HAVE WE LEARNED THE LESSONS OF THE WILLINGHAM CASE?
A NATIONAL SURVEY OF FIRE INVESTIGATORS

A RESEARCH PROJECT SUBMITTED TO NATIONAL UNIVERSITY

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And of course, I want to thank the 217 anonymous fire investigators all over the United States who participated in the National Survey of Fire Investigators. Had they not responded in the numbers they did, it would have been like trying to start an engine without fuel. Without them, this whole effort would have blown a fuse.

ABSTRACT

The research sought to quantify the extent to which six forensically faulty fire investigation methods, which were discredited by scientists more than 20 years ago, have continued to be used in the field as well as how the professional qualifications of fire investigators are related to their likelihood of using discredited fire investigation methods to infer that a given fire was intentionally set.

The researcher analyzed data gathered in the National Survey of Fire Investigators, which collected 12 demographic data items from 217 public-sector fire investigators in 36 US states and asked participants seven questions to identify the causes of six fire scene observations that were once universally accepted by arson investigators as compelling signs of arson.

The research showed that some of the arson investigation myths are still commonly believed to be legitimate indicators of arson, while others are no longer widely believed, and that attributes usually associated with professional competence do not reliably predict whether or not a fire investigator will recognize all six arson investigation myths.

Table of Contents

ACKNOWLEDGEMENTS.....iv

ABSTRACT.....v

TABLE OF CONTENTS.....vi

LIST OF FIGURES.....vii

CHAPTER I: Introduction.....1

CHAPTER II: Literature Review.....14

CHAPTER III: Methodology.....29

CHAPTER IV: Results.....34

CHAPTER V: Discussion, Conclusions, and Recommendations..48

APPENDIX A: Material from NFPA 921, 2014 Edition.....59

APPENDIX B: Survey Documents.....69

APPENDIX C: Chi Square Test Calculations.....96

REFERENCES.....100

List of Figures

Figure 1: Photograph of Alligatoring.....18

Figure 2: Photograph of Crazed Glass.....19

Figure 3: Three Photographs of Lines of Demarcation.....21

Figure 4: Photograph of Sagged Furniture Springs.....23

Figure 5: Photograph of Spalling.....24

Figure 6: Age and Experience Distribution.....35

Figure 7: Level of Post-Secondary Science Education.....36

Figure 8: Frequency of Scores.....36

Figure 9: Interpretations of Crazed Glass.....38

Figure 10: Interpretations of Alligatoring.....39

Figure 11: Interpretations of Depth of Char.....40

Figure 12: Interpretations of Lines of Demarcation.....41

Figure 13: Interpretations of "Puddle-Shaped" Burns.....41

Figure 14: Interpretations of Spalling.....42

Figure 15: Interpretations of Sagged Furniture Springs...42

CHAPTER I: Introduction

Background of the Study:

In 2009, the National Academy of Sciences released *Strengthening Forensic Science in the United States: A Path Forward*, (hereinafter 2009 NAS Report) a scathing report that challenged the validity of virtually all forensic science disciplines with the glaring exception of DNA profiling. Incidentally, DNA profiling is one of the few fields that began in the laboratories of a non-justice field and then only later found utility in the criminal justice system. On the other hand, most other fields of forensic science began in the criminal justice system and have largely dodged scientific scrutiny. One such field had long been fire investigation (Committee on Identifying the Needs of the Forensic Science Community, 2009). The methods used in fire investigation were first seriously challenged when John J. Lentini and John DeHaan were investigating a fire in Jacksonville, Florida in 1990. To test a hypothesis, they decided to burn down an identical house next door that had been abandoned. After they fixed it up with identical furnishings, wallpaper, and so forth, they started a fire in the same manner that the defendant claimed the fire started—that his child had lit a sofa on fire while playing with a cigarette lighter. Lentini and

DeHaan discovered that all of the "classic signs of an accelerant" were present in this fire, which actually simulated the accidental explanation of the defendant (Dahl, 2013; Lentini, 1992b). Then in 1992 the National Fire Protection Association published *NFPA 921: Guide for Fire & Explosion Investigations* (hereinafter NFPA 921), which called for incorporating scientific principles into fire and explosion investigations. The response from the professional community of fire investigators, largely represented by the International Association of Arson Investigators Inc. (hereinafter IAAI), was profoundly negative and visceral. In 1997, IAAI filed an amicus brief seeking to be exempted from the *Daubert* rules regarding the qualifications of expert witnesses and their testimony on the basis that arson investigation was an art and was "less scientific" (Michigan Millers Mutual Insurance Corporation vs. Benfield, 1997).

One case that is widely regarded as a poster child of forensic failures is the investigation of the house fire at 1213 West 11th Avenue in Corsicana, Texas on December 23, 1991, which led to the 2004 execution of Cameron Todd Willingham, whose three children died in the fire (Deeter, 2010; Mims & Bailey, Jr., 2011). The fire investigation

report identified “20 indicators of arson,” including “crazing,” “pour patterns” and “puddle configurations.” This was offered as evidence that an accelerant was used to set the fire (Vasquez, 1992). Further, Willingham was only slightly injured, suffering burns on his shoulders and hair, and suffering minor smoke inhalation. Other evidence against Willingham included the testimony of jailhouse informant Johnny Webb in exchange for a shortened sentence (Texas v. Willingham, 1992). Webb later recanted his testimony, and then recanted the recantation (Deeter, 2010). Tenacious investigative reporting has uncovered new evidence that Webb’s testimony was known to prosecutor John Jackson to be false, and that he bribed Webb to give it in exchange for a reduced sentence in his own robbery case as well as resources to help him after he was released including tuition payments and a new truck. This was concealed from the defense at the time of trial, and only came to light in October 2014 (Deeter, 2014).

In the 12 years after the fire and before Willingham’s execution, the scientific basis of arson investigation transformed from one driven by the lore passed down from generation to generation of firefighters to a system based on the scientific method backed by experiments about how

fires actually start and burn (Deeter, 2010; Hurst, 2004) (Hurst, 2004; Lentini, 2013; Lentini, 2012; Mims & Bailey, Jr., 2011).

Problem Statement:

Reliance on faulty forensic science leads to miscarriages of justice (Arson Review Committee, 2006; Beyler, 2009; Committee on Identifying the Needs of the Forensic Science Community, 2009; Scheck, Neufeld, & Dwyer, 2000; Turvey, 2012; Wolf, 2009). The first scenario that comes to mind in such cases is that the wrong person is convicted and that this allows the true perpetrator to go free; however, in the case of arson, the problem is that accidental fires are often incorrectly attributed to arson and are ruled intentional, or in the language of the profession, "incendiary." In these cases a person is charged with and often convicted of a crime that never happened in the first place. In improperly investigated arson cases, observations that have no bearing on the origin or cause of a fire are misinterpreted as evidence of arson (Lentini, 2013).

It is often believed that a remedy for problems such as this is post-conviction appellate review. However, this is not the case. The US Constitution explicitly forbids

the reexamination of facts determined by a jury (U.S. Const. amend. V.). If the jury says it is arson, then it is arson—forever. The fact that someone is later found to be factually innocent is not grounds to overturn a conviction, or even a death sentence. "Claims of actual innocence based on newly discovered evidence have never been held to state a ground for federal habeas relief absent an independent constitutional violation occurring in the underlying state criminal proceeding....This rule is grounded in the principle that federal habeas courts sit to ensure that individuals are not imprisoned in violation of the Constitution—not to correct errors of fact" (Herrera v. Collins, 1993) (Wolf, 2009). Considering this, it is of paramount importance that only valid and sound evidence is introduced at trial and that it is correctly interpreted.

The other alternative to post-conviction review by courts to correct miscarriages of justice caused by faulty forensic science or prosecutorial misconduct is executive clemency, commonly known as a pardon. However, it is very politically risky for a governor to issue a pardon or some lesser form of clemency. If it happens at all, governors usually do it *en masse* immediately before leaving office, such as when Illinois Governor George Ryan, a staunch supporter of capital punishment, commuted all 167 pending

death sentences to life in prison in 2003 after a string of DNA tests exonerated 13 of the state's death row inmates in a span of three years (Sarat, 2007).

Purpose and Objectives of the Study:

The present study was undertaken to determine the extent to which obsolete and forensically faulty investigation methods continue to be utilized by fire investigators, and to test hypotheses as to why. A survey instrument was developed to measure the forensic competence of respondents, particularly the prevalence of six obsolete "arson investigation myths." This phrase is not merely a snarky burst of theatre; leaders in the scientific reformation of the fire investigation field ubiquitously describe these obsolete fire investigation methods as "myths," "old wives tales," "witchcraft," and "lore" in every context from court documents (Hurst, 2004), to interviews with journalists (Deeter, 2010) (Mims & Bailey, Jr., 2011), to academic journals (Lentini, 2012) and college-level textbooks (Lentini, 2013).

The survey instrument asked other questions that were hypothesized from the literature to be related to an investigator's competence. For the limited purposes of this study, forensic competence of a fire investigator is

demonstrated by the immediate recognition that seven common fire-scene observations are not indicators of arson. The present research tested whether forensic competence is associated with:

1. whether a fire investigator works in an urban setting
2. the holding of highly regarded professional certifications in the field
3. post-secondary scientific education
4. years of experience

Rationale of the Study:

There was once a strong atmosphere of secrecy among fire investigators as to how they perform their job. The profession resisted the introduction of science into its work. The fire investigation community viewed its profession as a blend of art and science (Deeter, 2010; Lentini, Telephone Interview, 2015; Mims & Bailey, Jr., 2011). "A fire or explosion investigation is a complex endeavor involving both art and science" (NFPA 921 2.1). The 1992, 1995 and 1998 editions of NFPA 921 all contained this language, which was finally deleted in 2001. Leaders in the fire science community believe that some fire investigators continue to use outdated and discredited fire

investigation methods, but appear to have never studied the extent to which the problem persists.

Limitations of the Study:

Availability of participants and self-selecting bias: The participants were recruited by sending a two-page fax, (a letter and a flyer) to 19,000 randomly selected fire departments in the United States. The survey sample was drawn from the National Fire Department Census maintained by the US Fire Administration which includes 26,975 fire departments in the United States. Of those, 7,836 chose not to include their fax numbers in the publically accessible database. Only those fire departments that listed their fax number were available to be contacted. No trait could be discerened that would be peculiar to the fire departments that chose to keep their fax numbers private. Of the remaining 19,139 fire departments that listed their fax number in the database, 19,000 were randomly selected to be recruited. A marketing firm was hired to fax the recruiting letter and flyer to those 19,000 fire departments. Of those 19,000, some could not be contacted.

4 of the randomly selected numbers were not valid as phone numbers, e.g. 000-000-0000.

182 valid numbers were duplicates

7,505 were not reachable, e.g. busy, not fax numbers, and disconnected numbers.

11,309 fire departments were successfully contacted.

217 Fire investigators responded to the survey recruitment request.

Further, the letter asked fire departments to distribute the flyer to encourage fire investigators to participate in the study. This step of the recruiting constituted snowball sampling, which is itself a kind of self-selecting bias. Certain fire departments may have been more eager to participate than others. For instance, nine of the participants were from Cook County, Illinois, but no fire investigators in Louisiana participated, even though one fire department in Louisiana called to confirm the bona fides of the study. There is no way of knowing if any of the nine in Cook County were from the same fire department, or from different fire departments. Further, some states with smaller populations have many more fire departments than other states with much larger populations. For example, California has a population of 38.8 million and 862 fire departments, while Pennsylvania has a population of 12.8 million and 1,795 fire departments.

Because only fire departments were contacted, it is clear from the responses to the first question that all participants work in the public sector. There are some who stated that they investigate the origin and cause of fires as part of their work for a fire department or law enforcement agency. A small group stated that they were firefighters who were expected to observe and report things they believe may indicate the origin and cause of a fire while they were working to extinguish it.

Scope of Research:

While this research was undertaken to measure forensic competence among practicing fire investigators, it only addressed one aspect of it, the extent to which outdated fire investigation methods are still used in spite of scientific advances. It did not test their knowledge or use of current and accepted methods; however, it did ask them what references materials they use, what journals they follow, and what continuing education topics they have studied in the past four years, which were expected to offer subjective signs of interest in current methods. Keeping current in 16 topics related to fire investigation "by attending formal classes, workshops, and seminars and/or through professional publications and journals"

(NFPA 2014b 1.3.7) is a new provision in *NFPA 1033: Standard for Professional Qualifications for Fire Investigator* (NFPA, 2014b).

Theoretical Framework:

It is apparent in the literature that the term "arson investigation" and "fire investigation" are taken to be interchangeable. However, the term fire investigation was used for this study. The reason is a matter of an assumption that is not worthy of adoption until after the investigation is complete. It seems that if investigators view themselves as "arson investigators" then they will be seeking to prove that a fire was intentionally set. On the other hand, it seems that "fire investigators" are investigating fires without a cause already in mind. Further, the term arson investigation seems to be used more in older sources while fire investigation is used more in newer sources.

Another matter that calls for clarification is that while the literature about problems with the fair implementation of capital punishment, and its cursed relationship with sloppy forensic science was reviewed, the debate is beyond the scope of this research, and this research does not take a position on the moral or

philosophical merits or fallacies of the death penalty as a form of punishment.

However, this debate is usually what triggers sporadic public interest in wrongful convictions and their causes. The public consumption of media coverage about the Willingham case transformed from a forensic science debate to a death penalty debate. This poisoned the issue so badly that Governor Rick Perry would not even consider granting a stay of Willingham's execution because it would have been political suicide in the state that executes more people than any other (Deeter, 2010; Mims & Bailey, Jr., 2011). Vexingly, if the death penalty were abolished, it is likely that what little public interest there is in fixing the many problems in the forensic sciences might very well dry up as it would lose its urgency. It seems that people are not as bothered with an innocent stranger spending his life in prison as they are with that same person being gassed. In some Kafkaesque way, maintaining the *status quo* may very well serve to keep the pressure on us.

Research Hypotheses:

Hypothesis 1: Fire investigators in metropolitan areas are significantly more likely than fire investigators in non-

metropolitan areas to recognize that all six arson investigation myths are not indicators of arson.

