will allow the investigator to enter the property to determine the cause of the fire. If re-entry is needed for the purpose of re-examination of the fire scene or the seizure of evidence, a search warrant must be obtained prior to entry.

The facts and particulars, as they pertain to *Michigan v. Tyler*, are in the Appendix of this unit.

### **MICHIGAN v. CLIFFORD**

In 1984, the U.S. Supreme Court held that postfire investigations must adhere to stringent requirements with respect to the constitutional rights of the owner/occupants. (*Michigan v. Clifford*, Cert. to the Court of Appeals of Michigan, 82-pp. 357.)

The court also upheld the exigency rule that justifies a warrantless entry by fire departments to fight the blaze. Once in the building, fire officials need no warrant to remain for a "reasonable time to investigate the cause of a blaze after it is extinguished" (*Tyler*).

In its ruling regarding the fire investigation, the Supreme Court said that after investigators determine the cause of fire and have located the place it originated, search of other portions of the premises may be conducted only pursuant to a warrant.

The facts and particulars, as they pertain to *Michigan v. Clifford*, are in the Appendix of this unit.

### **CONSENT TO SEARCH**

Just as any firefighter has the right to enter a person's property to suppress a fire, the first responder or investigator has a similar right in order to determine the cause of the fire. Several court rulings have outlined procedures that must be followed regarding the timeliness of the investigation, of leaving and then returning to the scene, and securing evidence during the fire cause determination process.

As an extra measure of protection from a charge of illegal entry, it is recommended that you have a "consent to search" form signed by the owner/occupant when possible. This form will protect you and make the owner/occupant aware of the fire department's need to conduct a fire cause investigation.

### **COURTROOM DEMEANOR**

It is not unusual for a prosecuting attorney to request a first responder to testify at an arson trial regarding their initial observations and/or discovery of evidence at the fire scene. The following are some tips that will be helpful for the first responder who must give testimony in court.

Since criminal court cases can take place from six months to two years after the date of the incident, a review of the facts will be necessary. First, be sure to conduct a thorough review of the entire case prior to the court appearance. Be knowledgeable of the incident date, time, and location. Attempt to recall any observations you made, including means of entry and the fire conditions.

The prosecuting attorney will probably meet with you before your court appearance to review the case and advise you of what to expect at the trial.

Follow local policy or the advice of the prosecuting attorney regarding the manner of dress in the courtroom. Some jurisdictions require a uniform be worn, while others prefer civilian clothing. If a uniform is to be worn, wear your Class A (dress) uniform. If civilian attire is to be worn, a conservative, dark suit is preferred. In any case, your appearance should be professional.

The following is a list of suggestions for the first responder while testifying on the witness stand:

- Follow all directions given to you by officers of the court (attorneys, judge, etc.).
- Sit upright with both feet on the floor.
- Speak to the jury, not the attorneys.
- Keep hands in a natural position and avoid gesturing.
- Do not play with pen or pencil. This makes you appear nervous.
- When referring to the defendant, refer to him/her as "the defendant" or "Mr./Ms. \_\_\_."
- Exercise courtesy and patience at all times.
- **Never** argue with the defense counsel.
- Testify with the confidence gained by the complete and full knowledge of the facts of the case.
- Take enough time to understand fully all questions asked of you. If a question is not understood, ask to have it repeated.

- Be alert at all times and listen attentively to all questions, remarks, or statements by counsel or the court (judge).
- An accurate statement of facts is desired, and there should be no guesswork or speculation. If the facts are not known, say so. If exact times, distances, etc., are not known, qualify the statement with the words "about" or "approximately." If the **exact** words of a statement or conversation are known, use them; if not, qualify the statement with the phrase, "In sum and substance he said."
- **Tell the truth.** You are obligated by your oath, and more importantly, by your personal integrity. Your integrity as a firefighter and expert witness is your most valuable possession. **Never lie to obtain a conviction.** The loss of your reputation and integrity are not worth a conviction.
- Avoid slang or improper language unless it is a direct quote and necessary to the evidence.
- Remember, the jury is composed of lay people. Avoid technical language. If technical terms are used, follow them up with an explanation.
- Speak clearly and loudly enough to be heard, and do not hesitate to correct mistakes or errors.
- Do not give the impression that the conviction of the accused is a personal desire of yours.
- Do not volunteer information. Answer only what is asked of you.
- If either attorney makes an objection during a question, do not answer until the court has made a ruling on the objection and until the question has been repeated. If the objection is to your answer, do not complete the answer until directed to do so by the court.
- Notes may be used to refresh your memory; however, the permission of the court must be obtained before the notes may be used. **The defense has the absolute right to be provided with a copy of all your notes.**
- The object of cross-examination is to test credibility, knowledge, recollection, bias, prejudices, or interest of a witness relative to his/her testimony on direct examination.



