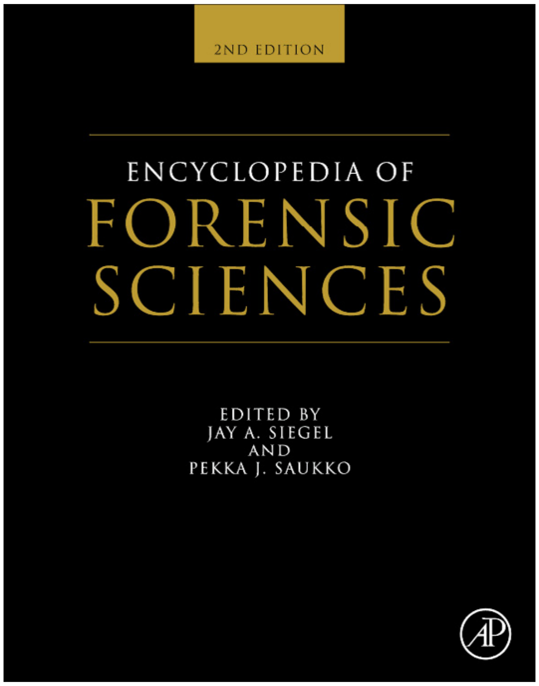

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Evidence Collection at Fire Scenes

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Glossary

Accelerant Any substance, usually a flammable or combustible liquid, that is used to initiate or spread a fire.
Flash point The temperature at which a still pool of liquid will produce sufficient vapors to ignite when exposed to a competent ignition source.
Ignitable liquid A liquid that is capable of burning, often a petroleum-based product. Ignitable liquids may be flammable or combustible. Flammable liquids are those having a flash point below 37 °C. Combustible liquids are those having a flash point above 37 °C.

Introduction and Overview

Evidence collected from fire scenes can take many forms. The most common type of evidence collected at a fire scene is material suspected of containing ignitable liquid residues (ILRs). Other evidence that may be collected for ILR analysis includes comparison substrate samples, liquid samples for comparison, or suspect's clothing and shoes.

Suspected ignition sources, such as incendiary devices or appliances suspected of malfunctioning, are also frequently collected in an attempt to test the field investigator's hypothesis about the origin and cause of the fire.

The identification of an ILR in a sample of fire debris can support a field investigator's hypothesis regarding the incendiary nature of a fire. The identification of such a liquid residue in a fire scene, however, does not necessarily lead to the conclusion that a fire was incendiary in nature. Further investigation may reveal a legitimate reason for the presence of flammable or combustible liquids.

Due to the volatility of ignitable liquids and the variations in sampling techniques, the absence of detectable quantities of flammable or combustible liquid residues does not necessarily lead to the conclusion that flammable or combustible liquids were not used to accelerate the fire.

In order to have any utility, samples collected for ILR analysis must be properly packaged and labeled prior to submission to the forensic science laboratory.

Sample Selection and Documentation

In arson cases, it is common for the arsonist to accelerate the fire by pouring ignitable liquids throughout the structure. Typically, the liquids are poured on the floor, so flooring, if it survives, is what fire investigators usually sample. Selecting a sample that is likely to test positive for ILR (assuming there is any present) requires care, practice, and luck.

Where ignitable liquid has been used, it is often present in overabundance and it may be easily detectable by odor, once the floor has been cleared of fallen debris. It is also possible to see where the ignitable liquid was poured by observing the damage patterns on the floor.

On carpeted floors, there is often a distinct line between burned and unburned areas, although such lines are common in cases where no ignitable liquid was present. Further, because of the way air is entrained into the fire plume of a piece of burning carpet, there tends to be a 'doughnut' pattern produced. This results in carpet at the center of the area saturated with ignitable liquid being less damaged than carpet at the edge of the area. Figure 1 shows a typical doughnut pattern. Obviously, the 'doughnut hole' presents the best sample. When no 'doughnut hole' exists, the sample should include both burned and unburned carpet from the edge of the pattern to its middle.

On hardwood floors, ignitable liquids tend to run in the cracks, as shown in Figure 2. Vinyl floors also may exhibit extra burning where the ignitable liquid has penetrated into seams or lower parts of a textured floor, as shown in Figure 3.