Hypothesis 2: Fire investigators who hold highly regarded professional certifications, (i.e. CFI and/or CFEI) are significantly more likely to recognize that all six arson investigation myths are not indicators of arson than fire investigators who do not.

Hypothesis 3: Fire investigators who hold a degree in a scientific field are significantly more likely to know that all six arson investigation myths are not indicators of arson than fire investigators who do not hold a degree in a scientific field.

Hypothesis 4: Fire investigators who began their fire investigation careers after the introduction of scientific principles into the field are significantly more likely to know that all six arson investigation myths are not indicators of arson than fire investigators who began their careers before the introduction of scientific principles into the field.

CHAPTER II: Literature Review

In 1977, the Law Enforcement Assistance Administration published *Arson and Arson Investigation: Survey and Assessment,* (hereinafter LEAA Survey) a survey of 20 leading arson investigators around the country. Among other things, it found that the "Interpretation of Burn Indicators" was the most common method of establishing that a fire was an act of arson (Boudreau, Kwan, Faragher, & Denault, 1977, p. 60). However, the report noted that there was a vacuum of scientific research about their validity. "Burn indicators—the effects on materials of heating or partial burning—are the most frequently used method for determining the points of origin and causes of fires, yet these indicators have received little or no scientific testing" (pp. xvi-xvii) and, "Although burn indicators are widely used to establish the causes of fires, they have received little or no scientific testing. There appears to be no published material in the scientific literature to substantiate their validity" (p. 88). The report included results of a second survey of another group of arson investigators that asked only about the needs of the field, to which only eight arson investigators responded. Only one of those eight recommended that the technical methods of arson investigators should be

scientifically tested (p. 114). The report described seven burn indicators and what inferences were to be drawn from them (pp. 87-88). As it turns out, each and every one of these inferences—yes, *all of them* have been debunked. They are *not* indicators of arson—ever. In some cases these observations mean entirely something else, and sometimes they add nothing to understanding the origin and cause of a fire. The LEAA survey recommended that the various methods of fire investigation be subjected to experiment and that a standardized handbook be published. This was not a new recommendation. This had been suggested in an article in the *Journal of Criminal Law and Criminology* by E. A. Wakefield, a detective with the Royal Canadian Mounted Police, who also wanted the research to emphasize learning about evidence that would exonerate innocent suspects and to standardize procedures so that arson investigators would report exculpatory evidence directly to prosecutors, defense attorneys and judges (Wakefield, 1951). In 1980, the highly reputable National Bureau of Standards (hereinafter NBS), the forerunner to the National Institute of Standards and Technology (hereinafter NIST), produced such a handbook, the *Fire Investigation Handbook*, but NBS never bothered to test any of the investigation methods first. The result was that a body of witchcraft and wives

tales became deeply entrenched in the fire investigation community (Lentini, email correspondence, 2015). "The LEAA survey brought all of the myths that had been floating around where no one knew where they came from and brought them all together into one document. Then the National Bureau of Standards—bless them—put it all into that manual, which made it all official, and they ruined fire investigation for 30 years" (Lentini, Telephone Interview, 2015). As a result, fire investigation as a forensic field has the unflattering distinction that throughout most of its history, not only have its practitioners not been trained how to do their job correctly, but for decades they had been actually trained to do it wrong.

While a wide array of reference books, textbooks and investigation manuals before and after the LEAA survey came out in 1977 have been hit-and-miss as to their treatment of the arson investigation myths, NFPA 921 clearly addresses all of them accurately, but the information is arranged in such a way that one must know what to look up in order to find it. On the other hand, Lentini took the unprecedented step of devoting a large part of his book *Scientific Protocols for Fire Investigation* to addressing the crisis head-on in a systematic manner. After explaining how

faulty fire investigation techniques gained momentum and managed to dodge scientific scrutiny, he describes how each incorrect interpretation was debunked as a matter of science. Lentini and others contend that some professional fire investigators continue to use these discredited methods because they are either not up-to-date on training and education, or they simply have made up their minds and stubbornly refuse to accept the findings of scientific research, or both. However, another factor appears to be that these arson investigation myths continue to be encouraged in recently published reference books (Fay, 2007, pp. 127-130), continuing-education courses approved by professional regulatory agencies (Fay, 2015), and best-selling, award-winning, college-level textbooks (Orthmann & Hess, 2013, pp. 492-494).

Rather than just telling readers how to conduct a fire investigation, Lentini's book alone focuses as much on how not to (Lentini, 2013). The book includes a chapter devoted to "The Mythology of Arson Investigation," which addresses the first six of the seven invalid arson indicators covered in the LEAA survey, as well as four others Lentini added. He also includes a chapter on "Sources of Error in Fire Investigation." This research

examines the six arson investigation myths addressed in both the LEAA survey and in Lentini's book.

Here, each of the "indicators" included in the 1977 LEAA survey is presented with a brief discussion of the indicator as addressed by various sources, and its now debunked meaning from the 1977 LEAA survey.

Figure 1 Alligatoring. Photo courtesy of Franklin County, North Carolina Sheriff's Department

Alligatoring: Alligatoring is the appearance of glossy blisters in an "alligator-skin" pattern on charred wood in a fire. How the char looks, whether the bumps are big, or how glossy they are is sometimes misunderstood to tell how quickly the fire spread or that a hydrocarbon-based accelerant, such as gasoline, was present. The implication is that a fast-moving fire, or one with hydrocarbon-based accelerant present was intentionally set.

LEAA Survey: "checking of charred wood, giving it the appearance of alligator skin. Large, rolling blisters indicate rapid, intense heat, while small, flat alligatoring indicates long, low heat" (Boudreau, Kwan, Faragher, & Denault, 1977, pp. 87-88).

Figure 2 Crazed Glass. Photo courtesy of Forensic Research Digest Inc.

Crazed Glass: Crazed glass refers to a pattern of tightly packed cracks in glass. Crazed glass was widely believed to indicate rapid heating in a fire. Investigators would then infer that such a fire was intentionally set. In 1991, Lentini visited the aftermath of the Oakland Hills fire in Oakland, California where 25 people died and nearly 4,000 homes were destroyed. He noted crazed glass at homes along the edges of the burn area more than in the center of the fire, which was known to be accidental. He surmised

that crazing was related to fire suppression activities somehow. He conducted laboratory tests of the behavior of glass at high temperatures and found that only rapid cooling causes glass to craze, and that heating, rapid or otherwise, will not cause crazing. In the context of a fire scene, crazing indicates that water from firefighting efforts rapidly cooled the glass. (Lentini, 1992a).

LEAA Survey: "formation of irregular cracks in glass due to rapid, intense heat—possible fire accelerant" (Boudreau, Kwan, Faragher, & Denault, p. 88).

Depth and Location of Char: This refers to where and how far through wood a fire has burned. The notion that it indicates the duration of the fire turns on the thoroughly unsupported idea that fire burns through wood at a certain rate as opposed to an uncertain rate, and curiously, only in one direction rather than on all surface areas. From this, investigators would surmise that the place with the deepest char depths was the origin of the fire. The argument is often presented as something like: *Pine naturally burns at a rate of ¾ inches per hour. The fire burned for 25 minutes. The fire burned through a 2 X 4. The fire was accelerated. This indicates arson* (Lentini, 2013). However, as early as at least 1979, John R. Carrol wrote that to say the depth of char will determine the

exact origin overstates its evidentiary value (Moenssens, Henderson, & Portwood, 2007).

LEAA Survey: depth of burning of wood—used to determine length of burn and thereby locate the point of origin of the fire.

Figure 3 Lines of Demarcation. The three photos above show different causes of lines of demarcation. Top left: Oak parquet floor that is burned after gasoline has been poured on it and ignited. Photo courtesy of Anthony D. Putorti, NIST. Top right: This pattern was produced by burning a cardboard box on a similar oak parquet surface. Because it "looks like a puddle," many fire investigators misinterpret this as where liquid accelerant was poured. Side-by-side, they are clearly distinguishable. Note that the burn caused by burning gasoline caused far less damage, something that contradicts intuition. Photo courtesy of John J. Lentini in Scientific Protocols for Fire Investigation, Second Edition, CRC Press. Bottom: These sharp lines of demarcation are caused by different areas being exposed to or protected from radiation. This often happens when household items cover some parts of the floor and not others. Also, when debris falls from above, such as sections of sheetrock, those things will protect random areas from being burned as badly as adjacent areas that are exposed. Photo courtesy of John J. Lentini in Scientific Protocols for Fire Investigation, Second Edition, CRC Press.

Lines of Demarcation: Lines of demarcation refers to the abrupt edges between the burned and unburned areas of a surface. This myth is more complicated than the rest because lines of demarcation can indeed aid in the understanding of what happened, and at other times, the appearance of lines of demarcation means nothing. The difference has to do with whether the fire reached flashover or full-room involvement. If the fire never reached flashover, then lines of demarcation can be of some assistance in understanding the progress of the fire and its origin and cause. However, if the fire reached flashover, then the meaning of any visual clues are ambiguous, and cannot be called upon to determine the progress, origin or cause of the fire (Lentini, 2013).

LEAA Survey: "boundary between charred and uncharred material. On floors or rugs, a puddle shaped line of demarcation is believed to indicate a liquid fire accelerant. In the cross section of wood, a sharp, distinct line of demarcation indicates a rapid, intense fire" (p. 88).

Figure 4 Sagged Furniture Springs. Photo courtesy of Texas State Fire Marshal

Sagged Furniture Springs: The fire investigation community has been all over the place as to the meaning of sagged or collapsed furniture springs. From at least the 1970s, fire investigators have long thought that sagged furniture springs observed at a fire scene can aid in determining the origin and cause of a fire. Aetna Life & Casualty once published a booklet called *fire...is it arson?* The booklet recommended that fire investigators be sure to photograph the furniture springs. It asserted that severely sagging furniture springs were a sign of a flammable liquid being used to set the fire. On the other hand, in his 1978 book, *Arson Investigation*, Robert E. Carter cites at length former Oregon Fire Marshal C.W. Stickney's experiments that implied that cigarettes are a likely heat source when collapsed furniture springs are observed (Carter, 1978).

Then in 1989, two FBI laboratory scientists conducted tests under many conditions, loaded and unloaded (with and without weights), with different temperature ranges, and concluded that sagging springs do not imply anything meaningful to a fire investigator. In *Kirk's Fire Investigation* (not to be confused with *Fire Investigation*, the 1969 treatise by eminent criminalist Dr. Paul Leland Kirk) John D. DeHaan argues that the degree of damage to furniture springs can provide insight on the progress of the fire, but he warns that collapse does not reliably indicate whether the fire was incendiary. Lentini shares DeHaan's view (2013).

Figure 5 Spalling. Photo courtesy Forensic Research Digest Inc.

Spalling: Spalling is the chipping off of surface material from masonry or concrete. Lentini insists that spalling is the most vexing of the myths because it is the most widely misunderstood. It is also the subject of a never-ending argument among fire investigators (2013). Historically, the opinions range from, "The spalling temperatures are usually much higher than the temperatures found in the normal dwelling or commercial building fire. Therefore, we know that accelerants were used" (Kennedy, 1977, p. 393) to, "There is no reliable scientific basis for the contention that spalling in concrete or any mineral base, surface, floor, wall, bulkhead, or ceiling denotes either the presence of hydrocarbon flammables or any other volatile accelerant, or that spalling indicates criminal or incendiary origin. On the contrary, spalling can reasonably occur as a result of poor cement or concrete surfacing techniques and with deteriorative spalling resulting from the use and weathering rather than from heat. Spalling is common where concrete surfaces are exposed to heat generated in a fire, regardless of the cause of the fire, and when water is applied to the hot surfaces during extinguishment causing rapid temperature change and cooling" (French, 1979, p. 64). In 1981, experiments supported French's view (Lentini, 2013).

However, at least as late as 2004, a Texas State Fire Marshal found a furniture warehouse fire to be arson on the basis that he observed "spalding"[1] (sic). The fire marshal then offered a pseudoscientific explanation for the phenomenon (Driscoll, 2004). It is worth noting that the fire sciences literature, even today, very seldom cites—let alone defers to-experts in masonry, such as engineers, chemists or manufacturers. Only one of the 15 references cited in NFPA 921 regarding spalling is a source outside of the fire science or forensic science fields (NFPA 921 A.6.2.5-A6.2.5.1.3). The Portland Cement Association (Portland cement is a type of cement, the most commonly used today, rather than a brand.) a trade organization that represents manufacturers, publishes a series of industry bulletins called *Concrete Information.* One of them describes the different kinds of concrete defects, their causes, and how to make various repairs. It gives a nuanced explanation of many defects that those outside the industry might call spalling collectively, but those in the industry distinguish as a number of different problems with

[1] Some practitioners incorrectly spell it "spalding" or "spaulding." The probable reason according to Lentini is that spalled is the past participle of spall. The Texas Fire Marshal in the documentary observed spalled concrete. Lentini suspects that those who do this have probably not read anything about it because these nonstandard spellings never appear in the scientific literature, and only occasionally in fire investigation reports.

many varied causes including improper mixing and curing, bond failure when concrete is poured in phases (known in the industry as courses), engineering errors, corrosive action, mechanical stress, freezing and thawing, and of course thermal stress from a fire (Portland Cement Association, 2001).

LEAA Survey: "breaking off of pieces of the surface of concrete, cement, or brick due to intense heat. Brown stains around the spall indicate the use of a fire accelerant." (Boudreau, Kwan, Faragher, & Denault, 1977, p. 88).

