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"Never doubt that a small group of thoughtful, committed citizens can change the world. Indeed, it is the only thing that ever has."
~Margaret Mead

Forensic Fire Scene Examination – What it Tells Us, and What it Doesn't

By Paul Bieber

Paul Bieber is a private investigator specializing in indigent defense investigation and the founder and director of the Arson Research Project. The project's mission is to examine the reliability of evidence used in the investigation and prosecution of arson, to identify arson convictions based on unreliable evidence, and to educate and inform the criminal justice and fire investigation communities in an effort to prevent and expose wrongful arson convictions. The Arson Research Project is hosted by the Constitutional Law Center of the Monterey College of Law.

A fire investigator's ability to sift through the debris of a fire to determine its cause and origin is almost folkloric. However, many aspects of fire scene examination have never been measured for reliability or accuracy. The minimal research that has been done in the field of cause and origin suggests a surprisingly high error rate and other areas of fire scene examination have been shown to be completely unreliable. Basing convictions on a forensic discipline with unknown accuracy raises a larger question – with nearly 500 people in California prisons on arson convictions,[1] how many of them might be innocent?

Determining precisely where a fire began and what caused it can be an arduous task. When a fire burns, a great deal of evidence is damaged or destroyed. Traditional forms of physical evidence, such as trace evidence, DNA, and fingerprints, are often rendered unusable. However, as the heat of the fire diminishes the value of some types of evidence, the fire itself creates a unique class of evidence that has been used in determining the fire's origin.

The examination of the evidence created by the fire is termed "fire pattern analysis"- the process of interpreting fire patterns and burn damage to determine how the patterns were created.[2] Generally speaking, fire pattern and dynamics analysis does not identify a suspect; these methods of forensic examination are simply used to determine where the fire began and if the cause of the fire was natural, accidental or intentional.

Whereas the majority of wrongful convictions have been overcome by the use of DNA evidence,[3] most arson cases do not involve biological evidence, making the opportunity for DNA exoneration impossible. Moreover, in a non-arson case the same DNA evidence that can be used to exonerate the wrongfully convicted can often serve to identify the true offender. Because many wrongful arson convictions are based on accidental fires that were misidentified as arson, there often is no true offender to identify. In these cases, there is no criminal because there was no crime.

Historical Background

Until the early 1990's, the fire investigation community lacked a cohesive standard of care. Procedures for conducting a comprehensive origin and cause investigation were taken from a variety of separate books and publications.[4]

In 1992 the National Fire Protection Association (NFPA) released its first edition of NFPA 921, *Guide for Fire and Explosion Investigations*.[5] NFPA 921 was developed to assist fire investigators throughout the United States in the investigation and analysis of fire incidents, and to aid in drawing conclusions and rendering opinions as to the origin and cause. NFPA 921 established guidelines and recommendations for the systematic investigation and analysis of fire incidents and contains specific procedures to assist in the collection and analysis of evidence.

NFPA 921 emphasizes an understanding of fire dynamics, fire pattern analysis and the scientific method as

the underpinnings of a comprehensive and objective cause and origin investigation. While its influence within the fire investigation community has steadily grown, widespread acceptance of NFPA 921 was not immediate. Many fire investigators countered NFPA 921's scientific approach with a culture that believed fire investigation was more *art* than *science*.

In the 1996 case of *Michigan Millers Mutual Insurance Company v. Janelle R. Benfield*,[6] the International Association of Arson Investigators (IAAI) filed an amicus curiae brief in which they claimed that fire investigation expert testimony should not be held to the standards developed under *Daubert* [7]because fire investigation is "less scientific". Years later, NFPA 921 has now been formally endorsed and accepted as the standard of care by both the country's largest fire investigator professional associations, the IAAI and NAFI (National Association of Fire Investigators).