- Do not introduce any criminal record or previous convictions of the defendant during your testimony. This will be grounds for the court to order an immediate mistrial.

## SUMMARY

A basic knowledge of your legal authority to enter property under exigent circumstances, to reenter property for purposes of determining origin and cause of a fire, and the right to confiscate evidence has been discussed in this unit. For the most part, it is only for your information and knowledge, and may be more pertinent to the fire investigator.

The section on courtroom demeanor is very important to you, the first responder, as more and more prosecutors are using first responder testimony in an attempt to obtain the arson conviction. Not only are the first responder's senses the initial "official" observations at a fire scene, but his/her testimony to the fire conditions and dangers faced by the firefighters weighs heavily on the minds of a jury. Juries are sympathetic to the dangers of a firefighter's job, and even more so with intentionally set fires.

If requested to testify in court, prepare by reviewing the case thoroughly prior to the court date. Be the professional you are when on the stand. This will be last segment of that particular fire incident, and a conviction that you, as the first responder, helped obtain will be a very satisfying moment.



**APPENDIX A**

***MICHIGAN v. TYLER***



***MICHIGAN v. TYLER***

A. Facts.

1. Fire starts shortly before midnight, January 21, 1970.
2. Chief See arrives at scene on January 21, 1970, at 0200.
3. Chief See's responsibility: "to determine the cause and make out all reports."
  - a. Chief See is informed by Lieutenant Lawson that two plastic containers of flammable liquid were found in the building.
  - b. Chief See determines the fire "could possibly have been an arson" and calls for Detective Webb.
  - c. Chief See "looked throughout rest of building to see if there was any further evidence, to determine what the cause of the fire was."
4. Detective Webb arrives at scene at 0330.
5. Fire is extinguished and firefighters depart at 0400.
6. Webb takes several pictures but abandons efforts because of smoke and steam.
  - a. Webb takes containers to fire station for safekeeping.
  - b. Neither Webb nor See had consent or a warrant for entries, nor for the removal of the containers.
7. See returns with Assistant Chief Somerville around 0800.
  - a. Somerville's job is to determine the "origin of all fires that occur within the township."
  - b. Fire was extinguished and building empty when they arrived.

8. Webb returns around 0900.
  - a. Webb discovers suspicious "burn marks in the carpet which he could not see earlier because of heat, steam, and darkness."
  - b. Webb also discovers "pieces of tape, with burn marks, in the stairway."
  - c. Webb removes the carpet and sections of the stairs to preserve as evidence.
  - d. Somerville searches through rubble "looking for any other signs of evidence that showed how this fire was caused."
9. Sergeant Hoffman of Michigan State Police Arson Section arrived on February 16, 1970, to take photos at scene.
  - a. Hoffman checked circuit breakers.
  - b. Hoffman had television repairmen examine remains of television sets found in ashes.
  - c. Hoffman's entries were without warrants or consent.
  - d. Hoffman's purpose was "of making an investigation and seizing evidence."
- B. Michigan Supreme Court holding.
  1. Once firefighters leave the premises, a warrant is required to reenter and search premises, unless there is consent, or premises have been abandoned.
  2. All evidence collected after fire was extinguished at 0400 was excluded in violation of Fourth and Fourteenth Amendments.
- C. State of Michigan's position.
  1. Entry to investigate cause of fire is outside protection of Fourth Amendment because no individual privacy interests are threatened.
    - a. If occupant set blaze, then his "actions show he has no expectation of privacy."
    - b. If fire has other causes occupants are treated as victims.

2. No purpose would be served by requiring warrants to investigate cause of fire.

D. Majority opinion.

1. Recognizes people still have protected privacy interests in burned property.
2. Courts specifically held that it is impossible to justify warrantless search on grounds of abandonment by arson.
3. Fourth Amendment applies to firefighters.
4. Both administrative searches and searches for evidence of crime are encompassed by the Fourth Amendment.
  - a. Probable cause for administrative searches exists if reasonable legislative or administrative standards for conducting area inspection are satisfied.
  - b. Such searches will not necessarily depend on specific knowledge of the conditions of the particular dwelling; rather, may be based upon passage of time, nature of building, condition of entire area, etc. *Camara v. Municipal Court*, 387 U.S. 523.
5. Major function of warrant is to provide property owner with sufficient information to reassure him of the entry's legality.
6. If authorities are seeking evidence to be used in criminal prosecution, the usual standard of probable cause will apply.
7. All entries in this case were without proper consent and were not authorized by valid search warrant--each is therefore illegal **unless** it falls within one of the carefully defined classes of cases (**exigent circumstances**).
8. Burning building is exigency to render warrantless entry reasonable.
  - a. Once inside, firefighters may seize evidence of arson that is in plain view.
  - b. Supreme Court specifically rejects position that once fire ends, the justification for being on property ends.

