Fire Investigator Health and Safety Best Practices

Third Edition
April 13, 2022

The International Association of Arson Investigators, Inc.
Health & Safety Committee

This edition of Fire Investigator Health and Safety Best Practices was prepared by the Health & Safety Committee of the International Association of Arson Investigators, Inc. (IAAI), its advisory panel of subject matter experts, and other technical advisors, and has been approved by the IAAI Training & Education Committee and the IAAI Executive Team for publication.

Every effort has been made to ensure the accuracy of all information presented, however, errors can occur despite this.

Please direct all correspondence regarding this document to: iaai-safety@firearson.com

Credit: Bedford County (VA) Fire Marshal's Office

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Cover photo credit: Mesa (AZ) Fire & Medical Department by Lloyd Sharp. L: Mike Brewer, R: Eric Peyton
Cover design: Scott Muthersbaugh, Perfecta Visuals

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"It is critical to maintain focus on wearing appropriate PPE on EVERY fire scene. I started my career early and was not very concerned with adequate PPE and decontamination, and just didn't know any better. It led to stage one aggressive bladder cancer in my 28th year of service, and now a lifetime of treatments going forward. Educate yourself and WEAR YOUR PPE."

David Rivers MIAAI, IAAI-CFI
Pageland, South Carolina

Appropriately attired warm and cold scene fire investigator.
Credit: Kevin Hays Fire Consulting, LLC

Preface

On behalf of the IAAI Health & Safety Committee, we are pleased to bring you this third edition of our best practices paper. As we continue to learn more about the health hazards associated with the post-fire environment and the safety actions necessary to address them, we share that information and the resulting process changes needed with all fire investigators through this document. By extension, this includes everyone else who works in the post-fire environment. This edition contains significant research findings that affect how we should safely conduct our work.

Four years ago, what started as a simple, sixteen-page white paper to address the lack of up-to-date information available on this vital subject has evolved into a comprehensive and authoritative resource document used worldwide to ensure that fire investigators and others know and understand the latest information about the hazards present at most post-fire scenes.

We greatly appreciate the efforts of our committee members and advisory panel of subject matter experts, technical reviewers, and others who have provided input. It is very humbling to know that the fire investigation community well receives the committee's work.

Be safe,

Jeff Pauley, Chairman and Pete Mansi, Co-chairman
IAAI Health & Safety Committee

> "In the past, without data, explanations were just hypotheses. Now, each new observation, each morsel of data, wields a two-edged sword: it enables fire investigator health to thrive on the kind of foundation that so much of the rest of science enjoys, but it also constrains theories that people throw up when there wasn't enough data to say whether they were right or wrong. No science achieves maturity without it."
>
> Excerpted from and adapted slightly for our profession; the red text replaced the word cosmology.
>
> Neil deGrasse Tyson, Astrophysics for people in a hurry, 2017, W.W. Norton & Co., pp 60-61

What's New in this Edition

This third edition includes many updates, additions, and enhancements based on the latest post-fire environment research and related information and contains the following changes and updates:

- A new, professionally designed cover to set it apart from previous editions
- A glossary – text words identified in italics, and others relative to the content, are defined
- The highlights text box and page
- Fire investigator testimonials
- A new equipment section
- More graphics and photos
- Updated field/gross decontamination procedures
- New information on safety management systems and total worker health
- New information about the IAAI accident and near-miss reporting program and data collection
- Added emphasis and details on hazard and risk assessment, and situational awareness, including an associated new appendix
- More recommendations to help improve fire investigator health and safety
- Additional and updated explanatory footnotes
- Additional training information
- A revised appendix that lists all the health and safety resource documents available on the IAAI website
- A new appendix that identifies the fire behavior of some common plastics

Lithium battery test burn while wearing proper PPE including a powered air purifying respirator. Credit: Dr. Peter Mansi.

Highlights

- **The single most important takeaway for all fire investigators is that a cold fire scene does not mean a safe scene or that no PPE is needed.**
- With few exceptions, it should be assumed that **EVERY** post-fire scene contains health hazards that require the use of adequate personal protective equipment, including respiratory protection.
- A cold fire scene (see Appendix A) is **NOT** a safe scene due to the continued presence of particulates that may or may not be seen. These remain until the scene is fully cleaned or demolished.
    - They are stirred up once you walk into the scene, and then more so when you move things or dig.
    - Once in the air, they can remain suspended there for hours.
- Under-ventilated fires often produce polycyclic aromatic hydrocarbons (PAHs), formed during incomplete combustion of organic materials, many of which are known, probable, or possible carcinogens.
    - These can be in the form of gases **AND** solids
    - Consequently, fire smoke, and specifically soot (particulates), presents an immediate health hazard in the post-fire scene.
- Chronic exposure to the toxic hazards at post-fire scenes can have a long-term health impact on those exposed.
- Fire investigators need to be aware of the possibility of take-home exposures and take precautions to prevent it.
- There is an underappreciation of the health risks associated with the post-fire scene by fire investigators. This is the culture we need to change.

