

First Responder Fire Investigations

*How the Scientific
Method Offers a Systematic
Approach To Collecting
& Analyzing Data*

By FRED HERRERA, CFI

Investigating the cause of a fire is a routine function of fire departments nationwide. A fire investigation and determination of cause are important for two primary reasons: there are deliberately set fires and persons who should be held responsible for the arson crime, and there may be trends identified in accidental fires that cause awareness or a manufacturer's recall of a faulty component. These two aspects of fire cause are responsible for many firefighter and civilian injuries and deaths. By accurately determining the cause of a fire, the company officer is fulfilling a task that will translate into a safer society in which to live.

The Uniform Fire Code (UFC) grants fire departments the authority

INTENTIONALLY SET STRUCTURE FIRES

Intentionally Set Structure Fires	Estimate for 2004	Change from 2003
Number of fires	36,500	-2.7%
Civilian deaths	320	+4.9%
Property loss	\$714 million	+3.2%

Source: Fire Loss in the U.S., NFPA Fire Analysis and Research, 9/2005

to investigate the cause of fires that they extinguish. UFC Section 104.2 states, "The fire department is authorized to investigate promptly the cause, origin and circumstances of

each and every fire occurring in the jurisdiction involving loss of life or injury to person or destruction or damage to property and, if it appears to the bureau of investigation that such fire is of suspicious origin, they are authorized to take immediate charge of all physical evidence relating to the cause of the fire and are authorized to pursue the investigation to its conclusion."

Prior versions of the UFC used the language "shall" instead of "is au-

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thorized" regarding the investigation of fires. This may have been the result of the emergence of dedicated fire investigation units, whose fire investigations are usually more comprehensive than the investigation performed by the first responder. The issue of whether a fire department was required to utilize its dedicated fire investigators for all fires due to the language in the UFC may have presented the potential for liability for fire investigations performed at the engine company level.

This is not to suggest that fire investigators assigned to engine companies, effectively multi-tasking, are as qualified as a full-time fire investigator. The comparison is to the company officer, whose primary duty is the suppression of the fire, with the need to determine cause for the statistical documentation required for all fire responses.

Right of Entry

A fire scene is entered by fire personnel under exigent circumstances, meaning that an emergency is occurring and there is no time to obtain the consent of the occupant or a court order. A part of the fire operations, or exigency, is the need to determine the cause of the fire for public safety. When the exigency is gone, there is no longer a right to enter. Any entries made after the exigency must be conducted under other means of entry; consent, administrative search warrant, criminal search warrant or abandonment.

- **Michigan v. Tyler.** This U.S. Supreme Court decision involving a fire in a furniture store stated that an investigation may continue for a "reasonable period of time" after the suppression of the fire without the need for a criminal or administrative warrant. This is somewhat subjective, but an example would be postponing an investigation to wait for daylight or to stabilize an unsafe structure.

- **Michigan v. Clifford.** A residential fire scene was re-entered by

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a fire investigator approximately six hours after fire units left the scene. The investigator had been informed that the fire was probably arson by fire personnel. Evidence collected from the scene by the investigator was suppressed by the court because he went to the scene to search for evidence of arson and therefore needed a criminal search warrant to re-enter the scene. The investigation was not an origin-and-cause investigation carried out during the exigent circumstance, but a criminal investigation after the exigency was abated.

Investigative Procedures

The recognized procedure for conducting an origin-and-cause investigation is the scientific method, which is a systematic approach to information gathering and analysis, with a resulting tested hypothesis. This is the basis for nearly all scientific inquiries and is not nearly as complicated as it seems.

The steps of the scientific method are:

1. Recognize the need
2. Define the problem
3. Collect data
4. Develop a hypothesis
5. Test the hypothesis
6. Select final hypothesis

On the fire scene the first three steps are completed by receiving the request to respond from the incident commander, systematically examining the scene from the least damage to the heaviest damage, and interviewing firefighters and witnesses. This hopefully provides enough data to develop a hypothesis, or opinion, on where the fire started and what caused the fire to occur in this location. By testing the hypothesis; using the behavior of fire and witness statements, a final hypothesis, or opinion, may be determined. In some cases, the test may include laboratory testing, other scientific procedures, or a more comprehensive investigation.

Origin & Cause

During the application of the scientific method, the goal is to identify an area of origin and the event that caused the fire. The cause cannot be determined if the area of origin is not identified. By determining an area of origin, the company officer or investigator can then identify potential ignition sources that exist within the area defined. If the area of origin is confined to a small area, there will most likely be fewer potential ignition sources.

However, the area of origin must contain all aspects of an area defined primarily by fire behavior, based on the examination of fire flow and fire intensity patterns. The area of origin must not be made small for convenience. Depending on the fire behavior observed and the amount of fire damage, the area of origin can be very isolated or an entire room, sometimes multiple rooms. There is a point where the amount of damage eliminates the ability to determine a cause, or even an area of origin.