9. Officials need no warrant to remain for reasonable time to investigate cause of blaze after extinguished.
10. Court finds morning reentry's by Chief See, after firefighters departed at 0400, acceptable as an actual continuation of the first entry.
  - a. Court permits the evidence collected on January 22 as admissible evidence.
  - b. All entries after January 22 were done without consent or valid warrant and no exigent circumstance existed to justify reentry.



**APPENDIX B**

***MICHIGAN v. CLIFFORD***



***MICHIGAN v. CLIFFORD***

A. Timeline.

1. Fire truck arrives at Clifford house on October 18, 1980, at 0540.
2. Fire extinguished and all fire and police depart 0704.
3. Lieutenant Beyer told to investigate Clifford fire on October 18 at 0800.
4. Lieutenant Beyer arrives at Clifford house on October 18 at 1300.
  - a. Beyer sees work crew on scene boarding up house.
  - b. Crew pumping six inches of water out of basement.
  - c. Neighbor tells Beyer he called Clifford and has been instructed to call Clifford's insurance agent to hire boarding crew to secure house.
5. Lieutenant Beyer begins search of house at 1330, after water is pumped out.

B. Evidence.

1. In driveway, Lieutenant Beyer sees fuel can which firefighters found in basement. He seizes the evidence.
2. Lieutenant Beyer begins search without a warrant or obtaining consent.
3. Beyer's search quickly confirms that fire originated beneath basement stairway.
4. Beyer detects strong odor of fuel throughout basement.
5. Beyer finds two more Coleman fuel cans beneath stairway.
6. Beyer further finds crock pot with attached wires leading to electrical timer plugged into outlet. Timer set to turn on at 0345 and to turn off at 0900. Timer had stopped somewhere between 0400 and 0430.
7. Beyer and partner then search remainder of house going through drawers and closets. They find nails but no pictures on the walls.

C. Clifford's position.

1. Exclude evidence in basement and upstairs searches because the searches were to gather evidence of arson and were conducted without warrant, consent, or exigent circumstance.
2. Search violated the Fourth and Fourteenth Amendments.

D. State's position.

1. Exempt from warrant requirement all administrative investigations into cause and origin of fire.
2. Modify *Tyler* to allow warrantless searches in this case.

E. Issue the Court decided.

Can an arson investigator, in the absence of exigent circumstances or consent, enter a private residence without a warrant to investigate the cause of a recent fire?

F. Plurality opinion (Powell, Brennan, White, and Marshall).

1. Court declines to exempt administrative investigation into cause and origin of a fire from warrant requirement.
2. Constitutionality of warrantless and nonconsensual entries onto fire-damaged premises turns on several factors:
  - a. Are there legitimate privacy interests in fire-damaged property that are protected by the Fourth Amendment?
  - b. Do exigent circumstances justify governmental intrusion regardless of any reasonable expectation of privacy?
  - c. Is the object of the search to determine the cause of the fire or to gather evidence of criminal activity?
3. Legitimate privacy interests.
  - a. Objective test: whether the expectation of privacy is one that society is prepared to recognize as "reasonable." (*Katz v. United States*.)
    - If yes then warrant requirement applies.

- If no, then there is no warrant requirement.
  - b. Court found Clifford's had personal belongings which remained after the fire and that they had taken action to secure their home against intrusion.
  - c. The Clifford's retained a reasonable privacy interest in their fire-damaged residence, and postfire investigations were subject to warrant requirement.
4. Exigency.
- a. Court followed *Tyler* and held that a burning building creates an exigency that justifies a warrantless entry to fight the blaze.
  - b. Once in the building the fire officials need no warrant to remain for a "reasonable time to investigate the cause of a blaze after it has been extinguished" (*Tyler*).
  - c. Determining cause and origin of fire serves a compelling public interest; warrant requirement does not apply in such cases.
  - d. Additional investigation begun after fire was extinguished and firefighters and police have left the scene generally must be made pursuant to a warrant or the identification of some new exigency.
5. Object of the search (if warrant is necessary).
- a. If primary objective is to determine origin and cause, an administrative warrant is sufficient. Must show:
    - Fire of undetermined origin has occurred on premises.
    - Scope of proposed search is reasonable and will not intrude unnecessarily on fire victim's privacy.
    - Search will be executed at reasonable and convenient time.
    - Evidence found in plain view may be seized in administrative search.
    - Administrative search into cause of a recent fire does not give fire officials license to roam freely through fire victim's private residence.