Sample size is usually dictated by the size of the available sample containers. A sample container of 1–5 l will usually be adequate. It should be noted that because the laboratory analysis will usually involve sampling the headspace in a container, filling the container completely is not advisable. If the container is filled completely, it will be necessary for the laboratory to repackage the debris into a larger container for analysis.

When collecting samples, it is imperative that the investigator takes steps to avoid cross contamination or even the appearance of cross contamination. If the tools used for sampling are the same tools used for debris removal, those tools should be decontaminated prior to sampling using a detergent solution. Tools should be cleaned off in between samples to avoid carrying liquid residue from one place to another. If the investigator has any sense of where in the scene there is a higher concentration of ILR, that area should be sampled after the less concentrated areas are sampled.

If arson is suspected, gasoline-powered tools should not be brought into the fire scene. If power is required, a generator should be used for electric tools and the generator should be kept outside. Fire extinguishment crews should be asked whether gasoline-powered fans were used on the fire, and whether it was necessary to refuel the fan at any time. Such data should be documented.

The most important attribute of any fire debris sample is its location. When the investigator makes the decision to sample a particular area, that area should be thoroughly photographed, and the location of each sample should be documented on the investigator's fire scene sketch. Once the sample has been placed in the container, another photograph should be taken

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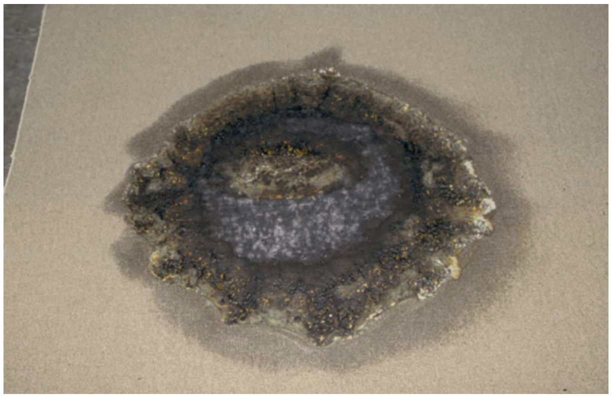

Figure 1 'Doughnut' pattern produced by gasoline burning on carpet.

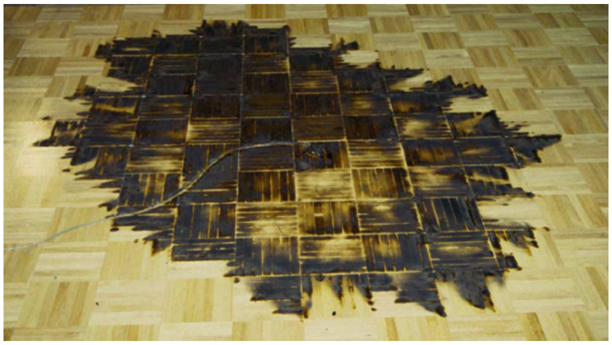

Figure 2 Burning in the cracks of an oak parquet floor.

showing both the area from which the sample was removed and the sample inside the container.

Disposable latex or nitrile gloves should be used to collect the samples and a new pair of gloves should be used for each sample. The use of gloves should be documented, preferably with a photograph of the discarded gloves at each sample location. Gloves should not be placed in the sample container.

Random sampling is not advisable. There should be a logical reason for the collection of samples. At times, this may mean nothing more than finding the location of doorways and hallways in a structure that has burned to completion.

Plastics and synthetic fibers, because of the way they respond to heat, tend to trap ILR in the melted polymer matrix. Wood flooring also tends to hold onto ILR by adsorbing the residues on the charcoal that is produced as wood burns.

Soils can retain some ILRs, particularly heavy petroleum distillates, almost indefinitely, but some residues in soils are subject to microbial degradation. Soil samples should be refrigerated if there is any significant delay (more than a few days) between collection and submission to the laboratory, or between submission and analysis. Concrete has been known to retain detectable quantities of ILR, but the overlying floor covering (if any) is more easily sampled.