When the area of origin is determined and the potential ignition sources are identified, a systematic examination and evaluation of each must take place. An ignition source must be capable of transferring sufficient heat energy to the first fuel ignited. If an ignition source is not capable of transferring sufficient energy to ignite the fuel package, then it would be difficult to support it as a cause, even though it exists in the area of origin. Conversely, if an ignition source existing in the area of origin does have sufficient heat energy to cause ignition, but is determined not to be the cause, the elimination must be supported. There has to be a reason why the ignition source ignited a fuel package and the investigator is tasked to identify not only the heat, fuel and oxygen, but also the event.

An example of multiple ignition sources in a small area of origin is a dresser top that has an ashtray and smoking materials, candles, incandescent lamp, radio and small electric space heater. Under the right conditions, any of these ignition sources could ignite an appropriate fuel package, but only one will have been the cause. To determine a cause in this fire, the cause must be identified and the other ignition sources must be eliminated. Physical proof of one cause is helpful in eliminating others, as is the inability of an ignition source to transfer enough heat to set fire to the first fuel ignited.

Myths & Misconceptions

There are many fire indicators that once were valid, but aren't now due to the changes in fuel packages found in modern structures, or never were valid and have been disproved in controlled studies. Due to the synthetic materials in modern furnishings, it is customary for a fire to spread rapidly throughout a bedroom-sized compartment. Post-flashover conditions are commonplace. Note that fire behavior, being a chemical reaction and process, remains unchanged. It is the materials burning that are different. The following fire indicators or conditions illustrate how fire progression has changed.

- **Depth of char/alligatoring.** A timeline used to be attributed to the depth of char found on wood framing. An investigator supposedly could estimate how long the fire burned by how deep the charring was. This has been proven to be false. Where the fire started and the intensity of the fire will dictate how much charring will occur, further influenced by fuel configuration and ventilation. Simply put, if a match is placed against a

piece of wood for one minute, it will cause less damage than a torch placed against the same piece of wood for one minute. It is simply a matter of time versus intensity; a long-duration, low-intensity event can present very similar to a short-duration, high-intensity event. In both cases, there will be more damage to vertical arrangements than to horizontal arrangements.

Depth of char is a very important indicator and can be used to show trends of fire travel; that is, all things considered equal, the fire will tend to cause more damage where it burns the longest.

Alligatoring is the rounded char blisters that occur as wood burns. If the blisters were large and shiny, it was thought to be an indicator that

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an ignitable liquid was used. This is untrue. An examination of various wood members in a fire scene will reveal that different pieces of wood show different sizes of char blisters while exposed to the same fire. There is no significance to the appearance of the alligatoring.

- **Spalling.** After a fire, sections of concrete have been seen to break down, exposing the aggregate below; sometimes in small areas, sometimes covering larger portions of the floor. It was believed to be areas where ignitable liquids had been poured and ignited, with the high temperatures of the burning liquids causing the concrete to fail.

Fire behavior dictates that the area beneath a puddle of liquid, even ignitable liquids, will be cooler than adjacent exposed surfaces during a fire. The floor beneath the liquid pool

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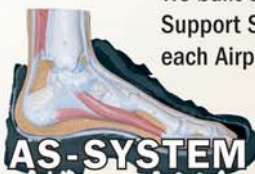


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should not get hotter than the boiling point of the liquid. Spalling has been shown to be the result of different rates of expansion within the concrete. This is influenced by the internal components, such as aggregate, steel mesh and rebar, which absorb heat more readily than adjacent areas. The most drastic change in expansion or contraction of the concrete occurs when water is applied by firefighting streams and is often the cause of spalling. Also consider that non-fire causes for spalling exist and the spalling may have been there prior to the fire.

- **Annealed bed or furniture springs.** Whenever furniture or bed springs are subjected to intense or prolonged heat they can lose their tensile strength and collapse.

Once thought to be the result of a long-duration smoldering event, typically a cigarette, it has been demonstrated that short-duration exposure of over 750 degrees Fahrenheit causes annealing as well. A significant factor is the use of foam padding with synthetic fillers and covers that combust vigorously, as compared to older cotton-batted and cotton-covered furnishings that were slower burning and prone to long-duration smoldering.

Annealing can be an important indicator, showing a comparison of fire behavior in like fuel packages, similar to using depth of char to quantify fire flow and intensity patterns.

- **Ignitable liquids/pour patterns on floors.** Narrow burn patterns on the floor were considered reliable proof of the presence of an ignitable liquid. While this can still be true, there are other situations that cause the same patterns. Floors that are covered with carpet will show the most wear in areas where people walk back and forth, such as from one doorway to an opposite doorway. If there is more carpet wear in these paths, than damage to the floor in post-flashover conditions will tend to penetrate these areas first. To complicate the issue, these paths are also the most commonly used to pour ignitable liquids, as the person backs out toward the entry of the room.