- b. If primary objective is to gather evidence of criminal activity, criminal search warrant may be obtained on showing of probable cause to believe relevant evidence will be found in place to be searched.
  - 6. Court found warrantless and nonconsensual search of basement and house would be valid only if exigent circumstances justified object and scope of each.
    - a. Beyer's search was for evidence of criminal activity as to basement and house.
    - b. Excludes all evidence except the gas can found on the driveway in plain view.
  - 7. Plurality distinguishes *Clifford* from *Tyler*.
    - a. Challenged search was not continuation of earlier search.
    - b. The Clifford's had taken steps to secure their privacy interests that remained in their residence.
    - c. The Cliffords' privacy interests in their residence were significantly greater than those of Tyler in the fire-damaged furniture store.
  - 8. Plurality holds: A subsequent postfire search must be conducted pursuant to a warrant, consent, or the identification of some new exigency.
- G. Steven's concurrence.
- 1. Unanimity exists, within the Court, regarding the scope of Fourth Amendment protection afforded to owner of fire-damaged building:
    - a. No one questions right of firefighters to make forceful, unannounced, nonconsensual, warrantless entry into a burning building.
    - b. Firefighters have the right to remain on premises, not only until the fire is extinguished and no danger of rekindling exists, but also to investigate the cause of the fire.
    - c. After investigators determine the cause of fire and have located the place it originated, search of other portions of premises may be conducted only pursuant to a warrant.

2. Argues the presumption that once firefighters depart, fire has been extinguished and any danger of rekindling is slight.
  3. Stevens argues fire investigators should give the homeowner reasonable advance notice of their reentry unless they have probable cause to believe the crime of arson has occurred.
- H. Dissent (Rehnquist, Chief Justice, Blackmun, and O'Connor).
1. Finds the plurality's distinction from *Tyler* to be inconsequential.
  2. Allows search of Clifford basement, but does not allow evidence from search of remainder of house.





## ***UNIT 7: REPORTING OF FINDINGS***

### **OBJECTIVE**

*The students will be able to recognize, recall, and report the pertinent information from their observations as they relay their findings to the Incident Commander or supervisor.*

---



## **INTRODUCTION**

One of the first responder's most critical tasks is the ability to recall facts after a short time. It is easy for the first responder to report his/her findings to the Incident Commander or supervisor. Explaining observations is easy but, in some cases, the first responder is the Incident Commander. It is his/her responsibility to make notes and drawings of the scene and his/her observations.

## **SCENE COMMANDER REPORTING TO INCIDENT COMMANDER OR SUPERVISOR**

It is important that the first responder be complete, concise, and accurate in giving information to the Incident Commander or supervisor. If the building has been destroyed by fire there may not be a second opportunity to look at the fire scene. Scene observation by the first responder is essential to the investigator in putting together his/her report for the investigation. Therefore, the information given to the Incident Commander or supervisor about the incident should recall all observations, beginning with the scene as the fire company arrived. It should include information on the following topics: where it was; what was burning; the intensity of the burning; the crowd; the traffic leaving the area; whether any obstruction impeded fire department access to the fire scene; the first indication that there were multiple fires within the structure, etc.

A first responder is responsible for being able to recall the situation as it progressed. Details observed by the first responder are important and should be related to the Incident Commander or supervisor as accurately as possible. The report should be in his/her own words and detail the point at which each observation was made during response, suppression, or postsuppression activities.

Remember, details are critical, and the smallest detail may be important to the investigator. These details should include the description of the occupancy (residential, mercantile, educational, institutional, public assembly, industrial, storage). As a first responder, you should ask yourself the following "detail prompts":

- What were the location and the path of travel of the fire?
- Was the progression of the fire above normal (small and medium burning upon arrival and, within a short time, total involvement)?

- Did fire suppression tactics do little to slow the progress of the fire?
- Were fire protection systems (sprinklers) operating, and were the sprinklers controlling the fire or was the fire progressing ahead of the system?
- How did the suppression crew enter the building?
- Was forcible entry necessary?
- Were there windows open, or did the suppression personnel have to ventilate the structure? Open doors and windows are important details that should be passed on to the Incident Commander or supervisor.
- Was anything unusual observed, e.g., blocked fire department access, vehicles leaving the scene?
- Were there holes in the walls or floors inside the fire building?
- Did it appear that furnishings had been moved around and/or were missing?
- Were items piled up in the center of the room?

Anything that may seem suspicious should be reported to the Incident Commander or supervisor. Do not forget to include even the smallest detail.

In some cases you may find evidence. This evidence should not be removed, but should be guarded and reported to the Incident Commander or supervisor. Do not handle any pieces of evidence, and be sure that someone is guarding it until it can be turned over to the investigator.

### **Postsuppression**

Overhaul and salvage operations should be discontinued until the investigator arrives and can take pictures of the location of the evidence, sketch the area, and take samples. Any evidence that has to be removed should be noted in the first responder's notes with a description of where it was found in relation to the fire. **Only** in cases where evidence is inside the fire building, or there is a chance that it may be destroyed should it be removed.

### **Critical Observations**

We will consider five phases during which critical observations are essential:

- reporting the fire;
- dispatch and travel to the fire;
- observations (location and extent of fire);
- suppression; and
- overhaul.