Properly attired hot A and B scene fire investigator. Credit: Mesa, AZ Fire & Medical Department

Properly attired warm and cold scene fire investigator. Credit: IAAI

Health & Safety Committee Members

Chairman: Jeffrey Pauley MSOSH, IAAI-CFI, IAAI-CI, CFEI, MIFireE; Partner/Chief Operating Officer and Fire Group Manager, Pacific Pointe Consulting, Inc.; Senior Fire Investigator, EFI Global, Inc.; former Battalion Chief/Fire Marshal, Bedford County (Virginia) Fire & Rescue
Co-Chair: Peter Mansi Ph.D. Eng Tech, IAAI-CFI, IAAI-ECT, FIFireE, FFireInv, MCSFS; Partner, Fire Investigations UK; retired Borough Commander and Group Manager of the Fire and Arson Investigation Unit, London Fire Brigade; IAAI past president
Devin Palmer Supervisory Special Agent/CFI, ATF; IAAI Director Liaison
Michael Brewer IAAI-CFI; Captain/Battalion Safety Officer, Mesa (Arizona) Fire & Medical Department
Donald Brucker CFEI and CVFI; Chief Deputy Fire Marshal, Allegheny County (Pennsylvania) Fire Marshal's Office
James Caton IAAI-CFI, CFEI, CVFI; Senior Fire Investigator, Donan Engineering, LLC
Dawn Dodsworth Ph.D., Supervisory Special Agent/CFI, ATF
Scott Ebbert CFEI, Captain, Baltimore County (Maryland) Fire Department, Safety Division; fire investigator, Fire & Arson Investigation Consultants, Inc.
Brian Gordon IAAI-CFI, CFEI; Fire Investigator, Palm Beach County (Florida) Fire Rescue, Bomb and Arson Unit
Gary Hodson IAAI-CFI, IAAI-ECT; Senior Fire Investigator, EFI Global, Inc.; retired Provo, Utah Police Department investigator
Bryan Lewis MSN; Fire Investigator, Dutchess County (New York) Department of Emergency Response
Tom Mooney IAAI-CFI, IAAI-FIT; Fire Marshal, Redmond (Oregon) Fire and Rescue
Karl Morgan MCJ; Captain/Fire Investigator, Division of Investigative & Forensic Services, Bureau of Fire, Arson, and Explosives Investigations, Office of Chief Financial Officer Jimmy Patronis, Florida Department of Financial Services
Sarah Pendley IAAI-CFI, CFEI, CVFI, CFII; Contract Investigative Consultant
Blair Rowllings, IAAI-FIT(V), Senior Specialist Fire Investigator, Fire Emergency New Zealand
Mike Stoddard IAAI-CFI, CFEI; Senior Fire Analyst, Genesis Forensics

Advisory Panel

Dr. Jeff Burgess, Associate Dean for Research and Professor, Mel and Enid Zuckerman College of Public Health, University of Arizona
Dr. Alberto Caban-Martinez, Assistant Provost for Research Integrity, MD-MPH Program Deputy Director & Associate Professor, Division of Environment & Public Health, Department of Public Health Sciences
Miriam Calkins Ph.D. MS, CDC/NIOSH/Division of Field Studies and Engineering – Field Research Branch
Cindy Ell, President, Fire Fighter Cancer Foundation, Inc.
Kenny Fent Ph.D., Research Industrial Hygienist, Team Lead for the National Firefighter Registry Program, CDC/NIOSH/Division of Surveillance, Hazard Evaluations, and Field Studies

Additional Subject Matter Experts

A special thanks to these subject matter experts who provided an additional technical review of this third edition:

Gavin Horn Ph.D., Research Engineer, Fire Safety Research Institute, Underwriters Laboratories Inc., Columbia, MD
Barbara Millet Ph.D., Director of the User Experience Lab, Assistant Professor of Interactive Media, Department of Interactive Media, School of Communication, University of Miami
Heidi Sewchok MPH, Physical Scientist, NIOSH, National Personal Protective Technology Laboratory, CVSDB; Secretary/Treasurer, International Respiratory Protection Society – Americas
Vicki Sheppard, co-chair of the statewide F.A.C.E. Team (Firefighters Attacking the Cancer Epidemic) of the Florida Firefighters Safety & Health Collaborative; retired Division Chief, Training & Safety Division, Palm Beach County (Florida) Fire Rescue

"Working at a large, commercial fire scene, we had a partial collapse of the remaining structure. During that collapse, I was caught in the debris field as a concrete masonry unit (CMU) wall came down. We had been at the scene for several days and had conducted scene surveys every morning. The weather changed and became warmer, ultimately melting the ice that was holding the CMU wall to the bricks that supported it. It was a very good reminder that you always must have situational awareness, not just each morning as you inspect the scene, but throughout the entirety of the day. As weather changes, winds come, things are moved, the scene itself changes and thus the stability of the building may also change."

Dan Heenan MIAAI, IAAI-CFI
Assistant Fire Chief
Fire Investigations
Clark County Fire Department
Las Vegas, Nevada
Retired ATF SSA/CFI

Text in *italics* is listed in the Glossary
Bracketed numbers **[99]** are listed references
Superscript numbers[99] are footnotes

Introduction

In recent years, research regarding fire investigator health and safety, and the resulting practice changes, has not kept pace with that of firefighters. While some information can be brought from the firefighter environment to the fire investigator's, some cannot. Therefore, in 2016 the International Association of Arson Investigators (IAAI) re-established its Health & Safety Committee with the mission "to promote health and safety knowledge, awareness, discussion, and action among members of the IAAI, its chapters, and the fire investigation community in general." One of the first steps in this process was to conduct a benchmark survey to determine the current state of knowledge, awareness, and practices. [1]

The next step was to develop this first-of-its-kind, peer, technical, and administratively reviewed best practices paper to help ensure the health and safety of all who attend fire scenes. Based on the most current research and information available, it identifies the practices that fire investigators and fire investigation companies/agencies/entities should be following when working in and around the post-fire environment.

This can also serve as a training guide and policy template for companies/agencies/entities that wish to follow the latest fire investigator health and safety best practice guidelines. Fire investigator health and safety is a dynamic subject area.

