BRADY FIRE SERIES

KIRK'S FIRE INVESTIGATION

EIGHTH EDITION

David J. Icove
Gerald A. Haynes

Pearson

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Eighth Edition

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Engineering A Fire Safe World

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Cover Printer: Phoenix Color/Hagerstown

Note: A portion of this book was prepared by David J. Icove, a former employee of the US Tennessee Valley Authority (TVA) and Federal Bureau of Investigation (FBI). The views expressed in this book are the views of Dr. Icove and his coauthors. They are not necessarily the views of TVA or the United States government. Reference in this book to any product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute its endorsement or recommendation by TVA or the United States government.

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Readers are warned that this textbook is intended for use only by those competent in the fields including, but not limited to, fire investigation, fluid dynamics, thermodynamics, combustion, and heat transfer; and the textbook is intended only to supplement the informed judgment of the qualified user. This textbook provides methodologies that may or may not have predictive capability when applied to a specific set of factual circumstances. Lack of accurate predictions by any particular methodology, calculation, or fire modeling application could lead to erroneous conclusions with regard to fire safety. All results should be evaluated by an informed user.

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Library of Congress Cataloging-in-Publication Data

Names: Icove, David J., 1949- author. | Haynes, Gerald A. (Firefighter), author. | based on (work): Kirk, Paul L. (Paul Leland), 1902-1970. Kirk's fire investigation.
Title: Kirk's fire investigation / David J. Icove, Ph.D., P.E., board certified, fellow, National Academy of Forensic Engineers, The University of Tennessee, Gerald A. Haynes, M.S., P.E., board certified, fellow, National Academy of Forensic Engineers, Forensic Fire Analysis, LLC.
Other titles: Fire investigation.
Description: Eighth edition. | NY, NY : Pearson, [2018] | Revised edtion of: Kirk's fire investigation / John D. DeHaan, David J. Icove. 2012. | Includes bibliographical references and index.
Identifiers: LCCN 2017030182| ISBN 9780134237923 (hardcover) | ISBN 0134237927 (hardcover)
Subjects: LCSH: Fire investigation.
Classification: LCC TH9180 .K5 2018 | DDC 363.37/65—dc23 LC record available at https://lccn.loc.gov/2017030182

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ISBN 10: 0-13-423792-7
ISBN 13: 978-0-13-423792-3

DEDICATION

The authors dedicate this eighth edition of Kirk's Fire Investigation to Dr. Vytenis (Vyto) Babrauskas, Fire Science and Technology Inc., San Diego, California.

Dr. Babrauskas has his Bachelor's degree from Swarthmore College in Physics followed by an M.S. degree in Structural Engineering and a Ph.D. degree in Fire Protection Engineering from the University of California, Berkeley. He was the first person ever to be awarded a Ph.D. degree in Fire Protection Engineering.

A Principal Member of the *NFPA 921* and *NFPA 901* Committees, Dr. Babrauskas single handedly has contributed much to the field of fire and explosion investigation. His keynote textbook, the Ignition Handbook, is a must-have reference in the field.

The authors recognize Dr. Babrauskas for his past, present, and continuing contributions.

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PREFACE TO THE EIGHTH EDITION

More has changed in the last year in the field of fire investigation than in all the years since the 1969 publication of the first edition of ***Fire Investigation*** by Dr. Paul L. Kirk and the 2004 publication of the first edition of ***Forensic Fire Scene Reconstruction***. Dr. Paul L. Kirk was a professor of biochemistry and criminalistics at the University of California at Berkeley, but it was his specialty of microchemistry that focused his attention on physical evidence and its analysis. In 1953, he wrote the landmark text, ***Crime Investigation***, and maintained a private criminalistics consulting practice where he became involved in a wide variety of fire and explosion cases. He published ***Fire Investigation*** in 1969 as the first textbook on fire investigation written by a scientist rather than a fire investigator. Dr. Kirk remained in charge of the criminalistics program at Berkeley until his death in 1970 and launched the careers of many criminalists who now practice around the world. His concern with using science to solve the puzzles of fires and explosions presaged the current emphasis on using the scientific method to investigate fires by more than 30 years. It is in honor of Dr. Kirk's pioneering work in bringing science to fire investigation that his name remains included in the title, ***Kirk's Fire Investigation***, and the spirit, of this text. No longer is the investigation of fires just limited to inspecting the ruins, asking questions of the witnesses, and applying basic common sense and observations to determine the fire's origin and cause. Fire investigators must now keep in step with the rapid changes in the forensic sciences, the innovations in fire scene documentation, and challenges in the court stressing precise defensible expert testimonies.

Dr. John D. DeHaan became the author of **Kirk's** in 1980, at the request of the then publisher, John Wiley & Sons. His involvement with international fire, explosion, and forensic professional organizations provided a wide variety of knowledge and the opportunity to share techniques and information with many renowned experts. His Ph.D. research was on the development of layers of flammable liquid vapors (University of Strathclyde, 1995). After more than 30 years however, Dr. DeHaan felt it was time for a newer generation of authors with skills in the engineering applications required of today's investigators to take the lead.

The eighth edition of ***Kirk's Fire Investigation*** blends the seventh edition of ***Kirk's*** with the third edition of ***Forensic Fire Scene Reconstruction***. The design of this new textbook meets the emerging forensic challenges. ***Kirk's*** still ranks as the foremost authoritative text for training as well as an expert treatise for fire investigation professionals. It also serves as a bridge textbook providing interoperation of the concepts presented in the latest editions of the National Fire Protection Association (NFPA) ***Guide for Fire and Explosion Investigation*** (*NFPA 921*), ***Standard for Professional Qualifications for Fire Investigator*** (*NFPA 1033)*, and related standards of care.

The premier aspect of ***Kirk***'s is that it maintains its role as the leading peer-reviewed and widely cited expert treatise in the fire investigation field. Concepts and investigative techniques presented are supported by peer-reviewed references and have already gained general acceptance in the fire and explosion investigation field. Notwithstanding, ***Kirk's*** ability to assimilate and interpret emerging techniques typically outpaces the publication of *NFPA 921* and other standards of care, and can be safely relied upon by expert witnesses.

Because forensic fire scene documentation is emerging as the cornerstone in nearly all judicially contested investigations, modest reconstructive efforts such as repositioning furniture and other post-fire artifacts into pre-fire positions no longer suffice. Therefore, during scene documentation, today's fire investigator must possess skill in scientifically based fire pattern analysis and must employ analytical methodologies based on expert interpretation of discernible patterns and fire dynamics principles.

Delving deeply into the forensic fire protection engineering field, this eighth edition of ***Kirk's*** covers engineering calculations and fire modeling, and features several exhaustive case studies that leverage the current technology explained in depth throughout the text. Several specialized topic areas also are covered, including use of scanning and panoramic photography, preparation of comprehensive reports, the ignition matrix, expert testimony, and computer modeling and laser imaging. Also included is an advanced discussion of tenability.

Paving the way for those investigators who seek to take their forensic investigation skills to the next level, this new edition emphasizes the need to use the scientific method and details the need-to-know information behind developing a working hypothesis. Readers are also thoroughly prepared for the courtroom with this guide, which teaches investigators how to form and authoritatively present their expert testimony.

Kirk's eighth edition is the most in-depth textbook in the field of fire investigation on the subject of arson crime scene analysis and examining motive as it relates to fire setting. For investigators seeking to gain a deeper and more advanced understanding of fire protection engineering concepts, technology, and analysis in the field of fire investigation, ***Kirk's*** takes readers to the next level of expertise.

About This Book

Forensic fire investigations go well beyond establishing what furnishings were present and where they were originally placed. Fire scene analysis and reconstruction involves identification and documentation of all relevant features of the fire scene—materials, dimensions, location, and physical evidence—that help identify fuels and establish human activities and contacts. This information, placed in context with principles of fire engineering and human behavior, is used to evaluate various scenarios of the origin, cause, and development of the fire and the interaction of people with it.

