Analysis of the Fire Investigation Methods and Procedures Used in the Criminal Arson Cases Against Ernest Ray Willis and Cameron Todd Willingham

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This report evaluates the fire investigation methods and procedures employed by fire investigators in the criminal arson cases against Ernest Ray Willis and Cameron Todd Willingham. The goal of the report is to evaluate the fire investigations as documented by the fire investigators in the form of reports and their trial testimony. The objective is to assess the methods and procedures with respect to the contemporaneous fire investigation standard of care and the contemporaneous knowledge in fire safety science. In addition, this report assesses the methods and procedures with respect to the current fire investigation standard of care and the current state of knowledge in fire safety science.

The Willis fire occurred in Iraan, Texas, on June 11, 1986, and the Willingham fire occurred in Corsicana, Texas on December 23, 1991. On October 6, 2004 Mr. Willis was released from prison and on February 17, 2004 Cameron Todd Willingham was executed by lethal injection.

STATE OF THE ART

The current standard of care in fire investigation is expressed by NFPA 921, *Guide for Fire and Explosion Investigations*, published by the National Fire Protection Association (NFPA). Work on this document was begun in the mid 1980s, but formal publication did not occur until 1992. Even after the initial publication date, there was a natural period of time before it had fully achieved the status of the standard of care. By 1995 when the second edition was published, the status of 921 a standard of care was well established, but not yet universally acknowledged. NFPA 921 provides a core methodology, methods for planning and conducting the investigation, and methods for collecting, interpreting, and documenting evidence. Most modern fire investigations texts mirror or amplify upon NFPA 921 (e.g., Icove and DeHaan (2004), DeHaan (2002), Lentini (2006)).

The core of the 921 methodology is the application of the scientific method to fire investigation. In the context of fire investigation this involves the collection of data, the formulation of hypotheses

from the data, and testing of the hypotheses. Conclusions can only be drawn when only a single hypothesis survives the testing process. None of the investigators employed this methodology. Indeed, in no case was any methodology identified. The testifying investigators admitted on the stand that there were possible alternate hypotheses that were consistent with the facts of the case. In no instance did this cause the testifying investigator to alter his opinions in the least. The overall standard that seems to be in use by the investigator is that his professional opinion with regard to cause was simply the explanation of the case facts that the investigator was personally most comfortable with. Of course this provides no basis for finding reproducible and defensible conclusions, an absolute requirement for rational use of fire investigation in the criminal justice system.

In testing hypotheses, the basis for evaluation is consistency with the case facts and consistency with our knowledge of fire science. A significant function of NFPA 921 has been the evaluation of methods and indicators historically used by fire investigators. NFPA 921 has sought to identify scientifically defensible methods and indicators, and provide suitable limitation to the use of these methods and indicators. Finally, NFPA 921 provides an educational resource to investigators in modern fire science in a manner that can be understood and applied by the fire investigation community.

Prior to NFPA 921 there was no single document that described the standard of care in fire investigation. For purposes of this analysis the standard of care before NFPA 921 was taken from fire investigation texts that were published before NFPA 921 was published in 1992 as well as from the articles published in *The Fire and Arson Investigator* in the 1980s. Because there are many sources that contribute to the definition of the standard of care, the standard is less clear and well defined than in the post-921 period. It is also important to distinguish the community standard of care from the norms as practiced in the field. In many instances the norms are well below the standard of care. That is fire investigation as actually practiced fell well short of the teachings of texts, courses, and articles of the day.

During the 1980s, fire investigation was in the early stages of maturation and change. The literature reflects some use of and impact of fire science, though the tradition of fire investigation as

an art based solely upon personal experience and the associated folklore was certainly still in place. The greatest impacts of science on fire investigation were in analytical chemistry and actual fire science was only beginning to be used. The status of fire science influence varied among different texts and within texts.

The status of fire science in the 1980s was sufficiently developed that its limitation did not pose problems for fire investigators. Much of the knowledge is older than most acknowledge and is chronicled in a history text (Richardson 2003). The knowledge of fire dynamics was strong and described in textbooks like Lie (1972) and Drysdale (1985). Thermal decomposition knowledge of the day is well described by Cullis and Hirschler (1981). Many aspects of fire science were in textbooks intended for college classes in fire service degree programs like Tuve (1975) and Friedman (1989). There was excellent information available about furniture fires the monograph by Babrauskas and Krasney (1985) and later followed up by Krasney, Parker, and Babrauskas (2001). The fire science basis for fire protection engineering was reduced to handbook form in the late 1980s (SFPE 1988).

While fire science was beginning to have an influence, it must be said that the tradition of fire investigation as an art based upon experience and folklore remained dominant. Before NFPA 921, fire investigations texts did not include discussion of an overall methodology. As such, the explicit notion of formulating and testing hypotheses was generally a foreign notion in the fire investigation community. As such, there was no rigor in the means of reaching conclusions from the data and its interpretation. Opinions were generally based upon the investigator's personal judgment, based on the information available and in the light of his experience. While never explicitly stated, certainty in opinions did not need to be any better than "more likely than not". This, of course, is well below the "beyond a reasonable doubt" standards that juries are instructed to employ. This should be viewed in the light of the low reliability of fire indicator evaluation possible at the time based on the very limited fire science impact. Together these created great potential for juries to treat fire investigators' opinions as being more reliable than they deserve, based upon the fire investigation upon which the opinions were to have been based.

The overall methodology in arson cases, as practiced in the 1980s, is the process of elimination. This approach is generally adopted in fire investigation texts. Specific examples include Kennedy (1977, 1985), DeHaan (1983, 1991), Roblee and McKechnie (1981), Bates (1975), Cardoulis (1990), Patten and Russell (1986) and Carroll (1979). The process of elimination requires that all other causes be eliminated except the determined cause. In particular, if a fire is to be determined to be arson, then all accidental and natural causes must be eliminated. A cause would be eliminated if it was inconsistent with known case facts or was not physically possible. An undetermined cause would result if more than one candidate cause could not be eliminated. This method is also consistent with the idea that all fires should be presumed to be accidental (Carroll (1979), Bates (1975), Kirk (1969)). A finding of arson would require that the evidence show that this presumption is not consistent with the facts.

Hobson (1992) characterized the situation as follows: "Up to now, most fire investigators have been taught to look for results, not to determine reasons. This is based on rote memory of indicators with little or no understanding of why or how they were formed and what they can actually mean."

One means of assessing the standard of care in fire investigation is to examine the teaching materials of the National Fire Academy, the focus of fire service training in the US. Teaching resources such as National Fire Academy (1988), National Fire Academy (1992), and National Fire Academy (1996) make use of the various editions of Kirk's Fire Investigation by DeHaan with little additional materials in the area of scene examination. In the post-921 era, NFPA 921 is also included as a course reference. National Fire Academy (1983) does not make use of Kirk's, but the content is similar to materials reviewed below.

Common characteristics of incendiary fires have been summarized as: 1. multiple origins, 2. point of origin where there is no rational ignition potential, 3.accelerant used as indicated by smell, pour patterns, chemical analysis, or dogs, 4. presence of trailers, 5. deliberately arranged fire load, 6. missing personal items, 7. extra items of contents added to fire load, 8. unusually fast consuming fire and a very high burning temperature in areas where the fire load is to all respects very ordinary. 9. tampering with FP devices, 10.unnatural fire pattern, 11. timers or incendiary devices found, 12. tampering with HVAC equipment to enhance fire spread, 13. tampering with utility systems to start

fires. (Noon (1995)). These are generally agreed upon as indicators, but the difficulties come in applying them and recognizing their limitations. Many myths have grown up that have no scientific basis. Some of these are addressed here and Lentini (2006) deals with such myths directly. The following discussion of the understanding of specific fire indicators is intended to include the indicators that investigators made use of in the cases included in this analysis. It is in no sense a comprehensive list of indicators nor is the discussion of any individual indicator in any sense exhaustive. The goal of the discussion is to understand the use and validity of these indicators in the fire investigation community and how that understanding has evolved from the 1980s to the present. For purposes of analysis, the understanding of fire indicators is separated into two general time periods; post-921 and pre-921. The post-921 period includes 1992 to the present and does not attempt to deal with the evolution of NFPA 921 during the period. The standard of care in the post-921 period is sometimes described as the current or modern understanding of fire indicators. The pre-921 includes the general period 1980–1992 and the standard of care in that period is often described as the contemporaneous understanding of fire indicators. The term contemporaneous is used to denote that it is the standard of care at the time of the initial investigations of the Willis and Willingham fires. Of course, both the Willis and Willingham cases were only finalized in 2004, so that both the current and contemporaneous periods are relevant.

V-Patterns

The general notion that V-patterns are formed by fires against wall surfaces is widely accepted and consistent with our knowledge of fire science. However, there are myths that the width of the V-pattern is a direct indicator of the rapidity of fire growth (Cardoulis (1990), Brannigan, Bright, and Jason (1980)). NFPA 921 recognizes that the width of the pattern is dependent on many variables such that simple conclusions are difficult. The presence of a V-pattern is indicative of burning occurring at the base of the V which in some instances may be the origin of the fire. The general trend over time is that the V was first recognized as likely the origin of the fire but may be caused by secondary ignitions to the simple current view that it simply indicates burning at the base of the V at some time in the fire. Low V-patterns are favored as origins due to the general tendency of fire to spread primarily upward.

Floor Patterns

Floor pattern analysis was the primary method used to substantiate that the fire was arson in these cases. At this time, the fire science and fire investigation communities are clear that floor patterns cannot be reliably used as an arson indicator in fully developed fires. The full scale fire test series reported by Shanley (1997) is the primary evidence used to substantiate that the fully developed fire and the associated radiation creates floor patterns and destroys preexisting pour patterns. This study was designed specifically to develop an improve understanding of fire patterns. In the fire science community it has long been recognized that the temperatures and radiation associated with fully developed fires is sufficient to ignite floor covering (Lie (1972), Blackshear (1974), Fang (1981)). Tu and Davis (1976) showed that carpeting did not play a significant role in pre-flashover fires. In some sense one can say that arsons using accelerants that are unsuccessful in creating a fully developed fire may have patterns that persist after the fire. This has been shown by Wolfe et.al. (2009).

Studies of spill fires have given insights into the patterns formed and the quantity of liquid required to create the patterns. Putorti (2001) studied spill fires on hard surfaces and carpets specifically to investigate these fires in the context of arson. Gottuk and White (2008) summarize the wider literature on spill fires, which of course are also of interest in the context of accident scenarios as well. The spill area per unit volume of liquid fuel is given by Gottuk and White as 57 square feet per gallon. In a normal room of 100–200 square feet, this requires 2–4 gallons to cover a hard surface, corresponding to a liquid depth of about 0.7 mm. For carpeted surfaces, Putorti found coverage areas of about 6–12 square feet per gallon. For both hard and carpeted surfaces, lower application rates are possible if the fuel is splashed around rather than simply poured. For context, a typical accelerant has a density of about 6 pounds per gallon and its heat of combustion is similar to plastics. A normal residential fuel load density is about 5 pounds per square foot so the actual energy contribution of even a massive accelerant application is very low compared to the typical fuel load of the room in which it is used. Its hazard is in its ease of ignition and fire spread, not its total energy contribution.

Modern fire investigation resources like NFPA 921 are now in line with the fire science community. NFPA 921 acknowledges that floor patterns are created by fully developed fires and

that signatures, like burning cracks and vinyl tile edge curling, can occur in the absence of accelerants due to radiant heating. NFPA 921 suggests that if an accelerant is suspected, then samples for laboratory analysis should be taken. Suggestions of accelerant use can include the patterns, smell, portable gas detector results, or canine identifications. The former methods are field methods that guide sample collection. Laboratory analysis is the method to determine if there is accelerant present and its identity. Melting plastics can create patterns that look like liquid spills.

The earlier views of floor patterns in the fire investigator community are both different from the fire science community and quite diverse. However, most urge caution in the identification of accelerant use solely based upon visual examination.

Cardoulis (1990) offers “while the inkblot, puddle and flow pattern left by a spilled liquid accelerant is very distinctive, fire investigators must be careful not to confuse it with a very similar pattern caused by the fire itself and heat itself.” He further offers that “the center of a burn configuration involving a flammable liquid puddle may exhibit no char at all because the fuel was consumed before reaching this point.” An example of a clean puddle pattern can be seen in tests conducted by Mealy and Gottuk (2006).

Hobson (1992) had a very modern view of floor patterns. “One of the more common burn patterns and one which is most often misinterpreted is the floor burn pattern. If one were to do a little study of the statistics that have been derived from many of the tests conducted, you will find that in 99 percent of the fires involving flashover there will be serious floor burn patterns.” “Far too many fire investigators, specifically those still involved in the old firemen’s tales school of thought, immediately, on seeing the floor burn pattern, conjure up the fact that it is a pour pattern resulting from a liquid accelerant.” He does offer that there are no fingers in burn pattern with innocent floor patterns and that fingers are characteristic of ignitable liquids. Hobson (1992) notes that ignitable liquid protects the floor so damage occurs at the edge of the pour and moves inward only as pour area reduces. He also recognizes that burning foam rubber yields a melt that gives patterns like ignitable liquids, though foam burns tend to yield more uniform patterns than ignitable liquid can display. He observes that asphalt tiles or vinyl tiles may reveal irregular patterns and discoloration

and blister in the absence of liquids due to the fire environment. He also points out that wood and carpet floors can show patterns in normal fire that result from wear patterns.

DeHaan (1983) suggests that patterns on floors may be apparent and not related to the origin of the fire. At the same time he offers that "any area which has a floor burned or a wall burned right down to the floor should be considered suspicious and deserving of further investigation. Such a burn does not mean by itself that the fire is incendiary in origin. It means only that the fuel load and the configuration of the fire environment were such that high temperatures were being produced at the floor level. Something normal to the room may have caused it to burn in this fashion." With regard to "Ghost Marks", DeHaan offers "Depending on the fire conditions and the nature of the floor tile, it has been observed in experimental room fires that the tile will shrink, exposing the floor to higher general temperatures and producing very similar effects; so it should not be considered absolute proof of the presence of a flammable liquid, but it is certainly a very strong indicator of such an accelerant."

DeHaan (1983) has an interesting perspective with regard to ultimate opinions by the investigator. "In the final analysis it is always the experience of the investigator that determines what importance is to be made of such patterns. The prudent investigator, when all indications are that a flammable liquid has been used, will recover samples of the flooring and nearby debris for laboratory testing no matter what odors are present." Thus, while DeHaan is very cautious about visually observable patterns, he still is in some sense willing to ultimately rely on the experience (read judgment) of the investigator. In 1983 he is cautious and encouraging of the use of science, but he has not yet abandoned the experientially based model of fire investigation.

DeHaan (1987) discussed that floor charring can occur due to radiant heat in normal fire or due to normal fuels on floor or due to drop down (including draperies and melting plastics). He identifies that intense local burn patterns on the floor can be created without ignitable liquids.

Bates (1975) acknowledges that low burn under furniture could indicate an accelerant, but that drop down can create patterns on floor. As such an inventory of items in the room is essential. Hobson (1992) talks about foam rubber furniture giving intense burning and heavy char on the floor

and melting onto the floor. Noon (1995) indicates that pour patterns may not be from a liquid pour, but may be secondary due to existing liquids or fall down burning.

Phillipps and McFadden (1986) recognized that ignitable liquids protect the floor while the liquid is present so that heat damage occurs at the edge of the existing spill area. More central damage occurs as the spill recedes. They state that flows of ignitable liquids under doors create patterns on bottom edge of door that ordinary combustibles cannot. This is inconsistent with our modern understanding. They also state that fire issuing from a room into another room would not normally involve burning of flooring in the adjacent room, so that if there is a pattern in the adjacent room it is an indicator of an ignitable liquid pour. At the same time they acknowledge that the presence of a floor pattern does not always mean that an accelerant was used. Their general views are somewhere between the historical myths and our modern understanding. Harmer et.al. (1983) studied flammable liquids on linoleum floors and found that patterns of bubbling and charring result. These tests were done without compartment effects. National Fire Academy (1983) describes burning on bottom edges of doors as unusual in accidental fires, indicating it is not a strong indicator of an arson fire.