In addition to his or her own olfactory senses, the investigator may employ a hydrocarbon sniffer, a mechanical device that senses hydrocarbons in the air. These devices are not very

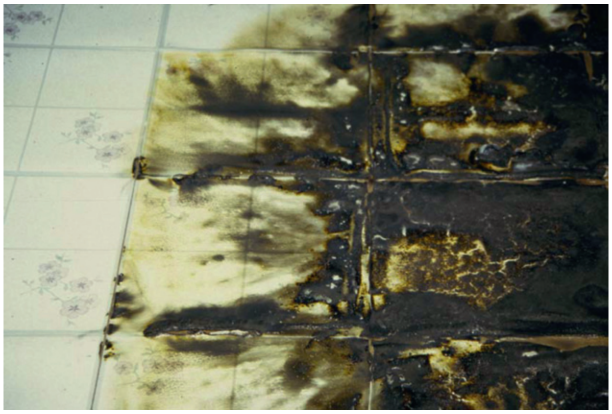

Figure 3 Burning in the cracks of a vinyl floor.

selective, however, and should not be used in place of laboratory analysis. False positives are common.

An 'accelerant-detecting canine' is probably the most effective aid to collecting samples that have a higher probability of testing positive in a laboratory. As with any tool, canines are subject to limitations. The canine responds to scents that it has previously been rewarded for alerting to. If, on a particular scene, a canine responds to pyrolysis products, rather than foreign ignitable liquids, it is likely to respond inappropriately for the rest of the day because it has been rewarded for doing so.

Canines are incapable of identifying different ILRs. This can only be determined by laboratory analysis. There are some investigators who insist that because their canine has demonstrated extreme sensitivity, a negative laboratory test of the sample selected by the canine can be ignored. This is not true. It is the considered opinion of the scientific community (including responsible canine handlers) that canine alerts unconfirmed by laboratory analysis do not constitute valid evidence of the presence of an ILR. Some canines have confirmation rates over 90%, but others fall below 50% on a regular basis. The canine is only a tool.

One useful attribute of this tool is that the animal is willing to spend all day sniffing out a large area, something that most fire investigators are unwilling to attempt. If the scene has been properly cleared prior to the canine's arrival and there is any ILR to be found, the canine will likely find it.

Comparison Samples

Beginning in the 1980s, forensic science laboratories acquired the ability to detect smaller and smaller quantities of ILRs. The lower limit of detection dropped by at least two orders of magnitude. The result of this improved technology has been that the laboratory can now detect 'background levels' of ILR that are normal to the area being sampled. Table 1 provides a list of common background materials that may be the source of ILRs. For example, the solvents used in hardwood floor-finishing products persist indefinitely in the thin polyurethane or other polymer film. For this reason, comparison samples are often necessary.

Table 1 Sources of 'background' ignitable liquids

Substance	*Potential source*
Toluene, xylenes, C_3- and C_4-alkylbenzenes, indenes	Adhesives, polymer decomposition, shoes, clothing
Medium petroleum distillates and heavy petroleum distillates	Adhesives, insecticides, polishes, lubricants, magazines, newsprint, shoes, clothing, asphalt smoke, plasticizers, floor finishes
Isoparaffins	Moisture barriers, adhesives, plasticizers
Normal paraffins	Vinyl flooring, carbonless forms, copier and laser printer toner
Alcohols, acetone	Combustion products

Because the fire investigator usually gets only one chance to sample the scene, comparison samples should be collected as a matter of routine. The samples should consist of the same substrates, such as carpet, flooring, concrete, as the suspect samples. Obviously, the comparison samples should be collected from areas where, in the fire investigator's judgment, no ignitable liquid would be expected. Except in cases where there is a large excess of ILR present on the sample, the absence of a comparison sample may render a positive finding from the laboratory invalid.

Packaging Options

Fire debris samples are typically packaged in metal cans, glass jars, or plastic evidence bags specifically designed for fire debris. Each type of packaging has advantages and disadvantages.

Metal cans are usually impervious to hydrocarbon residues, are commonly available, and resist breaking. Laboratory analysts sometimes prefer cans because the cans can be heated directly in the oven. One problem with cans is that they tend to corrode over time. Fire debris tends to contain water and acids that can cause perforation of an uncoated metal can in a matter of weeks. For this reason, lined cans, the type used for water-based paints, are recommended over unlined cans. Each time an investigator purchases a new batch of cans, an empty can should be submitted to the laboratory to verify that the can lining is not contributing significantly to the extract.

Glass jars, such as Mason jars, do not corrode, but they require careful packaging to avoid breakage and the cross contamination that may result. The two-piece lids on Mason jars were not designed for hydrocarbons, and the gasket can deteriorate if exposed to high concentrations of ILR. It is recommended that the gasket be turned away from the sample.