This textbook is intended for use by a broad range of both public and private sector individuals in the investigative, forensic, engineering, and judicial sectors. Intended users include the following:

- Public safety officials charged with the responsibility of investigating fires;
- Prosecutors of arson and fire-related crimes who seek to add to their capabilities of evaluating evidence and presenting technical details to a nontechnical judge and jury;
- Judicial officials seeking to better comprehend the technical details of cases over which they preside;
- Private-sector investigators, adjusters, and attorneys representing the insurance industry who have the responsibility of processing claims or otherwise have a vested interest in determining responsibility for the start or cause of a fire;
- Citizens and civic community service organizations committed to conducting public awareness programs designed to reduce the threat of fire and its devastating effect on the economy; and
- Scientists, engineers, academicians, and students engaged in the education process pertaining to forensic fire scene reconstruction.

A thorough understanding of fire dynamics is valuable in applying forensic engineering techniques. This book describes and illustrates the latest interpretations of systematic approaches for reconstructing fire scenes. These approaches apply the principles of fire protection engineering along with those of forensic science and behavioral science.

Using historical fire cases, both in the textbook, the authors provide new lessons and insight into the ignition, growth, development, and outcome of those fires. All documentation in the case examples follows or exceeds the methodology set forth by the NFPA in both the 2017 edition of *NFPA 921: Guide for Fire and Explosion Investigations* and its companion standard, the 2014 edition of *NFPA 1033: Standard for Professional*

Qualifications for Fire Investigator. This text includes the real-world case examples to illustrate the concepts that shed new light on the forensic science, fire engineering, and human factor issues. Each example is illustrated using the guidelines from *NFPA 921* and ***Kirk's Fire Investigation***. In cases where fire engineering analysis or fire modeling is applicable, these techniques are explored.

The authors acknowledge the numerous essential references from the Society of Fire Protection Engineers (SFPE) that form the basis for much of the material included in this textbook. These essential references, ranging from core principles of fire science to human behavior, include the *SFPE Handbook of Fire Protection Engineering* and many of SFPE's engineering practice guides.

New to This Edition

The eighth edition is one of the most adventurous editions over the last decade. Fully updated and streamlined from the previous edition, the eighth edition of ***Kirk's*** offers the latest information on investigative technologies and innovative documentation techniques.

The following highlights are changes to this edition that set it apart from previous ones:

- Meets the FESHE guidelines for Fire Investigation and Analysis, with correlations to the 2017 Edition of *NFPA 921 and* the 2014 Edition of *NFPA 1033*.
- Emphasizes and cross-references the critical Job Performance Requirements (JPRs) of *NFPA 1033* for fire investigators.
- Provides background for *NFPA 1033*'s "Basic Sixteen" knowledge requirements.
- Includes the latest information on applying the scientific method to fire investigations, particularly with the use of *Bilancia Ignition Matrix*™.
- Nearly all photos are now in color, making interpretation by the reader easier.
- Updated, in-depth case examples demonstrate the use of forensic fire investigation and analysis approaches.
- Comprehensive glossary of terms used throughout the textbook provides the latest definitions of common forensic fire investigation terminologies.
- The textbook is included in required and supplemental fire investigation professional training and certification programs by the National Fire Academy, the International Association of Arson Investigators (IAAI), and the National Association of Fire Investigators (NAFI).
- Provides the essential information required in preparing for the International Association of Arson Investigator's (IAAI) *Fire Investigation Technician (IAAI-FIT)* and *Evidence Collection Technician (IAAI-ECT)* Examinations.
- Provides websites for both instructors and students, including problem sets from NIST, NFPA, US Department of Justice, and the US Chemical Safety and Hazard Assessment Board.

Hallmark Features

- Describes a systematic approach to reconstructing fire scenes in which investigators rely on the combined principles of fire protection engineering along with forensic and behavioral science.
- Describes the scientific underpinnings of how fire patterns are produced and how they can be used by investigators in assessing fire damage and determining a fire's origin.
- Details the systematic approach needed to support forensic fire analysis and reports.
- Reviews the techniques used in the analysis of arsonists' motives and intents.
- Discusses the use of various mathematical, physical, and computer-assisted techniques for modeling fires, explosions, and the movement of people.

- Provides an in-depth examination of the impact and tenability of fires on humans.
- Reviews the applicable standard forensic laboratory and fire testing methods that are important to fire scene analysis and reconstruction.

Scope of the Book

Kirk's Fire Investigation is divided into the following chapters, which flow logically and build on one another:

Chapter 1, "Principles of Fire Investigation," describes the foundation and background of the rapidly developing field of determining origin and cause of fires. It presents a systematic approach to reconstructing fire scenes in which investigators rely on the combined principles of fire protection engineering along with forensic and behavioral science. Using this approach, the investigator can more accurately document a structural fire's origin, intensity, growth, direction of travel, and duration as well as the behavior of the occupants.

Chapter 2, "The Basic Science and Dynamics of Fire," provides the investigator with a firm understanding of the phenomenon of fire, heat release rates of common materials, heat transfer, growth and development, fire plumes, and enclosure fires.

Chapter 3, "Chemical Fires and Explosions," provides the fire investigator with a thorough coverage of the interrelationships of chemical fires and explosions, hazard classification systems. Significant contributions to this chapter were provided by Dr. Elizabeth Buc, an internationally recognized expert in the field.

Chapter 4, "Sources of Ignition," explores existing and new methodologies of investigating and identifying competent sources of ignition. This approach uses the Bilancia Ignition Matrix™ method to ensure that exhaustive hypotheses are systematically generated per the scientific method.

Chapter 5, "Fire Scene Examination," describes the science and engineering underpinnings of how fire patterns are used by investigators in assessing fire damage and determining a fire's origin. Fire patterns are often the only remaining visible evidence after a fire is extinguished. The ability to document and interpret fire pattern damage accurately is a skill of paramount importance to investigators when they are reconstructing fire scenes.

Chapter 6, "Fire Scene Documentation," details a systematic approach needed to support forensic analysis and reports. The purpose of forensic fire scene documentation includes recording visual observations, emphasizing fire development characteristics, and authenticating and protecting physical evidence. The underlying theme is that thorough documentation produces sound investigations and courtroom presentations. The chapter includes commentaries on new technologies useful in improving the accuracy and comprehensiveness of documentation.

Chapter 7, "Fires by Property Type," describes the principles of fuels, ignition, and fire behavior with which investigators should be reasonably familiar before undertaking the probe of a fire. This chapter covers structural, wildland, motor vehicle, and ship fires. It also discusses the necessity of having a clear understanding of the purposes and goals of the investigation and a rational, orderly plan for carrying it out to meet those purposes, as well as the value and limitations of post-fire indicators and the basic physical processes that create them.

Chapter 8, "Forensic Laboratory Services," describes the role of laboratory services in fire and explosion investigation and the types of examinations that can be requested. These include not only fire debris analysis but the application of a wide range of physical, chemical, optical, and instrumental tools on a variety of substances.

Chapter 9, "Fire Modeling," discusses the use of various mathematical, physical, and computer-assisted techniques for modeling fires, explosions, and the movement of people. Numerous models are explored, along with their strengths and weaknesses. Several case examples are also presented.

Chapter 10, "Fire Testing," describes how despite governmental regulations, fires in which fabrics are the first materials to be ignited are still a very common occurrence. The chapter discusses the nature of common fabrics and upholstery materials and their contributions to both ignition hazard and fuel load in current studies.

Chapter 11, "Arson Crime Scene Analysis," reviews the techniques used in the analysis of arsonists' motives and intents. It presents nationally accepted motive-based classification guidelines along with case examples of the crimes of vandalism, excitement, revenge, crime concealment, and arson-for-profit. The geography of serial arson is also examined, along with techniques for profiling the targets selected by arsonists.

Chapter 12, "Fire Deaths and Injuries," provides an in-depth examination of the impact and tenability of fires on humans. The chapter examines what kills people in fires, namely their exposure to by-products of combustion, toxic gases, and heat. It also examines the predictable fire burn pattern damage inflicted on human bodies and summarizes postmortem tests and forensic examinations desirable in comprehensive death investigations.

