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2.1 Introduction

This chapter is an introduction to fire investigations. It provides the chemist with a basic overview of fire department activities, how and why investigations are conducted, fire scene safety, the collection of evidence, and a discussion of arson enforcement resources. Becoming a professional fire investigator today requires an increasing amount of training, education, and experience. This chapter does not attempt to address all aspects of fire investigation; however, it will provide the chemist with the basic tools to operate as a member of an investigative team at a fire scene and to be conversant with a local fire investigator when discussing an investigation. There are many books, publications, articles, and other resources that address fire investigations; these should be consulted for more detailed information in this field. Additionally, it should be noted that for the purposes of this chapter the discussions are relevant to investigating structure fires. Many of the same principles and procedures apply to other types of fires, such as those that involve vehicles, marine vessels, and wild lands.

2.2 Fire Investigation Issues

2.2.1 The Fire Problem

According to the U.S. Fire Administration, in the year 2000 there were 1.7 million fires reported in the U.S., and many others were unreported. The U.S. has one of the highest death rates due to fire in the industrialized world at 14.5 deaths per million population. A total of 4,045 Americans lost their lives in fires in 2000, and another 22,350 were injured as the result of fire.
The direct property loss due to fire was estimated to be $11 billion. An estimated 75,000 fires were incendiary or suspicious in nature and resulted in 505 civilian deaths and $1.3 billion in property damage. As illustrated in the U.S. Fire Administration’s statistics, fire has a considerable impact on our society and takes an enormous toll in lives and property.

2.2.2 What Is Arson?

The term “arson” is commonly used today to describe a crime that involves the intentional burning of property. It originates from an Anglo-French word meaning “the act of burning.” The common law definition of arson was the willful and malicious burning of a dwelling; over the years, state statues and federal laws have replaced the common law definition. Most of today’s arson laws involve the intentional burning of property, not only dwellings. Statues vary from jurisdiction to jurisdiction. It is recommended that you consult local, state, or federal statutes for more details and specific language and application.

2.2.3 The Role of the Fire Department

It is the role of the municipal fire department to respond to reports of hostile fires and take appropriate action. Members of the local fire department are typically the first officials to arrive at the scene of a fire. Depending on the severity of the fire, numerous firefighting assets may arrive and participate in the operations. It is at this point that the fire investigation really begins. While not formally trained as fire investigators, firefighters can make note of the time of the fire, the fire conditions, the weather conditions, and the point of entry to suppress the fire. In addition, any suspicious or unusual activity surrounding the fire should be noted, including burn patterns, open doors or windows, alarms, unusual odors, deep-seated fire, and overall behavior and conditions.

The actions of a fire department at the scene can be separated into three distinct phases: (1) suppression, (2) overhaul, and (3) investigation. During the fire suppression phase, the first goal is to save lives; the second goal is the suppression of fire and the protection of property. In their mission, firefighters typically utilize hoses that are 1-1/2 to 2-1/2 in. in diameter to control and suppress the fire (Figure 2.1). As mentioned in the previous chapter, the application of water removes one side of the fire “triangle” — heat. After the fire has been extinguished, firefighters will search for hidden fire in walls, ceiling spaces, or other areas that are not easily accessible. This phase is termed “overhaul,” and includes opening walls, pulling down ceiling materials, removing flooring, etc., to ensure that the fire has been completely extinguished. During overhaul, firefighters can unwittingly alter the fire scene by
removing furnishings, devices, wiring, walls, and ceiling or framing materials. Unfortunately, this alteration of the fire scene can create difficulties for the fire investigator. Depending on the jurisdiction involved, the fire scene investigation can occur in conjunction with overhaul, where the investigators are on the scene to direct the overhaul activities and to ensure the preservation of evidence.

The final phase of fire scene activities involves the investigation of the fire with the intent of determining its origin and cause. Although this is identified as the final phase, the investigation of the fire scene can actually begin during the suppression or overhaul phase. The commencement of the investigation depends largely on the time of arrival of the fire investigator or the abilities and responsibilities of the fire suppression personnel. Fire investigators will attempt to determine whether the fire was accidental or intentionally set (incendiary). Upon completion of the fire scene investigation, the property is typically released to the property owner or insurance company for further action.

2.2.4 Why Investigate Fires?

As previously discussed, fire is enormously costly to society. Fire departments across the country are required to investigate fires to determine the origin and cause. A fire occurs when a fuel comes together with oxygen and a heat source. It is the role of the fire investigator to determine how and why these
factors came together and to answer the question: “Was this an accident or an intentional act?” It is not only the role of the fire department to suppress the fire but also to identify the cause of the fire.

The two primary reasons that fires are investigated are to determine what caused the fire and to identify and collect any evidence related to that cause. The purpose in determining the cause of the fire is to prevent the situation from occurring again. This is accomplished by identifying hazardous conditions or practices, product failures, or other fire causes. Once the cause is known, officials can educate the public or seek code changes in an effort to limit similar types of fires. Products suspected of causing fires can be examined more closely and modifications can be made or recalls issued in an effort to take corrective action. The second reason to investigate fires is to obtain evidence necessary to hold accountable the person or entity responsible for the cause — particularly in the case of an intentionally set fire. If the fire is determined to have been set, investigators will search for clues in the ashes in an effort to solve the crime (Figure 2.2).

2.2.5 Who Conducts Fire Scene Investigations?

This question is not always easy to answer and is sometimes unclear. While sworn law-enforcement officers typically investigate alleged or suspected crimes, this is not always the case with fire scene investigations. Persons from both the public and private sectors — often persons with varying technical backgrounds — investigate fires. Many of the public sector investigators are

Figure 2.2 A team of fire investigators systematically examines the scene to determine the origin and cause of the fire.
not law-enforcement officers but have some level of knowledge and have
achieved a level of competence in fire investigation. The person conducting
the fire investigation could be a volunteer firefighter with minimal training
or a full-time, career investigator working for the police or fire department.
In more rural parts of the U.S., a full-time fire investigator may be hours or
days away from the scene. Most states have a fire marshal’s office, yet these
investigators typically have large geographical areas to cover and, as a result,
may not be able to investigate every fire. Often it is the responsibility of the
volunteer fire department to make the initial examination to determine the
cause of the fire and request additional investigative resources if required.

In many cases, the property involved in the fire is insured. As a result,
the private side of fire investigations can have a role in the investigation of
the fire scene. Yet, this typically occurs after the public sector investigators
or the fire department have concluded their investigation and the custody
and control of the property is returned to the owner. Private fire investigators
and insurance representatives often visit the scene and conduct an indepen-
dent investigation of a fire to document the cause and collect any relevant
evidence. Depending on the circumstances of the fire, insurance companies
can hire other experts. These experts can include fire protection engineers,
electrical engineers, metallurgists, forensic scientists/chemists, heating and
air conditioning specialists, and others. Attorneys involved in investigations,
whether public or private, will often visit the fire scene to make observations
and discuss findings with other experts.