Ettling (1990) studied the ability of gasoline to flow under objects in contact with the floor. He found that gasoline did not flow under 2 x 4 lumber when gasoline was spilled around it. This indicates that the protected area not including residue of the accelerant does not mean that it was not present in the area. This was an investigation taken on by a single investigator no doubt in response to an issue in a case. In the 1980s and before there was little direct funding of fire investigation research and this type of contribution represents all that was being done.

The role of plastics in fire was evolving in the 1970s, though by 1980 plastics were widely used in furniture and furnishings (Zicherman and Allard (1989)). Part of the confusion about the potential role of plastic melts arises out of lack of fire science input to fire investigation and part of it results from a slow response to the changing character of materials in use, moving away from cellulosics to plastics. Fire (1985) recognized that plastic melt patterns look like ignitable liquid patterns, and called out polyethylene in particular. Roberts (1982) focused on splatter and trailer patterns associated with ignitable liquids. His discussions reflect views associated with cellulose

dominated fires, but shows some appreciates of polyurethane foam (in furniture and beds) and asphalt.

Stickevers (1982) identified that char depths are greater at outer edge of a spill due to recession during burning. He noted that falling drapery, foam rubber padding, and air flows can cause patterns that have nothing to do with accelerants. He also noted that the depth of a gasoline spill is about ⅛ inch and the duration of burning is about 40 seconds. This is generally consistent with more formal research by Putorti (2001) and reviewed by Gottuk and White (2008) conducted many years later. At the same time Stickevers asserted that uniform damage with height is not normal and indicates the use of a flammable liquid and that spalling is an indicator for flammable liquids. Neither of these is consistent with our current understanding.

Almirall and Furton (2004) indicated that thermal damage or a burn pattern on a combustible floor can be the result of ventilation, radiant energy from a nearby flame, radiation from hot gases, dropping or falling materials that burn on the floor, or the burning of an ignitable liquid. This comports with NFPA 921.

Overall, the 1980s' views of floor patterns were in transition from the experiential based rules to the modern science based understanding. There were many cautions available to discourage the reliance of investigators on floor patterns to indicate accelerant use. An astute investigator could have recognized that the volume of liquid required to explain room size patterns is beyond what is most often reasonable and available. Clearly, there was ample guidance to take and analyze samples to identify accelerants and many warnings about the potential for error in the absence of laboratory analysis. Nonetheless, it was clearly the case that investigators in these cases did not understand the importance of having more than visual evidence of accelerant use and were satisfied to base their opinions almost solely upon this and other equally unreliable indicators.

Crazed Glass

NFPA 921 does not accept crazed glass as an indicator of the use of an accelerant. Cardoulis (1990) and DeHaan (1983) indicate that crazed glass indicates rapid heat buildup, but do not uniquely associate this with arson scenarios. Roblee and McKechnie (1981) identify that crazing can occur due to hose stream application to hot glass, as may well have occurred in these fires,

given the stage of the fire on fire department arrival. Phillipps and McFadden (1986) indicate that large crack areas on glass indicate a slow growth fire, while small crack areas indicate a fast growing fire. Fire science research has not found a basis for these rate dependent crack areas or the crazing argument (Pagni (2003), DeCicco (2002)), though crack initiation temperatures have been identified and additional cracking occurs with additional temperature increases.

Spalling

NFPA 921 does not accept spalling as an ignitable liquid fire indicator. While high heating rates are associated with spalling, this is in way uniquely tied to arson fire. Cardoulis (1990) indicates that spalling may be an indicator of rapid heat buildup and as such could indicate the presence of a flammable liquid. Brannigan, Bright, and Jason (1980) discuss that spalling indicates an intense fire, though no direct link with arson is suggested. Canfield (1984) reported testing of small concrete floor samples exposed to accelerant fires which did not result in spalling. Smith (1981) indicates that spalling can occur with ordinary fuels, but does not occur with ignitable liquids. He indicates that spalling is not a good arson indicator. Lentini (1982) criticized the above small scale testing and documentation and provided evidence that a floor in an arson fire had spalled. Notably, Lentini cited Lie (1972) an early fire science text not widely read in fire investigation circles. Clearly, even in the 1980s, there was no clear indication that spalling was a good arson indicator.

Low Burn

Cardoulis (1990) indicates that low burn patterns may be an indicator of accelerant or may be the result of drop down burning. Brannigan, Bright, and Jason (1980) discuss the role of layer radiation in igniting objects and carpeting, thus refuting low burn as an indicator of accelerant use. Hobson (1992) identifies that in fully developed fires, high temperatures can exist low in the compartment and as such create low burn patterns. Roblee and McKechnie (1981) and Carroll (1979) state that low burn indicates the origin, but caution about drop down burning. Roblee and McKechnie (1981) indicate that burning ignitable liquids on flat surfaces forms an ink-like blob outline and that burning along the wall down to the floor level and under the edge of molding is characteristic of ignitable liquid fires. They indicate that Class A (normal fuels) materials tend to burn above the floor level and are rarely fully consumed without an accelerant. The notion that low burn on walls is a good indicator of ignitable liquids is not accepted by NFPA 921, or the fire

science literature. The notion ignores the role of radiation heat transfer in fire. The notion that ordinary combustibles do not burn completely is wholly without merit, based upon the fire science literature regarding fully developed fires.

Burn Intensity

The idea that the intensity or temperature of the fire is an indicator of accelerant use is not accepted by NFPA 921 or the fire science literature. Flame temperatures for normal vs liquid fuels are very similar, and compartment temperatures cannot be used to distinguish if ordinary or liquid fuels are involved. Roblee and McKechnie (1981) indicate that severe burning in a corner of a room or along a wall can indicate the possibility of an accelerant. This is in direct contradiction of the modern fire science understanding that radiation enhances burning intensity in corners and at walls.

Bates (1975) states that "the intensity of heat generated by the fire may indicate that some additional fuel has been added to the normal contents of the area." This suggests that foreign fuels such as liquids can intensify the fire, but he makes no direct claim that liquids create temperatures not obtainable by normal fuels. However, tests by Mealy and Gottuk (2006) have shown that the exponential fire growth from both class A and accelerant ignition scenarios of sofas were similar with the difference being in the initial development stage before exponential growth. Noon (1995) does indicate that flammable liquids burn at higher temperatures than ordinary flammable contents, and have higher heat release rates. The former is untrue, while the latter is most often correct. He also suggests that flammable liquids on a wood floor would yield higher char rates on floor than ordinary char rates experienced elsewhere on the same flooring. This is not consistent with our fire science understanding.

Ventilation Effects

NFPA 921 and the fire science literature are very clear on the role of ventilation influences on burning and the resulting patterns. Shanley (1997) showed clear evidence of this effect and documents that enhanced burning occurs proximate to the vent. A number of earlier works indicate the role of ventilation, burning, and patterns. Cardoulis (1990) states that ventilation influences burning, and that fire will normally burn in the direction from which it is receiving oxygen. Casto

and Wright (1984) recognized the role of ventilation in pattern generation. Overall, however, the 1980s' literature did not often describe ventilation effects on burn pattern formation.

Floor Sampling

Needless to say, NFPA 921 and modern fire debris analysis books (Stauffer et al (2008)) are not supporters of the wash the floor with a fire hose and then collect samples school of thought. NFPA 921 treats all field based accelerant methods as means of identifying samples for laboratory analysis. Cardoulis (1990) suggests that samples for analysis must be taken before the floor is washed with water and points out the potential for normally occurring petroleum products or pyrolysis products being confused with an accelerant. DeHaan (1983) indicates that successful cases have been prosecuted without any conclusive laboratory results for incendiary materials. Four years later DeHaan, J. (1987) strongly encourages laboratory analysis for accelerant residues. Gohar (1983) reported on room testing with hard wood flooring with nylon carpet and jute backing that indicates that accelerant traces will survive totally involved room fire conditions Stone and Lomonte (1984) reported that in only 107 of 310 cases (suspicious) they found evidence of hydrocarbon accelerants. They also point out the need for chemical analysis to avoid possible interpretation of pyrolysis products as accelerants. In more recent work, Lentini (1998) discusses analytical methods to avoid misinterpretation of materials, such as asphalt, as accelerants. It is fair to characterize that in the 1980s investigators widely accepted positive laboratory results for accelerants if it was available, but they also consider such evidence as entirely unnecessary in reaching conclusions that a fire involves intentional use of an ignitable liquid.

Annealed Furniture Springs and Other Furniture Effects

Based upon full scale and laboratory testing, Tobin and Monson (1989) and Tobin (1990) concluded that observation of the "collapsed" state of coiled furniture/bedding springs is not a reliable indicator of whether a fire was initiated by a smoldering cigarette or accelerated by the presence of a hydrocarbon. They also review the prior literature and the conflicting conclusions found in the fire investigation literature. Tobin's findings are consistent with NFPA 921.

Bates (1975) observed that smoldering couches lead to annealing of springs and rapid fires do not. DeHaan (1983) offered that annealed springs are an indicator of smoldering if localized, but

that this can also be produced by external fire, or by debris falling onto furniture. Clearly he does view it as a good indicator. Hobson (1992) opines that annealing springs occurs due to deep seated smolder and not from flaming fires initiated on the surface of the furniture. Phillipps and McFadden (1986) suggest that when flames travel to upholstered furniture, the damage is usually confined to the surface material. The fire will not burn down into the padding or drop down below the furniture. These things will occur if the furniture item is the origin. If springs retain their elasticity, then the fire could not have started there. They regard this as quite reliable! These views are not consistent with the modern fire investigation literature or the fire science literature.

Multiple Points of Origin

Multiple points of origin may indicate that a fire is intentionally set. However, there are means by which multiple origins may occur accidentally and more commonly multiple apparent points of origin may exist. In NFPA 921, such alternate means of creation of apparent points of origin include drop down burning, radiant ignition, and embers. DeHaan (1983) points to several obvious indicators of arson as separate multiple points of origin, the presence of trailers of flammable liquids, paper or rags, or igniting devices. These, he says, point to incendiarism. Bates (1975) notes that "in order to develop sufficient evidence to prove that the crime of arson did occur, it is necessary to overcome any possible accidental or providential origin of the fire. One method of developing such evidence is by proof of the existence of "separate" fires." Carroll (1979) cautions that multiple low points does not mean arson as they may occur due to fall down or spillage of flammable liquid in the course of the fire. Gudmann and Dillon (1988) identify radiation and drop down as causing the appearance of multiple origins. Clearly, this indicator has always been recognized to be fraught with difficulties.

WILLIS CASE

The Willis fire occurred in Iraan, Texas, on June 11, 1986. The Iraan Fire Department received notification of the fire at 4:44 am. Upon arrival, the front of the home was fully involved with flames extending from windows on the front of the home and with fire involving the front porch.

At the time of the fire, the home was occupied by Billy Don Willis, Ernest Willis, Gail Jo Allison. and Elizabeth Grace Belve. The tenants of the home, Michael Thomas Robinson and wife

Cheryl Lynn Robinson, had been arrested by police the evening before the fire as a result of noise complaints by neighbors. The unarrested temporary occupants of the home were warned that if they did not remain quiet, they too would find themselves in jail.

At the time of fire department arrival, Billy Don Willis and Ernest Willis were outside the front of the home. Gail Jo Allison. and Elizabeth Grace Belve were still within the home and their bodies were later found within the home.

Brown Report

A four page June 20, 1986 (nine days after the fire) report was prepared by Texas State Fire Marshall (FM) Le Roy Brown, based upon his investigation performed with Edward Cheever, a new Fire Marshall receiving on the job training with FM Brown. The report provides a brief narrative of the discovery of the fire which included Ernest Willis discovering the fire, attempting unsuccessfully to alert and rescue other occupants, leaving the home and phoning the fire department.

The report describes the construction of the home which includes numerous incorrect descriptions of the home. Among the significant disparities is that the wood paneling that existed in most of the home was described as sheetrock and the cellulosic ceiling tiles were described as sheetrock. The combustible wall and ceiling surfaces which FM Brown misidentified had a marked effect on fire growth rates within the home.

The report concludes that there were multiple points of fire origin within the living room and dining room. No bases for this conclusion are provided. The report further identifies that an unidentified flammable liquid had been applied to a large portion of the living room and dining room. The report indicates that the flammable liquid was ignited by an unknown means.

In the section entitled “Involved Subjects,” only Ernest Willis was identified. None of the other occupants or tenants was identified.

FM Brown interviewed Ernest Willis who stated that he was asleep on the couch in the living room and was awakened by smoke. Mr. Willis stated he ran through the fire in the living room and

the dining room to the kitchen and into the back bedroom and tried to get Elizabeth Grace Belve out, but was overcome by smoke. Mr. Willis stated he then turned around, bypassing the back door in the kitchen, ran through the fire in the dining room and the living room and out the front door. Ernest Willis then advised that he went around to the side of the structure and started knocking out windows trying to get individuals out of the residence. FM Brown also interviewed Billy Don Willis, who stated he was in the bed with Gail Jo Allison in the southwest bedroom of the residence, when he heard a loud popping and crackling sound. Billy Don Willis advised he got up and opened the bedroom door to investigate. When Willis opened the bedroom door, fire and smoke came into the room from the hallway. Mr. Willis advised that he then ran through the bedroom, jumped on the bed and out through the window. Mr. Willis advised he then turned around and tried to get Gail Jo Allison out, but could not because the window was too high. No mention of the state of the occupants due to their partying was included in the report. There is no indication that FM Brown had reviewed any hospital records or autopsies with respect to drug or alcohol levels of occupants.

The report does not document any photography or other documentation of the scene prepared by FM Brown on the fire scene and does not reflect any collection of samples for laboratory analysis. The report does not reflect the fact that FM Brown was on the scene for less than a day and that the scene had been severely altered by Deputy Sherriff Jackson and County Fire Marshall Kenley prior to FM Brown arriving on scene.

Both Billy Don and Ernest Willis voluntarily took polygraph examinations. Based upon the results, FM Brown concluded that Bill Don knew nothing of the fire and that Ernest Willis had knowledge of the fire and did start the fire. No basis for this conclusion is provided in the report.

The report concludes that based upon the physical evidence at the scene, the fire was incendiary. The nature of the physical evidence is nowhere described or provided.

This report provides conclusions about multiple fire origins, the use of flammable liquid as an accelerant, and the party responsible for the fire and provides no bases for any of the conclusions. As such, this report asserts conclusions based solely upon the personal judgment of the investigator. It provides no basis for a rational review of the report, its methods, or findings. Neither the

scientific method nor any other methodology is employed to develop hypotheses and evaluate identified hypotheses. There is no evidence in the report that any other potential fire causes were considered. The report amounts to the unsubstantiated personal belief of the investigator.

Dailey Report

Insurance investigator John Dailey prepared an 18 page reported dated 24 June 1986 (13 days after the fire). Mr. Dailey's report reflects that he interviewed members of the Iraan Volunteer Fire Department who responded to the call. These included Cynthia Green, Dina Collins, Randy Peterson, and Robbie Dominguez. He also interviewed Deputy Sheriff Larry Jackson, who had arrived shortly after the first arriving fire department units. Deputy Sheriff Larry Jackson also investigated the fire directly after the fire was extinguished and found the bodies of Gail Jo Allison. and Elizabeth Grace Belve. Apparently, it is Deputy Sheriff Larry Jackson who initially determined that the fire was suspicious and requested the assistance of Crockett County Fire Marshall Steve Kenley. Both Kenley and Jackson were present at the fire scene on 12 June 1986 when Dailey arrived and no other investigators were present.