The **Appendices** contain a short refresher lesson on scientific notations and calculations.

Peer Reviewers

Peer review is important for ensuring that a textbook is well balanced, useful, authoritative, and accurate. The following individuals, agencies, institutions, and companies provided invaluable support during the peer-review process in the present and past editions of ***Kirk's Fire Investigation*** and ***Forensic Fire Scene Reconstruction***.

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Patrick M. Kennedy (deceased), National Association of Fire Investigators, Sarasota, Florida

Frederick J. Knipper, Fayetteville State University, Durham, North Carolina

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ACKNOWLEDGMENTS

We have many people to thank for both their help on and their inspiration for this and past editions of this book, including the many individuals and present and past employees at the following institutions and agencies.

David M. Banwarth Associates, LLC, Dayton, Maryland: David M. Banwarth, P. E.
Bureau of Alcohol, Tobacco, Firearms and Explosives (ATF): Steve Carman (retired), Steve Avato, Dennis C. Kennamer (retired), Dr. David Sheppard, Jack Malooly (retired), Wayne Miller (retired), Michael Marquardt, Luis Velaszco (retired), John Mirocha (retired), Ken Steckler (retired), Brian Grove, John Allen, and Jeffrey E. Theodore.
J. H. Burgoyne & Partners (UK): Robin Holleyhead and Roy Cooke
Chambliss, Banner & Stophel, P.C., Chattanooga, Tennessee: Jeffrey, G. Granillo, Richard W. Bethea, William Dearing, and John G. Jackson
Donan Engineering, LLC: Sandra K. Wesson, James Enos, James Caton, and Thomas R. May
Eastern Kentucky University: Dr. Gregory E. Gorbett, James L. Pharr, Dr. Andrew Tinsley, and Ronald L. Hopkins (retired)
Federal Bureau of Investigation (FBI): Richard L. Ault (retired), Dr. Stephen R. Band, S. Annette Bartlett, James E. Bentley, Jr. (retired), Dr. John Henry Campbell (retired), Theodore E. Childress (deceased), R. Joe Clark (retired), Dr. Roger L. Depue (retired), Jon Eyer (retired), William Hagmaier (retired), Joseph A. Harpold (retired), Robert "Roy" Hazelwood (deceased), Timothy G. Huff (retired), Edwin Kelly (deceased), Sharon A. Kelly (retired), John L. Larsen (retired), Dr. James A. O'Connor (retired), John E. Otto (retired), Rex W. Ownby (retired), Robert K. Ressler (deceased), Dr. William L. Tafoya (retired), Dr. Howard "Bud" Teten (retired), Scott A. Wenger, Arthur E. Westveer (deceased), and Eric Witzig (retired)
Fire and Materials Research Lab, LLC.: Dr. Elizabeth C. Buc, P.E., Livonia, Michigan
Mark A. Campbell, Fire Forensic Research, Colorado.
Fire Safety Institute: Dr. John M. "Jack" Watts, Jr.
Fire Science and Technology: Dr. Vyto Babrauskas
Forensic Fire Analysis: Lester Rich
Gardiner Associates: Mick Gardiner, Jim Munday, and Jack Deans
Goodson Engineering, Denton, Texas: Mark Goodson, P.E. and Lee Green, P.E.
Rodger H. Ide
Iris Fire, LLC, Parker, Colorado: Robert K. Toth
Israel National Police, Jerusalem: Shalom Tsaroom (retired), Arnon Grafit, Dr. Dan Muller, Ran Shelef, Dana Sonenfeld, and Myriam Azoury
Kent Archaeological Field School, UK: Dr. Paul Wilkinson and Catherine Wilkinson
Knox County (Tennessee) Sheriff's Office: Carleton E. Bryant, IV; Knox County Fire Investigation Unit: Det. Michael W. Dalton (retired); Inv. Shawn Short; Inv. Greg Lampkin; Det. Aaron Allen; Inv. Michael Patrick; Inv. Daniel Johnson; Kathy Saunders, Knox County Fire Marshal
Knoxville Fire Department, Tennessee: Asst. Chief Danny Beeler
Leica Geosystems: Rick Bukowski and Tony Grissim
Mesa County Sheriff's Office, Colorado: Benjamin J. Miller
Metropolitan Police Forensic Lab, Fire Investigation Unit, London (UK): Roger Berrett (retired)
McKinney (Texas) Fire Department: Chief Mark Wallace

Murder Accountability Project: Thomas K. Hargrove and Eric Witzig
National Academy of Forensic Engineers: Michael D. Leshner, P.E.
National Institute of Standards and Technology (NIST): Richard W. Bukowski, Dr. William Grosshandler (retired), Dan Madrzykowski (retired), and Dr. Kevin McGrattan
National Museum of Bermuda: Dr. Edward C. Harris
New Hampshire State Fire Marshal's Office: J. William Degnan, Donald P. Bliss (retired)
New South Wales Fire Brigades: Ross Brogan (retired)
Nistico, Crouch & Kessler, P.C.: Kathleen Crouch and Rachel Wall
Novato Fire Protection District: Assistant Chief Forrest Craig
Ohio State Fire Marshal's Office, Reynoldsburg: Eugene Jewell (deceased), Charles G. McGrath (retired), Mohamed M. Gohar (retired), J. David Schroeder (retired), Jack Pyle (deceased), Harry Barber, Lee Bethune, Joseph Boban, Kenneth Crawford, Dennis Cummings, Dennis Cupp, Robert Davis, Robert Dunn, Donald Eifler, Ralph Ford, James Harting (retired), Robert Lawless, Keith Loreno, Mike McCarroll, Matthew J. Hartnett, Brian Peterman, Mike Simmons, Rick Smith, Stephen W. Southard, and David Whitaker (retired)
Panoscan: Ted Chavalas
Precision Simulators, Inc.: Kirk McKenzie
Quist, Fitzpatrick & Jarrard, PLLC, Knoxville, Tennessee: Michael A. Durr
Richland (Washington) Fire Department: Glenn Johnson and Grant Baynes
Sacramento County (California) Fire Department: Jeff Campbell (retired)
Saint Paul (Minnesota) Fire Department: Jamie Novak
Santa Ana (California) Fire Department: Jim Albers (retired) and Bob Eggleston (retired)
Seneca College School of Fire Protection Engineering Technology: David McGill
Tarrant County (Texas) Office of the Medical Examiner: Dr. Nizam Peerwani, Ronald L. Singer.
Tennessee State Fire Marshal's Office: Richard L. Garner (retired), Robert Pollard, Eugene Hartsook (deceased), and Jesse L. Hodge (retired)
Tennessee Valley Authority (TVA): Carolyn M. Blocher, James E. Carver (retired), R. Douglas Norman (retired), Larry W. Ridinger (retired), Sidney G. Whitehurst (retired), and Norman Zigrossi (retired)
Texas State Fire Marshal's Office: Chris Connealy
Underwriters Laboratories(UL): Dr. J. Thomas Chapin, Dr. Pravinray D. Gandhi, P.E., and Dan Madrzykowski, P.E.
University of Arkansas, Department of Anthropology: Dr. Elayne J. Pope, now at Office of the Chief Medical Examiner Tidewater District, Norfolk, Virginia
University of Edinburgh, Department of Civil Engineering: Professor Emeritus Dr. Dougal Drysdale
University of Maryland, Department of Fire Protection Engineering: Dr. John L. Bryan (Emeritus), Dr. James A. Milke, Dr. Frederick W. Mowrer (Emeritus), Dr. James G. Quintiere (Emeritus), Dr. Marino di Marzo, and Dr. Steven M. Spivak (Emeritus)
University of Tennessee: Dr. A. J. Baker, Dr. William M. Bass, Dr. Wayne Davis, Samir M. El-Ghazaly, Dr. Rafael C. Gonzalez, Sonja Hill, Dr. Michael Langston, Dr. Evans Lyne, Dr. Matthew M. Mench, Lindsey K. Miller, Dr. Masood Parang, Dr. Leon Tolbert, Dr. M. Osama Soliman, Dr. Dawnie Wolfe Steadman, Dr. Jerry Stoneking (deceased), and the many students in the Fire Protection Engineering concentration courses.
US Attorney's Office: Jack B. Hood, Jason R. Cheek, and Gary Brown
US Consumer Products Safety Commission: Gerard Naylis (retired) and Carol Cave

US Fire Administration, Federal Emergency Management Agency (FEMA): Edward J. Kaplan, Kenneth J. Kuntz (retired), Robert A. Neale (retired), Dr. Denis Onieal, Lester Rich

US Nuclear Regulatory Commission: Mark Henry Salley, P.E.