As you can see, the investigation of fires can be somewhat complex and
not as clear-cut as other forms of investigation. Fires are investigated by a
wide range of personnel, and can involve a very limited investigation or an
extensive investigation conducted by highly trained and experienced mem-
ers of a fire investigations unit within the fire or police department or even
the local prosecutor’s office. The private sector can play a large part in the
investigation of fires.

2.2.6 Fire Investigator Certification Programs

Public sector fire investigators typically receive formal training in fire inves-
tigation from state and local organizations, colleges, and on-the-job training
working with experienced fire investigators. The term “Certified Fire Inves-
tigator” or CFI is often used in the fire investigation community to identify
an individual who has obtained a recognized level of education, training, and
experience. The term, however, is sometimes loosely applied to an individual
who has been certified by a state as a fire marshal or fire investigator. While
the term may be variously defined depending on the area of the country,
there are presently only two organizations that certify fire investigators based
on a minimum set of standards for education, training, and experience: the
International Association of Arson Investigators (IAAI) and the Bureau of Alcohol, Tobacco, Firearms, and Explosives (ATF). Successful completion of these certification programs results in the designation of CFI. The IAAI certification process requires fire investigators to submit a detailed application describing their experience, training, education, and courtroom testimony. Once the minimum standards have been met and the application is approved, the candidate must take and pass a written examination administered by the IAAI. ATF also conducts a certified fire investigator program as part of its arson enforcement mission; however, the program is limited to ATF special agents only. This certification program spans a two-year period in which the CFI candidate must investigate and document 100 fire scenes with experienced fire investigators. In addition, ATF CFI candidates must attend approximately 200 h of ATF-organized training in the areas of fire investigation, fire behavior, and courtroom testimony. The candidate must complete various reading and writing assignments related to fire investigation, successfully complete two undergraduate fire science courses at a national university, and conduct a research project relating to some aspect of fire behavior or fire investigation. Upon completion of these requirements, the candidate is designated a Special Agent/Certified Fire Investigator. Both the IAAI and ATF certification programs have a recertification process that requires the investigator to maintain a level of competence by attending fire investigation training and conducting fire investigations.

2.2.7 Fire Scene Safety

The safety of the fire investigators and other investigative personnel working in and around fire scenes should be of utmost concern. Fires can cause a great deal of destruction and, as a result, dramatically impact the stability of a structure. Personnel involved in a fire investigation typically must enter the structure in an attempt to determine the origin and cause of the fire, document the scene, and collect appropriate evidence. It is paramount that these activities are conducted in a safe manner and that personnel are provided with the proper safety equipment, as illustrated in Figure 2.3. Working in and around fire scenes can be inherently dangerous, and the proper safety measures should be followed for every investigation.

Prior to entering the fire scene, the investigator should make an assessment of the exterior of the structure to evaluate potential hazards. Close attention should be paid to any nonsupported or partially supported building components (walls, floors, roofs, stairs) that may have the potential for collapse (as depicted in Figure 2.4). The location and status of all utilities (gas, water, electricity) should be determined as well as the presence of any hazardous materials (see Figure 2.5). If fire department personnel are still on the scene, they can provide an assessment of the building and point out any
hazardous situations that they have found during their fire suppression efforts. In addition, the fire department may be able to monitor the environmental conditions inside the structure, including the levels of oxygen, carbon monoxide, or other contaminants, with the use of an air monitor.

Not only is the fire investigator concerned with the integrity of the structure but other health and safety issues as well. One of the greatest safety hazards at a fire scene can be airborne contaminants. With the use of synthetic materials in household and commercial products, fire investigators are frequently exposed to respiratory hazards while conducting investigations. In a typical structure fire, products containing plastics, foams, insulation, paints, and fibers are nearly always present. When these materials are involved in fire, they can liberate gases and vapors as well as aerosols, fibers, and particles. Combustion products typically found at a fire scene include carbon monoxide, hydrogen cyanide, oxides of nitrogen, and aldehydes (formaldehyde). Exposure to these contaminants can produce both acute (immediate) and chronic toxic effects. Protection from respiratory hazards in the form of gas, vapor, or particulate material must be considered. Inexpensive air-purifying respirators can be worn in a fire scene with little discomfort and do not hamper the investigator’s ability to examine the scene (as depicted in Figure 2.6). Since

Figure 2.3  When working in and around a fire scene, the proper safety equipment should always be worn to protect against exposure to contaminants, sharp objects, falling debris, and other hazards.
fire investigators typically do not know all the respiratory hazards that may be present within a structure, it is important to equip the respirators with filters that protect against particulates, volatile organic compounds, acid gases, and formaldehyde. Most vendors offer these levels of protection in a single filter and these filters are readily available to the public.

Other health and safety issues at the fire scene include electrical activity, pooled water, confined spaces, biological hazards, and low lighting conditions. One of the primary safety considerations at the fire scene is the public utility service to a structure. Fire departments will typically secure the electrical service to a residential or light commercial structure by removing the electric meter. Gas service is easily controlled by the closure of a valve at the gas meter. Although the fire department may have terminated electrical activity to a structure, any electrical device or wiring should be treated as if energized until it is fully evaluated by the fire investigator. On occasion, a building may have more than one electrical service that is not apparent to the fire department or utility company and therefore not deactivated. Building occupants may have installed nonapproved wiring or may have illegally run electrical service from nearby structures; where present, these sources need to be deactivated. It is recommended that an alternating current (AC) voltage detector or similar device is utilized to detect the presence of any

Figure 2.4 The potential for structural collapse is an ever-present danger at fire scenes. An assessment of the condition of the structure should be conducted prior to entering.
voltage prior to handling electrical wiring. These detectors are inexpensive and provide a great deal of safety when working in and around a fire scene. Pooled water is also a concern, especially when conducting an investigation in a basement or on a concrete slab. What looks like a shallow pool of water may actually be a deep sump pit or other opening in the floor. Water in the structure can also contain bio-hazards (sewage, infectious waste), particularly in abandoned buildings where homeless individuals may have loitered or others have utilized the structure for criminal activities.

To protect against the typical hazards encountered at a fire scene, the following minimum safety equipment should be worn or utilized:

- Hard hat or helmet
- Steel-toed boots with steel shank
- Air-purifying respirator with appropriate cartridges
- Coveralls
- Work gloves
- Eye protection
- Ear protection (if necessary)
- Flashlight

**Figure 2.5** The location and status of utilities (electric, gas, water) should be determined in the initial stages of the fire scene investigation. Hazards should be mitigated prior to entering.
Because of the potential safety issues at a fire scene, it is recommended that two or more personnel are together at all times. No personnel on a fire scene should ever enter a structure without notifying someone. Fire department investigators typically are required to notify the department’s incident commander of their presence on the scene and their anticipated activities. The incident commander often authorizes entry to the structure when all primary fire suppression activities have been concluded. Fire departments typically utilize accountability systems that document the personnel operating at a scene. These accountability systems should also include fire investigators and related personnel such as forensic scientists. The use of two-way radios by fire investigators also allows for quick notification in case of an emergency.