Application of the Scientific Method to Fire Investigation

After the 1992 publication of NFPA 921 an interesting development occurred – the number of fires ruled as "arson" began to drop. A detailed analysis of this phenomenon was measured in Massachusetts and Texas (Figures 1 and 2).[8] During the same time period, total number of fires in Massachusetts increased slightly while fires in Texas remained essentially unchanged. In both states, the decrease in arson conclusions coincided with the gradual acceptance of NFPA 921 and a more scientific approach to fire investigation. Reviews of national fire statistics suggest this trend was nationwide.[9]

Area of Origin Determination and Flashover

The purpose of any fire investigation is to determine the cause, origin and development of the fire.[10] By far the most important determination is the area of origin – where the fire began. "Generally, if the origin cannot be determined, the cause cannot be determined…if the correct origin is not identified, the subsequent cause determination will also be incorrect".[11] Only after the area of origin is accurately determined can an examination be undertaken to identify what possible ignition sources, within that area, may have caused the fire. As a result, the core competency of a fire scene investigator is to reliably and accurately determine the area of origin of a fire.

The most common method used by fire investigators to determine the area of origin is "fire pattern analysis". The investigator will examine and interpret the shape, depth, texture and overall appearance of the patterns made by the heat of the fire on walls, floors or furniture, and try to understand how the patterns were created.[12] If accurately interpreted, this analysis can provide the fire investigator with valuable information regarding the location of the burning item or items that created the pattern(s), and in some cases can be used to gain insight into the fire's growth and progression. NFPA 921 lists various common fire patterns and effects created in normal room fires, including V-patterns, depth of char, lines of demarcation, soot and smoke deposits, and others.[13]

When a fire grows and several items burn simultaneously, each creating its own burn patterns, fire pattern analysis becomes more complicated. General "rules of thumb" can be misleading, such as assuming that the deepest char, greatest amount of burn damage or presence of a V-pattern, necessarily indicates the fire's area of origin.

A complicating factor in the determination of the area of origin is the condition known as "flashover". Flashover is a transient phase in an enclosed room fire where the temperature rises so high throughout the room that combustible items begin to burn, even at floor level and in areas of the room away from the fire's origin.[14]

Flashover conditions quickly transition to "full room involvement." This is the point in the progression of the fire where low burning and burning objects throughout the room can create conflicting burn damage and fire patterns that can easily distort or mask the fire's true area of origin. [15]

The burn patterns created in the early stages of fire development (those patterns likely to be in or near the fire's area of origin) may or may not persist through flashover and full

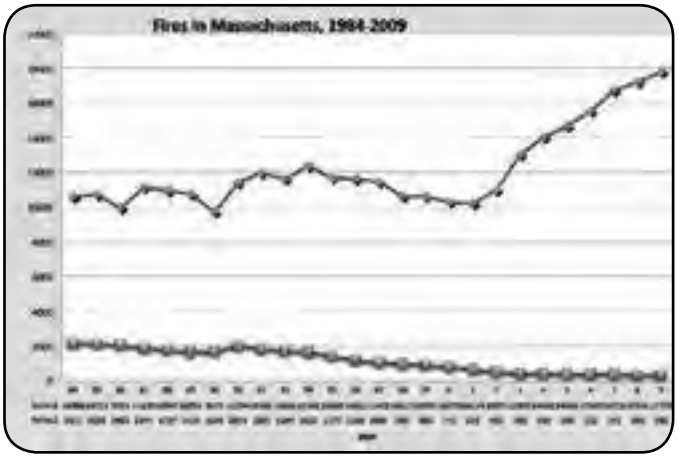

Figure 1

Figure 2

room involvement.[16] As well as creating new burn patterns throughout the compartment, flashover conditions often destroy or obscure the burn patterns in or near the area of origin which would have been observable had the fire been extinguished prior to flashover.

The Reliability and Accuracy of Post-Flashover Area of Origin Determination

The 2009 National Academy of Science (NAS) report, *Strengthening Forensic Science in the United States – A Path Forward*, recognizes that many forensic disciplines, including fire and explosion investigation, have a precarious relationship with science.[17] The report addresses the disconnect between the strong scientific basis in some forensic disciplines, such as DNA and Gas Chromatography, with more experiential disciplines, such as fire scene examination.