The first edition (2018) represented almost two years of work by the IAAI Health & Safety Committee members, assisted by a panel of subject matter experts.

The second edition (2020) included new and updated information on this continually evolving subject. It also had technical information provided by the U.S. National Institute for Occupational Safety and Health's National Personal Protection Technology Laboratory staff, clinical researchers, and other subject matter experts.

This third edition brings readers the latest information on fire investigator best practices based on the newest research from UL's Fire Safety Research Institute, the University of Miami, and other sources, as noted in the Reference List that builds on the first two editions. Post-fire environment research continues. There will be future editions as we learn more about the health hazards associated with this environment.

By necessity, this document includes footnotes and appendices to further explain certain items. Please take the time to read and understand <u>all</u> the information in this document.

While parts of this document refer to the U.S. Occupational Safety and Health Administration (OSHA) standards and the U.K. Health and Safety Executive (HSE), this is by no means a primer on government standards and regulations as they apply to the post-fire environment. Readers should review the applicable OSHA standards found in Subpart I of Part 1910 for complete information regarding personal protective equipment and the other relevant sections of the OSHA General Industry Standards, the corresponding HSE standards, or the applicable standards/regulations for your country.

Governments can have a difficult time implementing new standards and amending existing ones. This means that some U.S. OSHA standards are based on research data from the 1960s and 1970s. Understanding the shortfalls of some of OSHA's regulations and other countries' regulations can help readers understand the importance of going beyond the regulatory minimum. This approach is sometimes called best practice. For this reason, and because the recommendations herein can outpace research so that adequate protection can be taken, the IAAI has developed this best practice document. Some U.S.

[1] See Appendix E

OSHA material is presented in this document as things that should be done in keeping with the conventions throughout, even though compliance with the regulation may be required. U.S. agencies/companies that must comply with OSHA, and agencies/companies in other countries that follow HSE guidance, should review the appropriate regulations.

Like NFPA 921**[1]**, this document is a guide that provides the latest health and safety best practices information for fire investigators. However, this is not a consensus document. Instead, it is a compilation of best practices identified explicitly for fire investigators by experts and literature. It is a tool for individuals, companies, and organizations that want to minimize the risk of harm by using effective safety practices. These are industry-specific best practice guidelines to address post-fire workplace health and safety hazards.

The guidelines in this document also apply to any entity providing fire investigator training and live burns, including burn cells conducted for training or demonstration purposes. Much of the information also applies to others who work in the post-fire environment, many of whom do not understand the hazards.

Achieving the committee's goal of improving fire investigators' overall health and safety will require a fundamental culture change within the fire investigation profession. Changing culture is not an easy task. However, whether you are a public fire investigator, a privately employed fire investigator, or another interested party, there is something you can all do that is simple and could easily be the most significant shift yet toward that culture of safety envisioned in the first Firefighter Life Safety Initiative **[2]**: ***Define and advocate the need for a cultural change within the fire service relating to safety, incorporating leadership, management, supervision, accountability and personal responsibility***. To achieve this, we must change attitudes and beliefs.

Adopting the practices identified in this document simultaneously may be difficult. Still, small changes initiated over time, including new safety practices and procedures, will lead to significant health and safety improvements and set a positive example for our colleagues **[3]**.

It is understood and acknowledged that every fire scene is different, and no recommendation made here is absolute. These are all recommendations on how best to do things in most situations while considering the unique situation found by the fire investigator upon arrival at the scene.

While this is a stand-alone document, the committee offers companion training through an IAAI-approved presentation that includes in-depth information regarding many of these recommendations and the hazards present at post-fire scenes. For information on this training, please contact iaai-safety@firearson.com.

A variety of other documents support this paper. See Appendix E for a list.

This document references various U.S. regulations/standards, documents, and agencies, as well as U.K., E.U., and international regulations/standards and documents as necessary. Readers from other countries should refer to the similar appropriate items for their country or, if none exist, use the U.S. or U.K. ones for reference.

All listed website links were valid as of the publication date. The committee and the IAAI are not responsible for any broken links after the date of publication.

OUR GOAL IS TO FOSTER A CULTURE WHERE EVERY FIRE INVESTIGATOR AND THEIR EMPLOYER COMMIT TO A SAFE AND HEALTHY WORKPLACE ENVIRONMENT.

Background

The first edition of this document started to turn the tide; however, fire investigator health and safety continues to be one of the most neglected training areas throughout the fire investigation community; few organizations consider it a priority **[4]**. The IAAI is committed to changing this. Through a resolution adopted by the board of directors in September 2018, the IAAI:

- Took a position to support, enhance, and educate its members regarding the latest research information and best practices regarding fire investigator health and safety matters throughout its activities, efforts, and publications.
- Urges every committee to incorporate, where practical, health and safety awareness through their publications and activities utilizing information provided by the IAAI Health & Safety Committee and approved by the executive board.
- Encourages each chapter to embrace and educate its members on fire investigator health and safety matters through their activities, efforts, and publications, utilizing the educational materials approved and provided by the IAAI.
- Asks every member to follow the IAAI's health and safety best practices.

Health Hazards

Due to the complexity of the fire environment, it is difficult to characterize all the hazards that could be present. However, it is well-established that there are many hazards at almost every fire that can be very harmful to one's health.

A significant health problem that fire investigators should be aware of is that sudden cardiac events are a leading cause of on-duty deaths in the fire service. The documented risk post-suppression may be partially attributed to fireground exposures. See the cited references in **[35]**.

Beyond all the physical and environmental hazards that can be present at fire scenes (see NFPA 921, 2021 ed., Chapter 13 for additional information), fire investigators must also be aware of the biologic, including *toxic* and *toxicant* hazards that may be present.