When departing a fire scene, all personnel should notify fire department officials that their activities have been concluded. Any soiled or contaminated...
clothing (coveralls, boots, gloves, etc.) should be isolated in a plastic-type bag for later cleaning or decontamination. These articles should never be taken home for cleaning as there is potential for cross-contamination. Commercial cleaning facilities should be utilized to properly clean these items.

As discussed in this section, the fire scene can be a dangerous place, and it must be treated with the utmost respect.

2.2.8 Legal Considerations

The fire scene investigator must determine the legal authority that allows entry to a property prior to conducting an investigation. It is generally recognized that fire departments have the legal authority to investigate the cause of fires for the purposes of public safety, as previously discussed. However, this right of entry is not unlimited and, according to various legal decisions, must be conducted in a reasonable period of time. The Fourth Amendment to the U.S. Constitution addresses search and seizure. Fire investigators must adhere to these standards and follow the exceptions closely.

The two Supreme Court decisions that have had the most impact on the fire investigator’s right of entry involve Michigan v. Tyler (1978) and Michigan v. Clifford (1984). In the Tyler case, fire investigators left the scene and returned later that day to continue their investigation. The Supreme Court ruled that once the investigators departed, the property owner’s expectation of privacy was restored. Evidence recovered by investigators in the later search was ruled inadmissible. There had been a 5-h lapse between the suppression of the fire and the initiation of the fire scene investigation. Investigators in the basement of the residence later discovered evidence that the fire was intentionally set. The Supreme Court ruled that the lapse in activity had effectively released the property back to the owner and that any further entry to the property by investigators required permission or a warrant.

While fire departments are required to investigate the cause, the investigation must occur upon suppression of the fire or in a reasonable period of time. After this reasonable time, fire investigators are required to seek other authority to reenter the property, including consent (preferably in written form) from the property owner or an administrative or criminal search warrant.

2.2.9 Scientific Method

Over the past 15 years, fire investigation has evolved into a science-based endeavor as more and more research has been conducted in the area of ignition, fire growth, and material performance. No longer can a fire investigator base his or her opinion about the cause of a fire on unsupported beliefs and mere experience. The opinion must be sound and stand the challenge of reasonable examination. Several recent court decisions have examined the methods of
experts including fire investigators. These decisions have resulted in the further application and understanding of the scientific method as it applies to fire investigation. Investigators are encouraged to systematically follow the scientific method when examining the fire scene. The National Fire Protection Association’s Guide to Fire and Explosion Investigations (NFPA 921) defines the scientific method as

…the systematic pursuit of knowledge involving the recognition and formulation of a problem, the collection of data through observation and experiment, and the formulation of testing and hypothesis.

NFPA 921 further explains how each step of the scientific method is applied to fire investigations.

2.3 Fire Scene Examination

A safe and successful fire scene examination is conducted in a reasoned and systematic manner following established procedures. The goals of any successful fire scene examination are to:

1. Determine the origin of the fire (where it began)
2. Determine the cause of the fire (the ignition source)
3. Locate, document, and preserve evidence that relates to the cause of the fire or associated criminal acts

Whether the fire scene takes minutes, hours, or days to investigate, the basic procedures are the same. Fire scene investigations typically involve three broad areas: (1) witness interviews, (2) the physical examination, and (3) forensic or engineering analysis. Since each fire is different and the circumstances surrounding the fire are also different, the degree to which each component is involved varies from fire to fire. Depending on the complexity of the fire scene, one investigator can be responsible for the entire investigation or the duties can be delegated among numerous investigators. For example, one group of investigators may be solely responsible for the scene investigation, while another group conducts all the related interviews. When this occurs, coordination between the fire scene investigators and the witness interview teams is critical so that current information and data flows between the two groups. The following sections discuss these three areas and the issues involved in fire scene investigation and the subsequent determination of the fire cause.
2.3.1 Witness Interviews

Witness interviews are conducted as part of a comprehensive fire investigation. Fire investigators seek out the information provided by witnesses or other individuals to assist them in accurately determining the cause of the fire. On many occasions, it is a witness who provides the clues to the investigators that can lead to a determination of the fire cause. A credible witness who observed the actual origin of the fire will prove invaluable to fire investigators. This is especially true when the fire has caused extensive destruction to the structure and the origin of the fire is not readily apparent to investigators. Fire investigators will attempt to locate individuals at the fire scene who either directly witnessed the fire, had knowledge about the structure, or had some background information which may shed light on the potential cause of the fire or circumstances related to the event.

In an attempt to obtain information about the fire, the following questions are typically asked of a witness:

- How did you learn about the fire?
- Who else was with you at the time you observed the fire?
- What did you do after you learned about the fire?
- What did you see?
- Where was the fire located in the structure?
- Can you describe the fire?
- Can you describe the smoke?
- Did you hear anything?
- What was the condition of doors or windows?
- Did you see any windows break during the fire?
- Did you see any person, any vehicles, or other activity around the structure either before or during the fire?
- Did you smell anything unusual?
- Did you photograph or videotape the fire?

It is always recommended that a witness be escorted back to the fire scene and interviewed at the location where the observations were made. This does not necessarily need to be done at the initial interview, but at some time during the investigation eyewitnesses should be asked to return to the scene to discuss their observations with investigators. When interviewing witnesses at the scene, investigators should walk them through their accounts of the events. This means having a witness stand in the precise location, if possible, where the fire or other event was witnessed and describe what was observed. This walk-through usually gives the investigator a clearer understanding of what a witness observed and also enables the investigator to detect any information that might be in conflict with other facts surrounding the investigation.
Many other individuals can provide a great deal of useful information to fire investigators. However, investigators must evaluate the information provided and determine if it is relevant, material, and credible. On occasion, individuals can provide false or inaccurate information for myriad of reasons. It is up to the investigator to weigh the information provided by all the witnesses against the facts in the investigation. Fire investigators typically interview all persons who have information about the scene to determine the conditions or events that may have led up to the fire. Interviews of persons in the immediate area of the scene can provide a wealth of information. These interviews, often termed a “neighborhood canvas,” can include building owners, occupants, tenants, neighbors, delivery persons, postal employees, or newspaper carriers. These people can potentially provide a wealth of information relating to the fire, the structure, and its occupants.\(^1\)

Since fires occur within a larger set of circumstances, it is useful for the fire investigator to interview all persons associated with the fire scene. This will enable the investigator to have the clearest understanding of the conditions before, during, and after the fire. This knowledge can then be compared to observations made within the scene. There are many other individuals who can provide useful information to fire investigators, including:

- Building owners and tenants
- Firefighters
- Contractors
- Insurance representatives
- Security services/alarm companies
- Local building officials
- Police officers

Some of the initial interviews that fire investigators conduct include the first-responding firefighters. The firefighters can provide valuable information relative to the location, behavior, and conditions of the fire, unusual odors, observations of unusual or suspicious activity, condition of the doors and windows, and the location and condition of victims. Contact with the first-responding firefighters is crucial in a fire investigation, particularly in cases where no eyewitness or other persons who observed the fire in its early stages can be found. In Figure 2.7, investigators interview a firefighter about the fire and suppression activities to gain a better understanding of the fire spread.