Freezing of Leaves: Freezing of leaves refers to the phenomenon that the orientation of leaves on live trees will become fixed when there is a fire nearby. This is viewed by some as relevant in wilderness fires. However, there is very little in the literature about this. The 1977 LEAA report included this in its list of burn indicators, incorrectly saying that leaves move slowly throughout the day to take the most advantage of sunlight, and that the position of the leaves can be used to deduce the time of day when the fire froze them in place. However, the only other references that could be found about the freezing of leaves is in the *Wildfire Origin & Cause Determination Handbook* (2005) published by the

National Wildfire Coordinating Group, a partnership of a half a dozen federal government agencies with roles in wilderness management and in NFPA 921, which calls the phenomenon "foliage freezing." NFPA 921 says that the orientation of leaves that have been frozen in place indicate the wind direction at the time they locked up. The *Wildfire Origin & Cause Determination Handbook* agrees, but warns that the wind generated by the fire may itself have more influence on this than wind in the ordinary meteorological sense. Therefore it does not reliably indicate the direction that the fire passed through the area (p. 16). There is no further treatment of this topic in the present research.

CHAPTER III: Methodology

The present research consists of a nationwide survey of public-sector fire investigators that asked demographic questions regarding location (state and county where they do most of their work), age, years of experience, level of education, level of science education, professional organization affiliations, professional certifications, reference resources used, journals followed, and their experience giving expert testimony. The survey then asked participants to identify the meaning of the six arson investigation myths discussed in Chapter II: Literature Review.

Each hypothesis will be tested by using the Chi square test to compare various groups of respondents to see if there are correlations between a given demographic and whether the respondents correctly answered all seven questions about arson investigation myths. While this research covers six arson investigation myths, there were seven questions. Two of the questions asked about two different kinds of observations of lines of demarcation. There was one question each regarding the other five arson investigation myths.

The significance level chosen is $\alpha = .05$, as it is the standard in social science research.

Hypothesis 1 will be tested by using the Chi square test to determine if metropolitan fire investigators are significantly more likely than non-metropolitan fire investigators to answer all seven arson investigation myth questions correctly. For this test, the counties that respondents selected will be classified into metropolitan and non-metropolitan counties by drawing from the FBI Uniform Crime Report (UCR) for 2010 data on reported arsons. Some counties were not classified by the FBI in the UCR (FBI, 2010). The respondents from those counties will be excluded from this test. Hypothesis 1 will be accepted if the p value is equal to or below 0.05. The hypothesis will be rejected if the p value is greater than 0.05.

Hypothesis 2 will be tested by conducting three Chi square tests to determine if certified fire investigators are significantly more likely than non-certified fire investigators to answer all seven arson investigation myth questions correctly. The first test will compare those holding the Certified Fire Investigator credential (CFI) issued by the IAAI with those holding the Certified Fire and Explosion Investigator credential (CFEI) issued by the National Association of Fire Investigators, (hereinafter NAFI). Those who hold both certifications will be excluded

from the test because the Chi square test requires that the subjects in the two groups to be compared not share a tested attribute. To do so would make the sum of the two groups (CFI and CFEI) larger than the sum of the other two groups (those who answered all seven questions correctly, and those who did not) because those with both CFI and CFEI would be counted twice.

The second test will compare those holding a CFI and/or CFEI credential with those who hold neither. In this test, those who held both will be included.

The third test will involve another certification scheme which had not been considered earlier, nor specifically asked about. Some of the participants (38) reported having certification from their State Fire Marshal (SFM) or a similar state agency. This test will compare those who reported SFM certification or equivalent with those who did not report this kind of certification.

Hypothesis 2 will be accepted if the p value for at least two of the three tests is equal to or below 0.05. The hypothesis will be rejected if the p value of at least two of the three tests is greater than 0.05.

Hypothesis 3 will be tested by conducting one Chi square test to determine if those respondents with a degree in a scientific field are significantly more likely to

answer all seven arson investigation myth questions correctly than those without a science degree. Hypothesis 3 will be accepted if the p value is equal to or below 0.05, and it will be rejected if the p value is greater than 0.05.

Hypothesis 4 will be tested by conducting two Chi square tests to determine if those respondents who began their fire investigation careers after the introduction of scientific principles into the fire investigation profession are significantly more likely to answer all seven arson investigation myth questions correctly than those who began their fire investigation careers after the introduction of scientific principles into the fire investigation profession. The first test will seek to determine whether those who began their fire investigation careers after the introduction of NFPA 921 in 1992 are significantly more likely to answer all seven arson investigation myth questions correctly than who began their careers before NFPA 921 was introduced.

The second test will seek to determine whether those who began their fire investigation careers after the IAAI endorsed NFPA 921 in 2000 are significantly more likely to answer the arson investigation myth questions correctly than who began their careers before IAAI endorsed NFPA 921.

Hypothesis 4 will be accepted if the p value of each test is equal to or below 0.05, and it will be rejected if the p value of each test is greater than 0.05. An inconclusive finding will be made if the results are contradictory.

CHAPTER IV: Results

Over a one-week period in February 2015, 217 fire investigators submitted responses to the National Survey of Fire Investigators. A review of the results reveals the following noteworthy descriptive statistics.

The age distribution of the sample is a normal shape, but years of experience distribution is skewed strongly right. This would indicate that fire investigation is not a first career for most of them. This is consistent with the contention of fire science leaders that most fire investigators begin their careers as firefighters and then later become fire investigators. Lentini points out that firefighting and fire investigation require two different skill sets and two different mind sets, such that fire investigation is not a skill that requires firefighting skills and vice versa. The two are not in a logical sequence like being a being a cab driver and then a dispatcher, where having the skills of a successful cab driver makes one a more competent dispatcher.

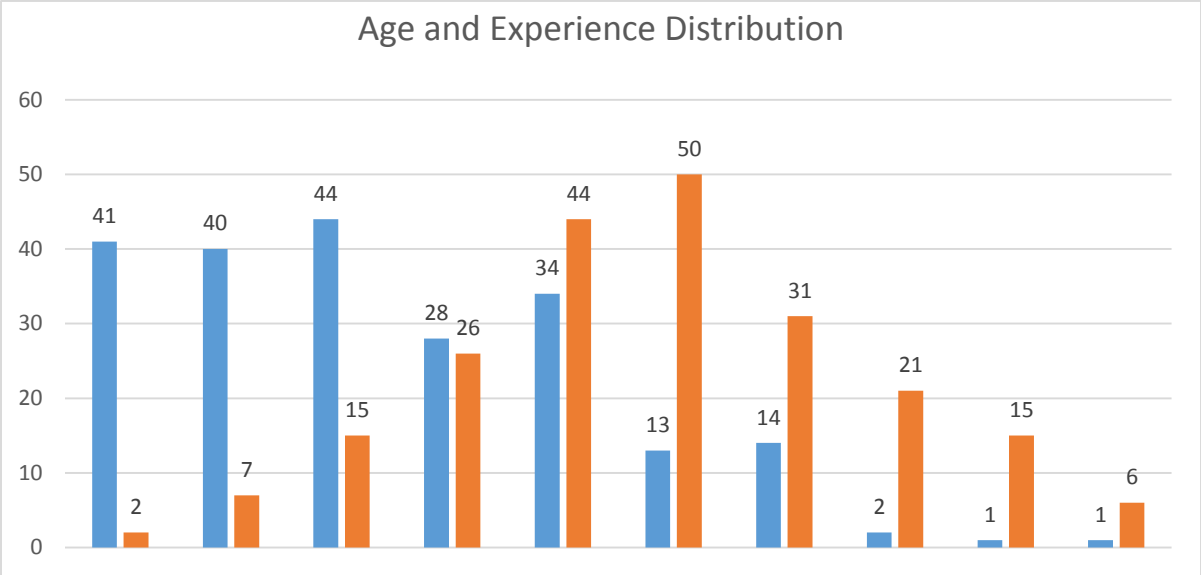


Figure 6

Most of the fire investigators in the sample have no college degree in a scientific field. Of those who do, an associate degree is the most common highest level of science education; none reported holding a doctorate.

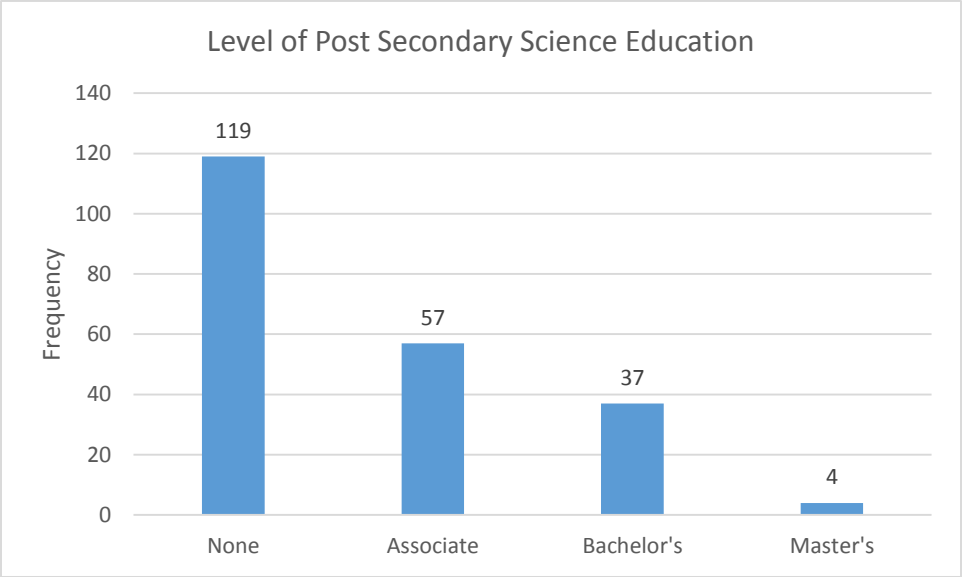


Figure 7

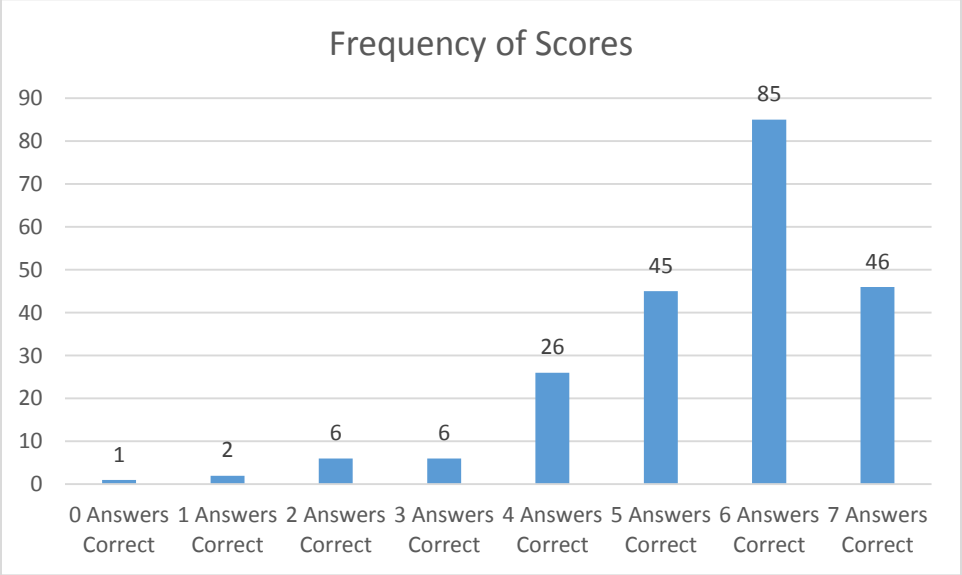


Figure 8

Some of the arson investigation myths discussed in Chapter II are still believed by a large minority of fire investigators in the sample. However, others are no longer believed by a sizable group. A notable segment of the

sample reported "I do not know the cause of..." for some of the myths. The grave consequences of that are discussed in Chapter V.

The slices in the following pie charts are color-coded to indicate the following characteristics about each answer choice represented:

Green indicates the correct answer.

Red indicates the answer that most explicitly implies arson, usually, that the observation is misinterpreted to indicate the presence of an accelerant.

Yellow indicates an answer choice that indicates arson, but less explicitly than the red slice.

Gray indicates "Do Not Know"

Other colors appear, but do not necessarily imply arson; they are nonetheless incorrect.

Incorrect beliefs about the cause of crazed glass are still alarmingly common. In 1992 Lentini produced the first correct explanation to appear in the literature, and still nearly 40 percent of fire investigators—23 years later—still do not know it.

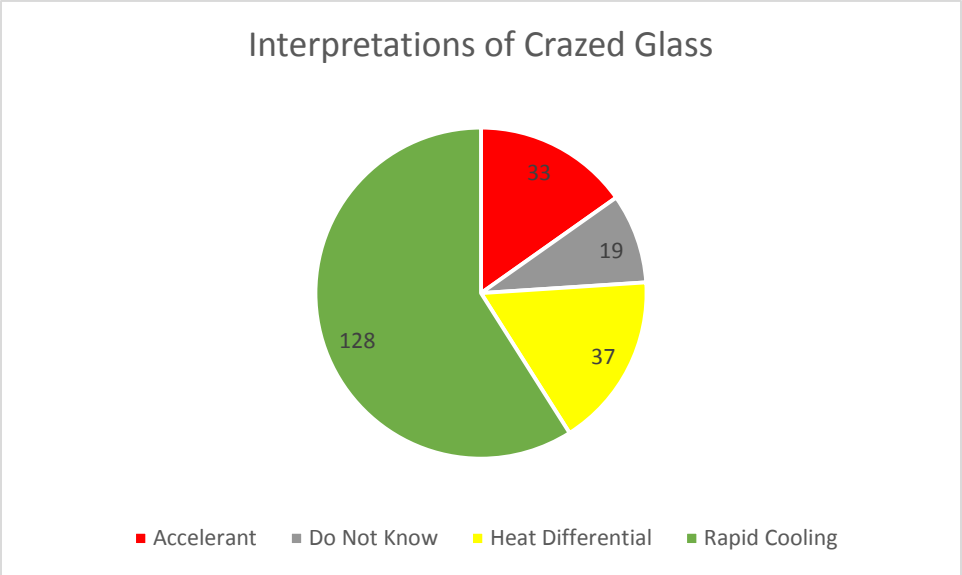


Figure 9: The arson investigation myth that the cause of crazed glass was a rapid buildup of heat do to the presence of an accelerant was once very widely believed. It was taken to be a very compelling indicator of arson. Another less common pseudoscientific explanation was that it was caused by one side of a pane of glass being much hotter than the other, labeled in the chart as "heat differential." The two myths are now believed with roughly equal frequency. This researcher could find nothing in the literature before 1992, when Lentini published the results of his lab experiments, that correctly indicated that it is caused by rapid cooling. It happens that this myth was perhaps the most susceptible to experiment, but it had never occurred to anyone to challenge it.