Our sincere, heartfelt thanks go to everyone who reviewed the early manuscripts, addressed technical questions, and made many beneficial suggestions as to the format and content of this textbook.

A very special mention goes to our development editor Carol Lazerick; our copyeditor, Bret Workman; proofreader Karen Jones; and Lisa Narine, Portfolio Management Assistant.

Also, special thanks go to our families and close friends over the years for their patient support.

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This textbook is coauthored by two of the most experienced forensic fire protection engineers in the United States. Their combined talents total more than 100 years of experience in the fields of fire service, behavioral science, fire protection engineering, fire behavior, investigation, criminalistics, and crime scene reconstruction.

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Photo courtesy of the University of Tennessee, College of Engineering.

An internationally recognized forensic fire engineering expert with more than 45 years of experience, Dr. Icove is coauthor of *Kirk's Fire Investigation,* 7th ed., *Forensic Fire Scene Reconstruction*, both leading treatises in the field, and *Combating Arson-for-Profit,* the leading textbook on the crime of economic arson. Since 1992 he has served and maintained an appointment as a principal member of the *NFPA 921 Technical Committee on Fire Investigations*. He is also chair of *NPFA 901 – Committee on Fire Reporting*.

As a retired career federal law enforcement agent, Dr. Icove served as a criminal investigator on the federal, state, and local levels. He is a Registered Professional Engineer, a Certified Fire Investigator (CFI) from the International Association of Arson Investigators, a Certified Fire and Explosion Investigator (CFEI) from the National Association of Fire Investigators, a Fellow in the Society of Fire Protection Engineers, and a Board Certified Diplomat and Fellow in the National Academy of Forensic Engineers (NAFE).

He retired in 2005 as an Inspector in the Criminal Investigations Division of the US Tennessee Valley Authority (TVA) Police, Knoxville, Tennessee, where he was assigned for his last 2 years to the Federal Bureau of Investigation (FBI) Joint Terrorism Task Force (JTTF). In addition to conducting major case investigations, Dr. Icove oversaw the development of advanced fire investigation training and technology programs in cooperation with various agencies, including the Federal Emergency Management Agency's (FEMA's) US Fire Administration.

Before transferring to the US TVA Police in 1993, he served 9 years as a program manager in the elite Behavioral Science and Criminal Profiling Units at the FBI, Quantico, Virginia. At the FBI, he implemented and became the first supervisor of the Arson and Bombing Investigative Support (ABIS) Program, staffed by FBI and ATF criminal profilers. Prior to his work at the FBI, Dr. Icove served as a criminal investigator at arson bureaus of the Knoxville Police Department, the Ohio State Fire Marshal's Office, and the Tennessee State Fire Marshal's Office.

His expertise in forensic fire scene reconstruction is based on a blend of on-scene experience, conducting of fire tests and experiments, and participation in prison interviews of convicted arsonists and bombers. He has testified as an expert witness in civil and criminal trials, as well as before US congressional committees seeking guidance on key arson investigation and legislative initiatives.

Dr. Icove holds BS and MS degrees in Electrical Engineering and a PhD in Engineering Science and Mechanics from the University of Tennessee. He also holds a BS degree in Fire Protection Engineering from the University of Maryland–College Park. He is currently the UL Professor of Practice in the Department of Electrical Engineering and Computer Science at the University of Tennessee, Knoxville; serves on the faculty of the University of Maryland's Professional Master of Engineering in Fire Protection program; and serves as an Investigator in the Knox County Fire Investigation Unit and as a Reserve Deputy Sheriff for the Knox County Sheriff's Office, Knoxville, Tennessee.

Gerald A. Haynes, PE, DFE, CFPS, CFEI, CVFI
Fire Protection Engineer
Haynes and Associates, LLC
Photo courtesy of Gerald A. Haynes, PE.

Gerald A. Haynes is a registered Professional Engineer with more than 40 years of experience in the field of Fire Protection. He holds both Bachelor of Science and Masters of Science degrees in Fire Protection Engineering from the University of Maryland—College Park. He is currently the President of Haynes and Associates, LLC and serves as an adjunct lecturer for the Office of Advanced Engineering Education at the University of Maryland.

Mr. Haynes' experience includes work at the U.S. Department of Justice, Bureau of Alcohol, Tobacco, Firearms and Explosives and the U.S. Department of Commerce, National Institute of Standards and Technology Building and Fire Research Laboratory. His experience is multi-dimensional, including municipal fire service, fire and explosion investigations, complex case analysis and engineering support, and military service. He has provided testimony as an expert witness in state and federal courts in cases related to fire cause and fire testing protocols. He has conducted numerous presentations in the U.S. and internationally in the areas of fire dynamics, fire modeling and forensic fire engineering analysis. He currently is a member of numerous professional organizations, including the Society of Fire Protection Engineers (SFPE), the National Academy of Forensic Engineers (NAFE), the National Society of Professional Engineers (NSPE), the National Fire Protection Association (NFPA), the International Association of Arson Investigators (IAAI), the National Association of Fire Investigators, (NAFI) and ASTM International. He is a former member of the technical committees of NFPA 921 Guide for Fire and Explosion Investigations, and NFPA 1033 Standard for Professional Qualifications for Fire Investigator.

COURSE DESCRIPTION

This course examines the technical, investigative, legal, and social aspects of arson, including principles of incendiary fire analysis and detection, environmental and psychological factors of arson, legal considerations, intervention, and mitigation strategies.

The National Fire Academy–developed Fire and Emergency Services Higher Education (FESHE) curriculum serves as a national training program guideline that is a requirement for many fire service organizations and training programs. The following grid outlines Fire Investigation and Analysis course requirements and where specific content can be located within this text.

Course Requirements	Chapter												
	1	2	3	4	5	6	7	8	9	10	11	12	13
Demonstrate a technical understanding of the characteristics and impacts of fire loss and the crime of arson necessary to conduct competent fire investigation and analysis.	X	X	X	X	X	X	X	X	X	X	X	X	X
Document the fire scene, in accordance with best practice and legal requirements.	X				X	X	X	X	X	X	X	X	X
Analyze the fire scenario utilizing the scientific method, fire science, and relevant technology.	X	X	X	X	X	X	X	X	X	X	X	X	X
Analyze the legal foundation for conducting a systematic incendiary fire investigation and case preparation.	X				X	X	X	X	X	X	X	X	X
Design and integrate a variety of arson related intervention and mitigation strategies.	X						X				X	X	X

Professional Levels of Job Performance for Fire Investigators as Cited in *NFPA 1033*, 2014 Edition

General Requirements for a Fire Investigator	**4.1.2** Employ all elements of the scientific method as the operating analytical process **4.1.3** Complete site safety assessments on all scenes **4.1.4** Maintain necessary liaison with other interested professionals and entities **4.1.5** Adhere to all applicable legal and regulatory requirements **4.1.6** Understand the organization and operation of the investigative team and incident management system
Scene Examination	**4.2.1** Secure the fire ground **4.2.2** Conduct an exterior survey **4.2.3** Conduct an interior survey **4.2.4** Interpret fire patterns **4.2.5** Interpret and analyze fire patterns **4.2.6** Examine and remove fire debris **4.2.7** Reconstruct the area of origin **4.2.8** Inspect the performance of building systems **4.2.9** Discriminate the effects of explosions from other types of damage
Documenting the Scene	**4.3.1** Diagram the scene **4.3.2** Photographically document the scene **4.3.3** Construct investigative notes
Evidence Collection and Preservation	**4.4.1** Utilize proper procedures for managing victims and fatalities **4.4.2** Locate, collect, and package evidence **4.4.3** Select evidence for analysis **4.4.4** Maintain a chain of custody **4.4.5** Dispose of evidence
Interview	**4.5.1** Develop an interview plan **4.5.2** Conduct interviews **4.5.3** Evaluate interview information
Post-Incident Investigation	**4.6.1** Gather reports and records **4.6.2** Evaluate the investigative file **4.6.3** Coordinate expert resources **4.6.4** Establish evidence as to motive and/or opportunity **4.6.5** Formulate an opinion concerning origin, cause, or responsibility for the fire
Presentations	**4.7.1** Prepare a written report **4.7.2** Express investigative findings verbally **4.7.3** Testify during legal proceedings **4.7.4** Conduct public informational presentations

Source: NFPA 1033: Standard for Professional Qualifications for Fire Investigator. Published by National Fire Protection Association, © 2014.