Two-layer nylon/polyacrylonitrile-co-methacrylate-cobutadiene bags, specifically designed for fire debris analysis, are available and have been shown to make an excellent container for fire debris, assuming they are properly sealed. Research has shown these bags to be superior to nylon or polyester bags that have been used for evidence collection. The evidence bags can withstand extraction oven temperatures of up to 70 °C. The bags have the disadvantage of being subject to punctures, and fire debris often contains materials capable of causing a puncture.

However it is packaged, the fire debris should be labeled in accordance with industry practices. The label should include a unique identifier that allows a chain of custody to be established. A label on a fire debris sample should also include an identification of the person who collected it, the date it was collected, a brief description of the substrate, and a brief description of the location of the sample. More elaborate descriptions of the sample can be provided on an evidence transmittal, such as the one shown in Figure 4.

Clothing and Shoes

Occasionally, law enforcement officers encounter a suspect shortly after a fire has been set and collect the suspect's clothing and shoes for ILR analysis. This can be a very useful means of linking a suspect to a fire scene, assuming it is done properly.

Clothing and shoes should be packaged separately to avoid contamination of the clothing with the background compounds on the shoes.

The left and right shoes should likewise be packaged separately. Shoes often contain significant quantities of ILRs because of the dyes and adhesives used in their manufacture. If an accelerant is splashed on an arsonist's shoes, it is unlikely that each shoe will be contaminated with the same amount. Thus, one shoe could act as a comparison sample for the other. It may be necessary to try to find a new pair of shoes of the same manufacture as the suspect's shoes, in order to determine what should and should not be present on the shoes.

Liquids for Comparison

Fire investigators will sometimes find containers of ignitable liquids at fire scenes that they wish to submit for comparison with residues extracted from test samples. This can be accomplished, but it is necessary to take affirmative steps to avoid contaminating the test samples with the comparison liquids. The liquid should be packaged and shipped separately from the test samples. Suitable containers for liquids include flint glass jars, or small evidence cans containing surgical gauze pads onto which a liquid is absorbed. Note that 'nonstick' gauze pads may contain petroleum products and are not suitable for absorbing liquids.

There are times when liquid absorbed onto a gauze pad is not suitable. Sometimes it is necessary to conduct a flash point test to determine whether a liquid meets statutory requirements. For example, some jurisdictions define a Molotov cocktail as a breakable container filled with a flammable liquid. In such a case, a sample of at least 5 ml of liquid is required and preferably 100 ml.

The laboratory procedures necessary to 'match' an ignitable liquid to a particular source are beyond the scope of this article, but readers should be aware that, except in the most unusual cases, the laboratory will only be capable of excluding a particular source, rather than positively identifying the comparison liquid as the source of the residue found on the test samples.

APPLIED TECHNICAL SERVICES, INCORPORATED

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EVIDENCE TRANSMITTAL

Date:______________________ Verbal Report To: ______________________

Phone #: ______________________

Submitted By:______________________ Written Report To:______________________

File #:______________________ Invoice To:______________________

Insured:______________________

Claim Number:______________________

Date of Loss:______________________

ATS Reference #______________________

Description of Evidence: Container, Size Type of Material, Condition of Material (burned or unburned) | Location Collected

1.______________________

2.______________________

3.______________________

4.______________________

5.______________________

6.______________________

Special Instructions:______________________

Chain of Evidence
(Signature Required)

From:____________ To:____________ Date:________ Time:______

From:____________ To:____________ Date:________ Time:______

From:____________ To:____________ Date:________ Time:______

From:____________ To:____________ Date:________ Time:______

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Figure 4 A typical chain of custody form for submission of fire debris samples to a private laboratory.

Evidence Collection for Other Types of Testing

Spontaneous Heating

The forensic science laboratory is capable of performing other chemical and physical analyses in addition to testing for ILR.

Oily rags, suspected of having undergone spontaneous ignition, are collected and packaged in the same way as fire debris submitted for ILR analysis. The investigator needs to tell the laboratory that spontaneous heating is suspected because the analytical procedure for finding the kinds of products that undergo spontaneous heating (usually vegetable oils) is different from the procedure used for detecting ILR. It is possible to conduct the testing for vegetable oils on the same sample used to test for ILR. ILR can be isolated using a nondestructive headspace concentration technique, and then the vegetable oils can be extracted with a solvent.