Another source of irregular floor patterns are drop-down fires, more so with synthetic materials, such as

when the plastic diffuser panel from a fluorescent light fixtures sags and falls to the floor, subsequently igniting and causing floor-level fire damage. The foam padding of furniture, such as couch cushions, can liquefy and run, effectively becoming an ignitable liquid.

An effective way to determine the presence of an ignitable liquid is by laboratory analysis, which will provide physical proof of the material present.

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- **Spontaneous ignition.** Spontaneous ignition is seen most commonly with the use of stained rags that are placed in a configuration that allows a heat buildup with a sufficient infusion of oxygen. If the configuration is too tight, not enough oxygen is available. If too loose, the heat is dissipated

faster than it can build. Spontaneous ignition occurs with natural products such as tung oil and linseed oil. Without these or other natural oils, there will not be spontaneous heating. Hydrocarbon-based oils, such as engine or lubricating oils will not spontaneously heat, nor will paint thinner and oil-based paints.

Fires occurring with paint products that do not have natural oils may be the result of ignition of the ignitable vapors present. The stains that can spontaneously heat also have ignitable vapors that can be ignited by a competent ignition source.

- **Electrical fire causes.** Electricity is blamed for many fires that are caused by other means. The earlier example of the fire on top of the dresser may be attributed to an electrical problem in the absence of tangible proof of the failure that caused the fire. The fire service has a dilemma with the determination of cause for what appears to be an accidental fire. In many cases, the determination is made by the company officer because no crime has occurred and fire investigators are not warranted.

However, sometimes a fire investigator will be requested to determine the exact cause. In either case, it is generally understood that in the absence of indicators of an incendiary fire, the evidence of accidental cause should not be inappropriately damaged. The company officer or fire investigator most times will not disas-

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semble an electrical appliance to find out specifically where the electrical failure occurred. This allows the interested parties; insurance companies, insureds, manufacturers and private investigators to continue the investigation and identify the failure and possibly the responsible party.

While examining the area of origin, there are commonly electrical components present because they are so prevalent in life. These electrical sources often will be damaged as the fire progresses. Energized electrical wires will fault when the insulation burns away and the conductors contact each other or another object that allows the current to flow improperly. This will often cause a bead on the end of a conductor as the electrical energy causes a separation arc. The presence of beading on exposed conductors is not a reliable indicator of cause, only that the conductor was energized at the time of the fire.

Opinions

Company officers should be aware that their opinions carry great weight with the legal system. The fire department personnel are often considered the only unbiased party in a legal proceeding. When the company officer lists a cause on a fire department incident report, it is considered reliable and has often been the basis for a subrogation claim against a manufacturer or contractor.

Manufacturers will vigorously defend their products, using an array of lawyers and experts to examine the case. This may be to defend against a single large loss or to prevent a trend of future litigation or the recall of a product. When the company officer is subpoenaed to testify on the origin and cause, the counsel representing the manufacturer or contractor will expect to hear how the cause was determined and how other ignition sources were eliminated. At the same time, the claimant attempting to recover a monetary judgment against the manufacturer or contractor will be expecting that the company officer is able to support the claim of responsibility. A clear line of right or wrong, win or lose is most times not the issue and the case is determined on degrees of responsibility. The testimony of the fire department personnel is very important, whether supportive or damaging, and the examination can be intense.

As is the case with a fire investigator, a company officer should be prepared to list the cause as unknown or undetermined if one is not identified or if other ignition sources in the area of origin are not eliminated.

Publications & Resources

Although there are numerous publications regarding the investigation of fires, having just a few will cover all aspects and issues involved. The most recognized texts are *NFPA 921, Guide for Fire and Explosion Investigations*, published every three years by the national Fire Protection Association, and *Kirk's Fire Investigation* by John DeHaan. *Firefindings*, a quarterly subscription publication, also contains excellent and accurate material. Lee Cole's *Investigation of Motor Vehicle Fires* contains specific techniques and issues pertaining to vehicle fires.

The websites of the International Association of Arson Investigators, www.firearson.com, and *Firefindings*, www.firefindings.com, have bulletin boards where investigators can post questions and receive replies from other investigators.

Conclusion

Fire investigations are complex ventures. Careful consideration of fire patterns and physical evidence on the scene, direct and circumstantial, must be evaluated in totality to successfully determine where the fire started and what ignition source was the cause. The opinion of the company officer can be the basis for a multimillion-dollar lawsuit against a party considered responsible years after the fire occurred. The responsibility to determine cause should be approached with this thought; what is entered on one line of a fire incident report can result in years of legal action.

Our opinions and reputations are valuable. Although municipal fire investigators as well as company officers are concerned with identifying and investigating criminal actions, they must also be proficient at recognizing accidental fire causes in order to fulfill the elimination process during the scientific-method/systematic-approach investigation.

Fred Herrera will present "Origin & Cause for Company Officers" and "Fire Scene Evidence" at Firehouse World, Feb. 19-23 in San Diego, CA.



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