On the other hand, incorrect beliefs about the meaning of alligatoring are much less common.

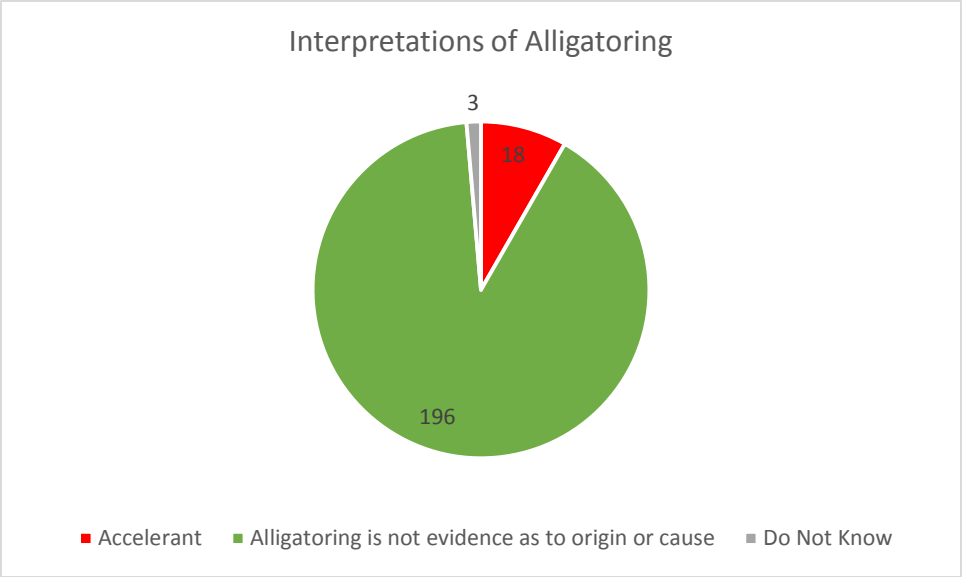


Figure 10

As discussed in Chapter II, arson investigators long believed that wood burned at a certain rate. From this, they would "deduce" how long a fire should have burned, and from that, that it burned too quickly unless it was "helped." Therefore, a fire that burned the wood too much was likely arson. No one in the survey reported not knowing the meaning of depth of char. This myth is no longer widely believed. Only 11 percent of participants still believed the myth.

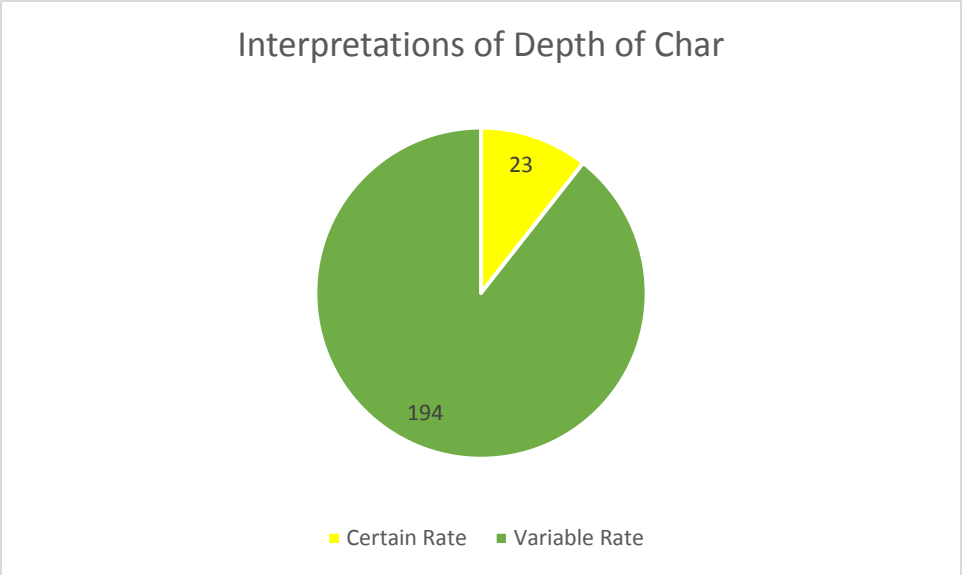


Figure 11

The arson investigation myth known as lines of demarcation was addressed in two questions in the survey. Lines of demarcation were once universally accepted as a conclusive indicator of arson because the burned areas were interpreted as the area where an accelerant was poured on a surface and that the unburned areas were where the person supposedly pouring the accelerant missed. The second question regarding lines of demarcation was more explicit by asking about two pictures with "puddle-shaped" burns. One was actually from accelerant and one was from a radiation burn left by a cardboard box burning on the same kind of flooring material. More participants misinterpreted these as indicators of an accelerant more than the other questions.

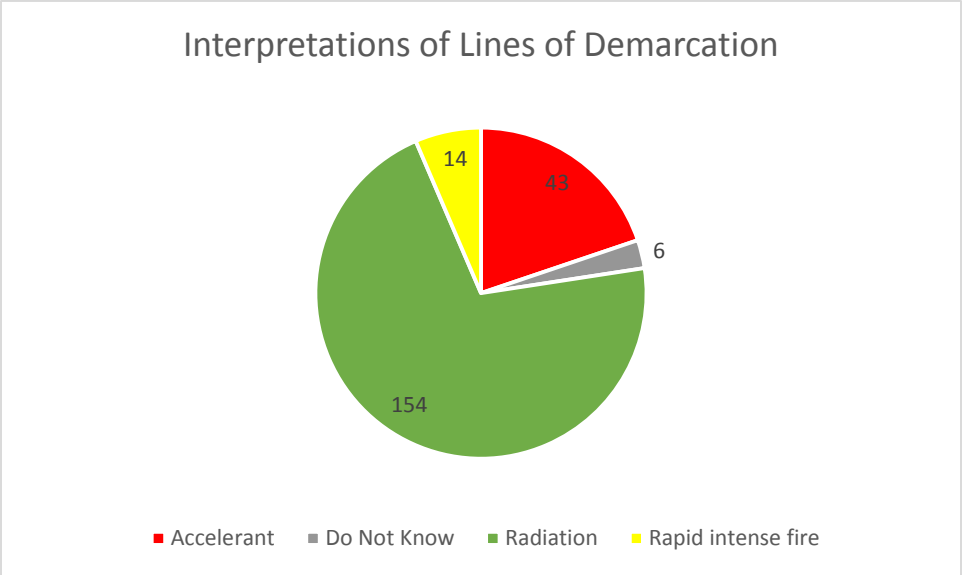


Figure 12

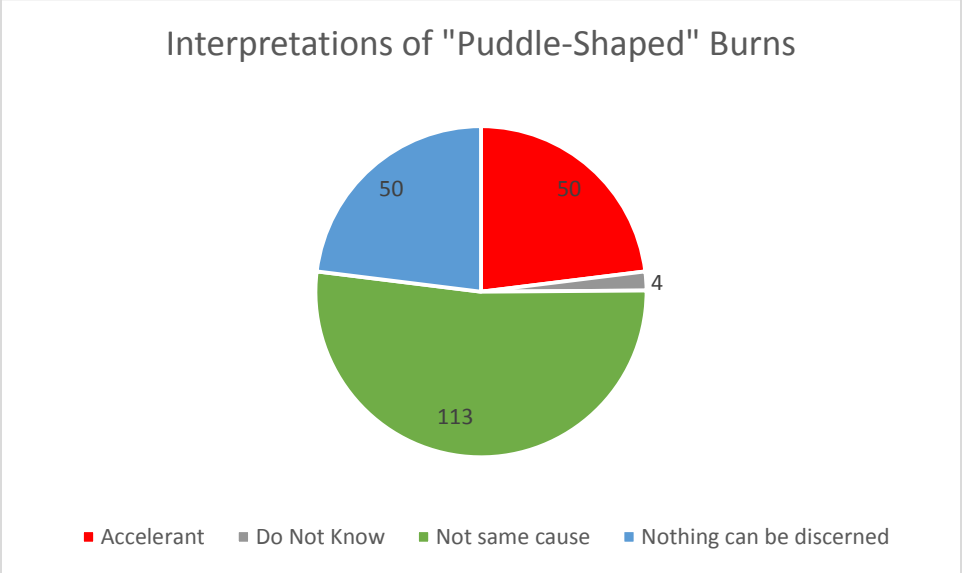


Figure 13

Nearly all participants recognized the spalling arson investigation myth while eight respondents believed that spalling indicates the presence of an accelerant. Only two

selected that they did not know the cause of spalling. Only three selected that spalled masonry indicates the point of origin.

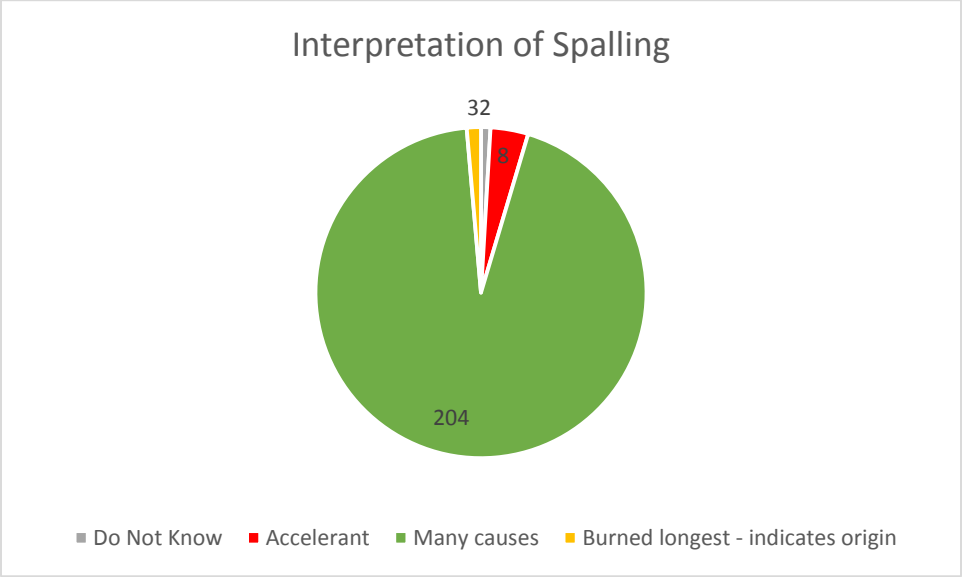


Figure 14

The sagged furniture springs arson investigation myth is based on two different supposed causes listed in the LEAA Survey. The current research separated the myth by offering separate answer choices, one for each of the two erroneous causes: a lit cigarette between two cushions, and an accelerant beneath the furniture. Nearly everyone answered this question correctly. No one selected accelerant beneath the furniture.

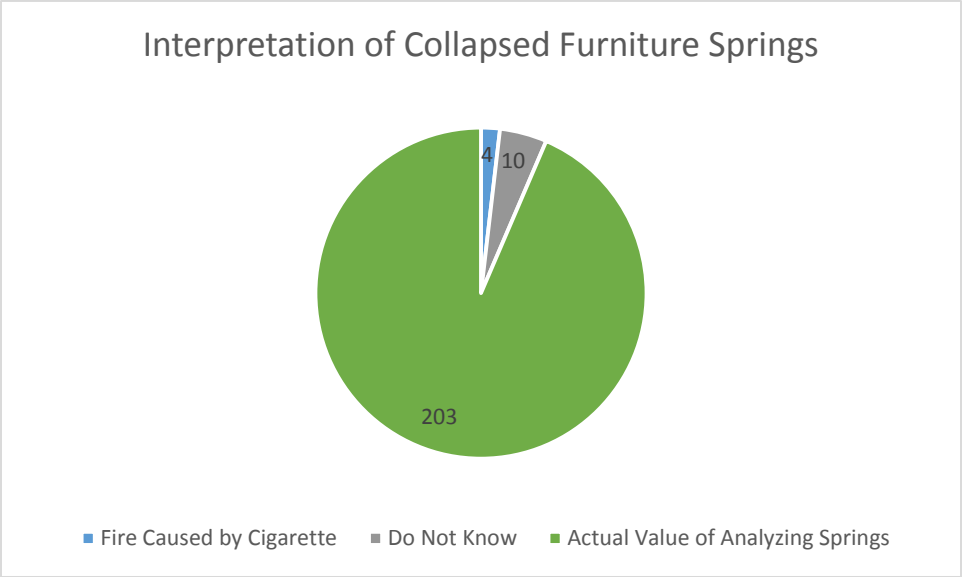


Figure 15

The four hypotheses were tested using the Chi square test of statistical significance to compare groups of fire investigators by various demographics. Based on the prediction that virtually no one would get any of the questions wrong, and that a competent fire investigator should not use discredited methods, the cross comparison was between those who answered all seven questions correctly (46), and those who did not (171). The significance level chosen was $\alpha = .05$, as it is the standard in social science research. See Appendix C for Chi Square test calculations.

Hypothesis 1: Fire investigators in metropolitan areas are significantly more likely than fire investigators in non-metropolitan areas to recognize that all six arson investigation myths are not indicators of arson.

Hypothesis 1 is REJECTED. P value was 0.691. The data provide sufficient evidence to conclude that fire investigators in metropolitan areas are not significantly more likely than fire investigators in non-metropolitan areas to recognize that all six arson investigation myths are not indicators of arson.

Hypothesis 2: Fire investigators who hold highly regarded professional certifications, (i.e. CFI and/or CFEI) are significantly more likely to recognize that all six arson investigation myths are not indicators of arson than fire investigators who do not.