The fire department eyewitnesses describe a consistent picture of the fire scene upon arrival and the actions taken by the fire department, though each person has their own vantage point on the activities. Upon arrival they indicate that the front of the home was fully involved and flames were issuing from windows and the porch gable. Breaking windows could be heard. Both Billy Don and Ernest Willis were observed outside the home and it was quickly learned that two victims were still inside. Both Willis's had bare feet and did not suffer burns. Firefighter Dominguez described his attempt to rescue the victims and his attempt to enter Bedroom #3. He did not observe fire in that bedroom, though he saw flamelets at the door between Bedroom #2 and #3. On numerous occasions Dailey reports in these narratives that the Willis's were unemotional and further noted at length the emotional upset of FF Dominguez upon realizing he had not succeeded in rescuing the victims. Dailey portrays by his treatment of the eyewitness statements that the Willis's were uncaring or indifferent to the fates of the victims. Notably, Dailey does not report having interviewed the Willis's.

In his walk around the home upon arrival on the scene, Dailey reports that no flammable liquid containers were visible outside the home. He noted that both the front and back doors had been burned off entirely, with severe external damage to the home in the front. The living room and dining room had been entirely cleaned out and washed down before Dailey arrived. The remnants of the contents of these rooms were on a pile on the front porch.

Upon examining the breaker box, all circuits were in the off position, indicating that firefighters or investigators had turned off the breakers and no information was available if circuits had tripped during the fire. The only furniture in the living room or dining room was the remnants of a couch and an upholstered chair that had been replaced by investigators after the cleaning out and washing out process. No remnants of the dining room table and chairs or a small china closet were found.

The front door of the home was entirely consumed with heavy damage to the door frame. The door sill showed evidence of heavy burning. The ceilings of both the dining room and living room had been penetrated by the fire and damaged the rafters above. The ceilings were sheetrock with cellulosic ceiling tiles installed over furring strips. The walls were noted to have been wood paneling throughout most of the home, which Dailey recognized as being significant with respect to fire growth rates.

Dailey noted that the cleaned and washed floors showed severe and extensive flammable liquid burn patterns which had gone through the carpeting, the foam rubber padding, the asphalt tile covering, and into the plywood subflooring. Dailey cites no methodology for this determination and apparently made the determination of the extensive application of flammable liquid solely on the basis of visual patterns of damage to the cleaned floor. At that time other rooms had not been excavated.

Dailey noted that low burning only occurred in the living room in the southeast corner where a couch had been. He attributed this low burn pattern to pouring of flammable liquid onto the couch. He attributed a similar fire pattern in the southeast corner of the dining room to flammable liquids as well. In examining bedroom #3, Dailey opined that rug damage at the foot of the bed and trails of damage toward the door leading to the kitchen were due to flammable liquid pour.

Dailey took samples from the living room, dining room, kitchen and bedroom #3 for analysis for evidence of accelerants. At the time of the writing of the report, lab results were not yet available. Ultimately, the samples proved negative. Dailey reports that he and FM Kenley each used his respective portable gas detector (sniffer) and found no indications of accelerant within the home.

Dailey reported that Deputy Sheriff Jackson became suspicious of the fire based upon his initial questioning of the Willis's. It was this suspicion that caused Jackson to clean out the living room and dining room immediately to examine the floor and of course found the severe burn patterns in these two rooms before FM Brown arrived. On June 13–14, Dailey oversaw the cleaning out of the entire house. Once again, they washed the floors in the kitchen, dining room, and living room with water. Dailey retained samples of the carpeting and padding from the living room/dining room and shag carpet from bedroom #3 for future use. However, neither the report nor his trial testimony indicates that these samples were used in the investigation.

Dailey examined the electrical outlets in the living room, dining room, and kitchen, finding no evidence of overheating or shorting. It is presumed that any appliances plugged into these outlets had been cleaned out with the general floor cleaning as no mention of analysis of these is presented.

Dailey cited the presence of low burn in the living room, dining room, and kitchen as consistent with the use of flammable liquids. He further opined that the complete consumption of the sofa, the sever burning of the easy chair, and the severe and uneven burning of a second couch further substantiated an "unnatural and set fire." He made reference to the extent of smoking of the glass windows broken out, but drew no direct conclusion from this evidence though he did note that such smoking could result from a hydrocarbon-based accelerant.

Dailey reported that the Pecos County Sheriff stated that Deputy Jackson was in charge of the fire investigation. Sheriff Wilson stated that he had gone to the scene to collect the bodies of the deceased. Sheriff Wilson notified the State Fire Marshall's Office of the fire deaths and FM Leroy Brown arrived on the scene on June 11, 1986. Apparently, FM Brown was on the scene only on June 11.

Dailey's report recounts portions of Deputy Sherriff Jackson's investigation and the events leading up to the fire. At 9:45 pm the evening before the fire, police received a complaint about noise at the home. The account is written using the personal pronoun, he, apparently referring to Jackson personally. He arrived at the home and found the four guests (Billy Don Willis, Ernest Willis, Gail Jo Allison, and Elizabeth Grace Belve) and Mr. and Mrs. Robinson, the tenants, drinking and making noise. Mrs. Robinson had been shoving a car down the street and Sherriff Jackson instructed them all to remain in the home and be quiet. About 30–40 minutes later, a further complaint call was received. He responded and took Mr. and Mrs. Robinson to the county jail, warning the others to go back into the hose and not come back out or he would arrest them as well. The police received no further calls.

Sheriff Wilson and Deputy Sheriff Jackson took the Willis's to Midland Texas where they were given polygraph examinations by the Texas Department of Public Safety regarding their knowledge of the fire. Deputy Sheriff Jackson advised that Billy had passed the test and Ernest failed the test badly indicating that he actually did set the fire at the home. Subsequently, Ernest continued to deny any knowledge of the fire, sticking to his original story that he spent the night on the couch and was awakened by smoke and fire. As a result of the polygraph results, Deputy Jackson went ahead the next morning to hire a crew of men to completely empty and clean the home so that all of the floors could be examined. It was at this time that the floors were seen to exhibit burn patterns from the front to the back of the home. The patterns were interpreted to indicate that an arsonist had poured flammable liquid from the foot of the bed in bedroom #3 through the home from the back to the front in such away as to seal off escape from the home. These patterns were taken to make Ernest's story unbelievable, because his story included him moving to bedroom #3 in a rescue attempt. If such an arson fire had been set, he would be expected to have injuries to the lower extremities, especially portions of the feet.

Dailey recorded that Mr. Robinson, the tenant, informed Deputy Jackson that Robinson had left four one-quart bottles of methanol on the front porch. Dailey reports that he and Jackson agreed that the volatility and water soluble nature of methanol was the reason that the sniffers did not respond. There are pictures in the file of one-quart bottles of malathion, but no bottles of methanol. It appears that there was a miscommunication regarding the identity of the liquid. Malathion is an

insecticide that uses petroleum distillates as a carrier/diluent. Thus, the product is not water soluble, is not highly volatile, and would be expected to be detectable by portable gas detectors if present. Jackson advised that a neighbor had a bottle of "methanol" on his front porch which apparently could have been used and replaced by the arsonist. This glass jar was sent to the laboratory for fingerprint analysis. No results of the test were provided in Dailey's report. Dailey and Jackson agreed that Ernest Willis is the person that set the fire in the home that morning based upon the above evidence and Ernest Willis' story.

Michael Robinson told Dailey that Billy Willis had been staying with them temporarily and that they had met Ernest only a few times. He also reported that drinking the afternoon before the fire through the time Michael and Cheryl Robinson being arrested them around 10:30 pm.
Mr. Robinson reported that Cheryl Robinson was diabetic and when she drinks she sometimes goes crazy. This is consistent with the disturbance involving pushing cars around out of doors.

Dailey interviewed a number of neighbors about the fire. The observations of the neighbors were consistent with the observations of the first responders' interviews with respect to the fire appearance and the Willis' actions.

Dailey concluded that the origin of the fire was the foot of the bed in Bedroom #3 where a small amount of flammable liquid had been poured along the bed. He found no evidence of a connecting trail of flammable liquid to the kitchen, dining room and living room where large amounts of flammable liquid had been poured. He opined that ignition occurred at the front door. He further opined that the two couches and an easy chair had also been doused with flammable liquid. He found no evidence of an accidental fire cause and opined that the four quarts of "methanol" stored on the front porch were used in the arson. None of the bottles were found and this was attributed by Dailey to the bottles falling down from the porch and being broken during firefighting.

Cheever Testimony

On direct examination FM Cheever indicated that he had become certified in fire investigation in November 1985, eight months before the fire, and that he had prior experience as a policeman and a firefighter. He indicated that he was working for FM Brown at the time, getting acclimated to

the territory and his new job, and that he was assisting FM Brown in the investigation. He indicated that he supervised some of the scene clean up and instructed the cleaners to pile the salvageable furnishings in a pile. He did not inventory any of these items.

FM Cheever provided the following list of evidentiary items that formed the basis of his opinion: 1) low burn on the walls, burn patterns on the floor, and general burn patterns, 2) the intensity of the damage to the ceiling of the living room and dining room, 3) the damage patterns and severity of damage to furniture, and 4) exclusion of one electrical outlet he examined. FM Cheever indicated that the low burn on the walls indicated that the heat source that caused the damage was low, consistent with flammable liquids on the floor. He also indicated that damage patterns on the floor indicated flammable liquids but had no idea how much flammable liquid would be needed to explain the evidence. The damage to the porch indicated low burn on the porch as well. He admitted his opinion that the fire was arson was solely based upon his own personal observations of damage to the home during his less than one day examination. He did not rely upon any outside sources of information nor did he rely upon the report prepared by FM Brown. He relied solely upon his training and observations. He took no photographs, took no samples or evidence, did not use a portable gas detector, and had no investigation notes. He was unaware of others collecting samples and apparently felt no need to consult the results of sample testing in formulating his opinions.

He told the jury that the damage patterns on the front of the house were indicative of the fire source being at very low level. He opined that if the fire had started high in the home, that the entirety of the home at that higher level would be consumed before such low level burning could be observed. He told the jury that the heaviest damage was in the living room and dining room, and to a lesser extent the kitchen, and that they focused on these areas as a result.

FM Cheever recounted that there was still debris on the floors of the living room and dining room when he arrived on the scene and that later the location of furnishings was provided by Mr. Robinson. The carpet remnants were removed with all other contents in the process of removing debris to evaluate patterns at the lowest level. The debris removal was ordered by FM Brown and was carried out using Deputies pressed into service. There was no evidence given that the removal

of the debris was done as part of the examination of evidence. Unskilled Deputies (i.e., not fire investigators) were the bulk of the work force and detailed examination of the debris seems to not have been the goal of the debris removal team. Cheever admitted that his investigation was limited to the dining room and living room only.

In his testimony FM Cheever explained the concept of radiation to the jury and its role in fire. The explanation involved item to item radiation heat transfer and gave no indication of the role of radiation from the hot gas layer in a room. He opined that the burning of the carpet was indicative of the use of a flammable liquid. He did not address the role in radiation from the hot gas layer to the floor as a potential cause of carpet burning. He further opined that the charring of the door jamb was due to flammable liquid burning and that no other fuel source could explain the damage. During his direct testimony he did not know the material that comprised the ceiling and never acknowledged that the walls were wood paneling. He also indicated that he did not examine the carpet padding closely and did not know what type of material it was. While he did not know what the ceiling material, he opined that if a ceiling tile fell down, it would fall directly down and could not fall under furniture. Apparently, he believed that falling items are incapable of falling on their edge and move horizontally. He opined that burn marks on the floor under the couch were the result of flammable liquid application, apparently unaware that polyurethane creates liquid melt during the course of a couch fire (see e.g., Wolfe et.al. 2009 for a photo).

The electrical examination was limited to one outlet that had apparently had problems historically, the light switches, and the breaker box. No other outlets were examined and no appliances were examined.

In examining the remains of a couch, the differential in damage from one end to the other was taken to be indicative of the use of flammable liquid on one end of the couch and the associated burn patterns on the floor were taken to indicate the burning of flammable liquid associated with the couch. He opined that the pattern of floor damage from the kitchen to the front of the house was indicative of a flammable liquid pour through the three rooms. He indicated that based upon his understanding of the pour patterns, the couches would have been involved immediately and that anyone on that couch at the time of ignition would have been burned.

In discussing the condition of the dining room, FM Cheever noted the complete consumption of the dining room table and chairs, which he opined was inconsistent with drop down burning. In his testimony he alluded to the possibility of flashover in the dining room. He never explained the concept to the jury and focused in his testimony on drop down burning as the alternative to a flammable liquid pour.

While FM Cheever opined that there was a flammable liquid pour from the front to the rear of the home, he had no idea the quantity of liquid that was poured and no idea what liquid was poured. He opined that flammable liquid poured in front of a couch onto a carpet and padding could flow under the couch despite the sponge-like nature of the carpet and pad. He seemed unaware of wicking phenomena and the effect of carpet and padding upon burning rates. During his cross examination, he reported arriving on scene between 1 and 3 pm. Since we know from Dailey that FM Cheevers and Brown were not on the scene the next day, the duration of the scene examination was nominally only half a day.

Under cross examination, when posed with hypothetical evidence of floor to ceiling burn patterns in one or more bedrooms would affect his opinions; FM Cheevers indicated that it would not have influenced his opinions. This is inconsistent with his own acknowledged methodology of association of severe burning with the potential for early involvement. FM Cheevers also associated the angle of damage into the floor as indicative of a flammable liquid fire. While he believes this myth of fire investigation, he did nothing to document the pattern in the form of photos or notes. In discussing his opinions on damage to the front door jamb, he persisted in the view that the damage was either flammable liquid or the result of drop down. He did not consider radiation from the hot gas layer or emerging flame at the front door as a potential source of the thermal energy required to damage the door jamb sill. On cross examination he admitted that radiation from above could scorch or ignite carpeting or other materials, but this realization did not seem to play a role in his formulation of opinions regarding the fire. He indicated that he had never seen a fire where radiation from above played a role in damage to the floor. He also acknowledged that patterns on the floor similar in appearance to flammable liquid pours could occur in the course of an accidental fire, but provided no basis for his determination that these patterns were due to flammable liquids.

While FM Cheever was aware of different flammability classifications for carpet, he knew nothing of the properties of the carpet in this home.

On redirect, FM Cheever cited that the uniform damage to the upper portions of the porch could not have come from flames issuing from the interior of the home. The unstated assertion was that something additional, like flammable liquids on the porch would be needed. Again on redirect, FM Cheever asserted that damage to the floor if ignited by radiation would be different below the dining room table. Apparently, he thought that the table burning would not have substantially the same radiative effect as other surfaces above like the ceiling. He was also unaware that radiation to the floor could cause irregular damage patterns.

Dailey Testimony

Mr. Dailey discussed his training and experience as a fire investigator and an FBI agent before that. His training as a fire investigator was completed in 1983, three years before this fire. He indicated that when he arrived at the scene, it had been significantly disturbed, including all contents removal from the living room and dining room and subsequent water washing of the floor. While FM Cheever spent only half a day on the scene, Dailey reported spending 2 ½ days on scene.

Mr. Dailey discussed his interviewing, consistent with his report, and told the jury that he did photograph the scene and collected 10 samples for laboratory analysis. The laboratory analysis was negative for any accelerant/ flammable liquid. He indicated that a negative finding in an arson incident was not unusual and this could be impacted by the fire department firefighting operations or simply the intensity of the fire. He failed to note that the removal of all floor coverings and washing down the surface by investigators might have an effect. He did not interview either of the Willis's. His investigation using his portable gas detector yielded negative results.