Biologic hazards can come from human and animal bodies, poisonous plants, bug and animal bites, and mold. These hazards can usually be mitigated using proper personal protective equipment (PPE).

While these must be considered during a scene safety assessment, they are either present or not. However, other *toxic* hazards are present at almost every fire scene (forest, brush, crop, structure, vehicle, trash). While fires are typically short-duration events, *chronic* exposure to these *toxic* hazards can have a long-term health impact on those exposed.

The primary health hazards for fire investigators are from the many *aerosols*, gases, and vapors contained in fire smoke and fire debris. Fire smoke consists of invisible vapors and gases, visible particulates, and invisible *nanoparticulates*, and all are hazardous to fire investigator health. These become *toxicants* when they contact humans in a sufficient quantity to be harmful, primarily through inhalation or absorption.

Fire debris also contains many different chemicals, gases, and particulates that are hazardous. During and immediately after a fire, there are many fire-related gases present. But after the fire, there are particulates of many different sizes, vapors, and gases present that can threaten the fire investigator. While much has been written about the effects of these *toxic* gases on firefighters in recent years, not enough has been said about their impact on fire investigators' health, but that is changing.

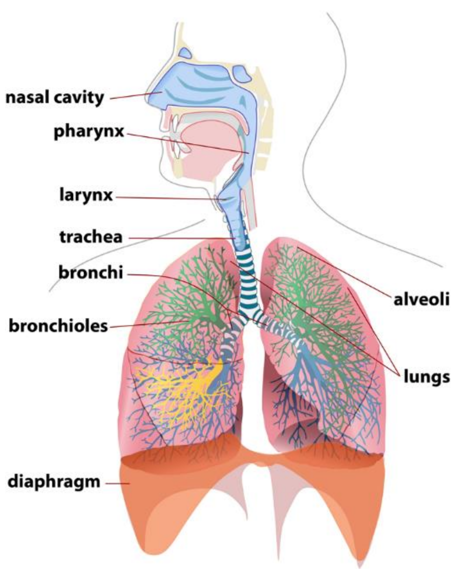
> *"There are many hazardous chemicals in the post-fire environment, and how they combine to form other hazardous compounds is presently unknown."*
> **Miriam Calkins Ph.D., CDC/NIOSH**

Several research projects have shown that, in some instances, many of the gases and vapors dissipate after several hours. However, particulate hazards can persist for the life of the scene. This presents a long-term health hazard for fire investigators. Many factors affect particulate behavior in the post-fire environment, but they can remain suspended for many hours once they are in the air[2].

[2] See: https://multimedia.3m.com/mws/media/1934851O/3m-anz-rpd-fit-test-poster-particle-hang-time.pdf

The composition of post-fire scene particulate matter depends on the nature of the burning fuel and the conditions of combustion. For example, structure fires typically involve burning plastics, synthetic materials, electronics, and building materials, which can produce a wide range of organic, oxygenated, and inorganic chemicals, as discussed elsewhere in this document.

Particulates are important to fire investigators because they can cause serious health problems when they get into your body. Particulate matter (PM) larger than 10 µm (microns) is typically removed from one's respiratory tract by the body's natural defense mechanisms (nasal hair, cilia in the throat area). Particles less than 10 µm are inhalable (can enter the lungs) and are potentially problematic for human health. Particles less than 2.5 µm are respirable; they can penetrate deep into the lungs and are potentially more problematic for human health. Particles smaller than 1 µm can penetrate very deep into the lungs, all the way into the alveoli, and are potentially very problematic for human health. There are more than 500 million alveoli per lung, all exposed to everything you breathe in. This is where gas exchange occurs, and the *toxins* get into your bloodstream and organs. See the graphic on page 35 for a size comparison.



Source: American Society of Safety Professionals

Research by Professor John Cimbala at Penn State University notes that, on average, most people can visually distinguish objects down to about 70 µm (microns), about the size of a single strand of hair. If the particulates are light scattering, they may be visible to 10 µm. **Combustion produces mostly submicron particles (less than1 µm). This means the particulate matter that can be the most harmful to fire investigators when inhaled cannot be seen.**

A 2010 study by Underwriters Laboratories, Inc. found that, regarding smoke particles collected during *overhaul*, 97+ % were too small to be visible by the naked eye suggesting that what may appear to be 'clean' air may not be really that clean **[5]**. These are the nanoparticulates and persist through the fire investigation stage and beyond.

We know that during the fire and for some time after, *carbon monoxide* (CO), *hydrogen cyanide* (HCN), and *formaldehyde* (FM) are present, but the duration for others can vary. Still, it is difficult to judge the extent of gas formation in fires. Gas composition varies widely, depending on the composition of the burning material, the temperature, and the oxygen supply. It is believed that between 60% and 80% of all deaths related to fire are attributed to *toxic* fumes, commonly referred to as smoke inhalation. *Carbon monoxide* is widely thought to be the primary cause. However, HCN is also formed. Forensic evidence has also shown that HCN can be an important contributor to death in fire victims. **[6]**.

Because the extent of this problem in the post-fire environment is fluid due to the many scene variables present, exposure precautions need to be taken, especially by public fire investigators who are often at the scene before extinguishment.

There are many human-made materials today that, when burned, give off *toxic* substances that can be very harmful when inhaled or absorbed. These materials are pervasive in today's structures, watercraft, aircraft, and vehicles. The following information highlights just a few of these.