Hypothesis 2 was tested with three comparisons. First, the two different certification schemes were compared with each other. Those who held both certifications were excluded from this test, as those investigators would have been counted twice. The P value was 0.202. Second, fire investigators holding either a CFI or CFEI credential with those who held neither. P value was 0.633. Those who held both were included in this test. The third test checked for significance between uncertified and those who reported on their own initiative that they held certification from their state fire marshal or equivalent. They had not been asked explicitly, so some with SFM certification may not have thought to report it.

P value was 0.680. None of the tests demonstrated a significant difference.

Hypothesis 2 is REJECTED. The data provide sufficient evidence to conclude that Certified Fire investigators (i.e. CFI and/or CFEI) are not significantly more likely to recognize that all six arson investigation myths are not indicators of arson than fire investigators who are not certified.

Hypothesis 3: Fire investigators who hold a degree in a scientific field are significantly more likely to know that all six arson investigation myths are not indicators of arson than fire investigators who do not hold a degree in a scientific field.

Hypothesis 3 was tested by comparing fire investigator who held a degree of any level (Associate, Bachelor's, Master's, Doctorate) in a scientific field such as chemistry, computer science, criminology, engineering, fire science, forensic science, Earth science, life science, materials research, mathematics, physics, science education or a closely related field with those who held no science degree. P value is 0.458.

Hypothesis 3 is REJECTED. The data provide sufficient evidence to conclude that fire investigators who hold a degree in a scientific field are not significantly more

likely to know that all six arson investigation myths are not indicators of arson than fire investigators who do not hold a degree in a scientific field.

Hypothesis 4: Fire investigators who began their fire investigation careers after the introduction of scientific principles into the field are significantly more likely to know that all six arson investigation myths are not indicators of arson than fire investigators who began their careers before the introduction of scientific principles into the field.

Hypothesis 4 was tested with two comparisons. The introduction of scientific principles in the field of fire investigation happened in two stages. The first was the introduction of NFPA 921 in 1992. The second was the adoption of NFPA 921 in 2000 by the IAAI. So, the first test compared fire investigators who began their careers before 1992 with those who began their careers in 1992 or later. The P value was 0.968. Next, fire investigators who began their careers before 2000 were compared with fire investigators who began their careers in 2000 or later. The P value was 0.995.

Hypothesis 4 is REJECTED. The data provide sufficient evidence to conclude that fire investigators who began their fire investigation careers after the introduction of

scientific principles into the field are not significantly more likely to know that all six arson investigation myths are not indicators of arson than fire investigators who began their careers before the introduction of scientific principles into the field.

CHAPTER V: Discussion, Conclusion, Recommendations

Discussion:

One expects that a physician with a medical degree would be significantly more proficient at diagnosing diseases than a patient with no medical education would be. We would also expect that things such as years of experience, specialized certifications, and the use of reliable reference sources, would make that doctor even more proficient. They would be less likely to use discredited treatments such as bloodletting, let's say. Similarly, one would expect that highly experienced fire investigators who hold a science degree and professional certifications, and who use reliable reference books would be significantly less likely to use discredited fire investigation methods. In both instances, these expectations do not always hold true.

First, the doctor. Psychiatry is the branch of medicine that incorporates the knowledge and principles of psychology. Psychology is the scientific study of behavior and mental processes. The four goals of psychology as a discipline are to describe, understand, predict and control behavior (Feldman, 2010). Research by psychologist Dr. David L. Rosenhan in the 1970s demonstrated that

psychiatrists have a *100 percent failure rate* in distinguishing the sane from the insane in psychiatric hospitals. In 1973, Rosenhan planted eight phony patients who reported identical symptoms in order to get admitted, and once admitted, behaved normally, in 12 psychiatric hospitals in five states and found that while hospital staff were unable to detect a single pseudopatient, nearly a third of the real psychiatric patients at those hospitals did. In a second experiment, hospital staff mistook a quarter of their real patients as fakes sent to them by Rosenhan, when in fact he had not sent anyone (Rosenhan, 1973). It suggests the troubling possibility that training in psychology may actually *diminish* one's ability to describe and understand behavior. While it generated reactions ranging from outrage to profession-wide humiliation, no one has seriously challenged the validity of Rosenhan's findings, which are consistent with the results of other experiments and journalistic investigations (Bly, 1887; Liddell, 2008; Temerlin, 1968).

The Rosenhan Experiment did not test the effect of the various qualifications of the hospitals' staff. And of course, it would be highly irresponsible to attempt to generalize those results to other branches of medicine or even nonclinical applications of psychology. But it is

certainly reasonable to expect that the hospital staff would be better equipped to diagnose psychiatric patients than the patients themselves would be. Further it is reasonable to expect that the hospital staff's education, training and experience would have a significant relationship to that skill. In fact, Rosenhan expected that the hospitals would immediately detect his chicanery and that his experiment would be a flop.

The present research has produced similarly inexplicable results. Statistical testing was unable to demonstrate a significant relationship between fire investigators who can recognize the six arson investigation myths and whether they worked in urban areas or not, their scientific education, years of experience, and professional certifications.

This research is not the first time that the competence of fire investigators as a group has been tested by researchers. In 2005, fire investigators from ATF put on a seminar in Las Vegas on fire dynamics. As part of the demonstration, they built two one-room furnished cabins, set each of them on fire, and after seven minutes, put them out. They then asked 53 experienced fire investigators to examine the two burn cells and determine which quadrant of each cell the fire started. Only 3 of the 53 identified

the correct quadrant in both cells (Carman, 2005). In another study, 658 fire investigators were given photographs of a staged post flash-over fire of a two-room cabin resembling a small apartment at the test burn laboratory at Eastern Kentucky University, and asked to determine the origin of the fire based on a grid system. Three quarters of that group correctly determined the origin to an acceptable degree (Tinsley & Gorbett, 2012).

The data show that some of the arson investigation myths have gone the way of bloodletting as a medical treatment, while others stubbornly persist, but none are any longer believed by a majority. That is definitely progress, considering that their appearance in the 1977 LEAA Survey showed that they were the most common things that arson investigators looked for to determine if they had an arson case or not.

When this project began, Lentini was asked to review the survey instrument to make sure that each of the seven arson investigation myth questions had only one correct answer choice, and that the incorrect answer choices represented actual incorrect explanations that people had been lead to actually believe. He also suggested additional demographic questions, and choices to include. In his response at that point, Lentini commented that he

believed that very few if any investigators would still believe any of them because he surmised that more than half of fire investigators practicing now would have begun their careers after the introduction of NFPA 921 in 1992, and that those who were retiring would be replaced by those who might never had been exposed to arson investigation myths. In a later interview, Lentini had reconsidered that position, saying that the pivot year should actually be 2000 because that is when the IAAI embraced NFPA 921 and the science behind it. Between 1992 and 2000, they had fought the implementation of NFPA 921 in court. So, 81 percent of the sample began their fire investigation careers after 1992, and 61 percent began their fire investigation careers after 2000. This led to hypothesis 4, which accepted as a premise a quote by the Nobel Prize winning German physicist Max Planck, that "A new scientific truth does not triumph by convincing its opponents and making them see the light, but rather because its opponents eventually die, and a new generation grows up that is familiar with it," (Planck, 1949, pp. 33-34) which is commonly paraphrased as, "Science advances one funeral at a time." As it turns out, the two tests showed the weakest correlation of all of the hypotheses, with P values approaching 1.

Recommendations:

It was expected from the outset that recommendations would be rather straightforward and in line with those already in circulation. For instance, the NAS Report recommended that fire investigators be certified. There must have been some basis for that recommendation. It is unfathomable that after spending years studying the problems of forensic science and utilizing a great think tank to figure out what to do, that it would just offer canned recommendations. Further, it is still reasonable to presume that certification may play a helpful part in a larger set of solutions. However, the system of certification appears to need some work. For instance, to apply for a CFEI credential, NAFI requires that the applicant demonstrate previous experience investigating fires. When NAFI was asked to clarify the substance of this requirement, a NAFI representative said that there was no hard and fast rule, but that 20 fire investigations would probably be about minimum. It is disturbing that people are expected to work in a profession, risking every day the possibility of doing that work incompetently before they are even allowed to test their competence. A fire investigator should not be able to perform a single fire investigation or have a single day of experience

investigating the origin and cause of a fire without having demonstrated competence. But what does that mean?

Once CFEI applicants have met all of the requirements, they may sit for the exam, a 200-question multiple-choice and true-false test that they are given two hours to complete. By comparison to other tests for entering various professions, this seems utterly cheesy, and that it would not separate the competent from the incompetent. For example, in Louisiana, the State Bar Exam takes 21.5 hours, and one cannot practice law at all in this state without passing it, except in the very limited circumstances of law students working as interns in law-school operated legal clinics and licensed out-of-state attorneys working under the supervision of local attorneys on specific cases and then only with the judge's approval. Nearly a third of those taking the Louisiana Bar Exam fail it. And at the bottom rungs of the legal profession are the paralegals, secretaries and other clerical staff. In New Orleans, many law firms use a big staffing agency that specializes in screening law office personnel. That staffing agency requires applicants to take a six-hour exam on a dozen different topics from legal terminology to filing to typing to note taking before they can even interview for a $10 per hour entry-level job in a law office. So, it seems that an

overhaul of the certification process and its level of difficulty is in order.

Additionally, the findings here scream for more research. First, considering that the present research did not cover the totality of fire investigation skills, more research in similar form to the present research ought to be taken up with a wider scope involving the larger knowledgebase expected of professional fire investigators.

Second, a survey of fire science programs around the country should be conducted to gather a snapshot of who is teaching the skills, their qualifications, the curriculum they are using and the exams they are giving to make sure that a degree in fire science from one school means roughly the same thing as a fire science degree from another school, and that those programs are in line with current scientific advances and that they are free from teaching arson investigation myths.

Third, an organized effort to cleanse the field of the arson investigation myths should be undertaken. In education theory, this process is known as unlearning (Becker, 2007). Some respondents reported not knowing the meaning of a given observation. That is risky. A person who has never heard of crazed glass may just as easily become an adherent to the accelerant theory as to the

correct rapid-cooling explanation. Suppose that Bob, a fire investigator who still believes the accelerant theory, goes into a break room at work and asks a colleague, Jim, who has never heard of crazed glass, to look over Bob's report of a recent warehouse fire. Now suppose, in that report, Bob has cited crazed glass as a reason to suspect arson. This is where Jim's do-not-know response risks becoming an arson-myth response. Jim looks over the report, come across the blurb about crazed glass and asks Bob about it. Bob proceeds to give him the arson investigation myth explanation, and now Jim thinks, "I never knew that; I will have to remember that." Further, he may go to the library and find literally dozens of books that confirm this new "knowledge," with the chance that he will never come across the very few that correctly address it, or Lentini's lone textbook that spends 35 pages deprogramming fire investigators of arson investigation myths.

This scenario is absolutely reasonable. While combing over the results of this survey, the search continued for any books that may have a take on fire investigation. A brand new bestselling textbook on criminal investigation, in its 10th edition, was found to still be parroting the LEAA Survey verbatim. Further, an entry in a 2007

encyclopedia on security management was still encouraging the arson investigation myths. It was later discovered that the author of that encyclopedia actually still teaches an arson investigation course approved by many states for continuing education units for private investigators that includes all of the arson investigation myths.

However, if in a class, someone had shown Jim how rapid cooling and only rapid cooling causes crazed glass, then Jim could get Bob up to speed.

The textbook, encyclopedia and continuing education course may be only the tip of the iceberg. If a third of fire investigators still believe that crazed glass indicates arson, and they are specialists, how many textbook authors, who are generalists, still believe it?

While none of the arson investigation myths are believed by a majority, a vast majority believe some combination of them. Remember that only 46 of the 217 respondents recognized all six arson investigation myths.

It appears that new information is not effectively supplanting the wives' tales. A massive effort to rid society of misinformation is not without precedent. As to how one may go about getting a program of unlearning underway, we can look to the way the government addressed the mass hysteria of the AIDS crisis. On May 26, 1988, in

response to an alarming wave of paranoia and confusion regarding AIDS, how one catches it, how it progresses as a disease, etc. US Surgeon General Dr. C. Everett Coop mailed *107 million copies* of an eight-page booklet to *every residential address it the United States* (Koop, 1988). A similar effort may be needed, but of course on a much smaller scale as it need only be directed to all fire departments, state fire marshals' offices, police detective bureaus, prosecutors' offices etc. rather than the entire population.

APPENDIX A: Material from *NFPA 921, 2014 Edition*

The following are sections from *NFPA 921: Guide for Fire and Explosion Investigation, 2014 Edition* related to the interpretation of six arson investigation myths studied in the research. Quotations from NFPA 921 are presented throughout as **"NFPA 921 N.N.N.N…"** rather than with page numbers. This is the accepted method of citing all NFPA publications.

Alligatoring:

"NFPA 921 6.2.4.3 Appearance of Char. In the past, the appearance of the char and cracks had been given meaning by the fire investigation community beyond what has been substantiated by controlled testing. The presence of large shiny blisters (alligator char) is not evidence that a liquid accelerant was present during the fire, or that a fire spread rapidly or burned with greater intensity. These types of blisters can be found in many different types of fires. There is no justification for the inference that the appearance of large, curved blisters is an indicator of an accelerated fire."

"NFPA 921 6.2.4.3.1: It is sometimes claimed that the surface appearance of the char, such as dullness, shininess, colors, or appearance under ultraviolet light sources, has some relation to the use of a hydrocarbon

accelerant or the rate of fire growth. There is no scientific evidence that such a correlation exists, and the investigator is advised not to claim indications of accelerant or a rapid fire growth rate on the basis of the appearance of the char".

Crazing of Glass:

"**NFPA 921 6.2.13.1.4** Crazing is a term used in the fire investigation community to describe a complicated pattern of short cracks in glass. These cracks may be straight or crescent-shaped and may or may not extend though the thickness of the glass. Crazing has been claimed to be the result of very rapid heating of one side of the glass while the other side remains cool. Despite widespread publication of this claim, there is no scientific basis for it. In fact, published research has shown that crazing cannot be caused by rapid heating, but can only be caused by rapid cooling. Regardless of how rapidly it was heated, hot glass will reproducibly craze when sprayed with water."

