



A firefighter encounters “flashover” during a training session in San Francisco, Calif.
AP Photo/ Steve Helbert



SCIENCE TRUMPS ART in FIRE INVESTIGATION

BY STEVEN W. CARMAN

In recent years, the legal and forensic science communities have focused on the state of expertise among fire investigators. Reviews of several fire-related criminal convictions have demonstrated that while the field of fire investigation has evolved considerably in the past 20 years, some investigators continue to base their conclusions on non-scientific principles in both criminal and civil cases.

For many years, the adage has been that fire investigation is a mixture of “art and science.” For many investigators, the identification and interpretation of burn patterns was the “art” of the profession. During the past 20 years, a significant shift has occurred. Today, there is a greater emphasis on fire science and engineering than ever before. While some investigators insist they regularly relied on science, the reality was that non-scientific myths and legends were often used. Burn patterns are still examined and analyzed, but the information used to decipher their significance is, more than ever before, based on provable scientific principles.

Most forensic science professionals working in specialty areas, such as DNA, serology, trace analysis, and similar specialties, are college-trained scientists. Historically, most fire investigators have come from the ranks of firefighters or law enforcement officers and would not be considered scientists, *per se*. In a 2000 survey of fire investigators conducted by the National Center for Forensic Sciences' Technical Working Group for Fires and Explosions (TWGFEX), the following statistics were gathered from 422 respondents: 67 percent had no college degree, 23 percent had a 'general' degree, and 10 percent had a science-related degree.^{1,2} The survey was sent to more than 1,400 investigators. How these percentages varied for the non-responding investigators is unknown. In the past decade, the number of fire investigators with formal scientific/engineering education may have increased somewhat, but still not to the levels of forensic investigators in other specialty fields.

Anecdotal information from the fire service suggests the practice of fire investigation was originally developed to bring arsonists to justice and to determine the causes of accidental fires to prevent their recurrence. To these ends, investigators have often relied upon available witness accounts along with examination of physical artifacts, such as trace evidence, gasoline cans, burn patterns, etc. Of the physical evidence remaining after a fire, it is burn pattern analysis that investigators most often use to support their conclusions of fire origin and cause.

Since the 1960s, while many fire scene investigators refined their art, more college-trained scientists began studying the physics, chemistry, thermodynamics, and fluid dynamics principles involved in fire behavior. This latter group became the workforce in organizations such as the National Institute of Science and Technology (NIST, formerly the National Bureau of Standards) and various academic and commercial entities involved in the technical aspects of fire and fire protection. These two groups often had little interaction.

Throughout the 1970s and 1980s, fire investigator organizations and associations became more prevalent and often focused their efforts on providing improved training. Investigator participation in these associations was — and still is — often voluntary and sporadic. Some fire and law enforcement organizations participated eagerly, others much less so.

Over the years, several attempts have been made to standardize and improve the profession. Government agencies and various investigative associations offered guidance and procedures for the scene investigator to follow. Until the early 1990s, much of this information was often based on anecdotal guidelines and not on hard science. Occasionally, these principles included information that is now known as "myths" of fire investigations.

These guidelines involved interpretations of burn artifacts, such as the alligator-like appearance of wood char, spalling of concrete, crazed cracking of glass, and the collapse or annealing of steel springs. The presence of such evidence was believed to be indicative of arson. Other myths involved claims of "flammable liquid pour patterns," "hot and fast fires," and "unusual, low level burning." This faulty evidence often formed the foun-



Investigators confer at a crime scene in Tyler.
AP Photo/Mike Fuentes



ation of criminal allegations. Few of these concepts were derived from rigorous scientific research. Even so, investigators often relied on them — and in some cases still do — to justify their conclusions.

For years, both civil and criminal proceedings have incorporated opinions from fire investigation experts who were trained in the lore of these myths and legends. Such theories were often justified and allowed into courts based on their level of general acceptance in the profession. Historically, when fire investigator training was loosely based on an apprenticeship model of elders teaching newcomers, such general acceptance was understandable. Gradually that practice has shifted toward science-based instruction of new investigators.

In 1992, the National Fire Protection Association (NFPA) published the first edition of NFPA 921, *Guide for Fire and Explosion Investigations*, which presented information accepted by consensus of a group of fire investigators, scientists, and others as germane to the profession. Initially, dissent against the guidelines of NFPA 921 reverberated throughout the fire investigation community. The degree of acceptance of its precepts varied greatly among investigators. Many individuals and organizations expressed lockstep resistance to the new guidelines. Over time, NFPA 921's general recognition by the investigation community as a source of sound guidance (and, in some cases, as a standard of care) has become more widespread.

Since the release of the first edition of NFPA 921 nearly 20 years ago, several newer versions have been published — the most recent being the 2011 edition. Each has incorporated additions and changes suggested by those in the investigation community and ultimately approved by voting members of the NFPA. From the beginning, the principal theme of NFPA 921 has been and continues to be that fire investigations must be based upon adherence to the scientific method.

The scientific method necessitates that investigators collect information, analyze it, propose hypothetical reasons for where and how a fire started, and test or evaluate those hypotheses. It is the author's opinion that the most common failure by investigators to meet these requirements is through the improper or insufficient evaluation of their theories. Attorneys and judges should pay particular attention to whether and how investigators have complied with this obligation.

Several legal decisions in the past two decades have induced changes in the fire investigation profession, in particular as related to expert testimony. Decisions like *Daubert v. Merrell Dow Pharmaceuticals*, *Michigan Millers Mutual Insurance Company v. Janelle R. Benfield*, and *Kuhmo Tire Co. v. Carmichael* have forced the overall sway of the profession toward a more scientific orientation.