Occupancies that are subject to fires caused by spontaneous heating include commercial laundries, restaurants, and health spas, as well as buildings under construction or renovation where oil-based paints and stains are used. Spontaneous heating fires tend to occur in clothes dryers when the laundry has not been thoroughly cleansed of vegetable oils. These fires happen after

the dryer has stopped, and sometimes after the laundry has been removed and stacked. Spontaneous fires associated with painting typically occur as a result of improper disposal of rags or filters contaminated with products that contain linseed or tung oil.

Laboratory analysis for vegetable oils can only determine whether the oils are present. The laboratory analysis will not allow a determination that the oils actually underwent spontaneous heating or combustion.

Electrical Malfunctions

Most public-sector forensic science laboratories do not have in-house capabilities for examining appliances or other electrical devices suspected of causing a fire. An engineering laboratory will usually be required for such analyses.

If a product malfunction is suspected, the fire investigator is advised to ensure that any entity that might be a party to litigation has the opportunity to participate in the inspection. When possible, this should include making any suspect device available both on the fire scene and in the engineering laboratory.

The appliance or device should be fully documented on the scene and then labeled to provide a chain of custody. If there are exemplars of appliances at the fire scene, they should be collected as well. Additionally, appliances in the general area of origin, which the investigator does not believe started the fire, should be collected for purposes of elimination. Appliances and devices damaged in fires are typically delicate. Conductors and other parts may have melted or become brittle. Care should be taken to avoid further damage in the packaging and transportation of damaged appliances to the laboratory.

Laboratory inspection will usually involve the use of a magnifying glass or a stereomicroscope. x-ray examination is desirable prior to performing any destructive disassembly of the appliance or device. Real-time x-ray is usually preferable to examination with industrial x-rays and film because it can be accomplished in a more reasonable time frame.

An experienced fire investigator or electrical engineer can usually recognize evidence of electrical activity. The hallmarks of electrical activity are that the damage to the conductor is highly localized and complementary, that is, one can identify both the high-voltage and low- (or zero) voltage side of the arcing event. On small-diameter stranded wires, such as low-amperage appliance power cords, it is possible to become confused between environmental melting and electrical melting. Scanning electron microscopy is often useful, especially when different metals were involved in the arcing event.

Except in cases where a loose connection results in 'series arcing,' electrical arcs are almost always a result of an energized conductor being exposed to the fire. The insulation on the conductor carbonizes and becomes conductive, resulting in 'arcing through char.' Such arcing may help to pinpoint the origin of the fire, but it is always a result of the fire.

There is currently no valid laboratory analysis that is capable of identifying an arc that caused a fire. Scanning electron microscopy and auger electron microscopy have both been tried, but neither is accepted as valid for making the identification of an electrical arc that started a fire.

Heat-producing devices are typically equipped with safety features that, surprisingly, may survive a fire in testable form. This is because the devices are designed to withstand a hot environment. One-time fuses can be tested to see if they are electrically open. Resettable bimetallic thermal cutoff devices can be examined to see if they are open or closed, and they can be heated with a hair dryer to determine whether they still respond to heat.

Some metals respond to heating by undergoing microscopic changes in their grain structure. These changes are capable of being identified by a metallurgist. The testing required to visualize the grain structure involves cutting and polishing a section of the metal, so appropriate steps regarding destructive testing need to be taken.

Other Forensic Analyses

Because of the destructive nature of fires, investigators often overlook traditional forensic evidence such as fingerprints, blood, toolmarks, and other kinds of trace evidence. Much of this evidence can actually survive the fire, and particularly in incendiary fires, is capable of associating a suspect with the scene.

In fatal fires, the body constitutes significant evidence. A toxicological evaluation of the victim's blood can determine whether the victim was alive during the fire. A victim with no carbon monoxide in his or her blood was probably dead before the fire began. Recent research has indicated that there is a relationship between carbon monoxide levels and the victim's location relative to the origin of the fire. Victims who die from thermal injuries because they were close to the origin typically have lower carbon monoxide levels than victims found in rooms some distance from the origin, particularly when the room of origin progressed beyond flashover.

See also: **Chemistry/Trace/Fire Investigation:** Analysis of Fire Debris; Chemistry of Fire; Interpretation of Fire Debris Analysis; Physics/Thermodynamics; Thermal Degradation; **Investigations:** Fire Patterns and Their Interpretation; Fire Scene Inspection Methodology; Types of Fires.

Further Reading

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Relevant Websites

CFITrainer.net IS the eponymous name of the website.