Mr. Dailey testified that he hired six guys to remove everything from the house (beyond the two rooms cleaned by the public sector investigators). Clearly, these individuals did not and were not qualified to examine debris evidence. The goal of this activity was simply to expose the floor.

In discussing fire patterns Mr. Dailey focused on the fact that fire goes up and only acknowledged banking down of heat in closed compartment fires, but regarded such banking down as unusual. He regarded the damage to the front door jamb as not consistent with a non-arson fire and as an indicator of a suspicious fire. At the same time, he acknowledged that charring to the porch deck was the result of radiation from burning above.

In examining the front door jamb sill, he noted severe charring as well as flammable liquid patterns on the underside of the jamb board. He believed the patterns on the underside could not have occurred due to heating from above and must have been the result of flammable liquid. He did not address the potential role of the carpeting or padding. He did describe the patterns on the jamb as similar to patterns on the living room floor. Mr. Dailey considered the patterns on the floor of the living room and dining room to be flammable liquid pour patterns. He considered the extent of damage to the furniture to be inconsistent with an accidental fire, indicating that the damage was due to the use of a flammable liquid. He noted the annealing of the couch springs and opined that this was characteristic of an accelerant being placed upon the couch. He eliminated a cigarette ignition of a couch as the cause, indicating that such ignitions are difficult and infrequent. As anyone who has followed the safe cigarette movement knows, this is far from the truth.

Dailey sees pour patterns underneath the couch that he attributes to the flow of flammable liquid under the couch through the carpet and pad. He seems not to recognize that when polyurethane burns, a liquid melt is formed which often burns beneath the couch in the same manner as a flammable liquid might, nor does he generally acknowledge that the carpet and padding also form liquids during decomposition, nor does he acknowledge that accidental fires generally can produce floor patterns. He also denies that upholstered furniture will burn completely in the absence of an accelerant (see e.g., Mealy and Gottuk, 2006, as an example of complete consumption of a couch). At the same time, Dailey acknowledges that low burn patterns are not unusual.

Dailey considers burning of linoleum as unusual in a fire and indicative of a flammable liquid fire. He ignores the fact that the back door was fully consumed in the fire and that this source of air would enhance local burning in this area.

Interestingly, at trial Dailey changed his mind about flammable liquid in bedroom #3. While his direct observation of bedroom #3 led him to believe that there was a pour pattern, on reviewing his photos he reconsidered this opinion and considered the damage due simply to drop down burning. It is notable that his photo was deemed more instructive than his direct observation during his scene investigation. While Dailey correctly understood the interior finishes to be wood panel walls and cellulosic ceiling tiles, he did not believe the cellulosic ceiling tiles were flammable. Rather he thought the tiles were glued to the ceiling and it was only the glue that was flammable. Later in his testimony he contradicted this construction and asserted that the ceiling tile was nailed into furring strips. Interestingly, Dailey took samples of the wood subfloor in the dining room and living room but did not take samples of the carpet or pad that had been in those rooms because the debris pile left to him by the public sector investigators included debris from both rooms together. Without being able to identify which room the sample came from, he declined to have the carpet and pad sampled at all.

While Dailey was clear in his own mind that flammable liquid had been poured in the living room, dining room, and kitchen, he had no idea how much liquid would be required to cause the observed pattern. He also opined that in his experience flammable liquid did not run horizontally in carpeted floors and burned only where poured. He also opined that the fire would not spread to the adjacent carpet where no flammable liquid was present. At the same time, he actually had no idea how much carpet had burned because he essentially ignored the debris pile on the porch as a source of evidence. He did not use his portable gas detector to investigate the debris pile.

While Dailey did inspect the breaker box in the home, he did not dissemble the outlets in the dining room and living room to evaluate electrical activity in these areas that may have caused the fire. He did no examination of electrical appliances in these rooms.

Dailey's direct testimony ended with him opining that the fire was in fact arson. He testified that no fuel load was present that could explain the burn patterns on the floor, could burn through the ceiling into the attic, and completely destroy the furniture items in the dining room and living room. Apparently, he did not recognize the carpet and padding as a fuel load, the wood paneling and cellulosic ceiling tiles as a fuel load, and the furniture as items fully capable of complete

consumption in accidental fires. Indeed, he directly testified that the dining room table was not part of the fuel load and he did not expect it to burn, only char. He opined directly that the consumption of the table was direct evidence that an accelerant was involved.

Dailey opined that Ernest Willis's statement of his actions upon discovering the fire were not possible because they did not comport with his view of the fire and the flammable liquid pour. Dailey spoke of the rapidity of the fire spread along the path of the flammable liquid, but nowhere in his testimony does the identity of the flammable liquid ever come up.

On cross examination Dailey acknowledged the rapid flame spread that is expected on the wood paneling present in the living room and dining rooms. Dailey was clear in his own mind that radiation from above could not create the burn patterns on a carpeted floor. He was unaware of any view in the profession that floor patterns could be created by radiation from above.

Willis Analysis

In the Willis case, the investigation included a number of organizations and individuals. The reports and testimonies of individuals do not generally reflect a team investigation approach. Deputy Sherriff Jackson seems to be the center of the investigation in terms of the time spent on the scene and interacting with the various investigators. The writer was not provided any documents that were produced by Sherriff Jackson and his trial testimony was similarly not available to the writer. The State Fire Marshalls made only a brief site visit and appeared to not have done any other form of investigation. While it is common for insurance investigators to cooperate with the public sector, in the Willis case, the private sector provided the most detailed report and overall documentation.

FM Cheever

In the Willis fire, we find the unusual combination of a very new and junior FM Cheever and an only slightly more experienced insurance company fire investigator, Investigator Dailey. The absence of FM Brown from the stand is notable. FM Cheever provides the most basic fire investigation deficiencies and problems. Beyond his inexperience, he spent less than a day on the fire scene and did no other form of investigation to develop his opinions. During his site work he

took no notes, no photos, collected no evidence, and collected no samples for laboratory analysis. The process of debris removal was performed without fire investigative purpose. Debris should have been carefully removed in a layering process with full documentation via photography. In the process, evidence of the original room contents, evidence of potential accidental causes, evidence of incendiary devices, or remains of foreign materials should have been sought and documented. In many fire scenes it is not uncommon to perform this process in a matrix with cells of 1-3 feet in dimension, using hand trowels and sifting screens. Contrast this process with the wholesale shoveling out of two entire rooms and piling it all together on the porch without examination. The evidentiary value of the two rooms was seriously compromised by the methods employed. FM Cheevers was only interested in uncovering the subfloor that he imagined would be a map to the fire. He was indifferent to the carpet, to the carpet padding, and only found value in well attached floor tiles and the subfloor.

FM Cheevers examined only one electrical outlet and no electrical appliances. One cannot legitimately eliminate all electrical causes with such a cursory examination. No other accidental causes were investigated. Indeed, any evidence which would have led to a testable hypothesis was shoveled out and put in a pile.

The indicators used by FM Cheever for an incendiary fire were low burn, the intensity of the fire damage, and the damage levels on furniture items. None of these are considered reliable indicators for the use of an accelerant. He had no idea what quantity of accelerant was needed to explain the damage, he had no idea what the liquid was, and he had no idea where the liquid came from.

His knowledge of fire science was significantly below current standards for fire investigators. He incorrectly thought that carpet could not burn in a room unless an accelerant was used. He thought that patterns under a furniture item were the result of an accelerant placed on the furniture. He apparently did not understand that polyurethane foam creates a melt while it burns which often burns as a spill on the floor beneath the furniture item. He did not understand that differential damage on a couch from end to end is a normal pattern (e.g., Mealy and Gottuk, 2006). He had no appreciation of the role of radiation in compartment fires which led to great misunderstandings of

the floor damage. He contended that he had never seen a fire where radiation from above played a role. That is a reflection both of his inexperience and his lack of understanding of what he had seen.

The investigative work by FM Cheever was well below modern standards as was his knowledge and insights into fire. His work could not be found to be anywhere near the standards anticipated by NFPA 921.

The investigation conducted by FM Cheevers did not meet the standards of the day. Books of the 1980s were very clear with respect to the important role of interviews, which FM Cheevers failed to do or consider. The books of the day were also clear about the need for documentation of the investigation in the form of notes, photos, logs, sketches, and reports. FM Cheevers failed to provide any form of documentation of his investigation and relied solely upon his personal memory of what he observed. The books of the day were equally clear about the need for evidence collection and sampling for the presence of accelerants. FM Cheevers did not examine most of the debris removed, retained no evidence, and failed to sample for the presence of an accelerant. He was further uninterested in the results of laboratory analysis of samples taken by others.

In terms of his use of indicators, the literature of the day was full of cautions about low burn and burn intensity indicators, indicating that these indicators could result from non-arson related causes. His interpretation of furniture damage patterns was at odds with many 1980's sources. His examination of only a single outlet and his failure to examine electrical appliances was not consistent with the standards of the day. FM Cheevers did not go through a process of elimination of other causes, the widely accepted methodology at the time.

The investigation by FM Cheever did not meet the process requirements of the day, and failed to consider the widely disseminated warnings about misinterpretation of low burn and burn intensity indicators. His investigation was sufficiently flawed that no conclusions could be justified with reference to the standards of care of the day.

Investigator Daily

Investigator Daily performed a reasonable investigation as an insurance investigator based upon the time spent and the documentation developed. Since the two most important rooms had been

destroyed from an evidentiary viewpoint before he arrived, he was at a distinct disadvantage. Nonetheless, he repeated the mistakes by others when he examined other rooms. Untrained crews were used to empty and clean the rooms without any eye toward examination of the debris as it was discovered and removed. He did use a portable gas detector to search for indications of ignitable liquids and he did collect samples for laboratory analysis. Most samples seem to have been taken after washing the floors, limiting the likelihood of finding a positive sample. He also ignored the debris pile from the rooms of origin in terms of taking samples. These are exactly the materials that could have had residues of ignitable liquids. Dailey did not dissemble electrical outlets and did not find or examine any appliances. Dailey also did interview eyewitnesses to the fire. His trial testimony was entirely devoid of any discussion of the identity of the accelerant, the quantity used, and the source of the accelerant. In his report, he opined that it was half a gallon of methanol, based upon his belief that this was on the front porch before the fire. He never located any bottles or fragments of bottles.

Dailey's fire science knowledge was severely limited. He did not believe the normal fuel load of the home was capable of creating floor patterns. He considered the complete consumption of furniture items to be abnormal and as such an indicator of arson. He believed that only an arson fire could anneal furniture springs. Remarkably, he eliminated smoking as a cause because he felt ignition of furnishings by a cigarette was highly unlikely. He thought that a pattern under a couch would be the result of a liquid poured on the carpet spreading under the couch and burning there, seeming to not understand that polyurethane foam creates a spill fire when it burns. He believed floor patterns could only be created by an arson event. He considered cellulosic ceiling tiles to be not flammable, but he did recognize the hazards of wood paneling. He did not think that a fire based upon the normal materials present in the home could create a fire that would breach the ceiling. Overall, his knowledge of fire phenomena was well below modern investigator standards.

By modern standards, Investigator Dailey's investigation relied upon incorrect understanding of fire indicators. He failed to use the scientific method and he attributed the fire to arson without identification of any accelerant via laboratory or field method. He failed to identify the accelerant used, its quantity, or the source of the accelerant. Under modern standards, his findings and conclusions cannot be sustained.

Investigator Daily performed a reasonable investigation as an insurance investigator based upon the time spent and the documentation developed. Since the two most important rooms had been destroyed from an evidentiary viewpoint before he arrived, he was at a distinct disadvantage and ultimately could not reach defensible conclusions due to the inability to adequately examine the apparent rooms of origin. He compounded the error by his unwillingness to examine the debris pile from the two rooms simply because the pile contained debris from two rooms. His electrical examination was so limited that it could not form the basis for excluding electrical ignition sources.

He relied significantly upon fire indicators that the texts of the day provided cautions about their reliability. He ultimately concluded that Willis started the fire because according to Dailey's understanding of the fire, had Willis been on the couch when the arson occurred, he would have died. Dailey never confirmed the presence of any accelerant, did not identify the accelerant in his testimony, and had no idea how much accelerant would be needed to spread accelerant over two entire rooms as he believed occurred. In essence he relied entirely upon floor patterns and the severity of burning as the basis for his finding of arson by Willis. At the time of his investigation, it was recognized in texts that these indicators were inconclusive. His investigation did not comport with the standard of care for arson investigation at the time of the investigation.

WILLINGHAM CASE

The Willingham fire occurred on December 23, 1991 at 10:34 am. Stacy Willingham had left the house at about 9:15 am, leaving husband Cameron Willingham and the three children, Amber, Karmon, and Kameron, sleeping. Cameron awoke as Stacy was leaving, heard the twins crying and gave them each a bottle. They were in their bedroom on the floor. Amber was asleep in her bed. Upon becoming aware of the fire by Amber, he instructed her to leave the home and went to rescue the twins. Only Cameron was able to escape the fire and the three children died.

Vasquez Report

Manuel Vasquez, of the State Fire Marshall's Office, conducted his scene investigation on 30 December 1991 and 2 January 1992, about a week after the fire. Other persons present during the examination were: Doug Fogg, Corsicana Assistant Fire Chief; James Palos, Corsicana Fire

Marshal; James Hensley and Rex Givens, Corsicana Police Detectives; Edward Cheever and Donald Turk, State Fire Marshal Deputy Investigators.

The report described the damage and patterns observed at the fire scene, and included two diagrams of the scene (see Figure 1 for a scene plan indicating damage) and 81 captioned photos. The home was a three bedroom single story structure. There was severe fire damage in the northeast bedroom where the children slept with flame extension from all windows of that room. There was severe damage in the hallway outside the bedroom and out the front door. Both the children's bedroom and the front door abutted the front porch of the home, which was severely burned as well. The rear portions of the hallway had heat damage and smoke damage. The living room (northwest) and the master bedroom (west) had heat and smoke damage. The door between the kitchen and the hall was closed during the fire and the kitchen and the rear bedroom (southwest) were subjected primarily to smoke damage. Fire did not propagate into the attic in any room of the home, but some damage above the ceiling of the porch was evident.

Both the children's bedroom and the front of the hallway had been fully involved in fire with burn damage over the full height of the spaces. There was a child's gate at the children's bedroom but this was wholly consumed and no door was present. The front door of the home was fully consumed and the screen door frame was fully consumed at the top and charred at the base. The aluminum threshold of the front door disclosed a burn pattern underneath, which was taken as an indication that a liquid accelerant flowed underneath and burned. There were burn patterns on the floor of the front part of the hallway that were taken as an indicator of combustible liquid pour. The floor tiles were fully consumed in portions of the area and the wood below was damaged. The floor damage and a V pattern in the hall were taken to indicate an area of origin. A space heater in the rear portion of the hall was examined and was deemed a victim of the fire rather than the cause.