Many other individuals can provide a wealth of information regarding the fire or its cause. Contractors can provide additional information about repairs, renovations, or maintenance to the structure or its systems. Local building officials often can provide information related to building inspections and original or preexisting building permits and plans. Police officers
at the fire scene may have information related to recent activity prior to the fire or may have valuable background information on the tenants or the business.

As you can see, information gained from witnesses can be extremely useful to fire investigators. The list of sources of information cited herein provides a basic understanding of the types of details that might be useful in a fire investigation.

One issue that may be of concern during the analysis of fire scene debris relates to the presence of background contaminants or cross-contamination. This information may be useful to the forensic chemist when conducting an analysis of the debris for the presence of ignitable liquids. Could there have been gasoline or a medium petroleum distillate naturally present at the scene well before the fire? Skilled investigators must obtain the answer to this question and others like it to assist forensic chemists in their evaluation of fire scene evidence.

2.3.2 Exterior Fire Scene Examination

The ultimate goal of the fire scene examination is to identify the first fuels ignited in the fire and the source of ignition. The ignition source must be capable of causing ignition of the suspected initial fuel. For example, a single paper match, while an ignition source, is not likely to ignite a solid oak log, but that same match is easily capable of igniting a piece of newspaper. When
the ignition source and the first fuel ignited are identified during the fire scene investigation, the cause of the fire may be established. Yet, the investigator must also explain how these two came together.

Generally, all fires start from a single ignition source such as an open flame (match, candle) or a hot surface, and then grow in size to room fires and to large, structure fires. Thus, it is important to focus the fire scene investigation on the early stages of the fire in an attempt to identify the initial fuel and ignition source. To accomplish this task, the fire investigator must examine the fire scene in a systematic and deliberate manner, documenting the findings along the way.

The fire scene examination typically begins from the outside of the structure and later progresses inside. The investigator should remain objective and have no preconceived notion as to origin or cause. The old saying “you can’t judge a book by its cover” certainly applies to fire scene investigation. What may appear to be a likely cause in the initial stages of the investigation may not be the cause, and one must delve into the fire scene to make a true judgment about what occurred. It is for this reason that the investigation must be conducted in a systematic and objective manner and must follow the scientific method.

During the examination of the exterior, the location and description of any heat or smoke damage to the structure should be noted. The examination of the exterior and the telltale smoke and heat damage or patterns may give a general indication about the origin of the fire, as shown in Figure 2.8. Items removed from the scene by firefighters during overhaul may be found outside and require a closer examination. The condition of all doors, locks, or other points of entry should be evaluated, documented, and photographed. The utilities should be located and examined. The investigator must be aware of any items or materials that do not appear to belong in the area or seem to be out of place. For example, are any containers observed near the building? Are there ladders present, allowing access to windows and roofs? Are tools or any other articles that do not appear to belong in the area lying near a window or door? The public areas around the scene should also be examined, including pathways, alleys, lawns, parking areas, or other places that could possibly contain items related to the scene. In the case of intentionally set fires, arsonists have been known to drop containers or other materials as they depart the area. In one case, an amateur arsonist unwittingly left his wallet outside the building while rolling on the ground to stop his clothes from burning. Responding firefighters found the wallet and gave it to fire investigators who made a quick arrest in the case. As you can see, examination of the exterior is a valuable piece of the overall fire scene investigation and should be conducted in a diligent manner to obtain all evidence related to the investigation.
A suitable perimeter around the fire scene should also be established at this time, if not already established by fire department personnel. The perimeter of the scene, typically established using crime-scene tape, will be used to protect the integrity of the fire scene by limiting access to only those who have official duties and whose entry is approved by the jurisdiction having authority. The size of the perimeter should be large enough to include the entire scene, any adjacent areas that are deemed relevant, and any remote locations that may include evidence or other materials relevant to the investigation. It may be necessary at times for the perimeter to be modified to include remote areas as the scene examination progresses. For example, if a gasoline container is found lying on a pathway a hundred feet from the structure, the perimeter should be expanded to include the pathway and the area up to the structure.

It is also at this time that weather conditions should be noted, as weather can play a role in fire behavior. Most important are the temperature, humidity, and wind conditions. Particular attention should be paid to the wind direction and speed as it can play a large role in fire spread, particularly in large fires.

2.3.3 Interior Fire Scene Examination

Once the entire exterior of the structure has been evaluated and a suitable perimeter established, it is time to enter the structure to begin the interior
examination. At this time, the investigator should have the proper equipment to safely and successfully investigate the fire scene. The recommended minimum equipment to be used during the fire scene examination includes:

- Personal protective equipment
- Flashlight (preferably lantern style)
- Writing materials (clipboard or similar)
- Assorted small tools or multipurpose tools (screwdrivers, wire cutters, knives)
- Measuring devices (20- and 100-ft tape measures)
- Camera, film, electronic media
- Shovel or other hand tools
- Rubber gloves
- AC voltage tester

These items assist in the safe, proper, and complete examination and documentation of the fire scene. Most of the small items mentioned in the list can be easily carried in a small tool bag, waist belt, or fanny pack. Additional evidence collection equipment and supplies may be required for the investigation, depending on the nature of the fire scene.

The investigation of the interior is typically conducted in a manner that follows the fire from the area of least damage to the area of most damage. By following the damage from least to most, the investigator can attempt to trace the fire back to its origin, as typically the most fire damage will occur in the area where the fire began. This is assumed because the fire usually burns at the point of origin for the longest period of time; thus, the greatest degree of damage occurs in this area. This assumption is correct if all factors within the fire scene are roughly the same. This point is illustrated in Figure 2.9, showing the early stages of a couch fire, and Figure 2.10, which depicts the resulting damage. It is clear that the greatest damage to the couch is located nearest the lamp. As you move further away from the lamp, the damage lessens. This is the basic process that fire investigators use to trace damage back to the source or origin of the fire.

Hot gases associated with a fire flow much like a liquid, leaving a pattern or a path back to the area of origin. The size of the area of origin is relative to the scene and could be a building, room, or closet, depending on the circumstances. In the case of a fire in a large 50,000-ft² warehouse, the area of origin may be the northwest corner of the structure and involve 5,000 ft². In the case of a residential fire, the area of origin may be identified as a small bedroom on the second floor. As indicated earlier, the greatest degree of fire damage “typically” occurs in the area of origin; however, this is not always the case. The fuels and fuel arrays involved in the fire must be evaluated to
Figure 2.9  In the early stage of the fire, the halogen lamp has ignited the upholstery and foam of a couch. This is the point of origin of the fire.

Figure 2.10  The greatest damage to the couch is apparent in the area of the lamp, which is where the fire originated. As you move further from the lamp, the degree of damage to the couch lessens.
determine their burning characteristics to ensure you are not comparing apples to oranges. As all fuels burn somewhat differently, and ventilation can affect overall fire damage, it is possible to have an area of origin with somewhat less damage than an adjoining area. For this reason it is important to identify the fuels that were present and the ventilation in that area and relate that to the observed damage.