During the incident the first responder will see thousands of images and make hundreds of decisions, many instantaneous. The many phases of the operation will give the first responder the opportunity to make particular observations that may be critical to the fire cause determination. On the other hand, he/she may note something casually that later will emerge from memory. This also may be a critical piece of information.

## **REPORTING OF THE FIRE**

### **Observations From the Person Reporting the Fire**

The first critical piece of information about the fire usually will come from the person calling in the fire alarm. This person may have discovered the fire, be the occupant of the fire building, or be a passer-by. The person receiving the information from the caller should try to record all of the following information.

- The name of the person reporting the fire. It is important to note any accents or speech impediments, or a pitch that would distinguish the voice of a child or a woman from that of a man. Also note the speed of speech, and any other distinctive traits.
- Emotional state of the person reporting the fire. The person taking the call should note whether the caller sounded calm or excited. If the fire was not planned, one would expect some level of excitement in the caller's voice, especially if it were the owner or occupant reporting the fire.
- Any background noises, especially if they are unusual. If a person is calling from inside a building, one would not expect to hear trucks rumbling by. But if one is calling from an outside telephone, the likelihood of trucks rumbling by or other traffic noise is much greater.

- The exact address of the fire, or at least specific information on the area such as street names, landmarks, etc.

## **Dispatch and Travel to the Fire**

### **Weather Conditions**

The first responder should note weather conditions, including wind direction and speed in relation to the direction of fire travel. Wind may account for the intensity and/or spread of the fire. Do not fail to make note of clear weather conditions versus rain, snow, or ice. If the fire was incendiary, it may have been the arsonist's intention to set the fire in bad weather in order to delay the fire department's response.

Obtain temperature and humidity readings. Freezing temperatures may cause fire hydrants to freeze, or pose other hazards that can delay fire suppression. Climatic conditions and statistics can be obtained by calling the closest office of the National Weather Service. Another key point to note is any change in weather conditions during or after the fire.

### **Response Route**

The next critical phase for making observations begins with the response. While en route, the first responder should be aware of anything unusual, especially as he/she nears the fire scene. Vehicles traveling away from the scene without lights at night or with persons crouching down in the seat to avoid being observed might be good indications that they were linked with the fire. Pedestrians may be casually or hurriedly leaving the fire scene itself; they may be acting in a strange or suspicious way.

Of particular interest to the first responder are other factors that are not directly associated with the fire itself but which may have some tie-in. Was the timing of the fire such that your response was slowed because of a train passing through a grade crossing, or a raised drawbridge? Road construction or repairs can cause delays, especially an unsuspected detour. Traffic patterns at certain times of the day (morning or evening rush hours) can cause delays. Someone who planned a fire may take advantage of a social event like a parade or an athletic event that can cause traffic bottlenecks. The first responder should note anything of an unusual nature.

The vehicles in the area of the fire may carry some valuable clues. The first responder may find it helpful to question witnesses and any other responding emergency personnel as to their observations. The first responder should note if the same vehicles have been observed at fire scenes on more than one occasion. Note and identify any vehicles that were damaged by fire, heat, or smoke. Try to find out why these vehicles were there. Attempt to obtain descriptions and license plate numbers and record this information. The driver/owner may be questioned later regarding the reason his/her vehicle was at the fire scene.

This listing is not all-inclusive. Experienced first responders can think of many more factors that can be noted during the response phase.

## **OBSERVATIONS AND EXTENT OF FIRE**

### **Observations Upon Arrival**

Without a doubt, the fire scene itself provides the greatest chance for observations. The first responder will want to take note of the spectators in the area. Large numbers of spectators usually will gather to observe any type of disaster. Fires are no exception.

Groups of spectators can be videotaped or photographed for later detailed review. Things which may prove helpful include

- Familiar faces or individuals seen at other fires.
- The actions of spectators, such as individuals who appear too concerned about the incident or are too vocal about the incident, and who voice criticism about fire and/or police agencies, neighbors, society, and/or government agencies.
- Individuals who appear to be too quiet or withdrawn, or overly frightened about the fire.
- Individuals who appear to be too excited about the emergency, or who are overly brave, helpful, or curious.

Spectators may provide helpful information. Construction or repair crews should be noted. Accidental fires often result from repair crews working in a structure. Repair crews may be reluctant to be interviewed because, if they had any part in the fire or fear liability from damages caused by the fire, they may fear losing their jobs. Spectators may show signs of having

been involved in starting the fire. They may be wearing fire-damaged clothing or clothing that has an odor of accelerants. They may show visible fire injuries.

Another important set of observations relate to the physical aspects of the fire itself. The first responder must observe the fire conditions at the time of arrival. Observe how the fire vented itself, noting natural ventilation versus fire company venting. Note any removal of debris, furnishings, stock, supplies, etc., and provide security for materials or debris which may aid in identifying the point of origin or fire cause.