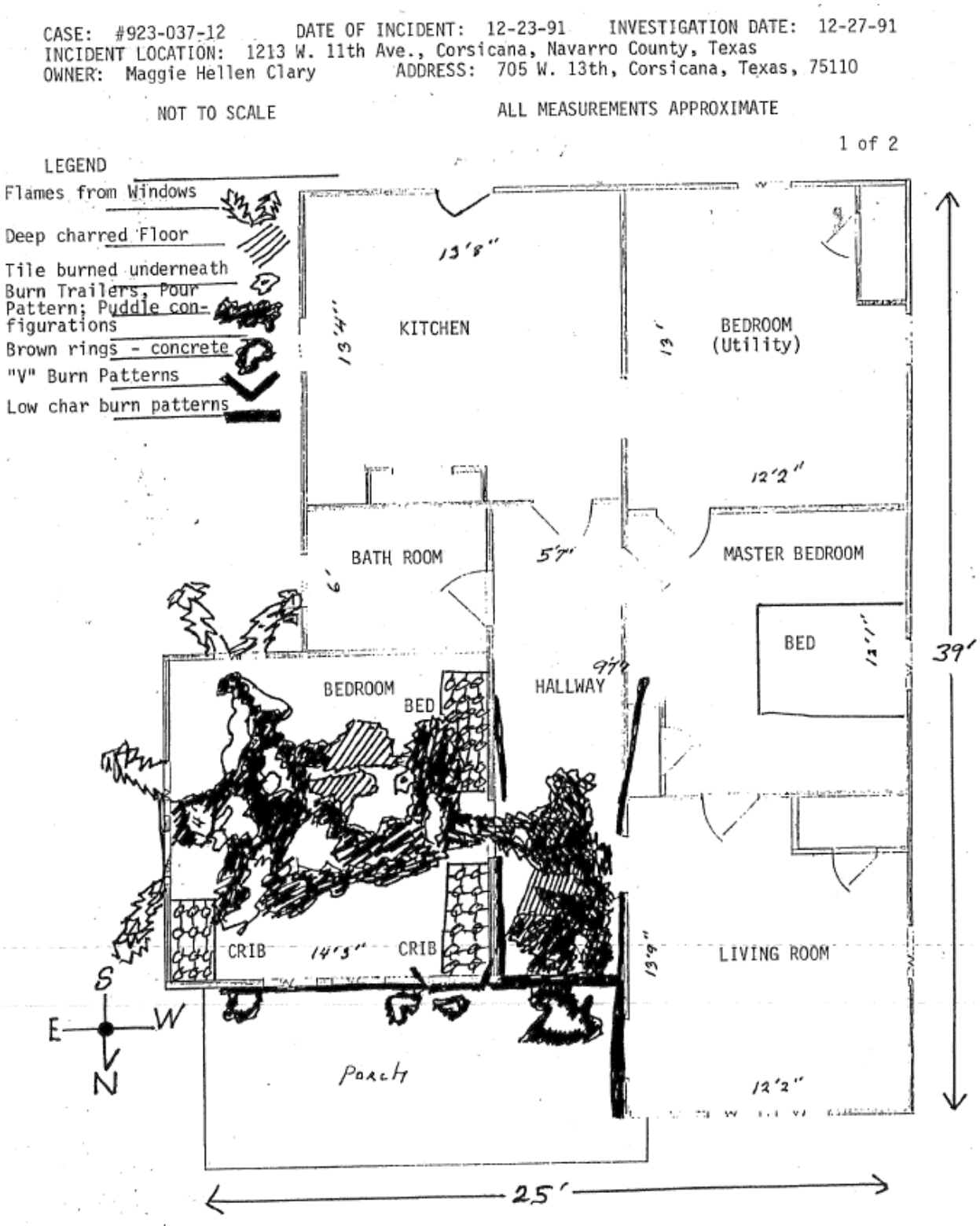

Figure 1. Scene diagram from the Vasquez report.

Floor damage patterns taken to be indicators of combustible liquid pour extended into the children's bedroom. Damage in the room was highest at the location of a bed and two cribs in the room. The electrical wiring was examined in this room and was not found to be the cause of the fire. A space heater in the children's room was excluded as a cause of the fire. The floor of the children's room had patterns that were taken as indicators of liquid accelerant.

Damage to the porch walls was from floor to ceiling and damage to the ceiling was severe. The damage to the walls adjacent to the porch were taken as inconsistent with normal burning because they extended to the floor level rather than simply upward from the window and doors where flame issued onto the porch. This was taken as an indicator of incendiarism. Crazed glass on the front porch side of the home was taken as an indicator of a fire that burned fast and hot. Brown stains on the porch were taken as indicators of a liquid accelerant burning on the porch. The underside of the porch screen door was charred and was taken as an indication that a liquid accelerant flowed under the door. A container of charcoal lighter was found in a damaged state at the end of the porch. A sample of wood debris from the base of the front door was found positive for kerosene.

FM Vasquez determined that there were multiple origins based upon his scene examination and from statements of eyewitnesses. The role of eyewitness observations in this determination was not provided. FM Vasquez satisfied himself that he had eliminated electrical and natural gas causes. He determined that the fire was incendiary and the fire traveled from the children's bedroom into the hall and out onto the porch. FM Vasquez found Willingham's statement of his actions the morning of the fire to be pure fabrication, saying "A fire does not lie." In essence he is indicating his confidence in his interpretation of the physical evidence over the statement of Mr. Willingham.

Police Report (Hensley Report)

Detective Corporal James Hensley provided the majority of the documentation of the police investigation of this fire. He also provides information obtained by Corsicana Fire Marshall James Palos. FM Palos did some eyewitness interviewing from December 27 and summaries of interview by Assistant Chief Doug Fogg are also included. The scene investigation occurred on 30 December, and 2 January. It appears that the police investigation started once the scene investigators determined that the fire was intentionally set. The narrative of the interviews appears to be a

complete record of interviews without respect to the person or organization who conducted the interview. In excess of 50 interviews were conducted in the course of the investigation.

Civilian Eyewitnesses to Fire (6 individuals)

Observations of eyewitnesses to the initial part of the fire are generally consistent. They describe the fire as severe with fire issuing onto the porch and flames extending from the porch, though at least one eyewitness saw the fire when only smoke was issuing from the building. One eyewitness in two different interviews noted that he saw flames coming through the front doorway, indicating that the door was left open. This is consistent with the view of the door hinge in the FM photographs, though this issue is not addressed in the report.

Eyewitnesses saw Willingham outside the home in a state of distress with a number of witnesses reporting that he called out that his babies were burning. Actions by Willingham noted by eyewitnesses included moving his car away from the home and breaking out the front window of the children's bedroom. After the fire department arrived, Willingham sat on the back of a fire truck and several times needed to be restrained from attempting to reenter the home. He was handcuffed by police for his own safety. Eyewitnesses identified that he was only wearing pants and that he had singed hair on his chest, eyelids, and head and had a two inch burn injury to his right shoulder. His wrists and hands were blackened with smoke. He was eventually transported to the hospital for treatment, still resisting and still in handcuffs.

Eyewitnesses provided important observation of the fire conditions as well. As might be expected in a police report, the fire observations obtained in the interviews is not the focus of the report. At the time the first eyewitnesses observed the home, there was smoke issuing from the front door, the windows were intact, and no fire was observable from the outside of home. Willingham was seen standing on the porch two feet in front of the door. Notably, an early eyewitness thought that Willingham could have gone back into the home to conduct a second rescue attempt based upon the lack of visible flame and the moderate smoke observed. The first observation of flame outside the building occurred when Willingham broke out windows in the children's bedroom. Flames issued from the broken window openings. Subsequently, the fire transitioned to a fully developed fire in the bedroom with flames issuing from all the windows

(regardless of whether they were broken out or not) and from the front door, consistent with flashover occurring in the children's bedroom. The flames then involved the ceiling of the porch and the exterior walls of the home on the porch. One arriving eyewitness noted low fire on the porch between the door and the window, though it is unclear whether he was referring to the children's bedroom window or the window from the living room onto the porch.

Firefighter and Police Eyewitnesses to Fire (5 individuals)

First arriving firefighters found the bedroom, hallway, and porch well involved in fire. Fire was issuing from all windows of the bedroom, from the front door, and the ceiling of the porch was fully involved. Firefighting proceeded fairly quickly with an initial external attack, followed soon thereafter by an interior attack through the front door. Rescue work occurred in parallel with fire suppression activities. Amber was located in the middle bedroom, was removed, and transported to a hospital. She died at the hospital. The twins were found in the children's bedroom, severely burned. They were pronounced dead at the scene.

Cameron and Stacy Willingham

Cameron Willingham's account of the incident was provided to investigators via a taped interview. He awoke in the morning as Stacey was leaving the home. He heard the twins crying and gave them each a bottle. The twins were on the floor of their room with a child gate at the door. Amber was in her bed in the children's bedroom. He went back to bed and was awakened later, hearing Amber calling daddy, daddy. He awoke to a room thick with smoke such that visibility was very limited. He felt for his pants, put them on, and instructed Amber to leave the home. He got up, checked the door to the kitchen, and found only light smoke in the kitchen. Smoke was heavier in the hallway and especially heavy moving forward in the hallway toward the children's bedroom. He had to crouch down to move forward in the hallway. He reported hearing electrical popping sounds. He went over the child's gate into the children's bedroom and as a result his hair was either thermally damaged or burned. He was unable to see in the children's bedroom due to the smoke density, but was aware of an orange glow high in the space. He crawled around the floor searching for the twins. He found a bottle and a doll, but did not find either of the twins. He never heard them cry or make any sounds. Burning material began falling from the ceiling, with one piece falling on his shoulder, causing a burn. He recalls entering to the center of the room where he touched the

child's slide that was already melting. He exited the room over the child gate and burned his hand while touching the door frame. In the front hallway, he struggled with the door, ultimately opening the door and screen door, exiting to the front porch, leaving the front door open. He caught his breath, recovering from the smoke exposure, and considered reentering the building. He saw neighbors and asked them to call 911 and called out that his babies were burning. While on the porch he heard a loud crash that he imagined was the ceiling fan falling from the children's bedroom ceiling. He did not reenter and broke open the windows to the children's bedroom in a failed attempt to enter the room. Flames came out of the window openings, indicating to him that he would not be able to enter. The electrical service line burned off the home and fell onto the ground. After the fire department arrived he was taken to the back step of a FD engine. He had to be forcibly restrained from attempting to go into the building and approach Amber when she was rescued. He was handcuffed and restrained by police and others. He was put on a stretcher and taken to the hospital for treatment. He was kept in the hospital overnight. He reported burns to his shoulder, ears, face, hair, and fingers.

Willingham reported the contents of the children's bedroom as including two cribs, one child's bed, a dresser, a ceiling fan, a space heater, a child's plastic slide, a Little Tikes kitchen, a wagon of toys, and a child's gate at the doorway. The floor was tile with a carpet patch defining a child's play area. In the hallway, the only contents were decorating items on the walls, like big plastic butterflies and whatnots.

Willingham indicated that they had squirrels in their attic for some time before the fire and indicated his concern that the fire was electrical in origin.

He reported his relationship with Stacey as rocky at first, but improving over time. They had married three months before the fire. They did have arguments and spats, the last of which was 2–3 weeks before the fire. He described his arrest history and his probation violation. Willingham was unemployed at the time of the fire and was watching the kids.

Stacy Willingham awoke 730–800 am the morning of the fire when the kids awoke. She changed their diapers and fed them. She left to run some errands. She was found by police and notified of the fire. She went directly to the hospital.

Stacy reported the last fight they had had two weeks before the fire. She noted that the front door was unlocked after she left the home because they had lost the key.

Persons with Knowledge of Cameron Willingham (~40 individuals)

These interviews are not summarized here as they do not deal directly with the fire scene investigation or the events of the day. They do provide information about Willingham's arrest history, his relationships with others, the dynamics of the household, and his past in general.

Fogg Report

Corsicana Fire Department Assistant Chief Douglas Fogg prepared an eight page report of the investigation. As a first responder he provided a narrative of the fire department operations. He arrived after the first FD unit arrived when Lt. Franks was operating a hand line from the porch. He saw Willingham outside the building with burnt hair and smoke on his face. He relieved Lt. Franks so the Lt. could don his breathing apparatus. He observed that the exterior attack quelled the flames but they reestablished themselves when the attack was ceased. He was relieved fairly quickly by another FF and he went to the rear of the home. He found the back door blocked by a refrigerator. When the refrigerator was moved and the door opened black smoke issued from the door. He moved to the front of the home to help establish ventilation and the primary search was underway. FF Vandiver found Amber and removed her from the home. Lt. Frank found the twins in the children's bedroom. Judge Mayfield declared them deceased on the scene and ordered an autopsy of the twins. Detectives Blake and Hollingsworth took photos of the twins before Assistant Chief Fogg removed the bodies from the home.

Lt. Frank was on the first arriving unit and flames were issuing from the front door and windows to the children's bedroom. The ceiling of the porch was fully involved in flame. The home was a single story wood frame building with walls of sheetrock and some wood paneling. The location of the paneling was not indicated.

Low burn was noted on the front porch under the children's room windows and on the exterior living room wall on the porch. Fire damage was limited to the children's bedroom and the front hallway with smoke and heat damage elsewhere in the home. The door to the kitchen had been

closed during the fire based upon the damage patterns. Damage in the children's bedroom was from floor to ceiling. Based upon damage patterns AC Fogg determined that the gas-fired space heater was not in the area of origin. He noted floor damage he judged consistent with liquid pour patterns in the front hallway and into the children's bedroom. The room was substantially burned out with the dresser 80–90% consumed and the chest of drawers was 60–70% consumed. The irregular pattern of floor damage was observed over most of the room's floor. Electrical wiring in the room showed no shorting but no appliances were noted. The fire did not penetrate the ceiling and spread to the attic. The presence of the ceiling fan and its condition were not reported. The twins were severely burned. The cribs and bed had remnants of their cotton mattresses.

Low burn patterns were found on the porch walls and the front door was fully consumed. The screen door was burned away at the top and had char on both faces of the remaining door as well as on the underside of the door. Remnants of two plastic containers were found on the concrete porch. No accidental cause could be found to explain the burn patterns in the children's bedroom, the hall, and the porch. Samples for accelerant detection were taken and sent to the lab but the nature and number of samples taken were unidentified. The front screen door was thought to have been initially closed but opened during firefighting operations. The methodology for examining the fire scene was not discussed and no mention of the pile of room contents outside the children's bedroom was found in the report. On December 26 the floors of the home were further cleaned and low burn and puddling marks were found to connect the children's bedroom, the front hallway, and the porch. AC Fogg opined that the fire was started at floor level in such a way to block the exit path.

FM Vasquez arrived on 27 December and additional unspecified samples were taken. The fire was taken to be arson at this time. On 30, 31 December additional unspecified samples were taken. Additional photographs and videos were taken of the fire scene. The burn patterns indicated that the fire started on the floor in the children's bedroom/hallway, and this was thought to be inconsistent with Willingham's story of his actions because he was not sufficiently burned as AC Fogg thought would be the case. On January 2–6 a class 3 petroleum distillate was found in unidentified samples.

Vasquez Testimony

After providing his training and experience, FM Vasquez offered that he has investigated 1200-1500 fires and that most of them were arsons. He reviewed the photographic evidence for the jury and noted that "The fire tells a story. I am just the interpreter," sounding much like a fortune teller. He continued, "And the fire does not lie, It tells me the truth." implying that he, the interpreter, could not be wrong. He identified from the condition of the floor once cleaned that a liquid had covered much of the floor area of the children's bedroom. He eliminated the space heaters as the cause of the fire because they were turned off, but provided no basis for knowing that the heaters were turned off, as he arrived at the scene four days after the fire and after significant activities on the scene had been completed. He regarded the fire damage to the children's bedroom to be "not normal", though he failed to provide a basis or rationale for this opinion. Later, he indicated that he believed the temperatures were higher at floor level than at ceiling level, though how he came to that conclusion is unclear. He concludes that this abnormality was due to the accelerant. In his examination of the porch, he concluded that the fire spread into the house and not out of the house. This is contradicted by early civilian eyewitnesses. In examining the threshold, he observes low burn at the doorway and melted aluminum. He opined that wood burns at 800F and concludes that an accelerant was necessary to cause the aluminum to reach its 1200F melting temperature. He went on to opine that there were pour patterns in the hallway and the intent of the pour was to block the exit. He further opined that a liquid had been poured on the door that was completely consumed, apparently thinking that the consumption of the door would not have been possible without accelerant on it. He opined that there was liquid pooling both sides of the door. He opined that the charring of the baseboard meant that a flammable or combustible liquid was poured in front of it, apparently rejecting the idea that radiation from the door and porch ceiling flame could have ignited the entire wall.