Many factors can influence the size, intensity, and length of burn time in a particular area. Nevertheless, it is an accepted practice to initially follow the fire from the area of least damage to the area of greatest damage. During this process, however, the investigator should continually assess contents, interior finishes, ventilation, and other factors that may have influenced fire behavior and resulted in greater-than-anticipated damage outside the area of origin. As an example, firefighters arrive on the scene of a large-scale fire that has been burning for 30 min and quickly suppress the fire in the area of origin. Yet, other areas of the building may have become involved in the fire and subsequently burn for a considerable amount of time before suppressed. This scenario will likely result in the area of origin having less damage than other areas of the structure that were involved at a later time and burned longer. In this situation, witness statements and interviews with responding firefighters is critical in accurately identifying the area of origin. The fuel distribution and ventilation within a structure can also play a role in the growth of the fire. A fire that originates in an area with minimal combustible materials and then spreads to areas that have a high concentration of readily combustible materials will likely result in a higher degree of fire damage outside the area of origin.

While conducting the initial examination of the fire scene interior, all safety issues should be noted and proper precautions taken. It is at this time that photographs or video may be used to record the initial findings. If conditions change within the structure, at least the investigator has the early photographs or video to document the scene. While following the trail from the areas of least to most damage, other issues can be documented along the way. Some of these issues include the presence and location of furnishings or other contents, identification of any flammable or hazardous substances, containers, electrical wiring, doors, windows, and other openings. In the case of a fatal fire, the location of bodies, if they have not been removed from the fire scene, should also be noted. The electrical panel should be located and documented as well. The position of the circuit breakers or condition of the fuses should be noted. In the case of a potential electrical fire, circuit protection in the form of a breaker or fuse could be important to the findings.

After following the damage from least to most, and evaluating the fire behavior relative to the contents and the ventilation of the structure, the area of origin should be located. As indicated earlier, the size of the area of origin
is relative to the amount of damage and the size of the structure. The area of origin can also decrease in size as additional information is obtained and the scene is examined. Fire investigators inspecting a fire involving an entire house may initially place the area of origin on the second floor. After further investigation, the investigation of the area of origin may close in on a specific second-floor bedroom, then to a portion of that bedroom.

Within the area of origin, a systematic removal of debris must be accomplished to examine the area further for fire patterns and evidence relating to the cause of the fire. This examination has often been compared to an archeological dig. As debris has accumulated as a result of the fire and destruction of the contents and structure, the area of origin is often hidden from view and any evidence of the early stages of the fire resides near the bottom of the debris. The debris within the scene must be carefully layered by hand, examined, and then removed from the fire scene, as shown in Figure 2.11 and Figure 2.12. This process is the most time consuming and requires a great deal of attention to detail on the part of the fire investigator. While systematically removing the fire debris, damage to all building materials, furnishings, electrical devices, and other contents should be documented and relevant items put aside for further examination. The investigator scrutinizes fire patterns within this area in an attempt to fully identify fire progression. The ultimate goal of this phase of the investigation is to identify the point of origin of the fire, which is described as the precise location where the ignition source and first fuel came together and burned. Sometimes the ignition source may have been destroyed in the fire or was removed from the scene by the person responsible for the fire — as in the case of a lighter removed as the arsonist flees the scene. It is up to the experienced investigator to make reasonable conclusions regarding the ignition source once all information has been gathered and the scene fully examined. The identification of the point of origin is key to the determination of the cause of the fire. In the case of an intentionally set fire, the fire investigator may discover multiple points of origin.

Once all the debris has been removed from the area and samples collected, the floor surfaces can be lightly washed with a fire hose, in a controlled manner, to remove any traces of the debris. This process can expose and highlight fire patterns and protected areas not yet observed by investigators. At this point, the remains of the furnishings can be placed back in their prefire location and examined along with the fire patterns. This reconstruction can be extremely helpful in determining the origin of the fire within a room as damage to the structure and contents are clearly visible. Documentation of this process should be made with an appropriate still or video camera.
Figure 2.11 Fire investigators must search the scene in a systematic manner to locate items that can assist in the determination of the origin and cause of the fire.

Figure 2.12 Fire investigators must carefully examine items found at the fire scene that may have a bearing on the cause of the fire. If further analysis is appropriate, the item can be collected and preserved at the fire scene.
2.3.4 Fire Patterns or Fire Indicators

The principal objectives in the determination of the origin and cause of a fire is the recognition, identification, and analysis of fire patterns. NFPA 921 defines fire patterns as the visible or measurable physical effects that remain after a fire (see Figure 2.13). These effects represent the history of the fire, as it is recognized that fires cause predictable patterns on materials as they burn. Since fires burn at or near the point of origin longer than at other places, all things being equal, then the most destruction should be at that point. Fire investigators use these patterns as pointers to trace the path of the fire back to its origin since gases from combustion flow like a liquid and will follow the path of least resistance around obstructions in an upward manner. Further examination of the scene can be focused in the suspected area of origin once the fire patterns or indicators have been identified. However, fire patterns can be cumulative and thus result in multiple patterns being overlaid, one atop another, as the fire progresses, other fuels become involved, and ventilation conditions change. It is the responsibility of the fire investigator to examine these patterns and assign them value as appropriate. With the proper examination of fire patterns, the investigator can trace the fire back to its origin. To do this, the investigator must fully understand the physics and chemistry of fire and the modes of heat transfer: convection, conduction, and radiation.

Often, there are many patterns or indicators that can be identified at a fire scene, some of which may be of value in the investigation. These patterns or indicators are not absolute and can be created in different ways. For example, the finding of thermal damage or a burn pattern on a combustible floor as shown in Figure 2.14 can be the result of ventilation, radiant energy from a nearby flame, hot gases, dropping or falling materials that burn on the floor, or the burning of an ignitable liquid or other flammable substance. The investigator may never know which event or series of events caused the fire pattern on the floor; yet, the observed damage cannot be dismissed, and must be noted and compared to other patterns or indicators that are observed at the fire scene. It is the culmination of fire patterns or indicators at the fire scene that the investigator uses to identify the origin or cause of the fire. No single indicator can be used to the exclusion of the others.

Patterns that are typically observed at fire scenes include “V” patterns, lines of demarcation, low burns and penetrations, charring (often called “alligatoring”), clean burns, and trailers. These patterns can be readily apparent to the casual observer, or hidden from view and apparent only upon removal of fire debris. Therefore, a comprehensive fire scene examination involves the systematic removal of debris so the investigator can fully evaluate the scene, the fire patterns, and the damage. It should be noted, however, that the formation of fire patterns is the subject of ongoing research to
quantify the factors involved in pattern development. Following are brief descriptions of some of the more-common fire patterns.