If fire suppression (extinguishment) activities still are occurring, note both damaged and undamaged areas of the structure. The structure may suffer extensive damage during the suppression phase.

Other fire areas may have required more immediate attention by fire personnel because of the need to protect dangerous materials, protect high-value areas, to stop fire extension to other areas of the building. The officer should note areas of open burning (visible flames) which may indicate the type of fuel being consumed. The first responder should ask himself/herself:

- Was there complete or partial collapse of the structure?
- Was there ignition or exposure of flammable or hazardous materials?
- Were there reports of any explosions?
- Were firefighters forced to fall back for any reason?
- Did a fast-spreading fire overtake the fire streams?

### **Observations During Sizeup**

The next important observation phase is the sizeup period. Upon arrival, firefighters need to seek available occupants to ascertain the rescue needs of occupants who have not yet been accounted for. This task does not negate the need for a primary search, but does narrow down search responsibilities.



During this activity, first responders should note several items:

- Is the clothing worn by occupants what one would expect for the time of day and year?
- Did the occupants have time to retrieve special items such as a child's favorite toy, a pet, an insurance policy, someone's favorite fishing pole or shotgun, photos, jewelry, or valuable antiques?
- Are there any signs that the occupants have burns, cuts, or singed body hair that may indicate they were close to the fire?
- Is there any sign of soot around their mouths to indicate they were breathing smoke?
- Do any of the occupants need medical attention?
- Are there any spectators who have been seen at other fires, especially fires of a similar nature in the same general area?
- Is anyone acting strangely, e.g., hiding in shadowy areas, standing out for some reason, or trying too hard to blend into the crowd?

Persons who intentionally start fires often will stay at the fire scene to see the results of their efforts. Many fire investigations reveal that the same person was observed at several fires.

### Location and Extent of the Fire

During sizeup and suppression you can make many observations about the location of the fire, the extent of the fire, and the path of fire travel. These observations may be critical during the fire scene examination to help determine if fire behavior was normal or if it was assisted in its path of destruction.

### First Responder Observations

One critical observation is to determine whether the location of the fire corresponds with the information from the caller who reported it to the authorities. A fire reported in the basement that, upon arrival, is a fully involved attic fire may be explained by the type of building construction. Or it may have been intentionally started in the attic with a trailer from the basement.

It also is important to establish if the fire spread and travel are as anticipated for the type of building and occupancy. The spread of the fire may be typical, or it may indicate some "assistance."

Any evidence of the occupants' escape needs to be noted. Things like ladders to windows, escape ladders from windows, bedsheets tied together, or reports from a neighbor that the mother dropped her baby two floors into the arms of a passer-by are strong indications that the occupant did not plan a fire.

### **Observations During Suppression Activities**

During fire suppression efforts the first responder probably will be in the best position to observe the fire. Physical aspects of the fire, such as materials burning, appearance of more than one area of fire origin, and the color of the fire are critical observations. It also is essential to note the current stage of burning and the intensity with which the fire is burning.

Among the many other things to be noted are the doors of the structure. Was forcible entry necessary, or were the doors already open or unlocked? Doors may have been left open accidentally in the occupants' rush to flee the fire, or the doors may have been opened intentionally. If the occupants state that they closed the doors, one should attempt to discover how they were opened. Neighbors or police officers who arrive before firefighters and try to help rescue the occupants often open doors to determine if everyone has made it out of the building.

Try to determine if the fire went out as would be expected or if the fire was difficult to extinguish. Fires that are difficult to extinguish and do not react normally to the application of water may have had an unusual fuel load. This should be noted and examined after the fire is out to determine the possibility of a high fuel load. Was there anything unusual found during suppression, such as windows covered to hide the fire, a means of egress intentionally blocked by furniture, or disabled fire detection and suppression equipment? If the structure had detection equipment such as smoke detectors, did any firefighter hear it operate? If the structure had fire suppression equipment such as automatic sprinklers, how did it perform in fire control and suppression? Had it been tampered with, or did it operate as it should?

The items mentioned in this unit are some of the most important observations. Experience will reveal many others, as will spending time with your colleagues in discussion.

## **Observations During Overhaul**

The last critical phase during which more observations can be made is the overhaul phase. In many respects, it is the best because you do not have to worry about the fire and you have plenty of time to carry out a careful examination. The overhaul phase is the first real opportunity to start making critical firsthand observations about the structure, its contents, and the circumstances that caused the fire.

The first thing to establish is whether there appear to be any items missing. On the other hand, note any items present that normally would not be there. Note any items that appear to have been moved prior to the fire.

A person planning a fire may remove things prior to the fire such as family photographs, favorite items of clothing, pets, or expensive sporting equipment and trophies. The first responder who makes these observations needs to speak with the owner or occupant about these items.