He summed up his internal home site investigation by noting that the damage to the floor indicates "that's the whole room here on the northeast (children's) bedroom is a point of fire origin." He went on to opine that the hallway was an additional area of origin and the porch was a third area of origin. He opined that these areas of origin were unconnected and as such they indicated that the fire was intentionally set by a human. Remarkably, he opined that the fire having

auto-ventilated (breakage of window glass) was an indicator of arson. He asserted, “That’s inconsistent with fire behavior.” He went on, “Puddle configurations, pour patterns, low char burning, charred floor, the underneath burning of the base board, the brown stains on the concrete, the underneath of the bed, because of the fire right underneath the bed, puddle configurations in that area, and the total saturation of this floor is indicated with pour patterns.” He told the jury that these were facts and he was just using the facts. He opined that the liquid needed to have been a combustible liquid and not a flammable liquid because with such a large pour area he would have expected injury to the arsonist or a loud sound associated with the ignition of the large cloud of flammable liquid. He cited Willingham’s testimony as a pure fabrication because it was inconsistent with FM Vasquez’s view of the fire patterns. He further eliminated child firesetting on the basis of the extent of the pour patterns and his conclusion that Willingham could not have escaped the home if the child did set such a fire because the front hallway exit path would have been involved in flame. He provided no basis for this opinion. FM Vasquez asserted that he was also able to determine that the bedroom pour was ignited, then the hallway, and then the porch. He remarked that “There was a discernible path, but it was not enough to be a connecting path.” No basis for this opinion was provided. While no basis was provided, apparently FM Vasquez was able to be sure that the fire in the bedroom could not have ignited the hallway pour or the porch pour, and that they must have been each ignited by a human. No basis for the opinion was offered. He further opined that Willingham’s injuries were self-inflicted. FM Vasquez diagnosed that Willingham did not experience smoke inhalation based upon his meeting with Willingham perhaps a week after the fire. FM Vasquez had apparently suffered some throat damage in a fire which he associated with smoke inhalation and saw on evidence of his own experience in talking to Willingham. This testimony was allowed. Later, he concluded “The fire, itself, tells me that it’s a very aggressive fire; and, therefore, the fire was not a planned fire. It was a spur-of-the-moment fire.”

On cross examination, FM Vasquez acknowledged that deep burns in the floor can be caused by means other than accelerants. He acknowledged that he did not know how large the carpeted area was within the children’s bedroom. During cross examination it became clear that FM Vasquez had not learned that there was a grill on the front porch at the time of the fire that was moved away during operations by the fire department. FM Vasquez described that debris had been shoveled out

of the bedroom and hallway. He indicated a lack of knowledge of the debris contents, indicating that he had not been present when the debris removal occurred or that he simply didn't examine the debris during removal. He even seemed unclear what tools had been used to remove the debris.

Defense counsel posited a hypothesis of an outside person entering the home and starting the fire. FM Vasquez acknowledged that such a scenario was possible and was consistent with the case facts. FM Vasquez indicated that the children's bedroom doorway had no door when he arrived, but did not know if there had been one at the time of the fire. On being shown a fire scene photo that showed no hinge plate, he acknowledged that there was no sign of a door having been present. FM Vasquez opined that the front door had been closed at the time of the fire. FM Vasquez was unaware of the initial eyewitness observations of no fire on the porch and the observations of smoke flow out of the front door prior to fire department arrival. He was unaware that a child's gate had been at the children's bedroom doorway.

Defense counsel posited a scenario of child firesetting using lamp oil and FM Vasquez agreed that based upon the available evidence, this scenario could not be ruled out. FM Vasquez was unaware of lighters collected from the house by the police. On redirect, he opined that he thought it unlikely that a two year old would be physically capable of this act.

FM Vasquez saw no need to secure the fire scene from the time of the fire through the end of the scene investigation. He opined that the fire was arson, with the intent to kill the children. Upon questioning by defense counsel he offered that his opinion regarding the motive was wholly based upon his fire scene investigation, i.e., his examination of the physical evidence of the fire. Later, he acknowledged that from physical evidence it was not possible for him to know who or how a pour had been formed. He also acknowledged that the fire started in the children's bedroom and it is possible for a person in the master bedroom to have escaped at a time where fire had not yet spread to the hallway.

Fogg Testimony

He first described his activities and observations during the fire. The description was brief and consistent with his report. They found no evidence that the space heaters had started the fire and

found no shorting in the bedroom wiring. No mention of appliances was made. He found floor damage he thought consistent with liquid pour patterns. He identified the floor construction to be carpet tiles with plywood underlayment, tar paper, and the original oak floor. He indicated that he examined the plastic toy remains and concluded that during the fire the toys had not melted. He opined that the damage at the front door threshold was caused by a liquid flowing under the threshold and burning under the threshold. He opined that the staining of the concrete was due to liquid accelerant.

On cross examination, he conceded that puddle patterns can be caused by other means than a liquid accelerant and that some clothing and plastic toys can melt. He acknowledged that the stain on the porch could be the result of a simple barbeque accident. He opined that latex paint is not flammable.

Chief Fogg acknowledged that a child could have started the fire with a lighter or match and that his evidence could not eliminate this hypothesis. On redirect he indicated that it was his opinion that a child did not start this fire based upon his interpretation of the pour patterns. He was unable to say that the child starting the fire was impossible, but rather that he simply regarded the possibility as remote. He also opined that tar paper and glue could not have been responsible for the burn patterns because they were not on the top of the floor assembly, despite the fact that the patterns seen were on the subflooring. He opined that glue could only cause the patterns if it had been poured on the floor. During the recross examination he testified that he did not recognize that glue could be thermally degraded and create melt without access to air. His understanding was that the glue would be unaffected until exposed to air where combustion could occur. Chief Fogg acknowledged that the porch stain could have occurred due to the charcoal lighter fluid that had been in the damaged containers found in the front of the home.

After having admitted that he had not excluded child firesetting as a cause, and that the porch stain evidence could have nothing to do with the fire, he reasserted his opinion that the fire was intentionally set. He relied upon his personal belief rather than using the scientific method or the process of elimination.

Willingham Analysis

In the Willingham case, the investigations include a number of organizations and individuals. The reports and testimonies of individuals do not generally reflect a team investigation approach. In the Willingham fire, it was unclear who the lead investigator was. The division of labor tended to reflect traditional roles with the fire department and State Fire Marshall's Office leading in the scene inspection areas, and the police focusing on interviewing. Communication did not always appear to be effective in that the police collected evidence that was unknown to the FM. Similarly, the FM seemed unaware of some of the eyewitness interviews conducted by others.

It is the goal of this analysis to examine the investigations in the light of both the current state of the art, as well as in the light of the contemporaneous state of the art.

Assistant Chief Fogg

In the Willingham fire, the fire investigators were Assistant Chief Fogg and Fire Marshall Vasquez. Quite normally, AC Fogg is the local fire official and FM Vasquez is the state investigator. While the local police were involved in interviewing and obtaining documents, they appear based upon the records reviewed that they worked in a supporting role with respect to the fire investigation.

AC Fogg was among the first responders and as such was involved directly with the investigation from the very beginning and it was he who called upon the State Fire Marshall's Office for assistance.

In examining potential causes of the fire, there was no mention of examining any electrical appliances or the ceiling fan in the children's bedroom.

AC Fogg relied upon the floor patterns throughout the children's bedroom as indicating that an accelerant had been spread over the entire bedroom. He also opined that based upon floor patterns, accelerant had been used in the hallway and porch. He was unable to identify an accidental fire cause that could explain the patterns. Indeed, the patterns need not be associated with the cause of the fire at all. The bedroom and hallway had simply been fully involved in flame such that floor

damage and associated patterning would be expected as a result of the fully developed fire, rather than due to the use of an accelerant.

The appearance of brown stain on the porch at the front door was taken as an indicator of an accelerant spill which was ignited to start the fire. AC Fogg did not consider or explain how this could be true in the light of the early eyewitnesses who saw no fire on the porch or at the front door. These eyewitnesses directly contradict the hypothesis that AC Fogg accepted. No samples of the concrete were taken for analysis and no consideration was given to accidental causes of spill residues at that location which were thermally decomposed by the heat of the fire to turn brown. The only positive test for liquid residues came from the front door threshold where petroleum distillates consistent with charcoal lighter were detected. There was evidence that charcoal lighter would have been used routinely on the porch to ignite a grill and that two fire damaged bottles of charcoal lighter had been on the porch at the time of the fire. These provide hypotheses regarding the presence of petroleum distillates at the front door threshold that involve accident spills of charcoal lighter prior to the fire and spills of charcoal lighter due to damage to the charcoal lighter containers found in the area of the porch. No basis for exclusion of these hypotheses was found. On cross examination, he admitted that the porch stain could have nothing to do with the cause of the fire. Professionally, he should have found the cause of the porch stain and the liquid residue at the threshold as undetermined and as such he should not have provided an opinion regarding their cause.

On cross examination, AC Fogg was asked if Amber could have started the fire. AC Fogg admitted that he could not rule out this hypothesis. On redirect he sought to minimize the likelihood based upon the patterns found, i.e., his opinion that it was not likely that Amber could have created such a spill pattern. Nonetheless, he could not rule it out. There is no available evidence that an outside individual was considered as the fire setter. It was known that the front door was unlocked. The only basis proffered for Willingham as the fire setter was that had the hallway been subjected to an accelerant spill, he could not have escaped without serious lower body injuries. This of course relies upon the correctness of the pattern interpretation in the hallway.

AC Fogg exhibited limited understanding of the patterns caused by fully developed room fires and the response of materials to heat. He discounted the ability of tar paper and glue to create melt patterns. During his trial appearance, he opined that glue could not be thermally decomposed without direct access to air. In examining the toys in the children's bedroom, he opined that they had not melted. He did not document this opinion and it is an incredible assertion. It is well known that toys like the slide and kitchen set are made of polyethylene. The idea that polyethylene would not melt in a fully developed fire is incredible. During his testimony, he asserted that water-based paints are not flammable. These are latex paints that use water as the carrier. Once the paint dries, it is a layer of latex which is an organic material that is fully capable of burning in a well developed room fire.

In the end, the only bases for the determination of arson by AC Fogg is the burn patterns on the floor of the children's bedroom, the hallway, and the porch interpreted as accelerant spill. None of these determinations have any basis in modern fire science.

AC Fogg's investigation did not comport with the requirements of NFPA 921, the modern standard of care. Further, his investigation did not satisfy the contemporaneous standard of care. His hypothesis was directly contradicted by eyewitness testimony and he admitted that he had not eliminated other possible causes.

FM Vasquez

FM Vasquez generally held the same opinions as AC Fogg, though he expressed additional opinions regarding arson indicators that he cites. He regarded the floor patterns in the bedroom, the hallway, and the porch to indicate an accelerant spill. Again, these have no actual basis.

He used the appearance of a V pattern in the hallway wall as an indicator of an origin in the hallway. While there can be no doubt there was low burning in the front of the hallway, the V pattern on the wall moving toward the back of the hall is in no way an indicator of origin necessarily. It resulted from burning in the front of the hallway and would be present whether the hallway was an origin or not.

He regarded the burning of the exterior walls of the house on the porch as not consistent with a natural fire and as such indicates arson. His views seem to be that arson fires are systematically more severe than natural fires. There is no basis for this notion in modern fire science. The low burning of the exterior walls resulted from the heating of the wall by ceiling flames in the porch. There is no need to postulate any special fire phenomenon or any spill fire. He takes the presence of crazed glass on the porch as an indicator of a fast and hot fire due to accelerant. In fact it is much more likely that any crazing resulted from the application of water to hot glass during firefighting.

His interpretation of the brown stain on the front porch as an accelerant pattern is without merit. He took no concrete samples for analysis and the stain has alternate hypotheses as already discussed. The charring of the underside of the screen door was taken as an indicator of an accelerant fire below the screen door. No such interpretation is supported by modern fire science and it ignores the burning of other materials and the thermal environment created by normal fires. Despite the presence of charcoal lighter use on the porch prior to the fire and the presence of charcoal lighter containers on the porch during the fire, FM Vasquez accepted the presence of these petroleum distillates as an arson indicator.

In his report, FM Vasquez indicated that the eyewitness statements supported his theory of three origins (porch, hallway, and bedroom). In fact, the early eyewitnesses observed no flame on the porch when Willingham was already outside and they simply observed modest smoke flow from the hallway. Indeed, from her exterior view, one eyewitness could not understand why Willingham wasn't reentering the building. This is hardly consistent with the theory of widespread use of accelerant and a rapidly growing fire. There is nothing in the eyewitness observations that suggests anything other than a local ignition in the bedroom with the fire growing to involve the hallway and reaching flashover conditions in the bedroom well after his exit from the building. The eyewitness observations are sufficient to cause the failure of FM Vasquez's hypothesis about the fire.

FM Vasquez is unique among the investigators of both fires in his attitudes toward arson and fire scene examination. His statistics of the fraction of fires which are in fact arson are remarkable and far exceed any rational estimate. It reflects his predisposition to find arson in his cases. This directly violates NFPA 921 and professional norms in general. His quotations that "The fire tells a

story, I am just the interpreter," and "the fire does not lie, it tells me the truth," are hardly consistent with a scientific mindset and is more characteristic of mystics or psychics. The quotes separate the findings from his own judgment and seek to make him not responsible for his own interpretation. It seems to deny the role of rational reasoning. It is an expression of fire investigation as a mystical art rather than an application of science and reason.

FM Vasquez opined that the front door was closed during the fire. He seemed unaware that early observers saw smoke flowing from the front doorway and they did not see flames on the porch initially. Both are inconsistent with his view of the fire. He opined that accelerant was splashed onto the surfaces of the door, apparently believing that the consumption of the door could not be explained by any other mechanism. There is no scientific basis for this assertion. Doors can be consumed fully by natural fires. Returning to his mysticism he states, "The fire, itself, tells me that it's a very aggressive fire; and, therefore, the fire was not a planned fire. It was a spur-of-the-moment fire." Such statements are beyond belief in the context of fire investigation as an applied science.

His ideas about fire are often inconsistent with modern fire science. He opines that auto ventilation is an arson indicator. It is and has been well known that natural fires can and do break out windows. He opined that wood burns at 800 F so that in order to melt aluminum (1200 F) an accelerant must be involved. It is and has been known that flame temperatures of ordinary combustibles like wood are no less than liquid fueled fires and both are more like 2000 F. He opines that a fully developed bedroom fire could not ignite the fire in the hallway or the porch. They must have been set separately. Indeed, fire spread from the bedroom to the hallway and its wood paneling and door are exactly what would be expected from a fully developed bedroom fire. The spread of fire out of the front door and windows and involving the ceiling of the porch and subsequently the porch walls is exactly what would be expected from a natural fire. This is normal fire dynamics, not a sign of arson. Similarly, he had no appreciation of the ability of thermal radiation to create floor and lower wall patterns and damage.

FM Vasquez's opinions about Willingham's injuries are remarkable. His injuries are entirely consistent with being exposed to a room fire environment with general singing of his upper body

areas. Self inflicting such injuries implies intentional self-exposure to a room fire environment. The injuries could not be created by any sort of localized heat and smoke source. If FM Vasquez's view of the fire is correct, it is unclear how Willingham could have entered a room with a hot gas layer at all. Understanding how burn injuries could occur is an important part of fire investigation and FM Vasquez seems to be wholly without any realistic understanding of fires and how fire injuries are created.