CHAPTER 1

Principles of Fire Investigation

Courtesy of David J. Icove, University of Tennessee.

KEY TERMS

abductive reasoning, *p. 23*
accident, *p. 9*
accidental fire, *p. 3*
arson, *p. 2*
cause, *p. 2*
combustion, *p. 12*
corpus delicti, *p. 51*
data, *p. 14*
deductive reasoning, *p. 16*
explosion, *p. 2*
fire, *p. 2*
fire cause, *p. 17*
fire dynamics, *p. 11*
fire investigator, *p. 3*
fire patterns, *p. 19*
fire scene investigation and reconstruction, *p. 3*
forensic science, *p. 19*
hypothesis, *p. 16*
incendiary fire, *p. 4*
inductive logic or reasoning, *p. 13*
job performance requirement, *p. 3*
negative corpus, *p. 51*
opinion, *p. 16*
origin, *p. 2*
peer review, *p. 4*
possible, *p. 17*
probable, *p. 17*
requisite knowledge, *p. 3*
requisite skills, *p. 3*
scientific method, *p. 13*
suspicious, *p. 7*
technical expert, *p. 13*
undetermined, *p. 9*
ventilation, *p. 12*

OBJECTIVES

After reading this chapter, you should be able to:

- Describe the role of fire investigators in their determination of the origin, cause, and development of a fire or explosion.
- Identify the major peer-reviewed publications in the field of fire investigation.
- Explain the impact of *NFPA 921* and *NFPA 1033* on scientific fire investigations and expert testimony.
- Explain scope and impact in the field of fire investigation of job performance responsibilities (JPR) expected from both public and private sector investigators.
- Explain the problem of the reporting of fire loss statistics in the United States and the United Kingdom, particularly in the estimation of incendiary fires.

- Discuss the levels of confidence as applied to expert opinions in fire and explosion investigations.
- Explain the need for science in fire investigation and scene reconstruction.
- Demonstrate an understanding of how to apply the scientific method in fire and explosion investigations.
- List the seven basic steps used in the systematic process of the scientific method.
- Describe the foundations of expert testimony as applied to fire scene investigation.
- Explain the concept of developing alternative working hypotheses.

1.1 Fire Investigation

This text focuses on the field of fire investigation, which is the formal process of determining the **origin**, cause, and development of a **fire** or **explosion**. Often called a **fire origin** and **cause** (O&C) investigation, the probe is launched after a fire or explosion is extinguished and investigators strive to determine what circumstances caused or contributed to the incident. Due to the complex nature of the event, where a fire often distorts or destroys the evidence, fire investigation is among the most difficult of the forensic sciences to practice. Not knowing whether the fire was **incendiary** or **arson**, investigators must prove or disprove any allegations or suspicions and piece together the pre- and post-fire events. If the investigation indicates that a fire was deliberately set, reasonable **accidental fire** causes must be evaluated and eliminated.

The latest edition of *Kirk's Fire Investigation* is considered the leading authoritative text and legal expert treatise in the field. The text is used both for training and as the basis for certification in many jurisdictions. A majority of the overall methodology of fire investigation relies upon *Kirk's*, as well as on the following three peer-reviewed sources:

- The third edition of *Forensic Fire Scene Reconstruction*, published in 2013, is also considered a leading forensic text that serves as a bridge textbook, tying the concepts of fire engineering analysis to fire investigations (Icove, DeHaan, and Haynes 2013).
- The National Fire Protection Association's *NFPA 921*: *Guide for Fire and Explosion Investigations*, approved by the NFPA Standards Council on November 12, 2013, and issued with an effective date of November 11, 2016 (NFPA 2017). The 2017 edition of *NFPA 921* supersedes all previous issues and is considered by practitioners and judicial authorities the standard of care for conducting fire and explosion investigations. *NFPA 921* was approved as an American National Standard on December 1, 2016.
- The National Fire Protection Association's *NFPA 1033: Standard for Professional Qualifications for Fire Investigator*, approved by the NFPA Standards Council on May 28, 2013, with an effective date of June 17, 2013 (NFPA 2014). The 2014 edition of *NFPA 1033* supersedes all previous issues and was approved as an American National Standard on June 17, 2013.

Fire investigators must possess and maintain broad and up-to-date **requisite knowledge** and **skills** in their field. Standard professional qualifications, also known also as **job performance requirements**, mandate that fire investigators have and maintain basic working knowledge of 16 essential areas beyond a high school educational level (NFPA 2014, pt. 1.3.7).

The process of **fire scene investigation and reconstruction** determines the most likely development of a fire using a science-based methodology. Reconstruction begins with an understanding of the conditions and actions just prior to the fire and follows the fire from ignition to extinguishment. It explains aspects of the fire and smoke development, the role of fuels, effects of ventilation, the impact of manual and automatic extinguishment, the performance of the building, life safety features, and the manner of injuries or death.

origin ▪ The general location where a fire or explosion began (NFPA 2017, pt. 3.3.133).

fire ▪ A rapid oxidation process, which is a chemical reaction resulting in the evolution of light and heat in varying intensities; uncontrolled combustion (NFPA 2017, pt. 3.3.66).

explosion ▪ The sudden conversion of potential energy (chemical or mechanical) into kinetic energy with the production and release of gases under pressure, or the release of gas under pressure. These high-pressure gases then do mechanical work such as moving, changing, or shattering nearby materials (NFPA 2017, pt. 3.3.56).

cause ▪ The circumstances, conditions, or agencies that brought about or resulted in the fire or explosion incident, damage to property resulting from the fire or explosion incident, or bodily injury or loss of life resulting from the fire or explosion incident (NFPA 2017, pt. 3.3.26).

arson ▪ The crime of maliciously and intentionally, or recklessly, starting a fire or causing an explosion (NFPA 2017, pt. 3.3.14).