A hidden hazard found in many structures is Teflon®, a PTFE (polytetrafluoroethylene) included in per- and polyfluoroalkyl substances (PFAS). Not only is this product found in virtually every residential kitchen, but many consumer electronics and commercial electrical insulation products also contain PFTE. Teflon starts to decompose at between 570°F (300°C) and 1,100°F (600°C) depending on whether its rigid or plasticized. This leads to hydrogen fluoride, phthalates, and fluorinated organics emissions. Once Teflon ignites at temperatures between 1,100°F

(600°C) and 1,470°F (800°C), it also emits *carbon monoxide*, benzene, and other organics **[7]**. The U.S. National Toxicology Program considers Teflon a reasonably anticipated human *carcinogen* **[8]**. There may also be other PFAS compounds present at the fire scene.

Appendix F lists the thermal characteristics and emissions of some other plastics. During a fire, all these materials decompose to release hydrocarbons that can be cancer-causing.

A particulate hazard of note is asbestos. From the 1930s to the 1970s, manufacturers mixed asbestos into a range of building materials as a cheap way to make almost anything more durable. Fires in these structures can release asbestos fibers from a variety of sources. While the use of asbestos was significantly reduced in the U.S. after the health hazards became better known, the material is still used today in some new products so it can be present after any structure fire **[9]**. Additionally, the regulations in other countries vary greatly, so the possibility of asbestos exposure in the post-fire environment is possible anywhere.

Another relatively unknown particulate hazard is lead. In addition to lead paint in houses built before it was banned (in the U.S.) in 1978, many things in today's homes contain lead, including jewelry, pipes, stained glass, antiques, electronics, and toys **[10]**. Lead vaporizes at 932°F (500°C) **[11]** and when it cools and solidifies, the lead dust is contained in the post-fire nanoparticulates. Exposure to lead *nanoparticulates* is especially hazardous to young children, newborns, and fetuses.

All fire investigators need to be aware of the potential for *take-home exposures*. The proper use of PPE and decontamination procedures will minimize this risk **[12]**.

Most occupational exposure happens little by little on a regular basis. But for fire investigators, exposure may also come in the form of one or more single encounters with harmful smoke or debris.

Other Fire Types

While many fire investigators spend much of their time working at residential and commercial structure fires, other fire types present the same health hazards.

The large amounts of plastics (see Appendix F) and composite materials (fiberglass is the most common, but there are others, such as carbon fiber/fibre) found in watercraft, aircraft, and motor vehicles, present significant inhalation and absorption issues. In addition to off-gassing, composite materials burn faster and hotter. "Fires involving composite materials release *toxic* fumes and microparticles into the air, causing serious health risks **[13]**."

Wildland and urban interface fires offer their own unique set of health hazards. Wildfire or biomass smoke is associated with an increased incidence and severity of cardiopulmonary disease and is recognized by the World Health Organization as a probable human lung *carcinogen*. Multiple studies report associations between wildfire smoke exposure and adverse health outcomes, including asthma, respiratory infections, cardiovascular disease, and mortality. Of the many components in wildland fire smoke, primary and secondarily formed particulate matter is a significant concern because they can remain in the air for days or weeks and be transported over long distances **[14]**.

THE BODY OF SCIENTIFIC EVIDENCE DOCUMENTING THE HEALTH HAZARDS OF THE POST-FIRE ENVIRONMENT IS RAPIDLY INCREASING.

While they are a health hazard by themselves, the hazard level increases when wildland fires involve residential or commercial structures.

This means that fire investigators working in these unique post-fire environments are exposed to health hazards that require protection. Proper PPE, including respiratory protection, as noted herein, is needed when operating at all scenes.

Research

One of the first documented research findings relating to fire investigators was the NIOSH/ATF study in 1996-97 that looked at actual fires & test burns. They found that fire investigator exposures to irritants that cause *acute* effects and *carcinogens* that have *chronic* effects are of concern. The use of respiratory protection and mechanical ventilation equipment can reduce the potential for exposure **[15]**.

A 2010 survey of 70 fire investigators attending an IAAI Arizona chapter seminar found that nearly 50% of the investigators did not routinely use any type of respiratory protection. In 2011, as part of a university course research project, Phoenix (AZ) Fire Department fire investigator Willie Nelson used a four-gas meter, and two sampling pumps that tested for O2, CO, H2S, HCN, and broad-spectrum aldehydes and took air samples while conducting investigations at 16 fire scenes. Eight of the scenes contained detectable levels of airborne hazardous *toxins*, with three approaching or exceeding the ceiling/*upper exposure limit* levels. Ventilation appeared to be the most significant factor in influencing the amount of dangerous airborne *toxins* that remained in the fire scene after *overhaul*. Time, by itself, however, was not a good predictor of possible hazards. In one instance, high levels of *formaldehyde* were found at a scene three days after the fire. Other findings included:

- The size of a fire is not a good indicator of the potential hazards
- The size of a fire in relation to the structure is not a good predictor of possible hazards
    - A small kitchen fire produced the highest readings
- Many factors affect the results:
    - Amount and type of ventilation
    - Size and location of the fire
    - Type of structure
- Ventilation may help with gases but not with particulates **[16]**

These findings are still valid today.

Reported in 2013, NIOSH carried out a study at a fire service training facility to determine if airborne polycyclic aromatic hydrocarbons (PAHs) and other aromatic hydrocarbons generated during live-fire training contaminate and pass through the skin of firefighters. Their recommendations included providing "as much natural ventilation as possible to burned structures before starting investigations" **[17]**. This can reduce gases/vapors but not particulates.