In his scene examination, FM Vasquez was indifferent to the contents of the rooms before the fire. He never sought to understand that the bedroom had no door and did have a child's gate. He knew little about the contents of the bedroom and hallway before the fire. He was also unaware of the presence of a grill on the front porch. He simply did not recognize that there was a normal use of charcoal lighter on the front porch and that the presence of the charcoal lighter was not an abnormal fuel.

At trial FM Vasquez denied that it was possible for a child to have accidentally or intentionally set this fire. He was unaware that the police had collected several cigarette lighters from the home. His rationale for eliminating the scenario was based upon his understanding that an accelerant was spread over most of the children's bedroom, the front of the hallway, and the front porch. He further opined if anyone other than Willingham had spread the accelerant to these areas, he would not have survived the fire. In the end, his elimination of this cause hypothesis is solely based upon his erroneous understanding of the floor patterns. FM Vasquez did acknowledge that the hypothesis that an outside person entered and started the fire is consistent with the case facts. Nonetheless, it did not change his opinion about cause.

In the end FM Vasquez concludes that the fire was arson based solely on the physical evidence at the fire scene. Remarkably, he gleans human intent from the physical evidence. Apparently, the fire communicates with FM Vasquez about people as well. FM Vasquez's opinions are nothing more than a collection of personal beliefs that have nothing to do with science-based fire investigation.

FM Vasquez's investigation did not comport with the requirements of NFPA 921, the modern standard of care. Further, his investigation did not satisfy the contemporaneous standard of care. His

hypothesis was directly contradicted by eyewitness testimony and he admitted that he had not eliminated other possible causes. FM Vasquez is unique among the investigators of both fires in his attitudes toward arson and fire scene examination. His approach toward fire scene investigation is not found in any text of the day.

CONCLUSIONS

The investigations of the Willis and Willingham fires did not comport with either the modern standard of care expressed by NFPA 921, or the standard of care expressed by fire investigation texts and papers in the period 1980–1992. The investigators had poor understandings of fire science and failed to acknowledge or apply the contemporaneous understanding of the limitations of fire indicators. Their methodologies did not comport with the scientific method or the process of elimination. A finding of arson could not be sustained based upon the standard of care expressed by NFPA 921, or the standard of care expressed by fire investigation texts and papers in the period 1980–1992.

REFERENCES

1. Almirall, J. and Furton, K. (2004), Analysis and Interpretation of Fire Scene Evidence, CRC Press, Boca Raton, FL, 272 pp.

2. Babrauskas, V., Krasney, J. (1985) *Fire Behavior of Upholstered Furniture*, NBS Monograph 173, NBS, Gaithersburg, MD.

3. Bates, E.B. (1975), *Elements of The Fire and Arson Investigator*, Davis Publishing Co., Santa Cruz, CA, 171 pp.

4. Blackshear, P., Editor (1974), *Heat Transfer in Fires: Thermophysics, Social Aspects, Economic Impact*, Scripta Book Co., Washington, DC, 516 pp.

5. Brannigan, F., Bright, R., and Jason, N., (eds.) (1980), *Fire Investigation Handbook*, US Government Printing Office, Washington, DC.

6. Canfield, D. (1984). "Causes of Spalling Concrete at Elevated Temperatures," *The Fire and Arson Investigator*, **33** (2), pp. 30–31.

7. Cardoulis, J. (1990), *The Art and Science of Fire Investigation*, (Self-published).

8. Carroll, J. (1979), *Physical and Technical Aspects of The Fire and Arson Investigator*, Charles C. Thomas Publishers, Springfield, IL.

9. Casto, R. and Wright, C. (1984), "Open Windows and Thermal Inversion May Complicate a Fire Investigation," *The Fire and Arson Investigator*, **34** (4), pp. 14–16.

10. Cullis, C.F. and Hirschler, M.M. (1981), "The Combustion of Organic Polymers," Oxford University Press, New York, NY.

11. DeCicco, P.R. (ed.) (2002), *The Behavior of Glass and Other Materials Exposed to Fire*, Applied Fire Science in Transition, Volume 1, Baywood Publishing Co., Amityville, NY, 207 pp.

12. DeHaan, J. (1983), *Kirk's Fire Investigation*, 2nd Edition, John Wiley and Sons, Ltd., West Sussex, England, 352 pp.

13. DeHaan, J. (1987), "Are Localized Burns Proof of Flammable Liquid Accelerants?" *The Fire and Arson Investigator*, **38** (1), pp. 45–50.

14. DeHaan, J. (1991), *Kirk's Fire Investigation*, 3rd Edition, Prentice-Hall Inc., Englewood Cliffs, NJ, 416 pp.

15. DeHaan, J. (2002), *Kirk's Fire Investigation*, 5th Edition, Pearson Education, Upper Saddle River, NJ, 448 pp.

16. Drysdale, D. (1985), *An Introduction to Fire Dynamics*, 1st Edition, John Wiley & Sons, Ltd., West Sussex, England, 451 pp.

17. Ettling, B. (1990), "Will Gasoline Cause the Underside of Boards to Burn?" *The Fire and Arson Investigator*, **40** (3), pp. 32–34.

18. Fang, J. (1981), Repeatability of Large-scale Room Fire Tests, Fire Technology, **17(1)**, pp. 5–15.

19. Fire, F. (1985), "Plastics and Fire Investigations," *The Fire and Arson Investigator*, **V36** (2), pp. 27–34.

20. Fitch, R. and Porter, E. (1975), *Accidental or Incendiary*, Charles C. Thomas Publishers, Springfield, IL, 224 pp.

21. Friedman, R. (1989), *Principles of Fire Protection Chemistry*, 2nd Edition, National Fire Protection Association, Quincy, MA, 254 pp.

22. Gohar, M. (1983), "Accelerant Behavior in Fire," *The Fire and Arson Investigator*, **34** (2), pp. 29–31.

23. Gottuk, D., White, D. (2008), "Liquid Fuel Fires," *SFPE Handbook of Fire Protection Engineering*, National Fire Protection Association, Quincy MA.

24. Gudmann, J. and Dillon, B. (1988), "Multiple Seats of Fire–The Hot Gas Layer," *The Fire and Arson Investigator*, **38** (3) pp. 61–62.

25. Harmer, R., Moss, R., Noland, T., and Thaman, R. (1983), "Liquid Burn Patterns on Linoleum," *The Fire and Arson Investigator*, **33** (4), pp. 3–4.

26. Hobson, C., (1992), *Fire Investigation, A New Concept*, Charles C. Thomas Publishers, Springfield, IL, 371 pp.

27. Icove, D.J. and DeHaan, J.D. (2004), *Forensic Fire Scene Reconstruction*, Pearson Prentice Hall, Upper Saddle River, NJ, 400 pp.

28. Kennedy, J. and Kennedy, P.M. (1985), *Fires and Explosions, Determining Cause and Origin*, Investigations Institute, Chicago, IL, 1505 pp.

29. Kennedy, J. and Kennedy, P.M. (1977), *Fire-Arson Explosion Investigation*, Investigations Institute, Chicago, IL, 1163 pp.

30. Kirk, P. (1969), Fire Investigation, John Wiley and Sons Ltd., West Sussex, England.

31. Krasny, J.F., Parker, W.J., and Babrauskas, V. (2001), *Fire Behavior of Upholstered Furniture and Mattresses*, Noyes Publications, Norwich, NY, 437 pp.

32. Lie, T.T. (1972), *Fire in Buildings*, Applied Science Publishers, London, England.

33. Lentini, J. (1982), "A Documented Case of Accelerant Induced Concrete Spalling," *The Fire and Arson Investigator*, **33** (2), pp. 30–31.

34. Lentini, J. (1998), "Differentiation of asphalt and smoke condensates from liquid petroleum distillates using GC/MS," *Journal of Forensic Sciences*, **43(1)**, pp 97–113.

35. Lentini, J.J. (2006), *Scientific Protocols for Fire Investigation*, CRC Press/Taylor & Francis Group, Boca Raton, FL, 604 pp.

36. Ma, T., Olenick, S., Klassen, M., Roby, R. and Torero, J. (2004), "Burning Rate of Liquid Fuel on Carpet (Porous Media), *Fire Technology*, **40**, 227–246.

37. Mealy, C.L. and Gottuk, D.T. (2006), "A Study of Unventilated Fire Scenarios for the Advancement of Forensic Investigations of Arson Crimes," Office of Justice Programs, National Institute of Justice, Department of Justice, 98IJCXK003, Washington, DC.

38. National Fire Academy (1983), *Student Guide for Fire/Arson Detection*, National Fire Academy, Washington, DC.

39. National Fire Academy (1988), *Incendiary Fire Analysis & Investigation Course Guide*, Open Learning Fire Services Program, Washington, DC.

40. National Fire Academy (1996), *Incendiary Fire Analysis & Investigation Course Guide*, Open Learning Fire Services Program, Washington, DC.

41. NFPA 921 (1992), *Guide for Fire and Explosion Investigations*, National Fire Protection Association, Quincy, MA, 120 pp.

42. NFPA 921 (2008), *Guide for Fire and Explosion Investigations*, National Fire Protection Association, Quincy, MA, 305 pp.

43. Noon, R. (1995), *Engineering Analysis of Fires and Explosions*, CRC Press, Boca Raton, FL, 277 pp.

44. Phillipps, C. and McFadden, D. (1986), *Investigating the Fireground*, Second Edition, Fire Engineering Books & Videos, New York, NY, 275 pp.

45. Putorti, A. (2001), Flammable and Combustible Liquid Spill/Burn Patterns, NIJ Report 604–00, National Institute of Justice, Washington, DC.

46. Quintiere, J. (2006), *Fundamentals of Fire Phenomena*, John Wiley & Sons, Ltd., West Sussex, England, 460 pp.

47. Pagni, P. (2003), 2002 Howard W. Emmons Invited Plenary Lecture – Thermal Glass Breakage. *Fire Safety Science* **7**: pp 3–22.

48. Patten, A., Russell, J. (1986), Fire Litigation Sourcebook, Garland Law Publishers, New York, NY.

49. Richardson, J.K., (ed.) (2003), *History of Fire Protection Engineering*, National Fire Protection Association, Quincy, MA, 312 pp.

50. Roberts, C. (1982), "The Challenge of Black Spots," *The Fire and Arson Investigator*, **32** (3), pp. 13–18.

51. Roblee, C. and McKechnie, A. (1981), *The Investigation of Fires*, Prentice-Hall Inc, Englewood Cliffs, NJ, 209 pp.

52. Shanley, J. (1997), *USFA Fire Burn Patterns Tests*, Federal Emergency Management Agency (FEMA), Washington, D.C.

53. Smith, F. (1981), "Concrete Spalling Under Controlled Conditions," *The Fire and Arson Investigator*, **32** (2), pp. 38–39

54. Society of Fire Protection Engineers (1988), *SFPE Handbook of Fire Protection Engineering*, 1st Edition, DiNenno, P.J. (ed.), National Fire Protection Association, Quincy, MA.

55. Stauffer, E., Dolan, J., and Newman, R. (2007), *Fire Debris Analysis*, Elsevier, Inc., Oxford, UK, 672 pp.

56. Stickevers, J. (1982), "Flammable Liquids Interpretations of Burn Patterns," *The Fire and Arson Investigator*, **33** (2), pp. 24–27.

57. Stone, I. and Lomonte, J. (1984), "False Positions in Analysis of Fire Debris," *The Fire and Arson Investigator*, **34** (3), pp. 36–40.

58. Swab, S. (1983), *Incendiary Fires: A Reference Manual for Fire Investigators*, Robert Brady Company, Bowie, MD, 168 pp.

59. Taylor, R. (1985), "Carpet, Wood Floor, and Concrete Burn Patterns Often are not from Flammable Liquids…Are a Highly Misunderstood Aspect of Fire Investigations," *The Fire and Arson Investigator*, **35** (3), pp. 32–34.

60. Taylor, R. (1986), "Flammable and Combustible Liquid Characteristics in Certain Types of Fires," *The Fire and Arson Investigator*, **37** (1), pp. 45–48.

61. Tobin, W. and Monson, K. (1989), "Collapsed Spring Observations in Arson Investigations: A Critical Metallurgical Evaluation," *Fire Technology*, **25(4)**, pp 317–335.

62. Tobin, W. (1990), "What Collapsed Springs Really Tell Arson Investigators," *Fire Journal*, **84(2)**, pp 24–27.

63. Tu, M., Davis, S. (1976), "Flame Spread of Carpet Systems Involved in Room Fires," NBSIR 76-1013, National Bureau of Standards, Washington, DC.

64. Tuve, R. (1976), *Principles of Fire Protection Chemistry*, National Fire Protection Association, Quincy, MA.

65. Wolfe, A. J., Mealy, C.L. and Gottuk, D. T. (2009), Fire Dynamics and Forensic Analysis of Limited Ventilation Compartment Fires – Volume 1: Experimental. Office of Justice Programs, National Institute of Justice, Department of Justice, Washington, DC.

66. Zicherman, J. and Allard, D. (1989), "PU Dominant for a Decade," *The Fire and Arson Investigator*, **40** (2).

Appendix A

CRAIG L. BEYLER, Ph.D., Technical Director

EDUCATION:

Ph.D. in Engineering Science, Harvard University, 1983
M.S. in Mechanical Engineering, Cornell University, 1980
M.Sc. in Fire Safety Engineering, University of Edinburgh, 1978
B.S. in Fire Protection Engineering, University of Maryland, 1976
B.S. in Civil Engineering, Cornell University, 1975

PROFESSIONAL EXPERIENCE:

Technical Director, Hughes Associates, Inc., 1990–present. Responsible for technical quality of fire protection design, research, and development projects and professional development of engineering staff. Project manager for a variety of fire protection R&D/T&E programs. Development and use of analytical methods in fire dynamics, fire chemistry, fire detection, fire suppression, smoke and heat venting. Development of mathematical fire models and modeling techniques for specialized applications, including zone and field models. Risk and hazard analysis for a wide range of specialized applications.

Principal, Fire Science Technologies, 1987–1990. Development of compartment fire models including computer-based models and simple correlationally-based models for ships and buildings. Preparation and presentation of a five-day short course for the HAZARD I hazard analysis package. Litigation support for a range of fire situations.

Assistant Professor of Fire Protection Engineering and Mechanical Engineering, Worcester Polytechnic Institute, 1985–1987. Taught graduate courses in Combustion, Fire Dynamics, and Fire Chemistry. Advised MS thesis work for FPE graduate students. Research in fire dynamics including compartment fire growth, smoke movement, pool fire radiation as well as fault tree approaches to link fire growth predictions to performance based fire safety objectives. Chaired a committee to totally restructure the graduate courses in the FPE degree programs and instituted an ongoing seminar program.

Visiting Scientist, Fire Research Station at Borehamwood, England, 1984–1985. Conducted experimental and theoretical investigations of piloted ignition of solid fuels. Prepared a review paper of the state-of-the-art of knowledge of plume and ceiling jet flows.

Postdoctoral Fellow, Harvard University, 1983–1984. Conducted an extensive experimental program to study the effect of oxygen starvation effects on the generation of projects of combustion, especially carbon monoxide, in a compartment fire environment. Experimental and theoretical studies of hot layer ignition in compartment fires.

Research Associate, Department of Fire Protection Engineering, University of Maryland, 1976–1977.

Engineer (part-time), Center for Fire Research, National Bureau of Standards, 1975–1976.