Depth and Location of Char:

"**NFPA 921 6.2.4.4 Rate of Wood Charring:** The correlation of 2.54 cm (1 in.) in 45 minutes for the rate of charring of wood is based on ventilation-limited burning. Fires may burn with more or less intensity during the course of an uncontrolled fire than in a controlled laboratory fire.

Laboratory char rates from exposure to heat from one side vary from 1 cm (0.4 in.) per hour to 25.4 cm (10 in.) per hour. Care needs to be exercised in solely using depth of char measurements to determine the duration of burning" (p. 49)

"**NFPA 921 6.2.4.4.1:** The rate of charring of wood varies widely depending upon variables, including the following:

(1) Rate and duration of heating

(2) Ventilation effects

(3) Surface area-to-mass ratio

(4) Direction, orientation, and size of wood grain

(5) Species of wood (pine, oak, fir, etc.)

(6) Wood density

(7) Moisture content

(8) Nature of surface coating

(9) Oxygen concentration of the hot gases

(10) Velocity of the impinging gases

(11) Gaps/cracks/crevices and edge effect of materials (p. 49)"

"**NFPA 921 6.2.4.4.3:** The investigator is cautioned that no specific time of burning can be determined based solely on the depth of char."

Irregular Burn Patterns:

"NFPA 921 6.3.7.8 Irregular Patterns. Irregular, curved, or "pool-shaped" patterns on floors and floor coverings should not be identified as resulting from ignitible [2] liquids on the basis of visual appearance alone. In cases of full room involvement, patterns similar in appearance to ignitible liquid burn patterns can be produced when no ignitible liquid is present.

"NFPA 921 6.3.7.8.1 The lines of demarcation between the damaged and undamaged areas of irregular patterns range from sharp edges to smooth gradations, depending on the properties of the material and the intensity of heat exposure. Denser materials like oak flooring will generally show sharper lines of demarcation than polymer (e.g., nylon) carpet. The absence of a carpet pad often leads to sharper lines.

"NFPA 921 6.3.7.8.2 Irregular patterns are common in situations of post-flashover conditions, long extinguishing times, or building collapse. These patterns may result from the effects of hot gases, flaming and smoldering debris, melted plastics, or ignitible liquids. If the presence of

[2] Ignitable and ignitible are both acceptable spellings. NFPA uses the latter in all of its publications; therefore this researcher adopts this spelling.

ignitible liquids is suspected, supporting evidence in the form of a laboratory analysis should be sought. It should be noted that many plastic materials release hydrocarbon fumes when they pyrolyze or burn. These fumes may have an odor similar to that of petroleum products and can be detected by combustible gas indicators when no ignitible liquid accelerant has been used. A “positive” reading should prompt further investigation and the collection of samples for more detailed chemical analysis. It should be noted that pyrolysis products, including hydrocarbons, can be detected in laboratory analysis of fire debris in the absence of the use of accelerants. It can be helpful for the laboratory, when analyzing carpet debris, to burn a portion of the comparison sample and run a gas chromatographic–mass spectrometric analysis on both samples. By comparing the results of the burned and unburned comparison samples with those from the fire debris sample, it may be possible to determine whether or not hydrocarbon residues in the debris sample were products of pyrolysis or residue of an accelerant. In any situation where the presence of ignitible liquids is suggested, the effects of flashover, airflow, hot gases, melted plastic, and building collapse should be considered.

"**NFPA 921 6.3.7.8.3** When overall fire damage is limited and small, or isolated irregular patterns are found, further examination should be conducted for supporting evidence of ignitible liquids. Even in these cases, radiant heating may cause the production of patterns on some surfaces that can be misinterpreted as liquid burn patterns.

"**NFPA 921 6.3.7.8.4** Pooled ignitible liquids that soak into flooring or floor covering materials as well as melted plastic can produce irregular patterns. These patterns can also be produced by localized heating or fallen fire debris.

"**NFPA 921 6.3.7.8.5** The term *pour pattern* implies that a liquid has been poured or otherwise distributed, and therefore, is demonstrative of an intentional act. Because fire patterns resulting from burning ignitible liquids are not visually unique, the use of the term pour pattern and reference to the nature of the pattern should be avoided. The correct term for this fire pattern is an irregularly shaped fire pattern. The presence of an ignitible liquid should be confirmed by laboratory analysis. The determination of the nature of an irregular pattern should not be made by visual interpretation of the pattern alone."

Sagged/Collapsed Furniture Springs:

"NFPA 6.2.14 Collapsed Furniture Springs. The collapse of furniture springs may provide the investigator with clues concerning the direction, duration, or intensity of the fire. However, the collapse of the springs cannot be used to indicate exposure to a specific type of heat or ignition source, such as smoldering ignition or the presence of an ignitible liquid. The results of laboratory testing indicate that the annealing of springs, and the associated loss of tension (tensile strength), is a function of the application of heat. These tests reveal that short-term heating at high temperatures and long-term heating at moderate temperatures over 400°C (750°F) can result in the loss of tensile strength and in the collapse of the springs. Tests also reveal that the presence of a load or weight on the springs while they are being heated increases the loss of tension.

"NFPA 921 6.2.14.1 The value of analyzing the furniture springs is in comparing the differences in the springs to other areas of the mattress, cushion, or frame. Comparative analysis of the springs can assist the investigator in developing hypotheses concerning the relative exposure to a particular heat source. For example, if at one end of the cushion or mattress the springs have lost their strength,

and at the other end they have not, then hypotheses may be developed concerning the location of the heat source. The hypotheses should take into consideration other circumstances, effects (such as ventilation), and evidence at the scene concerning duration or intensity of the fire, area of origin, direction of heat travel, or relative proximity of the heat source. The investigator should also consider that bedding, pillows, and cushions may shield the springs, or provide an additional fuel load. The portion with the loss of spring strength may indicate more exposure to heat than those areas without the loss of strength. The investigator should also consider the condition of the springs prior to the fire."

Spalling:

"**NFPA 6.2.5 Spalling:** Spalling is characterized by the loss of surface material resulting in cracking, breaking and chipping or in the formation of craters on concrete, masonry, rock, or brick.

"**6.2.5.1 Fire-Related Spalling:** Fire-related spalling is the breakdown in surface tensile strength of material caused by changes in temperature, resulting in mechanical forces within the material. In concrete, these forces are believed to result from one or more of the following:"

(1) Moisture present in the concrete

(2) Differential expansion between reinforcing rods or steel mesh and the surrounding concrete

(3) Differential expansion between the concrete mix and aggregate (most common with silicon aggregates)

(4) Differential expansion between the fire-exposed surface and the interior of the slab.

"6.2.5.1.1: A mechanism of spalling is the expansion or contraction of the surface while the rest of the mass expands or contracts at a different rate; one example is the rapid cooling of a heated material by water.

"6.2.5.1.2: Spalled areas may appear lighter in color than adjacent areas. This lightening can be caused by exposure of clean subsurface material. Adjacent areas may also tend to be darkened by smoke deposition.

"6.2.5.1.3: Another factor in the spalling of concrete is the loading and stress in the material at the time of the fire. Because these high-stress or high-load areas may not be related to the fire location, spalling of concrete on the underside of ceiling or beams may not be directly over the origin of the fire.

"6.2.5.2: The presence or absence of spalling at a fire scene should not, in and of itself, be construed as an indicator of the presence or absence of liquid fuel

accelerant. The presence of ignitible liquids will not normally cause spalling on adjacent surfaces, or a resultant fire may cause spalling on the surface after the ignitable liquid burns away.

"**6.2.5.3: Non-Fire-Related Spalling.** Spalling of concrete or masonry surfaces may be caused by many factors, including heat, freezing, chemicals, abrasions, mechanical movement, shock, force, or fatigue. Spalling may be more readily induced in poorly formulated or finished surfaces. Because spalling can occur from sources other than fires, the investigator should determine whether spalling was present prior to the fire."

APPENDIX B: Survey Documents

David Cook, BSc, FCSI
6000 Chef Menteur Highway #208
New Orleans, LA 70126
504-534-5339

February 10, 2015

RE: National Survey of Fire Investigators

To America's Fire Departments:

I am a graduate student at National University working on my thesis. The central component of my research is the **National Survey of Fire Investigators**. I need fire investigators to respond to the survey, which is online at **fireinvestigatorsurvey.org**, and takes less than 10 minutes to complete.

This letter is being sent to 19,000 randomly selected fire departments all over the United States. The greater number of investigators who respond, the more valid my research results will be.

Please forward this information to anyone who has any role in investigating fires, so they can participate.

The second page of this letter is a flyer that you can copy and circulate or put up on a bulletin boards to tell your fire crews about the survey. The research is important and may help improve fire investigator training.

I value and appreciate you all taking time to do this survey as it will make my research project more concrete due to the factual responses of personnel currently in the field.

Sincerely,

David Cook, BSc, FCSI

TO ALL FIRE INVESTIGATORS!!!

A GRADUATE STUDENT

NEEDS YOUR HELP

TO FINISH HIS THESIS!

Visit

fireinvestigatorsurvey.org

today!!!

Take the

National Survey of Fire Investigators

DO YOU INVESTIGATE FIRES?

- Fire Marshals
- Detectives at police and sheriff's departments
- Crime Scene Technicians
- Crime Lab Technicians
- Claims adjustors
- Firefighters who are expected to observe and report indications of a fire's origin and cause
- Private investigators
- Security Guards
- Scientists who do research about fire investigation
- Prosecutors
- Criminal defense attorneys
- Those who are training to become fire investigators
- Retired fire investigators

DO YOU TRAIN NEW FIRE INVESTIGATORS?

- Mentors who supervise apprentice fire investigators
- Those who teach fire investigation at collegesor universities.
- Those who teach fire investigation atpolice or fire academies
- Those who lead fire investigation seminars
- Those who develop teaching materials like videos and books.

Survey Instrument

[Italicized text in square brackets denotes explanatory content that was not included in the actual survey instrument.]

[Participants were directed by the faxed recruiting document to go to: fireinvestigatorsurvey.org, which would open with the following text:]

Thank you for participating in the National Survey of Fire Investigators. The study is being conducted by David Cook, a graduate student in the Mathematics and Natural Sciences Department at National University in San Diego, California. Your participation may help improve training for fire investigators and make it more widely available.

[After clicking on a button to go to the survey, participants would be shown the first question:]

As part of your work, or as a volunteer, what is your role in investigating the cause and origin of fires? Please check all that apply.

- ❑ I investigate the cause and origin of fires as part of my work for a public agency such as a police department or a fire department, (e.g. arson investigator, detective, fire marshal, police officer, crime scene processing technician, etc.)
- ❑ I investigate the cause and origin of fires as part of my work for a private entity such as an insurance company, (e.g. investigator, claims adjustor).
- ❑ I am a firefighter who is expected to observe and report indications of the origin and cause of fires.
- ❑ I am a private investigator who investigates the cause and origin of fires as part of my practice.
- ❑ I provide technical expertise (e.g. laboratory tests of physical evidence) to others investigating the cause and origin of fires.
- ❑ I conduct scientific research about topics relevant to determining the cause and origin of fires.

- ❑ I am a prosecuting attorney who has prosecuted the charge of arson.
- ❑ I am a criminal defense attorney who has defended a client against a charge of arson.
- ❑ I am currently undergoing training to investigate fires.
- ❑ I have investigated the cause and origin of fires in the past but I no longer do so (e.g. retired, disabled, new career etc.).
- ❑ I supervise apprentice fire investigators.
- ❑ I teach courses related to fire investigation at a college, university or military academy.
- ❑ I teach courses related to fire investigation at law enforcement, fire service or similar academy.
- ❑ I lead seminars on a fire investigation.
- ❑ I develop teaching materials like videos and books.
- ❑ No, I do not have any role in investigating the cause and origin of fires.

[If subject responded "No, I do not have any role in investigating the cause and origin of fires," they would have been excluded from the study. There was no way to stop their participation from this screen because the question asks to check all that apply, rather than only allowing them to make one choice, which allowed them to be directed to another page based on that response. Constructing the question and response choices to allow only one choice would have compromised the ability of the survey to answer the research question.]

[Next Screen]

State or Territory

Please select in which state, district or territory you perform the most fire investigations. If you work under federal jurisdiction such as the ATF, FBI, or a branch of the US Armed Forces, please select "Federal Agency" near the end of the list. If you work nationwide in some other capacity, please mark "Nationwide Non-Federal Government" at the end of the list.

- ❑ Alabama
- ❑ Alaska

- ❑ Arizona
- ❑ Arkansas
- ❑ California
- ❑ Colorado
- ❑ Connecticut
- ❑ Delaware
- ❑ District of Columbia
- ❑ Florida
- ❑ Georgia
- ❑ Hawaii
- ❑ Idaho
- ❑ Illinois
- ❑ Indiana
- ❑ Iowa
- ❑ Kansas
- ❑ Kentucky
- ❑ Louisiana
- ❑ Maine
- ❑ Maryland
- ❑ Massachusetts
- ❑ Michigan
- ❑ Minnesota
- ❑ Mississippi
- ❑ Missouri
- ❑ Montana
- ❑ Nebraska
- ❑ Nevada
- ❑ New Hampshire
- ❑ New Jersey
- ❑ New Mexico
- ❑ New York
- ❑ North Carolina
- ❑ North Dakota
- ❑ Ohio
- ❑ Oklahoma
- ❑ Oregon
- ❑ Pennsylvania
- ❑ Rhode Island
- ❑ South Carolina

- ❑ South Dakota
- ❑ Tennessee
- ❑ Texas
- ❑ Utah
- ❑ Vermont
- ❑ Virginia
- ❑ Washington
- ❑ West Virginia
- ❑ Wisconsin
- ❑ Wyoming
- ❑ American Samoa
- ❑ Guam
- ❑ Northern Mariana Islands
- ❑ Puerto Rico
- ❑ US Virgin Islands
- ❑ Federal Agency
- ❑ Nationwide Non-Federal Government

[If participants selected a state, they would be shown a list of counties, parishes (Louisiana), boroughs or census areas (Alaska), and independent cities (Virginia) in their state to select from before going to the next question. Participants who selected American Samoa, Guam, Northern Mariana Islands, Puerto Rico, US Virgin Islands, Federal Agency, or Nationwide Non-Federal Government would immediately be directed to the next question.]