2.3.4.1 V and Hourglass Patterns
As fires burn upward and outward from a fuel source due to buoyancy, they usually leave distinct patterns in the shape of a V, typically referred to as a “V” pattern. These patterns are usually apparent on vertical surfaces such as walls that are directly adjacent to a burning object. The apex of the pattern will be located at the fuel source. The pattern then widens as it spreads up and out, away from the fuel source. In Figure 2.15, a V pattern can be seen across the front of an apartment building. The lowest point of the pattern is on the second floor landing where the fire originated. V patterns can be large, as shown in Figure 2.15, or much smaller and visible on interior surfaces. This pattern is one indicator to be used in the determination of the origin of the fire. Recent analysis has been conducted to rebuff some myths regarding the angle of V patterns. Studies have shown that the width of the angle in a V pattern is associated with the rate of heat release of a material and the
length of time the material is burned. Patterns can also be in the shape of an hourglass, particularly when a pool of liquid fuel burns adjacent to a vertical surface, as shown in Figure 2.16.
2.3.4.2 Lines of Demarcation

Lines of demarcation are the visible patterns or borders that delineate regions affected by heat and smoke from adjacent unaffected or less affected regions. Lines of demarcation can be in many forms and are used by fire investigators to assess the smoke or fire progression within a structure. The lines or patterns are created by a thermal insult to an object or during the deposition of combustion products. In Figure 2.17, the pattern left by the smoke within the room is clearly evident and a line of demarcation is seen on the walls. This pattern is helpful in assessing which windows or doors were open within a room and in evaluating witness statements regarding the smoke layer. Lines of demarcation or surface effects can also be seen on any metals in the form of oxidation, discoloration, or melting. As a metal is exposed to increasing temperatures, it begins to exhibit patterns relative to the thermal exposure. These patterns can be used to evaluate the direction or location of the fire and the intensity of the exposure. In Figure 2.18, the lines of demarcation and effect on the metal surface of the device are clear. These effects

Figure 2.16  An hourglass pattern is formed from a burning ignitable liquid on the floor adjacent to the wall.
Figure 2.17  The line of demarcation separating the smoke layer above from the fresh air below can clearly be seen on the wall surfaces.

Figure 2.18  The line of demarcation on this metal cabinet was caused by extensive thermal heating within the unit. Clean paint can be seen on the lower (cooler) portion of the unit.
were caused by the overheating of the device, which subsequently ignited nearby combustibles, causing a fire. Investigators used these patterns to confirm the cause of the fire, as it was determined that the patterns were the result of internal heating of the unit and could not have been caused by external heat exposure.

### 2.3.4.3 Low Burns and Penetrations

The lowest point of burning observed at a fire scene should be examined closely as a potential point of origin. Any penetration in the floor (as shown in Figure 2.14) should be evaluated to determine its cause. While penetrations in the floor and associated low burning can be the result of the burning of an ignitable liquid, the patterns can also be caused by structural collapse, radiation, or the pooling or falling (drop-down) of burning materials. These areas are often the locations where flooring, carpet, and fire debris samples are recovered by investigators for forensic analysis.

### 2.3.4.4 Charring

Charring to wood materials is commonly found at fire scenes. The amount and depth of charring is commonly used by investigators to evaluate fire spread, intensity, and duration of the fire. While the rate of wood charring has been quantified in laboratory experiments, the use of a defined rate of charring for fire scenes is not appropriate. Since the rate of charring is dependent on the intensity of the fire, duration of exposure, species of wood, and moisture content, an evaluation of charred wood for the purposes of determining an accurate time of exposure may not be reliable for a fire scene investigation. However, the comparison of charring depths in various locations in a fire scene may be reliable in determining relative time of exposure, assuming the wood species are the same. In Figure 2.19, the charring to the floor joists is quite apparent. Two of the joints are extensively charred to the point of collapse, and as you move away, the charring lessens. This damage assessment assists the investigator in determining which joint was involved in the fire for the longest period of time. This information is helpful in determining the point of origin for the fire.

### 2.3.4.5 Clean Burn

A clean burn to the surface occurs at a fire scene when a surface is exposed to direct flame impingement. The direct flame contact causes the soot deposits to be burned away, leaving a clean area. The clean burn can vary in size, depending on the size of the localized flame. These patterns can assist fire investigators in identifying the location of burning materials and can sometimes lead to the origin of the fire. In Figure 2.20, a clean burn area can be
Figure 2.19  The examination of wood structural members can aid in locating the origin of the fire. The fire has extensively damaged the joists in the middle of the photograph.

Figure 2.20  A clean burn occurs when flames or intense heating burns off the soot in a localized area. This pattern was caused by a container of ignitable liquid burning near the wall surface.
seen on a wall. An ignitable liquid and a small container were burning on the floor in the area of this pattern.

**2.3.4.6 Trailers and Pour Patterns**

“Trailer” is a term used by fire investigators to describe a combustible material or ignitable fluid intentionally placed to spread fire from one location to another. The pattern resulting from an ignitable liquid trailer is often called a pour pattern. The telltale signs of a trailer can sometimes be observed at a fire scene; however, this is largely dependent on the overall degree of damage and the trailer materials used by the arsonist. In a postflashover environment, the persistence of ignitable liquid patterns is less identifiable. In Figure 2.21, a trailer of gasoline was used to spread the fire across the floor of this room. The gasoline was first poured on a desk and then trailed out of the room.
to the doorway, where it was ignited with an open flame. During the scene examination, the location of the trailer may not be apparent in the fire debris. However, with the removal of the debris and cleaning and washing of the floor, the pattern may become apparent. In Figure 2.22, a pour pattern, caused by the ignition of an ignitable liquid, is clearly visible on the flooring. In this case the liquid burned, but there was no fire spread beyond the trailer.

If the use of an ignitable liquid trailer is suspected at a fire scene, an accelerant detection canine team should be utilized, if available, to pinpoint the location of an ignitable liquid. Ideally, the use of the canine team would occur in the early stages of the scene investigation and again upon completion of the investigation.

2.3.4.7 Scene Documentation
As with any investigation, the fire scene must be documented to record the findings of the fire investigator. Documentation can involve note taking, report writing, photography, sketching, or diagramming. The tasks provide
a means of accurately and contemporaneously recording the findings of the investigator so that they can be recalled at a later time for administrative, civil, or criminal proceedings.

Photography is the easiest way to accurately document a fire scene. The use of quality photography equipment with a separate flash unit is recommended. This equipment can be an SLR 35-mm camera, a digital camera, or a video camera.

Because fire scenes by nature are typically dark with black surfaces, photography can be somewhat challenging. This is why a separate flash unit is important when photographing a fire scene. Portable lights from fire department apparatus or the fire investigations unit can be useful in lighting a scene as well. Consideration should also be given to the use of a wide-angle lens.

When taking photographs at a fire scene, it is important to record the subject of each individual photograph. Upon later review of fire scene photographs, many may look the same. Therefore, it is important to document each image in a log identifying the date, time, and subject matter of the image. Also, the first image on each roll of film or digital media should be a title sheet identifying the agency, date, location, photographer, and case number if known. This information will help in later cataloging numerous rolls of film, compact disks, and other storage media with numerous fire scene images.

A video camera may also be useful in the investigation. This type of recording is valuable when briefing others who did not visit the fire scene as it provides a better overview and typically can more easily orient the observer than a group of photographs. When documenting with a camera (film, digital, or video), it is important to methodically document the scene rather than jump from one area to another.