Look for indications of unusual prefire activity. In some situations fire is used to cover a burglary. The evidence of the burglary may be apparent after fire suppression. Vending machines or cash registers pried open will remain in the open position after the fire. File drawers forced open or left open are another indicator. Doors that have been forced, broken windows, or other structural damage not caused by the fire may go unnoticed unless you are observant during the overhaul phase. In this respect, it is critical during the overhaul phase that firefighters disrupt things as little as possible. Sometimes, in their haste to perform overhaul, these things can be removed or altered.

It also is important that the first responder note the features of the structure that allow the fire, heat, or smoke to travel. Open stairs, pipes or electrical shafts, laundry chutes, and heat ducts are some of the most common paths of fire travel. Building renovations often result in dropped ceilings, covered walls, or new voids. Often, these are responsible for hidden fire and fire travel. Fire is often hidden in these voids and may burn for a considerable length of time before being discovered.

Finally, the utilities need to be evaluated to determine if they were operational at the time of the fire, or shut down by fire suppression personnel. Try to determine if there were any signs of malfunctions, improper use of the utility, or other factors that could have caused or contributed to the fire.

## **ORAL AND WRITTEN NOTES OF FINDINGS**

There are a variety of reasons for collecting and documenting accurate and complete information about a fire. First, written documentation gives an accurate, step-by-step progression of the fire. Second, it provides information to enable the fire department to analyze and evaluate suppression and prevention performance. Third, it provides data on fire problems, fire protection equipment, building components, and fire losses.

Reports and field notes must be written so that the first responder can go back and review the information at a later date. Once field notes are incorporated into a report their disposition should be determined by department policy. Some departments recommend that the first responder keep the notes; other departments allow the first responder to destroy the notes after incorporating them into the report. Be aware of your department's policies before destroying or archiving fire incident notes.

The fire incident report usually is prepared by the Incident Commander. In some cases, it is the first responder who prepares the report. This report documents fire suppression methods, fire prevention systems, injuries/fatalities, and possible origin and cause determination.

### **Preliminary Report**

The preliminary report contains the basic information surrounding the fire scene. It includes fire notes, drawings, evidence (if removed), and a description of findings at the fire scene.

In preparing the preliminary report, take a look at the fire scene, take notes on each room, and describe the fire damage and travel. Also note fire suppression efforts, fire protection systems, forcible entry, point of origin, elimination of accidental and natural causes, and the fire cause with all supporting evidence. Document in notes and drawings the evidence discovered and collected. Compile field notes on all persons connected with the incident. In these notes identify the persons interviewed, other persons present during the interview, location of the interview, and the questions posed and answers received.

Notes should contain pertinent information. Avoid personal opinions or comments. Record only facts and objective observations. Do not compile information on different cases in the same set of notes. Include in each set of fire incident notes the address, times, dates, weather conditions, case name, description of the occupancy, and description of the fire scene. Be

sure to document ownership of the occupancy, person discovering the fire, any injuries or deaths, and any insurance information available.

As mentioned previously, always follow department procedures regarding storage/disposition of field notes. Remember, if field notes are retained, they are subject to subpoena for court appearances and/or depositions.

### **Notes of Observations**

Good documentation is complete and accurate. It should answer all questions concerning the incident, including ensuring that all persons and places mentioned in your notes are identified in detail. This should paint a complete picture of the incident.

Notes must be proofread to eliminate grammar, spelling, and punctuation errors. Readers of the notes must be able to focus on the facts in the case, and should not be distracted by errors. Notes should be concise. They should not be padded to increase their length, but they need to contain all the facts pertinent to the case. Notes need to answer these basic questions about the fire and investigation: who, what, where, when, why, and how.

#### Who

- Discovered the fire?
- Extinguished the fire?
- Provided scene security?
- Has pertinent knowledge regarding the fire?
- Was the victim?
- Made the report?
- Has a motive for the crime, if there was a crime?

#### What

- Happened?
- Actions were taken?
- Damage occurred?
- Was the crime, if there was a crime?
- Do witnesses know?
- Evidence was found?
- Was done with the evidence?
- Is the chain of custody of the evidence?
- Agencies are involved?

Where

- Did the fire start?
- Did the fire travel?
- Was the witness?
- Were the owners/occupants?
- Was the evidence collected?
- Is the evidence stored?
- Was the crime committed, if there was a crime?

When

- Was the fire discovered?
- Was it reported?
- Was the investigation conducted?

Why

- Did anyone make statements?
- Were the people reluctant to talk?

How

- Was the fire discovered?
- Did the fire start?
- Was the evidence collected and secured?

**PERSONAL NOTES AND DRAWINGS**

**Write the Way you Talk**

In writing any notes, preparation is the first step. All necessary information must be collected and compiled before writing the notes. Next, material should be arranged in a systematic order, and any material not pertinent to the incident should be discarded. The use of an outline helps to ensure that the notes are presented in chronological order. A rough draft is usually the next step. At this point, do not worry too much about spelling, punctuation, and grammar. The use of a rough draft usually allows for an easy transition into the final form.