TABLE 1-1	Professional Levels of Job Performance for Fire Investigators as Cited in *NFPA 1033,* 2014 Edition
CATEGORY	**JOB PERFORMANCE REQUIREMENT**
4.1 General Requirements for a Fire Investigator	**4.1.1** Shall meet the job performance requirements defined in Sections 4.2 through 4.7 **4.1.2** Shall employ all elements of the scientific method as the operating analytical process throughout the investigation and for the drawing of conclusions **4.1.3** Site safety assessments shall be completed on all scenes and regional and national safety standards shall be followed and included in organizational policies and procedures **4.1.4** Shall maintain necessary liaison with other interested professionals and entities **4.1.5** Shall adhere to all applicable legal and regulatory requirements **4.1.6** Shall understand the organization and operation of the investigative team within an incident management system
4.2 Scene Examination	**4.2.1** Secure the fire ground **4.2.2** Conduct an exterior survey **4.2.3** Conduct an interior survey **4.2.4** Interpret effects of burning characteristics on materials **4.2.5** Interpret and analyze fire patterns **4.2.6** Examine and remove fire debris **4.2.7** Reconstruct the area of origin **4.2.8** Inspect the performance of building systems **4.2.9** Discriminate the effects of explosions from other types of damage
4.3 Documenting the Scene	**4.3.1** Diagram the scene **4.3.2** Photographically document the scene **4.3.3** Construct investigative notes
4.4 Evidence Collection and Preservation	**4.4.1** Utilize proper procedures for managing victims and fatalities **4.4.2** Locate, collect, and package evidence **4.4.3** Select evidence for analysis **4.4.4** Maintain a chain of custody **4.4.5** Dispose of evidence
4.5 Interview	**4.5.1** Develop an interview plan **4.5.2** Conduct interviews **4.5.3** Evaluate interview information
4.6 Post-Incident Investigation	**4.6.1** Gather reports and records **4.6.2** Evaluate the investigative file **4.6.3** Coordinate expert resources **4.6.4** Establish evidence as to motive and/or opportunity **4.6.5** Formulate an opinion concerning origin, cause, or responsibility for the fire
4.7 Presentations	**4.7.1** Prepare a written report **4.7.2** Express investigative findings verbally **4.7.3** Testify during legal proceedings

From NFPA 1033: Standard for Professional Qualifications for Fire Investigator. Published by National Fire Protection Association, © 2014.

NFPA 1033 (2014) identifies the professional level of job performance requirements for fire investigators. This standard specifies the minimum job performance requirements for service as a fire investigator in both the private and public sectors. Job performance requirements for each duty are the tasks an investigator must be able to perform to successfully carry out that duty. These tasks are summarized in Table 1-1.

Not only must fire investigators refer to and rely on *Kirk's Fire Investigation*, *Forensic Fire Scene Reconstruction*, *NFPA 921*, *NFPA 1033*, and expert treatises, they also

accidental fire ■ Involves all fires for which the proven cause does not involve an intentional human act to ignite or spread fire into an area where the fire should not be (NFPA 2017, pt. 20.1.1).

fire investigator ■ An individual who has demonstrated the skills and knowledge necessary to conduct, coordinate, and complete a fire investigation (NFPA 2014, pt. 3.3.7).

requisite knowledge ■ Fundamental knowledge one must have in order to perform a specific task (NFPA 2014, pt. 3.3.10).

requisite skills ■ The essential skills one must have in order to perform a specific task (NFPA 2014, pt. 3.3.11).

job performance requirement ■ A statement that describes a specific job task, lists the items necessary to complete the task, and defines measurable or observable outcomes and evaluation areas for the specific task (NFPA 2014, pt. 3.3.9).

fire scene investigation and reconstruction ■ The process of recreating the physical scene during fire scene analysis investigation or through the removal of debris and the placement of contents or structural elements in their pre-fire positions (NFPA 2017, pt. 3.3.76).

must conduct their investigations using a systematic and scientifically guided approach. In addition to documenting the scene investigation, the investigator must collect physical and testimonial evidence, conduct a post-incident investigation, and prepare a comprehensive written report in anticipation of civil or criminal litigation.

incendiary fire ▪ A fire that is intentionally ignited in an area or under circumstances where and when there fire should not be a fire (NFPA 2017, pt. 3.3.116).

In cases of **incendiary fires**, in addition to determining the origin and cause of the fire, the investigator has the added responsibility of identifying the person who set the fire and providing proof to a trier of fact. Incendiary fires represent a significant percentage of all fires and, because they are set specifically with the intent of destroying property, an inordinately high percentage of dollar losses.

peer review ▪ A formal procedure generally employed in prepublication review of scientific or technical documents and screening of grant applications by research-sponsoring agencies. Carries with it connotations of both independence and objectivity. Peer reviewers should not have any interest in the outcome of the review (NFPA 2017, pt. 4.6.3).

A majority of the fire investigators who testify as expert witnesses have certification by one or more internationally recognized professional organizations. To be effective, the work products and results of fire investigators must be able to pass the eventual and rigorous scrutiny of **peer review** through cross-examinations, sworn depositions, hearings, challenges, and courtroom testimony. In summary, the test of a comprehensive fire investigation is that when peer-reviewed by a non-involved expert fire investigator, they would reach similar, if not the same, opinions and conclusions.

1.2 The Fire Problem

Internationally, fire continues to be the most costly of all public safety problems. Losses in human lives and injuries due to fires and explosions continue to occur. Fire-caused property losses far exceed those caused by all classes of crime and rival those produced by hurricanes and earthquakes. There is a major problem in identifying and quantifying the issues surrounding the fire problem due to the failure to obtain accurate incident data.

1.2.1 FIRE STATISTICS IN THE UNITED STATES

In the United States, fire incident data are collected by the Federal Emergency Management Agency's US Fire Administration (FEMA/USFA). In coordination with the National Fire Information Council, submitting agencies use the National Fire Incident Reporting System (NFIRS) on a voluntary basis. Shrinking state budgets have often resulted in the downgrading of the priorities of fire incident data collection programs.

Uniform Crime Reporting (UCR) statistics are amassed through the Federal Bureau of Investigation's (FBI's) National Incident-Based Reporting System (NIBRS), but arson incident data are collected only when a fire or police investigator actually submits a report into NIBRS. Subsequently, arson cases go unreported when fire departments fail to pass along and fill out a separate police report on intentionally set fires.

Although the National Fire Protection Association (NFPA) collects data on fire incidents, its estimates are based on data that the association receives from fire departments that respond to its National Fire Experience Survey. Since 1977, this annual sample enables the NFPA to compile national fire problem statistics that include the fires that local fire departments attend, and the resulting deaths, injuries, and property losses (Haynes 2015).

The NFPA estimated that public fire departments in the United States responded to a total of 1,298,000 fires in 2014, causing $11.6 billion in property damage. Of these, an estimated 494,000 were structure fires, which represented an increase of 1.3 percent from the number in 2013. The total monetary property loss for structure fires was $9.8 billion, an increase of 3.4 percent over the previous year's total. The average overall loss per structure fire was $19,931, an increase of 2 percent from the 2013 average. Residential fires accounted for about 74 percent of all structure fires, estimated at 367,500, a slight decrease of 0.5 percent from the previous year. The NFPA study estimated in 2014 that there were approximately 167,500 vehicle fires and 610,500 outside fires, increases of 2.1 and 8.1 percent, respectively (Haynes 2015).

No accounting can accurately reflect the loss in lives and injuries that result from fires. In 2014, the NFPA estimated that 53,275 civilians died as a result of fires, and

15,775 suffered injuries. Home fires were responsible for 2,745 deaths and 11,825 injuries, while vehicle fires caused 310 deaths and 1,275 injuries (Haynes 2015). The National Safety Council reports that accidental fire-related burn injuries are the sixth leading cause of all accidental deaths (NSC 2008).

The NFPA estimates that there were 3,275 civilian fire deaths and 15,775 civilian fire injuries in 2014, an increase from 2013 totals of 1.1 percent and a 0.9 percent decrease, respectively. An estimated 2,745 civilians perished and 11,825 were injured in residential fires. Another 310 civilians died and 1,275 were injured in highway vehicle fires (Haynes 2015).

NFPA statistics recorded 64 on-duty firefighter deaths in the United States in 2014 and 68 deaths in 2015, representing a decrease from 97 deaths in 2013. By contrast, in 2014, the largest multiple-death incidents were two double-fatality fires, both in apartment buildings. The annual average number of deaths over the past decade is 83 (Fahy, LeBlanc, and Molis 2015). During the previous year in 2013, 65,880 firefighter injuries occurred in the line of duty, along with 7,100 exposures to infectious diseases and 17,400 to hazardous conditions (Karter and Molis 2014).