Usually, the scene should be documented from general to specific. In other words, the scene should be photographed first from a distance and should include landmarks, street signs, or other reference points. Once this has been accomplished, the photographer can move into the medium-range photographs and then progress to more specific areas. It is also useful to photograph the fire scene from above. This may record fire damage or evidence that was not visible from ground level, giving the investigator a different perspective on the scene. Viewing the scene from above is particularly useful in large fires and can aid the investigator in identifying areas of greater damage. Depending on the size of the scene, the overhead view can be accomplished with the use of a ground ladder, a ladder truck, or an aerial platform, as shown in Figure 2.23. To get a full view of extremely large scenes, photographs from a helicopter may be more appropriate.

It is also recommended that a diagram or sketch be drawn to reflect the geometry of the involved structure. Accurate measurements that identify the overall size of the structure, including ceiling heights and window and door
openings, can be valuable information. This drawing can be very useful as a demonstrative tool when briefing others on the fire scene. Sketches can be hand drawn, as long as they are neat and clear. However, many fire investigators today utilize computer-based architectural drawing programs, which can produce professional-quality diagrams. Many of these drawing programs are commercially available and are fairly easy to use.

Note taking is an important method of contemporaneously recording observations and other information, and can be accomplished with pen and paper or with a small cassette recorder. Either method will work to accurately record activities at the fire scene. At some later time, the notes can be assembled with other documentation and a detailed report can be authored. For later identification, each page of notes should bear the author’s name and signature, along with the date the notes were recorded.

2.3.5 Forensic Analysis

Forensic analysis to assist fire investigators is becoming more and more common. This analysis typically involves the traditional laboratory analysis of fire debris, but can also involve other forensic disciplines such as tool-mark, fingerprint, trace evidence, DNA, pathology, and engineering. A dialogue or link
between the fire investigator and the forensic chemist or engineer is extremely important to the successful evaluation and analysis of evidence. The fire investigation is always better served as the fire investigator, forensic chemist, and forensic engineer understand and learn more about each other’s roles, methods, and techniques. This increased level of awareness can be accomplished through an ongoing dialogue between the parties regarding a specific investigation as well as joint training sessions and meetings. Fire investigators have often benefited from presentations provided by forensic chemists during annual training sessions that relate to the collection and preservation of evidence and subsequent laboratory examination. Forensic chemists and engineers often benefit from participating in actual fire scene investigations and working side by side with fire investigators. Through this partnership all the parties are able to provide a better level of service, as well as to develop a better understanding of the other’s duties and responsibilities.

The assistance of fire protection engineers, mechanical and electrical engineers, and fire scientists has increased in the fire investigation field. Engineers who are well versed in combustion, fire behavior, material performance, electrical systems, and fire codes are providing an ever-higher level of expertise to fire investigators (Figure 2.24). In addition, universities, research facilities, and

Figure 2.24  Fire investigators often work side by side with engineers and other technical experts to determine the cause of a fire.
federal agencies such as the National Institute of Standards and Technology, the ATF Fire Research Laboratory, and the Consumer Product Safety Commission are providing technical support to fire investigators in areas such as fire dynamics, product failures, and forensic fire reconstruction.

Fire dynamic calculations and mathematical fire modeling have become more advanced in recent years. The most recent fire model, developed by the National Institute of Standards and Technology, is a computational fluid dynamics model known as the Fire Dynamics Simulator (FDS). This model is linked to an animated, three-dimensional computer program (Smokeview) that aids the user in visualizing fire development and spread within a structure. State-of-the-art computer models like FDS can be used to predict fire phenomena such as time-to-flashover, gas temperatures, smoke concentrations, and sprinkler activation time. Over the past few years, fire investigators have relied on engineers to use models such as FDS to assist them in understanding fire behavior in a particular investigation or evaluate statements made by a witness or defendant regarding fire behavior. However, these models require a great deal of expertise to use effectively and to understand the science behind the model. As with any computer program there are limitations and they are not suitable for all investigations.

2.3.6 Fire Cause Classification

Once the fire investigator has reviewed all relevant facts and information surrounding a fire, the cause of the fire will be classified. Except in the most clearly defined circumstances, the cause of the fire should be based on the presence rather than the absence of evidence. The cause of a fire is generally classified as accidental, natural, incendiary, or undetermined. If the cause cannot be determined, the fire should be classified as undetermined. The cause can be undetermined for many reasons and may be due to the degree of damage to the structure, lack of witness information, or other physical evidence. The classification of undetermined may change at some later time if additional relevant information is developed. The determination of any fire cause, however, must be based on credible information and facts. While some investigators have used the classification of “suspicious”, this classification is discouraged because it is not an actual description of the fire cause. The following is a brief definition of the most commonly recognized fire classifications.

2.3.6.1 Accidental

This classification encompasses situations that generally do not involve direct human involvement, such as fires caused by appliance failure, electrical wiring, or other nonhuman causes. However, an accidental classification can be used in instances that encompass noncriminal human involvement. For example, a homeowner burning leaves may inadvertently cause a secondary
fire in some nearby brush. While the second fire may be caused by negligence, it is still accidental in nature.

2.3.6.2 Natural

This classification encompasses fires that are typically identified as acts of God, such as fires related to lightning strikes, earthquakes, etc. No human involvement is linked to the natural fire classification.

2.3.6.3 Incendiary

These fires are situations that are intentional, malicious, and are started by direct human intervention. They are criminal in nature and are often classified by law enforcement authorities as arson.

2.4 Collection and Preservation of Evidence

Evidence can be anything that furnishes proof and assists in supporting a theory. In the case of a fire scene investigation, evidence is typically used to support the cause of the fire or other issues related to the fire scene. Fire investigators should attempt to protect and preserve the fire scene and its contents as much as possible in an effort to properly identify the prefire conditions. This is why the establishment of a controlled-access perimeter around the scene is important. The entire scene should be protected as evidence until the completion of the fire scene examination as the determination of the cause of the fire is generally not known until the end of the investigation. Items of evidence are often found at a fire scene and include fire patterns and artifacts from the initial fuel or ignitions source.

Should fire investigators suspect that ignitable liquid was used to promote the rapid growth and fire spread within a building, samples of materials or debris should be collected for laboratory analysis to detect the presence of any unconsumed ignitable liquids (accelerants). Examples of other items which might be collected or documented at the fire scene include portions of a door and lock that indicate forced entry, containers of suspected ignitable liquids, tire or foot impressions, tools, documents, and blood.

As each fire scene is unique, it is the responsibility of the trained fire investigator to determine what constitutes evidence, and then make the proper arrangements for the collection and preservation of these items.

The determination of what constitutes evidence and the need for the collection of the items can change depending on the responsibility and role of the investigator. In the case of an accidental fire caused by a product failure, the government or public sector investigator may choose not to collect the suspect product from the fire scene but, rather, defer to the insurance investigator for collection of the item, subsequent analysis, and potential civil
litigation. The government fire investigator, however, should always collect evidence related to criminal activity.