In the early 1990s, the Bureau of Alcohol, Tobacco, Firearms, and Explosives (ATF), the agency tasked with investigating fires in federal jurisdiction, began certifying its special agent fire investigators. Previously, fire investigator certification programs were rare. Now, organizations such as the International Association of Arson Investigators (IAAI) and the

National Association of Fire Investigators (NAFI) offer investigator certification programs, some of which are nationally accredited and promote standardized training to achieve those certifications.

Despite the prevalence of such certification programs, most fire and law enforcement managers, insurance company supervisors, and even some attorneys do not *require* their fire investigators to be certified. The unfortunate reality is that many are unaware of the large gaps between the certification guidelines and the skill and knowledge levels of their investigators. Acceptance of newer guidelines and the dedication to embrace them has largely remained voluntary.

Some blame economic pressures for the loss of funding needed to maintain adequate investigator training. Fortunately, high-quality training is available for free to any fire investigator with Internet access. The IAAI's online training platform, **CFITrainer.net**, offers more than 25 testable training modules that cover many of the basic and advanced topics crucial to all fire investigators. Additionally, many texts, references, and other training materials are available at reasonable prices.

While there have been significant improvements in investigator training and education, public managers, insurers, attorneys, and judges are challenged with knowing whether a particular investigator's conclusions are the result of proper

techniques and sound science. Although today's investigators are, as a whole, better trained than ever before, some still adhere to unsound practices and beliefs.

The minimum prerequisite knowledge for investigators can be found in the NFPA's *Standard for Professional Qualifications for Fire Investigator*, NFPA 1033. Among other things, the standard (which, if adopted by local jurisdictions, carries the force of law) lists several subjects in which fire investigators must maintain currency. Sections 1.3.7 and 1.3.8 of the 2009 edition state:

1.3.7* The fire investigator *shall* remain current with investigation methodology, fire protection technology, and code requirements by attending workshops and seminars and/or through professional publications and journals.

1.3.8* The investigator *shall* have and maintain at a minimum an up-to-date basic knowledge of the following topics beyond the high school level at a post-secondary certification level:

- (1) Fire science;
- (2) Fire chemistry;
- (3) Thermodynamics;
- (4) Thermometry;
- (5) Fire dynamics;
- (6) Explosion dynamics;
- (7) Computer fire modeling;
- (8) Fire investigation;
- (9) Fire analysis;
- (10) Fire investigation methodology;
- (11) Fire investigation technology;
- (12) Hazardous materials; and
- (13) Failure analysis and analytical tools.

Every reputable fire investigation training organization is familiar with these requirements and now tailors its training to assist investigators in meeting these standards.

While legal decisions, improved knowledge, and standardized practices have directly led to improvements in the profession, significant challenges remain. Unlike most "crime scenes," fire events almost always result in evidence either disturbed by first responders or damaged by the fire. The more severe the damage, the more difficult it can be for investigators to reach an accurate origin and cause determination.

One area of fire investigation that continues to challenge the profession involves fully involved compartment fires that have burned beyond a phase known as "flashover," which occurs when gases from burning material become so hot that they ignite. Accurate interpretation of the severe damage following such fires can be daunting, making origin determination difficult even for the most talented investigator. There is probably no greater threat of incorrect origin and cause determinations than from the investigation of such incidents.

At a 2005 fire training conference in Las Vegas, Nev., the author and other fire investigators from ATF designed and pre-

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sented a seminar on the science of fire behavior. As part of the training, two identical, one-room compartments (burn cells) measuring 12-feet by 14-feet were burned. The fires were ignited similarly but in different locations and allowed to burn for seven minutes. Each fire reached flashover about halfway through the test. The exercises were akin to comparable training presented by ATF at the Federal Law Enforcement Training Center (FLETC) in Glynco, Ga.

Fifty-three fire investigators/students who had not observed the fires were later asked to briefly walk through the burn cells and decide in which quadrant of each cell they thought the fires had started. These assessments were brief and not expected to produce precise origin determinations. Even so, only three of 53 investigators/students correctly identified the correct quadrant of fire origin in each cell, a success rate of 5.7 percent. A review of similar FLETC exercises revealed comparable difficulty in identifying the origins in post-flashover fires. There, success rates were typically less than 10 percent of all students. Since then, several efforts have been made to improve these numbers through more thorough training. The challenges posed by post-flashover fire scenes are slowly but steadily being met.^{3,4}

While results such as these may seem disheartening, improvements continue throughout the profession. The biggest

impetus to change will undoubtedly be when managers and employers either voluntarily choose or are forced to require their investigators to meet minimum qualifications. This, along with improved awareness of the potential problems associated with untrained investigators, will lead to further reductions in the threat from incorrect fire cause determinations.

NOTES

1. Minnich, Tom and McCardle, J. Ron., "Forensic Investigation: Fire, Arson, Explosion Scenes, and Devices," *Interfire Online* website, www.interfire.org/features/NCFS_overview.asp.
2. Website of the TWGFEX Survey, http://ncfs.ucf.edu/twgfex/docs/Scene+Survey+Results+Report.pdf.
3. Carman, Steven W., "Improving the Understanding of Post-flashover Fire Behavior," *Proceedings of the International Symposium on Fire Investigation Science and Technology*, 2008, Sarasota, Fla.
4. Carman, Steven W., "Progressive Burn Pattern Development in Post-flashover Fires," *Proceedings of Fire and Materials*, 2009, Interscience Communications, London, UK.



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