Security Clearance: DOD Top Secret
DOE "Q" (inactive)

PROFESSIONAL STANDING:

Committees, Boards, and Panels:
International Association for Fire Safety Science
Chairman, International Association for Fire Safety Science, 2005–present
Vice Chair, International Association for Fire Safety Science, 2002–2005

PROFESSIONAL STANDING (Continued):

Program Committee Chair, International Association for Fire Safety Science–8th International Symposium, 2003–2005
Program Committee, International Association for Fire Safety Science–7th International Symposium, 2001–2002
Awards Committee, International Association for Fire Safety Science–4th and 5th International Symposia

Society of Fire Protection Engineers
Member, SFPE Technical Steering Committee, 1998–present
Chair, SFPE Task Group on Engineering Practices: Radiation from Fires, 1996–present
Chair, SFPE Task Group on Engineering Practices, 1996–1998
Member, Research Committee, Society of Fire Protection Engineers, 1988–1995
Member, Engineering Education Committee, Society of Fire Protection Engineers, 1983–1995

National Fire Protection Association
Toxicity Technical Advisory Committee, National Fire Protection Association, 2002–present
Member, Guide for Fire and Explosive Investigations, NFPA 921, 1998–present
Task Group for NFPA 204: Guide for Smoke and Heat Venting, 1996–present
Alternate Member, Smoke Management Systems, National Fire Protection Association, 1996–present
Task Group for NFPA 92B: Guide for Smoke Management in Malls, Atria, and Large Spaces, 1992–present
Member, Contents and Furnishings Committee, National Fire Protection Association, 1992–present
Member, Subcommittee on Fire Detection Design Methods, 72 EM, National Fire Protection Association, 1983–1988

Academic Advisory Boards
Advisory Board, University of Maryland, Dept. of Fire Protection Engineering, 2003–present
Advisory Board, Worcester Polytechnic Institute, Center for Firesafety Studies, 2000–2008
Industrial Advisory Board, Oklahoma State University, Fire Protection and Safety Engineering Technology Department, 1998–2006

Government Evaluation Boards
Panel Member, Board on Assessment of NIST Programs, National Research Council, 1999 to 2005
National Academy of Science, Committee to Identify Innovative Research Needs to Foster Improved Fire Safety in the US, 2001–2002

Society Memberships:
Member, National Fire Protection Association, 1987–present
Member, International Association for Fire Safety Science, 1985–present
Member, Society of Fire Protection Engineers, 1983–present
Member, Combustion Institute, 1980–present
Member, Salamander Honorary Fire Protection Engineering Society, 1977–present

Technical Journals and Books:
Founding Editor, *Journal of Fire Protection Engineering*, 1988–1992

PROFESSIONAL STANDING (Continued):

Associate Editor, *Fire Technology*, 2009–present
Member, Editorial Advisory Board, *Fire Safety Journal*, 2004–present
Member, Editorial Advisory Board, *Journal of Fire Protection Engineering*, Society of Fire Protection Engineers, 1992–present
Member, Editorial Advisory Board, *Fire Technology*, 1984–present

Co-editor, *SFPE Handbook of Fire Protection Engineering*, 1st, 2nd, and 3rd editions, 1984–present
Reviewer, *Combustion and Flame*, *Fire Safety Journal*, *Journal of Fire Science*, *Fire and Materials*, *IAFSS International Symposia*, *Combustion Institute International Symposia*

Honors:
Rasbash Medal, Institution of Fire Engineers, 2009
Arthur B. Guise Medal, Society of Fire Protection Engineers, 2000
Harold E. Nelson Service Award, Society of Fire Protection Engineers, 2005
Fellow, Society of Fire Protection Engineers, 1999
Hat's Off Award, Society of Fire Protection Engineers, 1995
Jack Bono Engineering Communications Award, with Curt Ewing and Homer Carhart, 1995
Special Commendation Award, Society of Fire Protection Engineers, 1995
Special Commendation Award, Society of Fire Protection Engineers, 1993
President's Award, Society of Fire Protection Engineers, 1990
Director's Award, Society of Fire Protection Engineers, 1989

Patents:
Multi-signature Fire Detection, Roby, R.J., Gottuk, D., Beyler, C., Patent Number 5,691,703, November 25, 1997.

3/09

SELECTED PUBLICATIONS LIST

Craig L. Beyler, Ph.D.

Swann, J.H., Hartman, J.R. and Beyler, C.L., "Study of Radiant Smoldering Ignition of Plywood Subjected to Prolonged Heating Using the Cone Calorimeter, TGA, and DSC," *Fire Safety Science – Proceedings of the 9th International Symposium*, International Association of Fire Safety Science, Karlsruhe, Germany, September 21–26, 2008, pp. 155–166.

Trelles, J., Beyler, C.L., Floyd, J.E., Scheffey, J.L., and Yee, K., "Fire and Smoke Spread Modeling to Support Damage Control Assessment and Decision Making in Shipboard Environments," *Proceedings of the American Safety of Naval Engineers Automation and Control Conference*, Biloxi, MS, December 11, 2007.

Beyler, C.L. and Gottuk, D.T., "Development of a Technical Basis for Carbon Monoxide Detector Siting," The Fire Protection Research Foundation, Quincy, MA, October 2007.

Beyler, C.L. and Gratkowski, M.T., "Low-Voltage (14VAC) Electrical Circuit Fire Initiation," *ISFI 2006 Proceedings Addendum*, International Symposium on Fire Investigation Science and Technology, Cincinnati, OH, June 26–28, 2006, pp. 15–23.

Beyler, C.L., Gratkowski, M.T., and Sikorski, J., "Radiant Smoldering Ignition of Virgin Plywood and Plywood Subjected to Prolonged Heating," *ISFI 2006 Proceedings Addendum*, International Symposium on Fire Investigation Science and Technology, Cincinnati, OH, June 26–28, 2006, pp. 3–14.

Beyler, C., "Self-heating properties of styrene-butadiene rubber," *Fire and Materials*, **30** (3), May/June 2006, pp. 215–222.

Beyler, C.L., Fay, T., Gratkowski, M., Campbell, B., and Hartman, J.R., "Ignition studies of cerium nitrate treated towels," *Fire and Materials*, **30** (3), May/June 2006, pp. 223–240.

Gratkowski, M.T., Dembsey N.A., and Beyler, C.L., "Radiant smoldering ignition of plywood," *Fire Safety Journal*, **41**, May 2006, pp 427–443.

Beyler, C., "A brief history of the prediction of flame extinction based upon flame temperature," *Fire and Materials*, **29** (6), September 2005, pp. 425–427.

Beyler, C., "Toxicity Assessment of Products of Combustion of Flexible Polyurethane Foam," *Fire Safety Science – Proceedings of the 8th International Symposium*, Gottuk, D. and Lattimer, B. (eds.), International Association of Fire Safety Science, Beijing, China, September 2005, pp. 1047–1058.

Lattimer, B. and Beyler, C., "Heat Release Rates of Fully-developed Fires in Railcars," *Fire Safety Science – Proceedings of the 8th International Symposium*, Gottuk, D. and Lattimer, B. (eds.), International Association of Fire Safety Science, Beijing, China, September 2005, pp. 1169–1180.

Beyler, C., "Relationship Between Structural Fire Protection Design and Other Elements of Fire Safety Design," *NET-SFPE Workshop for Development of a National R&D Roadmap for Structural Fire Safety Design and Retrofit of Structures: Proceedings*, Almand, K.H. and Phan, L.T. (eds.), NISTIR 7133, National Institute for Standards and Technology, Gaithersburg MD, 2004, pp. 100–106.

Lattimer, B.Y., Hunt, S.P., Wright, M.T., and Beyler, C., "Corner Fire Growth in a Room with a Combustible Lining," *Fire Safety Science–Proceedings of the Seventh International Symposium – June 16-21, 2002*, Evans, D. (ed.), International Association for Fire Safety Science, 2003, pp. 419–430.

Beyler, C., White, D., Peatross, M., Trellis, J., Li, Sonny, Luers, A., and Hopkins, D., "Assessment of the Fire Exposure in the Airplane Impact Areas of the Two World Trade Center Towers," *Design Structures for Fire – Structural Forensic Conference held September 30 - October 1, 2003 at the Radisson Plaza Lord Baltimore*, Society of Fire Protection Engineers, Bethesda, MD, 2003, pp. 65–74.

Gottuk, D., Peatross, M., Roby, R., and Beyler, C., "Advanced Fire Detection Using Multi-Signature Alarm Algorithms," *Fire Safety Journal,* **37**, 2002, pp. 381–394.

Reneke, P., Peatross, M., Jones, W., Beyler, C., and Richards, R., "A Comparison of CFAST Predictions to USCG Real-Scale Fire Tests," *Journal of Fire Protection Engineering*, **11** (1), 2001, pp. 43–68.

Beyler, C.L., "Fire Safety Challenges in the 21st Century," *Journal of Fire Protection Engineering*, **11** (1), 2001, pp. 4–15.

Beyler, C.L., and Cooper, L.Y., "Interaction of Sprinklers with Smoke and Heat Vents," *Fire Technology*, **37** (1), 2001, pp. 9–35.

Forssell, E.W., Back, G.G., Beyler, C.L., DiNenno, P.J., Hansen, R., and Beene, D., "An Evaluation of the International Maritime Organization's Gaseous Agents Test Protocol," *Fire Technology*, **37** (1), 2001, pp. 37–67.

Back, G.G., Beyler, C.L., and Hansen, R., "The Capabilities and Limitations of Total Flooding Water Mist Fire Suppression Systems in Machinery Space Applications," *Fire Technology*, **36** (1), 2000, pp. 8–23.

White, D.A., Beyler, C.L., Williams, F.W., and Tatem, PA., "Modeling Missile Propellant Fires in Shipboard Compartments," *Fire Safety Journal*, **34**, 2000, pp. 321–341.

Back, G.G., Beyler, C.L., and Hansen, R., "Quasi-Steady-State Model for Predicting Fire Suppression in Spaces Protected by Water Mist Systems," *Fire Safety Journal*, **35** (4), November 2000, pp. 327–362.

White, D., Beyler, C.L., Fulper, C., and Leonard, J., "Flame Spread on Aviation Fuels," *Fire Safety Journal*, **28**, 1997, pp. 1–31.

Beyler, C.L., Hunt, S.P, and Iqbal, N., "A Computer Model of Upward Flame Spread on Vertical Surfaces," *Fire Safety Science–Proceedings of the Fifth International Symposium*, Y. Hasemi (ed.), International Association for Fire Safety Science, London, England, March 1997, pp. 297–308.

Peatross, M.J. and Beyler, C.L., "Ventilation Effects on Compartment Fire Characterization," *Fire Safety Science–Proceedings of the Fifth International Symposium*, Y. Hasemi (ed.), International Association for Fire Safety Science, London, England, March 1997, pp. 403–414.

Beyler, C.L., "Flammability Limits of Premixed and Diffusion Flames," *SFPE Handbook of Fire Protection Engineering*, Second Edition, NFPA, Quincy, MA, Chapter 2-9, 1995, pp. 2-147–2-159, (First Edition, 1988, Chapter 1-17, pp. 1-286–1-297.)

Beyler, C.L. and Hirschler, M.M., "Thermal Decomposition of Polymers," *SFPE Handbook of Fire Protection Engineering*, Second Edition, NFPA, Quincy, MA, Chapter 1-7, 1995, pp. 1-99 - 1-119, (First Edition, Beyler (sole author), Chapter 1-12, 1988, pp. 1-165–1-178.)

Gottuk, D.T., Roby, R.J., and Beyler, C.L., "The Role of Temperature on Carbon Monoxide Production in Compartment Fires," *Fire Safety Journal*, **24**, June 1995, pp. 315–331.

Back, G., Beyler, C., Tatem, P, and DiNenno, P, "Wall Incident Heat Flux Distributions Resulting from an Adjacent Fire," *Fire Safety Science–Proceedings of the Fourth International Symposium*, International Association of Fire Safety Science, Boston, MA, 1994, pp. 241–252.

Ewing, C.T., Beyler, C.L., and Carhart, H.W., "Extinguishment of Class B Flames by Thermal Mechanisms; Principles Underlying a Comprehensive Theory; Prediction of Flame Extinguishing Effectiveness," *Journal of Fire Protection Engineering*, **6** (1), 1994, pp. 23–54.

Peatross, M.J., and Beyler, C.L., "Thermal Environment Prediction in Steel-Bounded Preflashover Compartment Fires," *Fire Safety Science–Proceedings of the Fourth International Symposium*, International Association of Fire Safety Science, Boston, MA, 1994, pp. 205–216.

Gottuk, D.T., Roby, R.J., and Beyler, C.L., "A Study of Carbon Monoxide and Smoke Yields from Compartment Fires," *Twenty-fourth Symposium (International) on Combustion*, The Combustion Institute, Pittsburgh, PA., 1993.

Beyler, C.L., "A Unified Model of Fire Suppression," *Journal of Fire Protection Engineering*, **4** (1), 1992, pp. 5-16.

DiNenno, P.J. and Beyler, C.L., "Fire Hazard Assessment of Composite Materials: The Use and Limitations of Current Hazard Analysis Methodology," *Fire Hazard and Fire Risk Assessment, ASTM STP 1150*, Marcelo H. Hirschler (ed.), American Society for Testing and Materials, Philadelphia, PA, 1992, pp. 87–99.

Gottuk, D.T., Roby, R.J., Peatross, M.J., and Beyler, C.L., "Carbon Monoxide Production in Compartment Fires," *Journal of Fire Protection Engineering*, **4** (4), 1992.

Beyler, C.L., "Analysis of Compartment Fires with Overhead Forced Ventilation," *Fire Safety Science–Proceedings from the Third International Symposium*, Elsevier Applied Science, NY, 1991, pp. 291–300.

Fitzgerald, R.W., Richards, R.C., and Beyler, C.L., "Firesafety Analysis of Polar Icebreaker Replacement Design," *Journal of Fire Protection Engineering*, **3** (4), 1991, pp. 137–150.

Skelly, M.J., Roby, R.J., and Beyler, C.L., "An Experimental Investigation of Glass Breakage in Compartment Fires," *Journal of Fire Protection Engineering*, **3** (1), 1991, pp. 25–34.

Deal, S. and Beyler, C.L., "Correlating Preflashover Room Fire Temperatures," *Journal of Fire Protection Engineering*, **2** (2), 1990, pp. 33–48.

Shanley, J., and Beyler, C.L., "Horizontal Vent Flow Modeling with Helium and Air," *Second International Symposium on Fire Safety Science*, Hemisphere Publishing Co., 1989, pp. 305–314.

Shokri, M. and Beyler, C.L., "Radiation from Large Pool Fires," *Journal of Fire Protection Engineering*, **1** (4), 1989, pp. 141–149.

Thomson, H.E., Drysdale, D.D., and Beyler, C.L., "An Experimental Evaluation of Critical Surface Temperature as a Criterion for Piloted Ignition of Solid Fuels," *Fire Safety Journal*, **13**, 1988, p. 185.

Beyler, C.L., "Fire Plumes and Ceiling Jets," *Fire Safety Journal*, **11**, 1986, p. 53.

Beyler, C.L., "Major Species Production by Diffusion Flames in a Two Layer Compartment Fire Environment," *Fire Safety Journal*, **10**, 1986, p. 47.

Beyler, C.L., "Major Species Production by Solid Fuels in a Two Layer Compartment Fire Environment," *First International Symposium on Fire Safety Science*, Hemisphere Publishing Co., 1986, p. 431.

Beyler, C.L., "A Design Method for Flaming Fire Detection," *Fire Technology*, **20** (4), 1984, p. 5.

Beyler, C.L., "Ignition and Burning of a Layer of Incomplete Combustion Products," *Combustion Science and Technology*, **39**, 1984, p. 287.

Beyler, C.L. and Gouldin, F.C., "Flame Structure in a Swirl Stabilized Combustor Inferred by Radiant Emission Measurements," *Eighteenth Symposium (International) on Combustion*, The Combustion Institute, Pittsburgh, PA, 1981, p. 1011.

Beyler, C.L., "An Evaluation of Sprinkler Discharge Calculation Methods," *Fire Technology*, **13** (3), 1977, p. 185.