The NAS Report recognizes two crucial underpinnings in evaluating the reliability of forensic evidence: The extent to which practitioners in a particular forensic discipline rely on imprecise human interpretation; and the extent to which the discipline is founded on a reliable scientific methodology.[18]

Fire pattern analysis is based entirely on human interpretation. Unlike a true scientific measurement, the analysis, importance, and underlying cause of any given fire pattern is completely up to the subjective interpretation of the examiner.

Although NFPA 921 attempts to provide a scientific procedure for determining a fire's origin by examining burn patterns and applying fire dynamics analysis, the reliability and accuracy of this methodology remains a largely unanswered question.

A live-fire exercise conducted by the Bureau of Alcohol, Tobacco and Firearms (ATF) in 2005 showed the accuracy of fire investigators to determine the correct quadrant of origin in a room fire that had burned two minutes past the onset of flashover was less than 6%.[19] A similar set of exercises conducted by the Federal Law Enforcement Training Center had an accuracy rate that hovered between 8 and 10%.[20]

In a follow-up exercise in 2007, three similarly constructed and furnished rooms were burned 30-seconds, 70-seconds and 180-seconds past the onset of flashover and full-room-involvement. The accuracy of fire investigators in determining the correct quadrant of origin in these fires was 84%, 69% and 25%, respectively.[21]

A broader and more rigorous study involving over 600 fire investigators revealed that approximately 75% of the participants were able to choose the correct general area of origin in a post-flashover fire.[22] For this study, a room was lightly furnished, allowed to burn only 1-minute past flashover, and care was taken not to disturb the fire scene during extinguishment and overhaul. Even under these ideal circumstances, post-flashover area of origin determination had an error rate of approximately 25%. This means that a quarter of the time investigators could be searching for a cause of the fire in the wrong location. Follow-up review of the study results showed that errors in determining the correct area of origin were largely attributable to fire investigators applying pre-flashover fire pattern analysis to a post-flashover fire scene.

Additional research revealed that during the full-room-involvement following flashover, ventilation patterns became the dominant factor in the creation of fire patterns, not the location of burning objects as was the case in a pre-flashover environment.[23] In other words, during flashover and full room involvement, fire patterns and the amount of burn damage on walls, ceilings, floors and pieces of furniture will be primarily the result of air flow currents through the room and have absolutely no bearing on the area of origin of the fire. This research also showed that burn patterns near the area of origin created early in the fires progression (prior to the onset of flashover) sometimes remained visible during and after the onset of flashover, and sometimes did not.[24]

It is clear from all these studies that the general reliability and accuracy of fire investigators to determine the correct area of origin in a room fire that has burned beyond flashover by analyzing the remaining burn patterns, even under best case circumstances, cannot be established to a reasonable degree of scientific, engineering or technical certainty.

When post-flashover fire scene conditions move beyond "best case circumstances" due to longer burn times, damage or movement of contents during overhaul, or the additional damage and burning caused by ceiling collapse, the accuracy of determining where the fire first began diminishes even further.

Incorrect Area of Origin Determination and Negative Corpus

An incorrect area of origin determination is not the end of the problem; it is often just the beginning. Once a fire investigator narrows down the area where the fire began the next step in the process is to search that area for a potential heat or ignition source.[25] At this point the search is for evidence of what caused the fire and specifically if the cause was natural, accidental or intentional.

If the area of origin is misidentified, the search for an ignition source will be fruitless. Until very recently, the lack of evidence of a natural or accidental cause, which would be the case in a misidentified area of origin, was seen as positive evidence of an intentional cause. This methodology, known as "negative corpus", was a common occurrence in fire investigation until the most recent edition of NFPA 921 when it was soundly rejected as a violation of the scientific method.[26]

The problem is magnified when flashover conditions create burn patterns and fire damage that are interpreted by the fire investigator as "multiple areas of origin". The same post-flashover conditions which can lead to an incorrect single area of origin determination can easily be misinterpreted as multiple areas of

origin. To many fire investigators, the presence of more than one area of origin is a prima facia case of arson. When an examination of each suspected area of origin fails to reveal an accidental or natural heat or ignition source the investigator's confidence is compounded.