The notes will be read by peers, supervisors, the public, and colleagues. They must take into account all items discussed in this unit. Correct grammar and spelling are essential; misspellings and improper grammar can give the entire investigation a sloppy appearance. Each document needs to be proofread for completeness and accuracy.

When writing notes, it is proper to use the first person: "I arrived at the scene," or "I observed...." Avoid second and third person styles such as, "This first responder....," or "This officer observed...." The first responder needs to determine the target audience and write for that audience. Since the reader may know nothing about fire investigation, avoid terminology that only fire personnel understand. If such terminology is required, provide a clear explanation. For example, explain that "V patterns" point toward the area of origin or that a "liquid accelerant pour pattern" is typical for the use of accelerants. Avoid terminology that cannot be explained, such as "smelled like benzene."

Reports should contain only material and information pertinent to the incident. Personal opinions, conclusions, and suspicions need to be eliminated.

### **Personal Drawings of the Fire Building or Area**

Notes made by the first responder must be accompanied by drawings. The drawing of the fire scene should be a basic floor plan or layout of the structure. If possible, include the dimensions of the structure. As the first responder makes the drawing, he/she should note the basic room and highlight unusual occurrences such as clothing piled on the bed, that was then set on fire. Any evidence placement should be noted on the drawing, e.g., gas can in the corner of the bedroom. Use natural measurements to describe the exact location on the drawing (five feet from south wall next to closet door). Include all items found in the building in your drawing, as well as the location of any fatalities or serious injuries that occurred. On the drawing, note all areas of burning. For example, the two end bedrooms show a large amount of burning as well as the kitchen, but the third bedroom, which was in the middle, shows only smoke damage. These drawings will be of great assistance to the investigator. Be as accurate as possible with the drawing so that you may recall details of your observations and identify the various aspects of the scene, fire structure, and any evidence that was found.

## SUMMARY

Careful and methodical observations on the part of the first responder are critical in helping to make a determination of origin and cause. Observations made at the time of the alarm and during response, sizeup, suppression, and overhaul will contribute a vast amount of useful information. Later, this information will be sorted out and evaluated to see which parts can help determine origin and cause.

The importance of careful and accurate reporting of observations cannot be underestimated. It is perhaps the most important aspect of fire investigation. Often, the first responder's notes will be the only source of information available concerning the fire incident. These notes should be written so that an investigator reading it for the first time would have at least a general understanding of what occurred.



## Activity 7.1

### Visual Walkthrough of Fire Scenes

#### Purpose

To examine a series of slides of a fire and to make some basic observations, using the material presented in the course.

#### Directions

1. Watch each slide for 15 seconds.
2. You will have 2 minutes to write down what you have observed, using the material that has been presented to you in the course.
3. There will be a group discussion after each slide is shown.

#### Slide 1

---

---

---

#### Slide 2

---

---

---

#### Slide 3

---

---

---

**Slide 4**

---

---

---

**Slide 5**

---

---

---

**Slide 6**

---

---

---

**Slide 7**

---

---

---

**Slide 8**

---

---

---

**Slide 9**

---

---

---

**Slide 10**

---

---

---



## ADDITIONAL READINGS

NFPA manuals contain forms commonly used by fire investigators.

|               |   |
|---------------|---|
| NFPA 902M     | <i>Fire Reporting Field Incident Manual</i> |
| NFPA 906-M-1  | <i>Field Notes for All Fires</i>            |
| NFPA 906-M-2  | <i>Structure Fires</i>                      |
| NFPA 906-M-3  | <i>Motor Vehicles</i>                       |
| NFPA 906-M-4  | <i>Wildland Fires</i>                       |
| NFPA 906-M-5  | <i>Fire Casualties</i>                      |
| NFPA 906-M-6  | <i>Witness Statements</i>                   |
| NFPA 906-M-7  | <i>Evidence</i>                             |
| NFPA 906-M-8  | <i>Photographs</i>                          |
| NFPA 906-M-9  | <i>Sketches</i>                             |
| NFPA 906-M-10 | <i>Insurance Information</i>                |
| NFPA 906-M-11 | <i>Records and Documents</i>                |



## BIBLIOGRAPHY

*Fire Cause Determination for Company Officers*, Instructor Guide and Student Manual. Emmitsburg, MD: National Fire Academy.

*Fire Service Communications*, Instructor Guide and Student Manual. Emmitsburg, MD: National Fire Academy, 1983.

*Initial Fire Investigation*, Instructor Guide and Student Manual. Emmitsburg, MD: National Fire Academy.

NFPA 902M, *Fire Reporting Field Incident Manual, Basic Incident Reporting*. Quincy, MA: National Fire Protection Association, 1990.

NFPA 906M, *Guide for Fire Incident Field Notes*. Quincy, MA: National Fire Protection Association, 1988.

