FISC Bulletin Board
IAAI Fire Investigation Standards Committee (FISC)
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NFPA 1033 List of 16 Part 2: Understanding Topics 5 to 8

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This submission of the FISC Bulletin Board will continue to address the topics listed in NFPA 1033 Section 1.3.7. The first article in this series was published in the January 2018 F&AI Journal and is available to IAAI members on the IAAI website at this URL: https://www.firearson.com/Publications-Resources/Fire-Arson-Investigation-Journal/Default.aspx (sign in required).

The intent of the FISC Committee is to provide the reader with resources to gain the requisite knowledge, and the ability to better articulate that knowledge, of the topics listed in NFPA 1033 Section 1.3.7 "beyond the high school level." Any opinions expressed in this series are those of the FISC and do not necessarily reflect the opinions of the National Fire Protection Association, the NFPA Technical Committee on Fire Investigations, the NFPA Technical Committee on Fire Investigator Professional Qualifications or the International Association of Arson Investigators, Inc.

NFPA 1033, as a Standard, requires that "The fire investigator shall remain current in the topics listed in section 1.3.7 by attending formal education courses, workshops and seminars and/or through professional publication and journals".[1] A competent fire investigator must be able to properly apply their knowledge, explain how that knowledge was applied to a set of facts (or to hypothetical situations), and articulate their work in a litigation setting. With that in mind, let us continue with discussion on topics 5 through 8.

(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
(13) Failure analysis and analytical tools
(14) Fire protection systems
(15) Evidence documentation, collection, and preservation
(16) Electricity and electrical systems

5) Fire Dynamics

Fire Dynamics is defined as "the detailed study of how chemistry, fire science and the engineering disciplines of fluid mechanics and heat transfer interact to influence fire behavior."

Essentially, fire dynamics is the study of all fire behaviors, with an emphasis on how fire interacts with its surroundings. The fire investigator should be aware that Fire Dynamics is, perhaps, the most important topic of those topics listed in section 1.3.7. Fire dynamics will be used to explain the formation of the fire patterns used in the Origin Determination process. Fire dynamics will also serve as the foundation in analyzing fire spread and the data used to develop and evaluate origin hypotheses.[2] NFPA 921 Chapter 5 discusses the fire science principles related to fire dynamics. NFPA 921 Chapter 6 discusses principles related to fire pattern development.

Fire spread analysis is a fundamental piece of the proper use of the Scientific Method, as it relates to fire origin determination. The origin hypothesis must be consistent with the resulting growth and spread of the fire. Principles of fire dynamics will be used to evaluate data such as the availability of oxygen at the hypothesized area of origin, the identification of all potential fuels within the hypothesized area of origin, the effect of ventilation on the growth and development of the fire, the analysis of subsequent fuel package involvement, the analysis of the resulting fire patterns, and the analysis of the competency of potential ignition sources within the hypothesized area of origin.[3] NFPA 921 Section 18.2.1.1 and Section 18.4.7 are two important references regarding the use of fire dynamics in the origin determination process. The application and use of fire dynamics principles in the Failure Analysis process is also discussed in NFPA 921 Section 22.4.8. Finally, the following CFI Trainer modules contain information on fire dynamics: "Post Flashover Fires" and "Impact of Ventilation on Building Structures on Fire Development".

6) Explosion Dynamics

Explosion Dynamics is defined as "The study of how chemistry, physics, fire science, engineering disciplines of fluid and solid mechanics, and heat transfer interact to influence explosion behavior."[4] Explosion dynamics is used to assist in determining the area of origin for the explosion by identifying the explosion force vectors that plot the path of explosion damage. The proper application of explosion dynamics

principles will also aid in determining the fuel source, ignition source, and determining the manner and method of how the fuel and ignition source came together within that area of origin. [5]

As with a fire investigation, the first priority for the investigator at an explosion incident will be to secure the scene."[6] Securing the site in a timely manner will prevent unauthorized persons from entering the scene and possibly compromising evidence. The initial perimeter should be established at 1 ½ times the distance from the farthest piece of debris evidence found. Securing this perimeter will also serve as a means to prevent injury to those entering an unsafe area.[7]

The analysis of the origin and cause of explosions is a complex and technical task.[8] The complexity of the explosion incident is often compounded by the fact that the initial event (blast) causes extensive damage, but there can be subsequent ignition of flammable vapors that result in significant fire damage…sometimes to the detriment of the evidence of the original explosion.[9] For that reason, the fire investigator should have a solid working knowledge of the material detailed in NFPA 921 Chapter 23. This information includes discussions on the types of explosions, characterization of explosion damage, explosion effects, explosion investigation process, and comprehensive discussion of dust explosions. A module titled "Explosion Dynamics" can also be found on CFI Trainer.