In addition to these direct losses are the incalculable indirect fiscal costs. The actual dollar property losses previously listed probably represent only 10 percent of the total costs. There are inestimable losses due to lost business income, unemployment, reduced property values, and reduced tax bases as a result of nearly every major fire. In a 2005 *Fire Protection Engineering* article, Frazier estimated that the total cost of fire in the United States is on the order of $130–$250 billion per year (Frazier 2005). In the suppression of every fire, personnel and equipment costs are incurred and historic structures are lost forever. Wildland fires destroy watersheds, timber, and wildlife, which cannot be replaced at any cost.

The latest NFPA statistics (Hall 2014) show that the total cost of fire in the United States is a combination of the direct losses caused by fire combined with funding spent on fire prevention, protection, and mitigation. For 2011, that total cost is estimated at $329 billion, more than 2 percent of US gross domestic product. The NFPA arrives at this estimate by including economic loss due to property damage ($14.9 billion), insurance coverage ($20.2 billion), career fire departments ($42.3 billion), new building costs ($31.0 billion), other ($48.9 billion), donated time from volunteer firefighters ($139.8 billion), and civilian and firefighter deaths and injuries due to fire ($31.7 billion) (Hall 2014).

1.2.2 FIRE STATISTICS IN THE UNITED KINGDOM

The United States is not alone in the problem of fire loss. In 2009, the fire and rescue authorities in the United Kingdom adopted an electronic Incident Recording System (IRS), replacing its predecessor, the Fire Data Report system. The Department of Communities and Local Government (CLG) in the United Kingdom collects, maintains, and analyzes the UK fire statistics.

Statistics in Great Britain from April 2013 to March 2014 show the fire service responding to 212,500 fires, which continues a generally downward trend of the past decade. Nearly 19 percent of the fires were dwellings, and 68 percent were outdoor fires consisting of refuse, road vehicles, grasslands, and heathlands (Crowhurst 2015).

During this time period, there were 322 fire-related deaths, the lowest recorded figure in 50 years. Dwelling fires account for 80 percent of the fatalities, with individuals over 80 years old at four times the fatality rate. Gas, smoke, and toxic fumes impact 41 percent of the victims, with burns accounting for 20% of the fatalities (Crowhurst 2015).

1.2.3 ROLE OF THE FIRE INVESTIGATOR IN ACCURATELY REPORTING THE CAUSES OF FIRES

What role does the fire investigator play in these tragedies? By accurately and efficiently identifying the causes of fires, whether accidental or incendiary, investigators can make a substantial contribution to reducing these terrible losses. Fewer lives have been lost because in the 1960s investigators identified the danger of flammability of clothing and bedding, in the 1970s tracked down the problems with instant-on televisions, and in the 1980s identified the danger of coffeemakers and portable heaters. In the 1990s scores of potential victims in several large cities were saved when serial arsonists were caught and incarcerated. Saving lives and preventing injuries are the real reasons fire investigators spend long hours searching a fire scene or doing laboratory analysis and fire research.

The role that thorough fire investigation plays in the regulatory and code-making process is also significant. Advances made in improving life safety and fire safety codes have resulted in reducing the frequency of fires and fire deaths. Although these codes are written on the basis of the best predictive models, the only way to be sure they have the desired effect and do not create other, unanticipated risks is to document the effects of fire in code-compliant buildings and transport. In the early 1900s builders were proud of fire-resistant buildings constructed with stone, concrete, steel, and glass. It was not until major tragedies like the Triangle Shirtwaist fire in 1911 that people realized that building contents and not just the structures were major factors in fires, and having adequate means of escape was critical to survival (Von Drehle 2003). Manual alarm and firefighting systems were also found to be woefully inadequate.

1.3 The Detection of Incendiary Fires

Few other investigations are as daunting as that of a fire scene. Because a fire scene has to be investigated before it can be established whether the crime of arson has been committed, every fire scene must be considered a possible crime scene from the standpoint of scene security, processing, and evidence collection. As a crime scene, the typical fire scene is the antithesis of the ideal.

There has been wholesale destruction of the physical material and substance of the scene, first by the fire itself and second by fire suppression and overhaul by the firefighters. This destruction affects evidence of both accidental and incendiary causes.

Vehicles, personnel, equipment, hoses, and large quantities of water contaminate the scene. Scene security and control of unauthorized persons are difficult because of the attraction fire offers to the public and the press, and may be further complicated by the large area involved in many fire scenes.

Often, the scene investigation is carried out days or weeks after the incident, after weathering and vandals may have further compromised whatever evidence remains. Considering these negative factors, it is not surprising that police and fire personnel have often let fire investigation fall through the cracks of responsibility. As a result, it is surprising that fire causes are ever accurately determined, and civil and criminal cases successfully brought to trial.

1.3.1 REPORTING ARSON AS A CRIME

The *Uniform Crime Reports (UCR),* published by the FBI of the US Department of Justice (DOJ), provides enlightening statistics on arson in the United States. Statistics for 2014, published in 2015, are used in this chapter. Annually, the FBI publishes *Crime in the United States*, which catalogs the entire crime picture of the United States. *UCR* reported in 2013 that the number of arson offenses decreased 13.5 percent compared with those reported in 2012 (FBI 2015).

The FBI's UCR Program defines arson as

> *any willful or malicious burning or attempting to burn, with or without intent to defraud, a dwelling house, public building, motor vehicle or aircraft, personal property of another, etc.*

The FBI collects data only on the fires that through investigation were determined to have been willfully set. Fires whose cause are labelled as "suspicious" or are "unknown or undetermined" are not included in the data.

The FBI points out that arson rates are calculated based on data received from all law enforcement agencies that provide the UCR Program with data for 12 complete months. Unlike other national reporting systems, UCR Program data collection does not include any estimates for arson because the level of reporting arson offenses varies from agency to agency.

According to the 2014 *UCR*, 15,324 law enforcement agencies (providing 1–12 months of arson data) reported 42,934 arsons, which was a 4 percent decrease from 2013. Of those agencies, 14,646 provided expanded offense data on about 40,268 arsons. These data show that arsons involving structures (residential, storage, public, etc.) accounted for 17,790 fires, or 44.2 percent of the total number of arson offenses. Mobile property was involved in 23.2 percent of arsons, and other types of property (such as crops, timber, fences, etc.) accounted for 31.5 percent of arsons (FBI 2015). See Table 1-2 for a detailed breakdown of the 2014 statistics for FBI Uniform Crime Reporting reported by 14,750 agencies representing an estimated population of 262,342,126 persons.

The 2014 FBI statistics showed that the average dollar loss per incident due to arson was $16,055. Arsons of industrial/manufacturing structures resulted in the highest average dollar losses (an average of $167,545 per arson incident). Regarding arson rates, the 2014 *UCR* data showed that nationwide, the rate of arson was 14.2 offenses for every 100,000 inhabitants in the United States (FBI 2015).

The NFPA noted in its 2008 report that in Version 5.0 of the NFIRS the classification of arson was changed to "intentionally set" from the previous "incendiary" category. NFIRS no longer carries a **suspicious** fire category in its reporting system (Karter 2009).

suspicious ■ Fire cause has not been determined, but there are indications that the fire was deliberately set and all accidental fire causes have been eliminated.