There have been several other studies conducted with similar results. The cumulative results of this research tell us that:

- Fire investigators generally are at more fire scenes than most firefighters
- Particulates can be present long after the fire is extinguished
- Fire investigators typically wear less PPE than firefighters
- Fire investigators have a high exposure risk to toxic hazards
- While we see more *SCBA* use by firefighters during *overhaul*, fire investigators are generally not using adequate respiratory protection[3]

In the Fall of 2018, fire investigators were added to the U.S. federally funded Fire Fighter Cohort Study https://www.ffccs.org/ as the Fire Investigator Expansion Study (FIES). The project's purpose is to develop a framework for establishing a long-term firefighter multicenter prospective cohort study focused on carcinogenic exposures and health effects. The IAAI is represented on the Study's Oversight and Planning Board.

The IAAI Health & Safety Committee is at the forefront of promoting new research into the post-fire environment.

One of the more significant studies underway in the FIES is the University of Miami's wristband project. Public and private fire investigators around the US are wearing silicone wristband material while working at a post-fire scene. These wristbands are used because silicone can absorb the chemicals and compounds found in residual gases, which can then be analyzed for 16 US EPA Priority PAHs.

While cumulative results have not yet been published, in one group of 27 North Carolina fire investigators, 90% of recorded exposures were

[3] There is a growing trend among public fire investigation units to wear SCBA during the entire post-fire scene examination. When activities are well-planned and staffed there is typically only a minimal increase in scene examination time.

attributed to lower molecular weight PAHs[4]. These are produced in smoldering fires versus the higher molecular weight PAHs produced during an active fire. There were significantly high Naphthalene[5] and Phenanthrene[6] readings in all 27. The average exposure was 6.2 days post suppression, with most occurring within three days. This strongly suggests that hazardous gases persist in the post-fire environment for an extended period, creating an exposure hazard that requires respiratory protection. The IAAI Health & Safety Committee was instrumental in getting fire investigators involved in the University of Miami wristband study.

At London South Bank University, particulate filters that have been worn one time by fire investigators are being analyzed to measure the quantity and size of particulates present. This project was suspended in 2020 due to COVID but is expected to restart.

In a two-year, AFG-funded research project that started in early 2021, the Fire Protection Research Foundation and the Textile Protection and Comfort Center at North Carolina State University are analyzing the effectiveness of various fire investigator apparel ensembles in the post-fire environment. This study will also be the first independent look at the efficacy of decontamination wipes.

In late 2020, the Underwriters Laboratories, Inc.'s Fire Safety Research Institute conducted experiments to measure the amounts of gases and particulates in burned structures over time. This work looked at post-fire structures up to five days after extinguishment in various situations to simulate typical fire investigator activities, ranging from just minor disturbances such as walking through the scene, to significant disturbances such as digging out the scene.

This study consisted of 18 (nine bedroom and nine common area) test fires with air sampling at one hour and, for some experiments, one, three, and five days after extinguishment for gases and particulates **[35]**.

- Particulate levels ranged from moderate to extremely hazardous AQI levels in most scenes out five days.
- Most gas levels were down after two hours; however, *formaldehyde* levels increased over time in some, and in a couple of cases, exceeded the NIOSH ceiling limit.

> "The most important findings of this (UL FSRI) study are that 1) elevated and hazardous levels of airborne particulate may be encountered during all phases of the post-fire investigation depending on the activities of the fire investigator and 2) airborne formaldehyde concentrations could exceed recommended exposure limits in extended phases of the post-fire investigation."
>
> Journal of Occupational and Environmental Hygiene
> (see Reference 35 for full citation)

These results highlight the need for respiratory protection during all phases of the fire investigation process.

Additional research projects in the planning stages will further our understanding of the health hazards associated with the post-fire environment.

Discussion

What does all of this mean for fire investigators? First, investigator safety and health need to be a higher priority in many agencies and companies. Effective, fact-based policies and procedures should be adopted and embraced by fire investigators to ensure their long-term health and well-being. The consistent availability and use of appropriate PPE, coupled with basic knowledge of the *toxic* and cancerous hazards in the post-fire scene environment, is imperative. Research has shown that inhalation and absorption hazards remain hours and often days after fire suppression.

[4] In UL studies, a wide range of PAH molecular weights were produced by structure fires and training fires.
[5] *IARC* Level 2B – possibly carcinogenic to humans. See also https://pubchem.ncbi.nlm.nih.gov/compound/naphthalene#section=GHS-Classification
[6] *IARC* Level 3 - Not classifiable as to its carcinogenicity to humans. See also https://pubchem.ncbi.nlm.nih.gov/compound/phenanthrene#section=Safety-and-Hazards

Fire investigators must understand the warning signs of *acute toxicity* and ensure that area monitoring for *carbon monoxide* (CO) and hydrogen cyanide (HCN) is conducted during the scene investigation at a minimum, whenever possible. Not all hazards are immediately visible, and the effects of *toxic* exposure may take years to appear. Low readings obtained from monitoring should not preclude using the minimum level of respiratory protection recommended herein (see Appendix B); these readings do not mean the atmosphere is entirely safe, only that alert thresholds have not been met. As we disturb fire debris during our scene examination, levels are also likely to fluctuate.

Today's fire scene is vastly different than that of twenty or more years ago, and it is getting more hazardous as the use of human-made materials continues to increase. Years ago, what is now called legacy furniture was commonplace. These items were made of natural products that burned slower and generally did not produce the same magnitudes of harmful chemicals commonly seen in the combustion of today's furnishings. As opposed to the older, traditional construction materials and methods, the modern-built environment has resulted in more cost-effective building materials that can increase fire spread and decrease the time to flashover. Unfortunately, households today are also full of human-made products that produce many harmful chemicals during a fire, and the list of potential sources is long, including these common sources in addition to others previously mentioned:

- Plastics – trash bags, pipes, electronics, upholstery, carpet, & clothing
- Pesticides – home & agricultural
- *Aldehydes* – insulation, carpet dyes, & glues
- Creosote – roofing & wood preservative

Many of these items produce known *carcinogens* when they burn. The effects of some substances are not yet fully understood.