[Next Screen]

Please indicate your age range:

- ❑ 18-25
- ❑ 26-30
- ❑ 31-35
- ❑ 36-40
- ❑ 41-45
- ❑ 46-50
- ❑ 51-55
- ❑ 56-60
- ❑ 61-65
- ❑ 66-70

- ❑ 71 or older

In what year did you first work as a fire investigator? Please enter approximate year: (e.g. 1977)

_____

[Next Screen]

Highest level of education.
Please indicate your highest level of education.

- ❑ I did not complete high school.
- ❑ High school diploma or GED.
- ❑ Certificate from a community college or vocational school.
- ❑ Academy training provided in the armed services.
- ❑ Academy training by a fire department.
- ❑ Academy training provided by a law enforcement agency.
- ❑ Associate degree
- ❑ Bachelor's degree
- ❑ Master's degree
- ❑ Doctorate

[Next Screen]

Highest degree in a scientific field.
Do you have a degree in a scientific field such as chemistry, computer science, criminology, engineering, fire science, forensic science, Earth science, life science, materials research, mathematics, physics, science education or a closely related field? If so, please indicate the highest degree that you hold in a scientific field.

- ❑ Associate
- ❑ Bachelor's degree
- ❑ Master's degree
- ❑ Doctorate
- ❑ I do not have a degree in a scientific field.

[Next Screen]

Professional organizations.
Please indicate if you are a member of any of the following professional organizations. Check all that apply.

- ❑ National Association of Fire Investigators
- ❑ International Association of Arson Investigators
- ❑ Institution of Fire Engineers
- ❑ National Fire Protection Association
- ❑ American Academy of Forensic Sciences
- ❑ American College of Forensic Examiners Institute
- ❑ National Association Fire Chiefs
- ❑ I do not belong to any of the listed organizations.
- ❑ Other:

[Next Screen]

Fire-investigation related certifications.
Please indicate if you hold any of the following certifications. Check all that apply.

- ❑ Certified Criminal Investigator (CCI®) - American College of Forensic Examiners Institute
- ❑ Certified Forensic Consultant (CFC®) - American College of Forensic Examiners Institute
- ❑ Certified Instructor (CI) - American College of Forensic Examiners Institute
- ❑ Certified Fire Investigator (IAAI-CFI®) – International Association of Arson Investigators
- ❑ Fire Investigation Technician (IAAI-FIT®) – International Association of Arson Investigators
- ❑ Evidence Collection Technician (IAAI-ECT) – International Association of Arson Investigators
- ❑ Certified Instructor (IAAI-CI) – International Association of Arson Investigators
- ❑ Technician (TIFireE) – Institution of Fire Engineers
- ❑ Graduate (GIFireE) – Institution of Fire Engineers
- ❑ Chartered Engineer (CEng) – Institution of Fire Engineers
- ❑ Certified Fire and Explosion Investigator (CFEI) – National Association of Fire Investigators

- ❑ Certified Fire Investigation Instructor (CFII) – National Association of Fire Investigators
- ❑ Certified Vehicle Fire Investigator (CVFI) – National Association of Fire Investigators
- ❑ I do not hold any of the listed certifications.
- ❑ Other:

[Next Screen]

Continuing education.
Please indicate if you have attended formal educational courses, workshops or seminars covering any of the following topics in the last four years. Check all that apply.

- ❑ Fire science
- ❑ Fire chemistry
- ❑ Thermodynamics
- ❑ Thermometry
- ❑ Fire dynamics
- ❑ Explosion dynamics
- ❑ Computer fire modeling
- ❑ Fire investigation
- ❑ Fire analysis
- ❑ Fire Investigation Methodology
- ❑ Fire Investigation Technology
- ❑ Hazardous Materials
- ❑ Failure analysis and analytical tools
- ❑ Fire protection systems
- ❑ Evidence documentation, collection, and preservation
- ❑ Electricity and electrical systems.
- ❑ I have not attended formal educational courses, workshops or seminars covering any of the topics listed in the last four years.

[Next Screen]

Reference materials you use.
Please indicate if you use any of the following reference materials to help you perform fire investigation tasks. Their order is alphabetical and is no indication of their authority. Check all that apply.

- Almirall, J.R. & Furton, K. G. (2004) *Analysis and Interpretation of Fire Scene Evidence*, Boca Raton: CRC Press
- Becker, R. F. & Dutelle, A. W. (2013) *Criminal Investigation* (4th ed.) Burlington, MA: Jones & Bartlett.
- Boudreau, J. F., Kwan, Q. Y., Faragher, W. E., & Denault, G. C. (1977). *Arson and arson investigation: Survey and assessment*. Washington, DC: Law Enforcement Assistance Administration, USDOJ.
- Custer, R. L. P. (Ed.) (2007) *Field Guide for Fire Investigators*, Sudbury, MA: Jones and Bartlett.
- Daéid, Niamh Nic, (2004) *Fire Investigation*, Boca Raton, FL: CRC Press.
- DeHaan, J. D., Dixon, B. M., Kelly, R. L., & Smith, D. W. (Eds.). (2000). *Fire and Arson Scene Evidence: A Guide for Public Safety Personnel*, Washington, DC: NIJ.
- Fay, J. J. (Ed.) (2007) *Encyclopedia of Security Management* (2nd ed.), Amsterdam: Butterworth-Heinemann
- French, H. M. (1979) *The Anatomy of Arson*, New York: Arco Publishing
- Gardiner, M. (2000) *Pocket Guide to Fire and Arson Investigation* (2nd ed.) FM Global and Gardiner Associates
- Gardner, R. M. (2012) *Practical Crime Scene Processing and Investigation* (2nd ed.), Boca Raton: CRC Press
- Icove, D. J., & DeHaan, J. D. (2004) Forensic Fire Scene Reconstruction, Upper Saddle River, NJ Pearson Education.
- International Association of Arson Investigators (2012) *Fire Investigator: Principles and Practice to NFPA 921 and 1033* (3rd ed.), Sudbury, MA: Jones & Bartlett.
- Kennedy, J. M (1977) *Fire, Arson and Explosion Investigation*, Chicago: Investigations Institute.
- Kirk, P. L., (1969) *Fire Investigation: Including fire-related phenomena: arson, explosion, asphyxiation*, New York: John Wiley & Sons.

- ❑ Lentini, J. J. (2012) *Scientific Protocols for Fire Investigation* (2nd ed.) Boca Raton, FL: CRC Press
- ❑ Lentini, J. J. (2006) *Scientific Protocols for Fire Investigation* (1st ed.) Boca Raton, FL: CRC Press
- ❑ National Fire Protection Association (2014) *NFPA 921: Guide for Fire & Explosion Investigations* (2014 ed.), Quincy, MA: NFPA
- ❑ Noon, R. (1995) *Engineering Analysis of Fires and Explosions*, Boca Raton, FL: CRC Press
- ❑ O'Connor, J.J. (1987). *Practical Fire and Arson Investigation*, New York: Elsevier
- ❑ Pietzak, G (Ed.) (2007) *Fire Investigator Field Guide* (2nd ed.) Burlington, MA: Jones and Bartlett.
- ❑ Redsicker, D. R., & O'Connor, J. J. (1997). *Practical Fire and Arson Investigation* (2nd ed.). Boca Raton: CRC Press.
- ❑ Saferstein, R. (2011) *Criminalistics: An introduction to forensic science* (10th ed.), Boston: Prentice Hall
- ❑ I do not use any of the reference materials listed.
- ❑ Other:

[Next Screen]

Journals and magazines you read.
Do you subscribe to or regularly read any of the following journals or magazines? Their order is alphabetical and is no indication of their authority. Please check all that apply.

- ❑ Criminal Investigation
- ❑ Criminal Justice
- ❑ Criminal Law Bulletin
- ❑ Evidence Technology Magazine
- ❑ FBI Law Enforcement Bulletin
- ❑ Fire & Arson Investigator
- ❑ Fire Engineering
- ❑ Fire Journal
- ❑ Fire Technology
- ❑ The Forensic Examiner
- ❑ Forensic Magazine
- ❑ Forensic News

- ❑ Forensic Science Communications
- ❑ Forensic Science International
- ❑ Global Forensic Science Today
- ❑ Journal of Analytical & Applied Pyrolysis
- ❑ Journal of Chemical Education
- ❑ Journal of Criminal Law & Criminology
- ❑ Journal of Criminal Law, Criminology & Police Science
- ❑ Journal of Failure Analysis and Prevention
- ❑ Journal of Fire Protection Engineering
- ❑ Journal of Forensic Research
- ❑ Journal of Forensic Sciences
- ❑ Journal of the Forensic Science Society
- ❑ National Forensic Journal
- ❑ NFPA Journal
- ❑ NIJ Journal
- ❑ Police Chief
- ❑ Police Journal
- ❑ Policing & Society
- ❑ Science
- ❑ Scientific American
- ❑ Talanta
- ❑ I do not subscribe to or regularly read any of the listed journals or magazines.
- ❑ Other:

[Next Screen]

Expert testimony.
Have you been certified as an expert witness regarding the origin and cause of fires by any court in the United States?

- ❑ Yes
- ❑ No
- ❑ I don’t know.

[Subjects who answered “Yes” were taken to the following question. Those who answered “No” or “I don’t know” were not asked the following question.]

[Next Screen]

Exclusion of your expert testimony.
Has your expert testimony ever been excluded from a trial on Daubert or Frye test grounds? This is not the same as evidence suppression, which refers to the judicial remedy available to defendants who are victims of police conduct that results in the illegal seizure of evidence. The question here is more concerned with whether your expertise has ever been successfully challenged.

- ❑ Yes. My expert testimony regarding the origin and cause of fires has been successfully challenged on at least one occasion.
- ❑ Yes. My expert testimony regarding the origin and cause of fires has been successfully challenged on at least one occasion, but the results of the challenge were later overturned or reversed.
- ❑ No. My expert testimony regarding the origin and cause of fires has never been successfully challenged.
- ❑ I don’t know if my testimony has ever been successfully challenged.
- ❑ I don’t know if my testimony has ever been challenged.

[Next Screen]

Next, we are trying to learn the extent to which there is a consensus among fire investigators regarding various observations one makes at a fire scene and their meaning as to the origin and cause of a fire.

Please indicate what you believe is the best answer.

[Next Screen]

Crazed Glass

This is a picture of crazed glass. “Crazing” is the formation of irregular, tightly pack cracks. Crazed glass found at a fire scene indicates:

- ❑ Rapid buildup of intense heat because of an accelerant such as gasoline.
- ❑ Rapid cooling caused by water sprayed on the hot glass.
- ❑ One side of glass was much hotter than the other.
- ❑ I do not know the meaning of crazed glass observed at a fire scene.

[Next Screen]

Alligatoring

This is a picture of "alligatoring" on charred wood. Alligatoring is the appearance of glossy blisters in an "alligator-skin" pattern on charred wood in a fire. Which statement about the appearance of alligatoring is the most accurate?

- ❑ Large, rolling blisters indicate rapid, intense heat caused by an accelerant while small flat blisters indicates long, low heat.
- ❑ There is no scientific evidence that the appearance of char indicates an accelerant or rapid fire spread.
- ❑ I do not know the meaning of alligatoring observed at a fire scene.

[Next Screen]

Depth of Char

The depth and location of char refers to where and how far through the wood the fire burned. Which statement about the depth and location of char is the most accurate?

- ❑ Fire burns through wood at a certain rate; therefore you can use it to determine how long the fire burned and thereby locate the origin of the fire.
- ❑ The rate of charring of wood varies widely depending on many variables; therefore the length of time that a fire burned cannot be determined solely based on the depth of char.

- ❑ I do not know what the depth of char observed at a fire scene means.

[Next Screen]

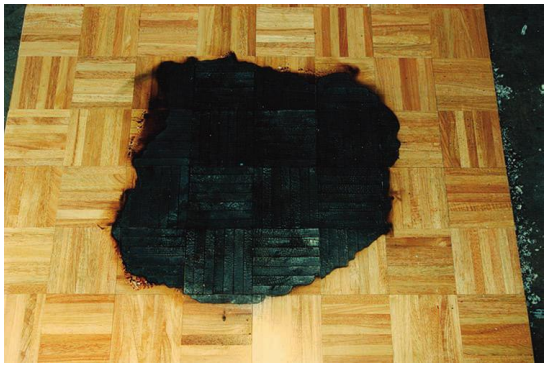
Lines of Demarcation

Lines of demarcation refers to the boundary between charred and uncharred material. In the picture above, what do that sharp lines of demarcation indicate?

- ❑ The sharp lines of demarcation indicate areas where a liquid accelerant was poured on the floor.
- ❑ The sharp lines of demarcation shown above indicate a rapid, intense fire.
- ❑ The sharp lines of demarcation shown above indicate areas that were exposed to and protected from intense radiation.
- ❑ I do not know what lines of demarcation mean.

[Next Screen]

Irregular shaped burned patterns.



These are "puddle-shaped" burn patterns on an oak parquet surface. What do puddle-shaped burn patterns indicate?

- ❑ The puddle-shaped burn patterns shown indicate that a flammable liquid was poured on the surface.
- ❑ The puddle-shaped burn patterns shown in the pictures do not have the same cause.
- ❑ Nothing can be discerned from the burn patterns shown in the pictures.
- ❑ I do not know what puddle shaped patterns observed at a fire scene mean.

[Next Screen]

Spalling

This is a picture of spalled concrete. Please indicate what you can infer from observing spalled concrete.

- ❑ Spalling indicates intense heat that can only be caused by an accelerant burning.

- ❑ Spalling indicates the origin of the fire because it is the place that burned the longest.
- ❑ There are a several different causes of spalling; therefore, it only tells us that the concrete was heated sometime during the fire.
- ❑ I do not know what the spalling indicates.

[Next Screen]

Collapsed furniture springs.

This is a picture of collapsed furniture springs found after a fire. What do collapsed furniture springs indicate?