7) Computer Fire Modeling

The inclusion of the topic of Computer Fire Modeling in Section 1.3.7 has caused some confusion within the fire investigation community. There is no requirement within NFPA 1033 that a fire investigator have the knowledge and capability to prepare and conduct a computer model of a fire incident. But there are several reasons why the fire investigator should be familiar with the concepts of a computer fire model.

Dr. Vytenis Babrauskas defines Computer Fire Models as "the prediction of fire characteristics by the use of a mathematical method which is expressed as a computer program."[10] NFPA 921 discusses Mathematical Modeling of fire scenarios in Section 22.4. NFPA 921 states "Mathematical models are intended to simulate or predict real-world phenomena using scientific principles and empirical data."[11] It is important to note that the use of mathematical models in fire analysis has been in use for decades. The widespread use of computers capable of running complex mathematical formulas has made the use of computer fire models much more prevalent.

Fire investigators should understand that the computer and mathematical models are not evidence or proof of a fact, but they are a tool. Professor Greg Gorbett, Eastern Kentucky University, has written extensively about computer fire models. He states "Due to the recent increase in the use of computer fire models for fire investigations, it is imperative that all investigators are aware of the models' capabilities, assumptions, appropriate uses, and limitations. Currently it is an underutilized tool in the fire investigation and analysis profession. Not every case will warrant the use of this tool during an investigators' analysis, but all investigators need to begin collecting the data required at the scene to ensure that if the need arises they have adequately collected the important data. As an analogy, not many investigators can use a GC/MS, but most are aware of the appropriate collection and preservation methods to ensure that samples can be sent into the laboratory for fire debris analysis. The same methodology and knowledge should be passed onto those investigators in the field. The use of modeling should be supported by the investigation community, but should also be constantly monitored to ensure its proper and objective use."[12]

Detailed information regarding the appropriate use and limitations of a computer fire model can be found in NFPA 921 Sec. 22.4. There are two modules on this topic found in CFITrainer; "Introduction to Fire Dynamics and Modeling" and "Fire Dynamics Calculations Version 2.0". Detailed discussions of the technical and practical aspects of computer fire modeling can be found in the following papers:

> Babrauskas, Dr. Vytenis. 1997. "Fire Modeling: An Introduction for Attorneys"
>
> Gorbett, G.E. 2008. "Computer Fire Models for Fire Investigation and Reconstruction".
>
> *International Symposium on Fire Investigation Science and Technology,* 23–34. Google Scholar

8) Fire Investigation

NFPA 921 defines Fire Investigation as: *"The process of determining the origin, cause and development of a fire or explosion".*[13]

In NFPA 921 Chapter 4 – Basic Methodology – 4.1 Nature of Fire Investigations goes further to say, *"A fire or explosion investigation is a complex endeavour involving skill, technology, knowledge and science. The compilation of factual data, as well as an analysis of those facts, should be accomplished objectively, truthfully, and without expectation bias, preconception, or prejudice."*[13]

It is highly recommended that a systematic approach be undertaken during the conduct of the investigation and in that case the *"Scientific Method"* should be utilised, which is the method used in the physical sciences, and is a principle of inquiry that forms a basis for legitimate scientific and engineering processes, including fire incident investigation. NFPA 1033 states *"The fire investigator shall employ all elements of the scientific method as the operating analytical process throughout the investigation and for the drawing of conclusions".* [14]

According to Kirk's Fire Investigation (Icove & Haynes, 8th Edition 2018) Fire investigation is often called a *"Fire Origin and Cause"* (O&C) investigation; as it is essential that the origin is determined and once there, a cause defined. Investigators need to strive to determine what circumstances caused or contributed to the incident. Because fire often destroys evidence, or may distort it in some way, a fire investigation is one of the most difficult of the forensic sciences to practice.[15]

In accordance with NFPA 1033 the investigator is required to conduct the investigation in accordance with local laws, and regulations applicable to the incident scene.[16] and if a 'team' is required to investigate the incident (owing to the fire scene size) the investigator needs to be able to understand

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the organization and operation of the team within an incident management system.[17]

Fire investigators must follow a basic set of protocols that define the approach that should be taken when undertaking a scene inspection and fire investigation. (These should be covered, later, in Section (10) Fire Investigation Methodology).[17]

The safety of the individual investigator is paramount and the question could be posed *"If I am injured and cannot complete this investigation – who will?"* Prior to entering a scene the investigator must endeavour to discuss any known safety problems with the OIC of the fire service attending the scene, or conduct a risk assessment to determine the safety hazards that exist (if any) and what mitigation tactics can be undertaken to lessen or eliminate the risk.[18] The fire scene safety website cited below is an excellent site for safety issues.