Cognitive Bias in Fire Scene Examination

Expectation and role bias are just two types of cognitive bias that play a role in many forensic and criminal investigations.

Expectation bias is the tendency for observers to believe and express data that agree with their expectations for the outcome of an experiment, and to disbelieve, discard, or downgrade the corresponding weightings for data that appear to conflict with those expectations.[27] The observer's conclusions are contaminated with a pre-existing expectation and perception, reducing the observer's objectivity and laying the groundwork for selective attention to evidence.[28] The less instrumented and more subjective a forensic technique or measurement, the more it is subject to expectation induced errors.

The vague and subjective nature of fire pattern analysis makes it especially susceptible to expectation bias. In a two-part blind research study on the affects of expectation bias on fire pattern analysis conducted by the Arson Research Project in 2012, fire investigators who were given biasing information prior to analyzing a set of fire patterns were 18% more likely to choose an unreliable methodology in conducting their analysis than a control group who examined the same fire patterns without biasing information.[29]

Role bias results from adopting a specific point of view based on an assigned role, such as when a fire investigator adopts the role of a criminal investigator, which threatens objectivity. The change of perspective has a direct impact on what information an investigator seeks, as well as how the information is perceived and processed.[30] Fire investigators can be especially at risk of assuming the role of a criminal investigator – in many jurisdictions fire investigators are both forensic examiners and law enforcement officers on the same case. In place of the independence of forensic examination recommended in the NAS Report many public agencies have adopted the Arson Task Force

model – fire department investigators teaming up with police detectives and DA investigators – where the lines between fire scene examiner and criminal investigator are not just blurred but are obliterated.

In the Arson Research Project study, fire investigators that were associated with law enforcement were 33% more likely to choose an unreliable methodology in fire pattern analysis than independent, private sector fire investigators.[31] Moreover, the law enforcement investigators were 14 to 30% more confident in their conclusions, yet the accuracy of their analysis was virtually identical.

In no other forensic discipline is the forensic examiner expected to determine if a crime has or has not occurred, or to examine evidence outside the examiner's area of expertise in order to identify a suspect, verify a suspect's opportunity to commit the crime, or develop a motive. Only fire investigation, particularly as practiced in the public sector, has embraced the merger of forensic examiner with criminal investigator, seemly unaware of the pitfalls this potential bias creates.

Conclusion

Fire investigation has a mixed reputation within the forensic science community. Since the first publication of NFPA 921 the increased reliance on science has clearly helped to move fire scene examination towards a more stable footing. The recent rejection of negative corpus as a methodology to determine a fire's cause was a tremendous boost to the discipline's credibility.

However, lingering questions persist in regards to the underlying reliability and validity of some techniques, particularly area of origin determination and the misidentification of multiple areas of origin in a complex fire scene or where the fire has burned beyond flashover.

Like any expert testimony based on forensic science, the conclusions of the fire scene investigator must be considered through the prism outlined in the NAS report. Were the conclusions based on a reliable methodology with a measured rate of accuracy and error? How much of the analysis relied on subjective human interpretation and were the results influenced by bias? Finally, was the fire investigator an independent forensic examiner simply tasked with determining the fire's cause and origin, or was he playing the dual roles of forensic examiner and criminal investigator?

The answers to these questions might give a jury pause. They certainly should be asked by any prosecutor or defense attorney who hopes to use or overcome this type of testimony in court.

Endnotes

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13 *Id*, chapter 6, at 43-63.

14 *Id*, 5.10.4.1, pg. 42. Definition of "flashover": The transition from a condition where the fire is dominated by burning of the first item ignited (and nearby items subject to direct ignition) to a condition where the fire is dominated by burning of all items in the compartment.

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