The list of harmful and, in many cases, cancer-causing chemicals in fire-produced gases is long. Most fires also give off polycyclic aromatic hydrocarbons (PAH), which are products of incomplete combustion that can exist as particles and gas so they can be inhaled AND absorbed. Of the 18 PAHs commonly produced in today's fires of all types, nine are known, probable, or possible *carcinogens* **[17]**.

The effects of exposure to products of combustion may be *acute* or *chronic*. While *acute* problems are typically dealt with in the short-term, *chronic* issues can take many years to manifest and are affected by the concentration and duration of the exposure(s) and the entry route. **The two most common entry routes for fire investigators are inhalation and dermal absorption.** Not coincidentally, the body's two largest organs are the lungs and the skin. And just to make matters more complicated, the body's natural defense mechanisms and each person's susceptibility are also a factor as to whether exposures result in cancer formation.

The body's dermal layers (skin) provide an important pathway for *toxins* to enter the body. Of importance to fire investigators entering the post-fire scene is that skin permeability is likely to increase as the skin temperature increases[7] **[18]**.

Dermal exposure is a significant exposure pathway. Studies have reported PAH contamination in the neck region after firefighting activities and shown that PAHs can be readily absorbed through the skin. As we become more aware of the risks, we must implement control measures to reduce contamination reaching the skin **[45]**.

Unlike inhalation exposure, there are no U.S. occupational exposure limits (OEL) for dermal exposure. The regular removal of soot and unseen particulates from the skin helps limit the absorption of the many harmful chemicals found in the post-fire environment **[19]**. The World Health Organization notes that dermal occupational exposure limits are hard to determine due to the number of variables involved and that knowledge of the hazardous characteristics of the compound is necessary **[20]**. This is virtually impossible to determine in the post-fire environment.

Even though we crawl around in and dig up fire debris that contains particulates and nanoparticulates and

[7] Multiple documents and websites state that, "skin's permeability increases with temperature; for every 5°F increase in skin's surface temperature, absorption increases 400%." While there can be an increase, the original author of this statement has recanted it as not valid.

can release *toxic* gases, or the gases just ride along on the particulates on their trip into your unprotected lungs, the culture of the past has been, “It hasn’t hurt me yet so why should I change?” or “That’s the way we’ve always done it” or even worse, “It isn’t manly to wear all that stuff.” Unfortunately, this old school mentality is exacerbated by the fact that absent something bad happening at or immediately after being at a scene, we go home feeling OK and not thinking about the cumulative or *chronic* effects of these exposures, so when medical issues do develop in later years, it is too late to go back and change things. This is an inherently dangerous attitude that needs to change.

Chronic exposure symptoms of disease typically do not present themselves for years[8]; this is known as latency. Establishing, following, and enforcing scene safety protocols today will save fire investigators’ lives in the future. The number one way to accomplish this is using PPE, especially respiratory protection **[21]**.

Safety Hazards

While there are many health hazards in the post-fire environment, there are also safety hazards. Completed and pending NIOSH Fire Fighter Fatality reports include three that involve public fire investigators.

- In January 1999, a fire investigator was killed when a chimney collapsed **[22]**.
- In July 2000, a fire investigator died from blunt force trauma after a fall **[23]**.
- In August 2011, a 55-year-old male fire marshal suffered a sudden cardiac event during a fire department physical ability test **[24]**.

These reports do not include public sector fire investigator injuries, and no source documents the injuries or fatalities of private fire investigators. However, these reports do offer examples of fire scene safety hazards. While not every post-fire scene hazard can be mitigated, it is necessary to make every effort to identify the hazards and assess their risks.

Safety Management System

The failure to identify or recognize hazards is one of the root causes of workplace incidents. This can be especially true in the post-fire environment, where many different potential hazards can be present. Just like every fire is different, every post-fire scene is different.

“The system safety concept calls for a risk management strategy based on identification, analysis of hazards, and application of remedial controls using a systems-based approach. The systems-based approach to safety requires the application of scientific, technical, and managerial skills to hazard identification, hazard analysis, hazard elimination, control, and management of hazards throughout the life cycle of a system **[25]**.”

Appendix D more fully addresses the risk assessment and analysis process related to the post-fire scene.

Associated with this is the importance of having a Total Worker Health program; policies, programs, and practices that integrate protection from work-related safety and health hazards with promotion of injury and illness-prevention efforts to advance worker well-being.
See https://www.cdc.gov/niosh/twh/totalhealth.html for additional information.

Related Activities

It is challenging to quantify the health impact of fire investigation-related occupational diseases because of the relatively transient nature of persons who do this work or otherwise have been exposed to the post-fire environment. Therefore, it is essential for fire investigators to document their exposures, and almost every fire scene attendance is an exposure.

In July 2018, the Firefighter Cancer Registry Act was signed into law in the U.S. The Act requires the Centers for Disease Control and Prevention (CDC) to develop and maintain a voluntary registry of firefighter exposures. Fire investigators will be included in this registry. This National Firefighter Registry will include the number and type of fires

[8] *Chronic* exposures can lead to leukemia in as little as three years while lung cancer can take as long as thirty years to appear, according to Dr. Burgess.

each person attended. Information in the registry will be used to improve the monitoring of cancer incidents among firefighters and collect and publish information about cancer occurrences among this population. Registry data will be available for research for free if the research findings are made public **[26]**.