The duties of the investigator shall include inspecting the scene and any evidence relative to a scene, reviewing documentation generated during the investigation and other documentation relative to the incident so as to determine area or point of origin, source of ignition, materials first ignited, and the progression, extinguishment and control of the fire.[19]

The most important aspect of the duties of the investigator is the final determination and classification of the fire. The cause of a fire may be classified as Accidental, Natural, Incendiary or Undetermined. Use of the term Suspicious is not an accurate description of the classification of a fire cause. Suspicion is not an acceptable level of proof for making a determination and should be avoided. Whenever the cause cannot be proven to an acceptable level of certainty, the proper classification is Undetermined.[20]

One process that has been written about quite extensively in recent times is the use of *"Negative Corpus"* in making a determination of fire cause. Kirk's explains that:

"The use of Negative Corpus, or arson by default approach (the process of ruling out all accidental causes for a fire without sufficient scientific and factual basis to determine what did cause the fire), is rarely an acceptable methodology for determining that a fire was intentionally set. It implies that the ***Corpus Delecti*** (the facts and circumstances constituting a crime. (concrete evidence of a crime, such as a corpse) of the event (not necessarily a crime) has not been proven."[21]

It must be understood that each and every fire investigation COULD be subject to legal review, whether that be civil or criminal in nature. As such the objective of every investigation should be securing the most successful outcome possible.

NFPA 1033 – Annex A – 1.3.8 warns that fire investigation technology and practices are changing rapidly and it is essential that investigators maintain their performance and knowledge, and keep up-to-date with technology, test results and information, as it comes to hand (published) or is available via the Internet through sites such as those below:

- IAAI Training site/seminars/tutorials www.cfitrainer.net
- Fire Findings magazine www.firefindings.com/
- International Association of Arson Investigators www.firearson.com/
- INTERFIRE Interactive Investigations www.interfire.org/
- National Fire Protection Assoc. USA www.nfpa.org/
- National Institute of Standards & technology http://nist.gov/
- National Institute of Justice USA [research reports on Fire & Explosion investigation] http://www.nij.gov/topics/law-enforcement/investigations/crime-scene/guides/explosion-bombing/pages/welcome.aspx
- Safety for Fire Investigators (Munday – *"Fire safety at scenes of fire"*) – www.firescenesafety.com
- The Fire Scientist – Mythology of Fire Investigation http://www.firescientist.com/Documents/The%20Mythology%20of%20Arson%20Investigation.pdf

Specifically related to the topics in this article, from www.CFITrainer.net are the following modules:

- Introduction to Fire Dynamics and Modelling
- Process of Elimination
- Scientific method for Fire Investigation
- Explosion Dynamics

Conclusion

Over the next three months, before the next edition of this *Journal* is published, a review of the CFI Trainer modules relating to the next four topics would be helpful to the fire investigator and others striving to learn. In the next edition of the *FISC Bulletin Board*, we will be exploring the next four topics in the list, Fire Analysis, Fire Investigation Methodology, Fire Investigation Technology, and, Hazardous Materials.

Endnotes

1. NFPA. 2014. *NFPA 1033, Standard for Professional Qualifications for Fire Investigator.* Section 1.3.8. Quincy, MA. National Fire Protection Association.
2. NFPA. 2017. *NFPA 921: Guide for Fire and Explosion Investigations.* Sec. 3.3.70. Quincy, MA. National Fire Protection Association.
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10. Babrauskas, Dr. Vytenis. 1997. "Fire Modeling: An Introduction for Attorneys" http://www.doctorfire.com/mod_test.html
11. NFPA. 2017. *NFPA 921: Guide for Fire and Explosion Investigations.* Sec. 22.4.1.2. Quincy, MA. National Fire Protection Association.
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15. Icove D.J., Haynes G.A. 2017.Kirk's Fire Investigation. 8th edition. New York (NY).: Pearson. Brady Books.

16. NFPA. 2014. *NFPA 1033, Standard for Professional Qualifications for Fire Investigator.* Section 4.1.5. Quincy, MA. National Fire Protection Association.
17. NFPA. 2014. *NFPA 1033, Standard for Professional Qualifications for Fire Investigator.* Section 4.1.6. Quincy, MA. National Fire Protection Association.
18. Munday, J.W. 1994. "Fire Safety at Scenes of Fire and Related Incidents.www.firescenesafety.com
19. NFPA. 2014. *NFPA 1033, Standard for Professional Qualifications for Fire Investigator.* Section 4.2. Quincy, MA. National Fire Protection Association.
20. NFPA. 2017. *NFPA 921: Guide for Fire and Explosion Investigations.* Chapter 20. Quincy, MA. National Fire Protection Association.
21. Icove D.J., Haynes G.A. 2017.Kirk's Fire Investigation. 8th edition. New York (NY).: Pearson. Brady Books. P. 51.

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