The NFPA statistics for the years 2007–2011 estimated that 282,600 intentionally set fires reported by fire departments in the United States resulted in 420 deaths and

TABLE 1-2 Arson in the United States by Type of Property, 2014

PROPERTY CLASSIFICATION	NUMBER OF ARSON OFFENSES	PERCENT DISTRIBUTION[1]	PERCENT NOT IN USE	AVERAGE DAMAGE	TOTAL CLEARANCES	PERCENT OF ARSONS CLEARED[2]	PERCENT OF CLEARANCES UNDER 18
Total	**39,174**	**100.0**		**$16,055**	**8,555**	**21.8**	**25.5**
Total structure:	**17,854**	**45.6**	**14.6**	**$29,779**	**4,577**	**25.6**	**25.6**
Single occupancy residential	8,630	22.0	14.9	$27,742	2,109	24.4	18.2
Other residential	3,071	7.8	10.1	$26,786	848	27.6	15.2
Storage	1,113	2.8	18.9	$11,341	233	20.9	41.6
Industrial/ manufacturing	141	0.4	29.8	$167,545	35	24.8	14.3
Other commercial	1,594	4.1	16.7	$56,592	370	23.2	23.2
Community/public	1,513	3.9	14.9	$15,948	579	38.3	63.0
Other structure	1,792	4.6	14.6	$33,161	403	22.5	27.0
Total mobile:	**9,154**	**23.4**		**$7,716**	**1,051**	**11.5**	**10.4**
Motor vehicles	8,608	22.0		$7,416	937	10.9	9.4
Other mobile	546	1.4		$12,458	114	20.9	18.4
Other	**12,166**	**31.1**		**$2,189**	**2,927**	**24.1**	**30.6**

[1] Because of rounding, the percentages may not add to 100.0.
[2] Includes arsons cleared by arrest or exceptional means.
FBI Uniform Crime Reporting offenses reported during 2014 by 14,750 agencies with an estimated population of 262,342,126

TABLE 1-3 Annual Averages of Intentional Fires by Incident Type

INCIDENT TYPE	FIRES		CIVILIAN DEATHS		CIVILIAN INJURIES		DIRECT PROPERTY DAMAGE (IN MILLIONS)	
Outside or unclassified fires	211,500	(75%)	20	(4%)	150	(11%)	$60	(5%)
Outside trash or rubbish fires	126,300	(45%)	0	(1%)	40	(3%)	$10	(0%)
Outside or unclassified fires (excluding trash or rubbish fires)	85,200	(30%)	10	(4%)	110	(8%)	$50	(4%)
Structure fires	50,800	(18%)	370	(92%)	1,150	(84%)	$1,050	(86%)
Vehicle fires	20,400	(7%)	30	(8%)	70	(5%)	$180	(14%)
Total	282,600	(100%)	420	(100%)	1,360	(100%)	$1,290	(100%)

Source: Reprinted with permission from NFPA's report, "Annual Averages of Intentional Fires by Incident Type" Copyright © 2014, National Fire Protection Association.

1,360 injuries to civilians, along with $1.3 billion in direct property damages. Of these fires, only 18 percent involved structures, 7 percent involved vehicles, and 75 percent involved outside or unclassified incidents (Campbell 2014). See Table 1-3 for a detailed breakdown of the 2007–2011 statistics.

These estimates are almost certainly very low, since some US jurisdictions may not always report arson incidents (structural or vehicular) to law enforcement incident collection systems. In addition, arsons classified as vandalism may also be underreported.

A recent audit survey of selected jurisdictions by Scripps Howard News Service and the University of Tennessee reveal that many investigators think that the total of intentionally set structure fires is closer to 40 percent of all fires (Icove and Hargrove 2014). These statistics may be further compromised as departments facing budget reductions devote larger portions of their resources to other emergency services and less to fire investigation.

1.3.2 PROBLEMS ASSOCIATED WITH ESTIMATING INCENDIARY FIRES

The US estimates are on the conservative side, since many fires are never properly investigated because of lack of time, or are misidentified inadvertently as accidental fires due to lack of experienced investigators, or intentionally to avoid the complications that arise from identifying a fire as a criminal act. These complications can range from administrative, such as requiring more investigative time or involving another public agency, to political, such as generating negative publicity about the community. The sharp contrast between the UK estimates and the NFPA estimates that only 6.1 percent of the reported structure fires were incendiary demonstrates a systematic problem with the NFPA's data gathering and statistical processing.

Recent NFPA estimates indicate that the incidence of intentionally set fires has fallen since 1980. Total intentional fires have declined 69 percent from a high of 859,800 in 1980 to 269,900 in 2011. These estimates include the decrease of intentionally set structure fires by 76 percent, vehicles by 77 percent, and outside and unclassified fires by 65 percent (Campbell 2014).

One significant reason offered for this decrease is that the NFIRS changed its categories in 2003, eliminating the outmoded "suspicious" causation category. Only fires specifically determined to be intentionally set are now reported in the "incendiary" category. In the past, estimates of half of "suspicious" and "undetermined" fires were added to the "incendiary" total. Fire investigators across the United States suspected that even the old percentage (15 percent) was far below the reality of actual investigations.

Lack of evidence, lack of time and resources, and limited cooperation of other public agencies make the selection of **undetermined** or even **accidental** causation the expedient solution. These problems have recently been exacerbated. Budgeting problems at all levels of state and local governments have severely curtailed or even cut fire investigation services in both fire and police agencies. Consequently, the decision-making process has reverted to fire company officers who may or may not be trained or prepared to identify evidence supporting an incendiary cause.

undetermined ▪ The final opinion is only as good as the quality of the data used in reaching that opinion. If the level of certainty of the opinion is only "possible" or "suspected," the fire cause is unresolved and should be classified as "undetermined" (NFPA 2017, pt. 19.7.4).

accident ▪ An unplanned event that interrupts an activity and sometimes causes injury or damage or a chance occurrence arising from unknown causes; an unexpected happening due to carelessness, ignorance, and the like (NFPA 2017, pt. 3.3.3).

In 2000, the National Institute of Justice published *Fire and Arson Scene Evidence: A Guide for Public Safety Personnel* for first responders in police, fire, and medical services (NIJ 2000). The NIJ hoped that by educating these professionals with the basics of fire-related investigation and physical evidence, a higher percentage of them could contribute toward successful prosecutions. With the cutbacks in public services experienced across the United States, it is not known whether this guide has been successfully utilized. From the small percentages of fires actually reported as intentional via NFIRS, it would appear not.

The situation is made even more critical by the law enforcement agencies that find themselves unable to cope with the onslaught of criminal cases of homicide, rape, assault, and drug-related activity and decide to ignore arson as a crime. This practice is conveniently expedited by categorizing arson as a property crime so that it can be allotted reduced priority and less tactical support than the more urgent crimes against persons.

It must be recognized that arson is a crime against people. It is aimed against people where they live, where they work, and where they do business or go to church. Fire is just as much a weapon as a gun, a knife, or an axe. When aimed at persons, fires may be set directly on them or, more often, set deliberately to trap the victims in a structure or vehicle. Every set fire is a crime against the personnel of fire and police agencies who are obligated to respond to and enter fires in lifesaving efforts.

Successful fire investigation, culminating in an accurate determination of cause, is the only way to minimize these terrible losses. Accidental fires can be prevented by the identification and elimination of hazardous products and processes or careless practices, as well as the development and enforcement of better building codes and fire safety practices. As the recent British experience with vehicle arsons has shown, incendiary fires can be reduced by recognizing them, identifying those responsible, and prosecuting them (ODPM 2005).

With such massive losses involved, it is not surprising that fire losses are one of the most common subjects of civil litigation. Yet, for all its economic and legal importance, fire remains one of the most difficult areas of investigation. It is challenging because the destruction of the fire and, sometimes, its suppression create difficulties in reaching firm and unassailable conclusions as to the fire's cause. It is the investigator's responsibility not only to identify the origin and cause of the fire but also to be prepared to defend their conclusions in a rational, logical manner supported by scientifically valid data. In the absence of rational reconstruction or scientific data, conclusions cannot be substantiated, and successful prosecution for arson is virtually impossible. Civil cases, even with their reduced requisite of proof, are made more difficult to decide fairly without such scientific analysis.

As Sherlock Holmes pointed out, "It is a capital mistake to theorize before one has data. One begins to twist facts to suit theories instead of theories to suit facts." (Doyle 1891) From the standpoint of public safety and economic considerations, it is important that investigative methods for accurately determining the causes of fires be understood and applied to the fullest extent possible. There should be no presumption that a fire is either accidental or incendiary. It is vital that the investigator not prejudge any fire as to cause without evaluating all the collected evidence. If an investigator decides that a fire is arson before collecting any data, then only data supporting that premise are likely to be recognized and collected.

The same caution is necessary for those who decide that all fires are accidental, no matter what their true cause may be. Although fire has been known since prehistoric times, it is still poorly understood by many people, including some firefighters, fire investigators, and others whose services depend on such understanding.