- ❑ Sagged furniture springs indicate that a lit cigarette is the heat source because the padding insulates the cigarette and allows the heat to accumulate between two cushions.
- ❑ Sagged furniture springs indicate the presence of a liquid accelerant because the fire was at least 1150 degrees Fahrenheit and the fire burned underneath the furniture.
- ❑ The value of analyzing the furniture springs is in comparing the differences in the springs to the other areas of the mattress, cushion, or frame and can assist the investigator in developing a hypothesis.
- ❑ I do not know what sagged furniture springs indicate.

Please click on button to submit your responses.

Your responses have been recorded. Please go to http://www.fireinvestigatorsurvey.org/nsfi-debriefing-statement.html for a complete explanation of the research.

[Next Screen]

DEBRIEFING STATEMENT

Thank you for participating in this research. This step of the process is called debriefing. It is designed to fully explain the research to you and your role in it.

This survey is part of a supervised research project undertaken by David Cook, a Master of Forensic Sciences degree candidate at National University in San Diego, CA. In this role, he is known as the "principal investigator." Mr. Cook's research is supervised by a committee of three experts: two National University professors of forensic science and an attorney. One of the forensic science professors is an expert in crime scene documentation procedures, and the other is an expert in statistics and forensic science research methods. The attorney practices criminal law in Louisiana and Tennessee.

Before the survey was launched, and he recruited subjects, his research proposal was reviewed by the National University Institutional Review Board, an entity whose purpose is to minimize harm to human subjects participating in scientific research. The Institutional Review Board found that this research is exempt from review because the research involves only the use of educational tests, and survey procedures, and you were not asked for information that, if disclosed, would reasonably place you at risk of criminal or civil liability or be damaging to your financial standing, employability, or reputation.

PURPOSE OF THIS RESEARCH

The purpose of this research is to determine the extent to which new developments in the field of fire investigation are disseminated, understood and adopted by the fire investigation community.

WHY THIS RESEARCH IS IMPORTANT

Misunderstood observations at fire scenes have been shown to lead to miscarriages of justice. In particular, several observations at fire scenes that were once believed to be indicators of arson are now known to NOT be indicators of arson. The result is that there have been times that people have been charged with and convicted of arson using evidence that is now known not to indicate guilt. A number of leaders in the fire investigation community assert that in spite of advances in fire investigation techniques, these miscarriages of justice continue to occur with intolerable frequency. The data collected in this survey are being analyzed to determine if this assertion is true, and if so, why. Your participation in this research may help fire science researchers and educators improve fire investigation training and make it more widely available. This in turn may prevent an innocent person from being accused of a heinous crime and wrongfully punished for an event that was never a crime at all.

Correct Answers to Questions Regarding Observations at Fire Scenes.

The correct answer to the question regarding alligatoring is: *There is no scientific evidence that the appearance of char indicates an accelerant or rapid fire spread.*

Photo courtesy of Franklin County, North Carolina Sheriff's Department

The correct answer to the question regarding crazed glass is: *Rapid cooling caused by water sprayed on the hot glass.*
Photo courtesy of David Cook, Forensic Research Digest Inc.

The correct answer to the question regarding Irregular-shaped burn patterns is: *The puddle-shaped burn patterns shown in the pictures do not have the same cause.*
Photos courtesy of John J. Lentini in Scientific Protocols for Fire Investigation, Second Edition, CRC Press and Anthony D. Putorti, National Institute of Standards and Technology

The correct answer to the question regarding depth of char is: *The rate of charring of wood varies widely depending on many variables; therefore the length of time that a fire burned cannot be determined solely based on the depth of char.*

The correct answer to the question regarding lines of demarcation is: *The sharp lines of demarcation shown above indicate areas that were exposed to and protected from intense radiation.*
Photo courtesy of John J. Lentini in Scientific Protocols for Fire Investigation, Second Edition, CRC Press

The correct answer to the question regarding collapsed furniture springs is: *The value of analyzing the furniture springs is in comparing the differences in the*

springs to the other areas of the mattress, cushion, or frame and can assist the investigator in developing a hypothesis.
Photo courtesy of Texas State Fire Marshal

The correct answer to the question regarding spalling is: *There are a several different causes of spalling; therefore, it only tells us that the concrete was heated sometime during the fire.*
Photo courtesy of David Cook, Forensic Research Digest, Inc.

This research was proposed in response to a greater awareness among forensic scientists that many fields of criminal investigation lack scientific credibility. In 2009, the National Academy of Sciences released a report that challenged the validity of virtually all forensic science disciplines with the glaring exception of DNA profiling. Incidentally, DNA profiling is one of the few fields that started out in the laboratory and then only later found utility in the criminal justice system. On the other hand, most other fields of forensic science began in the criminal justice system and have largely dodged scientific scrutiny. One such field had long been fire investigation.

Since the early 1990s, the scientific basis of fire investigation has transformed from one driven by the beliefs passed down from generation to generation of firefighters to a system based on the scientific method backed by experiments about how fires actually start and

burn. This survey was designed to measure the extent to which the out-of-date information regarding burn indicators is still lingering in the fire investigation community and to try and find out why.

HOW MR. COOK CHOSE THE DEMOGRAPHIC QUESTIONS FOR THIS SURVEY.

Demographics are the quantifiable characteristics of a given population such as gender, age, ethnicity, knowledge of languages, income, employment status, and location. Demographics are used to identify groups within the larger group of survey participants. Demography is very commonly used in surveys. Mr. Cook chose demographic characteristics that he believes may be related to your competence as a fire investigator. They are location, age, level and focus of education, number of years in the profession, participation in professional organizations, and familiarity with relevant scientific literature.

In science, it is important to understand what a hypothesis is and what a theory is. A hypothesis (plural hypotheses) is A PROPOSED EXPLANATION for an observed phenomenon. A scientific theory is a WELL-ESTABLISHED EXPLANATION of observations. For a hypothesis to be scientific, it must be testable by experiment. An experiment cannot prove that a hypothesis is true. Instead, a valid experiment is designed to detect if a hypothesis is false. This is called “falsification.” A theory arises when hypotheses have been repeatedly tested by experiment and have not been shown to be false, and thereby the results of those experiments continue to support the theory. Scientists generally

propose hypotheses based on previous observations that existing scientific theories cannot adequately explain. It is also possible that a new experiment may prove such hypothesis or even a theory to be false.

Every question in this survey was carefully written so that responses could be used as a factor in testing the hypotheses. For example, Mr. Cook wants to know if fire investigators with a science degree are more competent than fire investigators without a college degree, and if so, how much it matters what the investigator studied. Another hypothesis is that fire investigators who work in urban areas are more competent than fire investigators who work in rural areas. That is why he asked you what county, parish, or borough you work in.

HOW MR. COOK CHOSE THE QUESTIONS ABOUT FIRE INVESTIGATOR OBSERVATIONS AT A FIRE SCENE

In 1977, the Law Enforcement Assistance Administration published a survey of 20 leading arson investigators around the country. Among other things, it found that the "Interpretation of Burn Indicators" was the most common method of establishing that a fire was an act of arson. However, the report noted that there was a vacuum of scientific research about their validity. "Burn indicators—the effects on materials of heating or partial burning—are the most frequently used method for determining the points of origin and causes of fires, yet these indicators have received little or no scientific testing" and, "Although burn indicators are widely used to establish the causes of fires, they have received little or no scientific testing.

There appears to be no published material in the scientific literature to substantiate their validity." A second survey of another group of arson investigators that asked only about the needs of the field, to which eight investigators responded. Only one of those eight recommended that the technical methods of arson investigators should be scientifically tested. The survey recommended that the fire investigation methods be scientifically tested and that a handbook be published to standardize fire investigation methods. In 1980, the highly respected National Bureau of Standards, the predecessor to the National Institute of Standards and Technology published such a handbook, but the "burn indicators" were never tested for their validity. As a result, the burn indicators became entrenched into the fire investigation community and were seldom questioned again until 1992 when the National Fire Protection Association published NFPA 921.

The LEAA Survey described seven burn indicators and what inferences were to be drawn from them. As it turns out, each and every one of these inference—YES, ALL OF THEM have been debunked. They are not indicators of arson. In some cases these observations mean entirely something else, and usually add nothing to understanding the origin and cause of a fire. John J. Lentini's book, *Scientific Protocols for Fire Investigation*, (2012) has a chapter devoted to "The Mythology of Fire Investigation," which addresses the first six, and four others he includes in his list. Lentini explains how faulty fire investigation techniques gained momentum and managed to dodge scientific scrutiny. He describes how each incorrect interpretation was debunked as

a matter of science, but continues to be asserted in the field by professional fire investigators who are either not up-to-date on training and education, or they simply have made up their minds and stubbornly refuse to accept the findings of scientific research, or both. Also, Mr. Cook has discovered that all of the myths listed in the LEAA Survey continue to be advanced in some highly respected reference materials. Mr. Cook recommends that as a starting point for improving science-based knowledge of fire investigation techniques, fire investigators study the following resources:

Committee on Identifying the Needs of the Forensic Science Community, et al. (2009). *Strengthening Forensic Science in the United States: A Path Forward*. Washington: National Academies Press.

DeHaan, J. D., Dixon, B. M., & Kelly, R. L. (Eds.). (2000). *Fire and Arson Scene Evidence: A guide for public safety personnel*. Washington, DC: NIJ.

Lentini, J. J. (2013). *Scientific Protocols of Fire Investigation* (2nd ed.). Boca Raton, FL: CRC Press.

National Fire Protection Association. (2014). *NFPA 921: Guide for Fire & Explosion Investigations* 2014 Edition. Quincy, MA: NFPA.

Thank you again for participating in this research.

Mr. Cook would like to thank John J. Lentini of Scientific Fire Analysis LLC in Islamorada, Florida for his assistance

and expertise in developing the questions and answer choices for this survey.

If you have any questions about the study, please contact Mr. Cook.
If you have any questions for concerns regarding your rights as a subject in this study, please contact the National University Institutional Review Board at irb@nu.edu or by calling 858-642-8134.

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APPENDIX C: Chi Square Test Calculations

Hypothesis 1:

CHI SQUARE TEST - METROPOLITAN VS. NON-METROPOLITAN FIRE INVESTIGATORS

ACTUAL RESULTS

Geographical demographic	Metropolitan	Non-Metropolitan	Row Total
Answered all AIM questions correctly	32	12	44
Did not answer all AIM questions correctly	109	35	144
Column Total	141	47	188

EXPECTED RESULTS IF LEFT TO CHANCE

Geographical demographic	Metropolitan	Non-Metropolitan	Row Total
Answered all AIM questions correctly	33	11	44
Did not answer all AIM questions correctly	108	36	144
Column Total	141	47	188

P Value - attributable to chance	0.690773616

Hypothesis 2:

CHI SQUARE TEST - CFI vs. CFEI

ACTUAL RESULTS			
Credential	CFI	CFEI	Row Total
Answered all AIM questions correctly	6	3	9
Did not answer all AIM questions correctly	15	20	35
Column Total	21	23	44

EXPECTED RESULTS IF LEFT TO CHANCE			
Credential	CFI	CFEI	Row Total
Answered all AIM questions correctly	4	5	9
Did not answer all AIM questions correctly	17	18	35
Column Total	21	23	44

P Value - attributable to chance	0.202154872

CHI SQUARE TEST - CFI and/or CFEI vs. Not Certified

ACTUAL RESULTS			
Credential	CFI/CFEI	Not Certified	Row Total
All Correct	10	36	46
Not all correct	43	128	171
Column Total	53	164	217

EXPECTED RESULTS IF LEFT TO CHANCE			
Credential	CFI/CFEI	Not Certified	Row Total
All Correct	11	35	46
Not all correct	42	129	171
Column Total	53	164	217

P Value	0.633041769

CHI SQUARE TEST - State Certified SMF or Equivalent

ACTUAL RESULTS			
Certification Status	SMF	Not SMF	Row Total
Answered all AIM questions correctly	9	37	46
Did not answer all AIM questions correctly	29	142	171
Column Total	38	179	217

EXPECTED RESULTS IF LEFT TO CHANCE			
Certification Status	Both Certs	Neither Cert	Row Total
Answered all AIM questions correctly	8	38	46
Did not answer all AIM questions correctly	30	141	171
Column Total	38	179	217

P Value - attributable to chance	0.679719195

Hypothesis 3

CHI SQUARE TEST - Science Degree vs. No Science Degree

ACTUAL RESULTS			
Holds science degree	Yes	No	Row Total
Answered all AIM questions correctly	23	23	46
Did not answer all AIM questions correctly	75	96	171
Column Total	98	119	217

EXPECTED RESULTS IF LEFT TO CHANCE			
Holds science degree	Yes	No	Row Total
Answered all AIM questions correctly	21	25	46
Did not answer all AIM questions correctly	77	94	171
Column Total	98	119	217

P Value - attributable to chance	0.457559678

Hypothesis 4.

CHI SQUARE TEST - Years of Experience (1992)

ACTUAL RESULTS			
Began Fire Investigation Career	Before 1992	1992 or later	Row Total
Answered all AIM questions correctly	9	37	46
Did not answer all AIM questions correctly	33	138	171
Column Total	42	175	217

EXPECTED RESULTS IF LEFT TO CHANCE			
Began Fire Investigation Career	Before 1992	1992 or later	Row Total
Answered all AIM questions correctly	9	37	46
Did not answer all AIM questions correctly	33	138	171
Column Total	42	175	217

P Value - attributable to chance	0.967547453

CHI SQUARE TEST - Years of Experience (2000)

ACTUAL RESULTS			
Began Fire Investigation Career	Before 2000	2000 or later	Row Total
Answered all AIM questions correctly	18	28	46
Did not answer all AIM questions correctly	67	104	171
Column Total	85	132	217

EXPECTED RESULTS IF LEFT TO CHANCE			
Began Fire Investigation Career	Before 2000	2000 or later	Row Total
Answered all AIM questions correctly	18	28	46
Did not answer all AIM questions correctly	67	104	171
Column Total	85	132	217

P Value - attributable to chance	0.994995581

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