The evidence most frequently collected from the scene of a suspected incendiary fire is debris and other materials such as flooring, carpet, baseboard, and pieces of furnishings. These items are collected for later examination for the presence of an ignitable liquid. Information developed by fire investigators from witnesses and the fire scene examination will generally lead to a determination as to the origin of the fire. As mentioned earlier in this chapter, the fire investigator must then seek to identify the specific cause of the fire within the area of origin. If the cause of the fire is suspected to be incendiary in nature, the fire investigator may possibly collect samples from the scene to determine if an accelerant was used. However, arsonists often utilize available materials such as paper, cardboard, and other lightweight items to initiate and accelerate the spread of the fire. Thus, the use of an ignitable liquid may not occur in all incendiary fires. It is up to the trained fire investigator to be aware of any telltale signs relative to the use of an ignitable liquid. Some of these signs could include abnormal fire spread, intense localized fire damage, the presence of flammable liquid containers, the odor of petroleum products, a visible sheen on the surface of pooled water and burn patterns consistent with the use of an ignitable liquid.3

2.4.1 Cross-Contamination Issues

The potential for contamination of evidence during the collection of samples from the fire scene must be considered by the fire investigator well before the actual collection of samples is conducted and even before arriving at the fire scene. The evidence samples collected from the fire scene should not be contaminated with any substances either prior to or during the collection process. It is for this reason that the use of gas-powered equipment within a fire scene should be limited and all evidence collection equipment and containers be maintained in an appropriate manner. Unfortunately, it is not always possible to control the activities of the fire department personnel during fire suppression activities. Therefore, a fire investigator should make an accurate accounting of the use of power equipment in the fire scene and evaluate the potential for cross-contamination of samples collected from the fire scene. Any concerns relating to this issue should be fully discussed between the fire investigator and the forensic chemist.

Contamination can occur through the use of tools, evidence collection equipment, and evidence containers, clothing, and footwear. Therefore, it is recommended that all items used in connection with the collection of evidence at a fire scene be thoroughly decontaminated prior to use. Fire investigators must also consider potential background contamination that may be naturally present at the fire scene. Medium petroleum distillates are often
used as a carrier for insecticides, flooring adhesives contain solvents and various commercial cleaning supplies are petroleum based. The collection of a comparison sample may be useful in some situations so the forensic chemist can determine if the sample in question has some potential background contamination. Comparison samples are defined as materials that are not suspected to contain any contamination and accurately represent the pre-fire condition of the material to be tested. The comparison sample is typically collected as close to the original sample as practical, but ideally in an unburned area and not exposed to water. If this is not possible, then a sample should be taken in an area where the presence of an ignitable liquid is not suspected.

Comparison samples are not required for routine identification of common ignitable liquids. The fire investigator must determine the potential for cross-contamination through witness interviews and observations made at the fire scene. The forensic chemist can provide further guidance relative to the use of comparison samples.

2.4.2 Collection Procedures

Samples of fire debris or the material suspected of containing ignitable liquid residue are generally placed in clean, unused metal cans with a friction-fit lid (often called a “paint can”) as shown in Figure 2.25. These metal containers are the same type used for the retail sale of paints. They provide a secure and convenient way to collect and preserve fire scene evidence that may possibly contain volatile residues. Because by nature fire debris tends to be wet, the use of Teflon™-lined cans is recommended over unlined cans for the collection of fire debris at fire scene. The lined cans will limit the potential for rust, keeping the sample intact. The sample taken today at a fire scene may not be
introduced in court for many months or years. The ability to present a pristine evidence can provides a much-better image to the court than a rusted and degraded can that is leaking its contents.

The use of an accelerant detection canine (ADC) should be considered when evaluating the cleanliness of evidence containers and collection equipment. The ADC team can inspect all evidence collection material before it enters the scene to confirm that no cross-contamination exists. If possible, it is recommended that an ADC team be used by fire investigators before they ever respond to a fire scene to assist in inspecting the evidence containers. Once the inspection is complete and the evidence cans are determined to be clean, they should be closed, sealed with evidence tape, and marked with the date that the can was inspected by the ADC team. This process allows for the fire investigator to bring a preinspected evidence container into the fire scene.

Disposable tools are often useful in the collection of fire debris evidence. Hand shovels, rakes and trowels used in gardening are inexpensive and work well when collecting small amounts of debris for analysis, as depicted in Figure 2.26. The shovel is rigid enough to scrape and pry debris that may have adhered to the substrate. These tools can be disposed of at the conclusion of the fire scene investigation or decontaminated.

When collecting debris samples from the fire scene for subsequent laboratory analysis for the presence of ignitable liquids, the following procedures should be followed:

Figure 2.26  Small, inexpensive garden tools such as hand trowels and rakes work well when attempting to collect fire debris for analysis. As with any tool used within the fire scene, it should be properly decontaminated prior to use in collecting samples.
• Wear new, clean and unused disposable gloves during the collection of each piece of evidence.
• If possible, only one person should handle and package the evidence to eliminate potential chain of custody issues.
• Use a clean (decontaminated), unused tool in the collection of evidence or utilize the can lid to assist in the recovery process.
• Use an evidence marker to identify each item of evidence collected; photograph the evidence collection area with and without the evidence marker in place.
• Photograph each step of the collection process. Make sure to include one photograph that shows the relative location of the sample collected within the structure.
• After the sample is collected, seal the friction lid of the can, making sure that no debris rests in the groove of the can. Use a rubber mallet to seal the can. The use of a hammer is not recommended, as it can damage the can and disrupt the seal.
• Write the date, time, location, item number, description, and collector’s name on the metal can using a permanent marker; additional information can also be added as appropriate.
• After the evidence container is sealed, new disposable gloves should be worn by the person collecting the next item of evidence should don new disposable gloves.
• Dispose of the contaminated tools or properly decontaminate at the conclusion of the fire scene examination.

As indicated, the collection of evidence at the fire scene must be conducted in a methodical manner while fully documenting the process. The exact location of the collection site within the structure can be very important, especially when presenting the information in court. Photographing the entire process can pay dividends in the end. It is also recommended that all items collected be recorded on an evidence log that corresponds to the information recorded on each evidence can. Care should also be taken on the log to record the precise location where the sample was collected within the fire scene. The location of the evidence collection sites can also be recorded on a fire scene diagram or sketch.

2.5 Summary

The goal of any successful fire scene examination is to accurately identify the first fuel ignited and the ignition source that caused the fire. Many factors enter into this process, and this is often not a simple task to accomplish. As
represented in this chapter, fire investigations can be complex endeavors that involve many different disciplines. Witnesses must be interviewed, the scene examined, and analysis conducted. No one factor or indicator can be used to determine the origin or cause of the fire. It is the analysis of all relevant data that leads the fire investigator to an accurate determination of the fire cause. Once all the information is assembled, the fire investigator must make a reasonable judgment as to the cause of the fire and answer the question: “Was this an accident or a crime?” As with many specialties, it can take years for a person to obtain the requisite experience, education, and training to be a successful fire investigator. This chapter provides the forensic chemist with a general overview of fire scene investigations so he or she can participate as a member of a fire investigative unit or adequately discuss a fire scene examination with a fire investigator. Many other texts and publications exist that can provide additional information on fire investigations and related activities and should be consulted for additional information on this subject.

References