The Personal Exposure Reporter (PER) is an app developed by the University of Miami as part of the Florida Firefighter Cancer Initiative to learn more about fire service exposures to *toxins* and identify safety measures to reduce any identified risks. The Personal Exposure Reporter is a free, password-protected application allowing firefighters and fire investigators to keep a digital record of their exposures to hazardous environments and conditions. **This data collection tool is available for all fire investigators in every country.** See https://per.miami.edu Every fire investigator is strongly encouraged to create an account and document their exposures. While other apps track firefighter exposures, PER is the only one known to include fire investigators specifically.

An area lacking in the fire investigation community is *accident* and *near-miss* reporting. While there are programs for the fire service in general, they do not adequately address the needs of fire investigators.

In the fall of 2021, the IAAI board approved the creation of a unique, dedicated Fire Investigator Accident and Near-Miss Reporting Program. In a cooperative project managed by the IAAI Health & Safety Committee and the University of Miami, PER is the data collection tool for this program. This part of PER is open to fire investigators in every country, like the exposure reporting. With PER user permission, summary data, de-identified, will be shared with IAAI to inform the development or refinement of training programs, policies and procedures, and other processes.

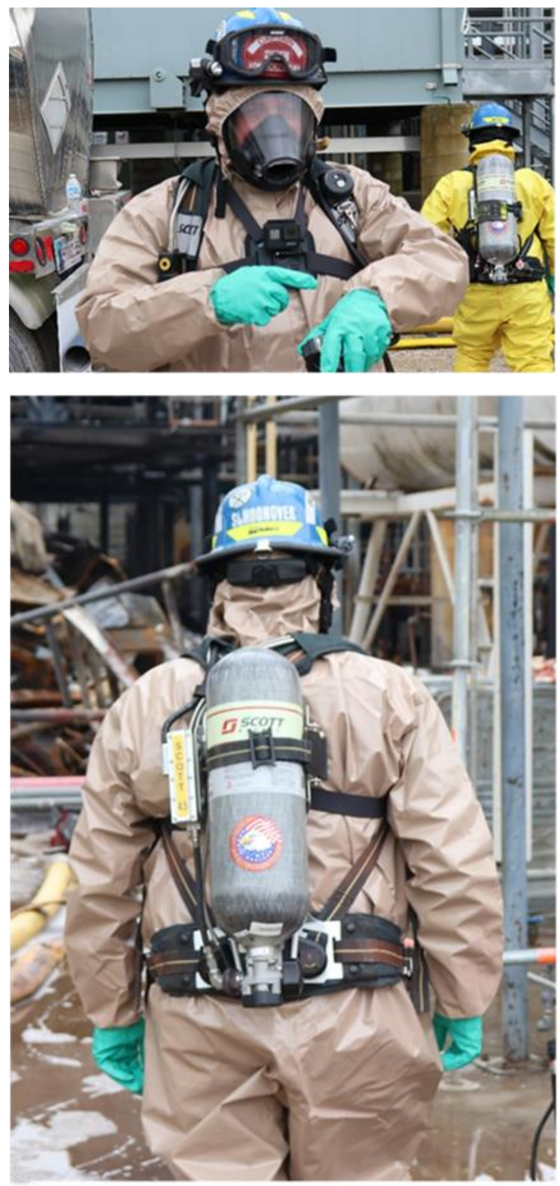
We strongly encourage every fire investigator involved in an *accident* or *near-miss* incident to anonymously report it using PER. The more information collected, the better the summary data will be, and this helps every fire investigator.

The Bottom Line

There are many potential hazards in and related to the post-fire environment, which could present significant health issues to fire investigators and anyone else working in this environment at some point in the future. Following the modifiable risk factors identified in these best practices can be a great asset to your long-term health.

Many fire investigators work alone or in very small groups where it is easy not to follow this document's research-supported health and safety recommendations. Yet, regardless of regulations or employer policies, each of us must decide whether we want to do the right thing and protect ourselves now from something that may or may not occur at some point in the future.

But the other side of this is that we should also be interested in setting a good example for others, especially those just entering or who have recently



Hot Scene A PPE
Credit: Harris County, TX Fire Marshal's Office

joined the profession. We set a positive example by teaching the best practices and stressing their use, and by older, longer-serving fire investigators wearing their PPE and following the best practice protocols. This is vital to our profession's future.

"I have been a firefighter for 26 years, a paramedic for 23 years and worked in a busy system. I started performing fire investigations on my days off five years ago. A little over a year ago I was diagnosed with CPTSD (complex post-traumatic stress disorder) from the experiences in my line of work. I had turned to alcohol to drown out all the nightmares, flashbacks, and memories when I ran out of ways to cope. I turned into a very angry person. I held it all in and shoved everything down because I was afraid to look weak. I am proud to say I went to a facility that specializes in first responders to get help with my CPTSD and found out that it's ok to be human. Making that phone call and admitting I needed the help was the hardest thing I have ever had to do. I am glad to say that I have been doing very well with the help of my support network and family. I have not had a drink in over 13 months. I do not have nightmares and flashbacks nearly as often as I did. They still occur from time to time, but I have the tools to make them manageable and allow me to live my life. I say this because recovery is possible. I'm back to doing the job I love and most of all being the man my wife married. I get the honor to be there for my two boys and enjoy them. I want to leave you with these words...... NO one has to fight alone, and recovery IS possible!"

Troy Clements MIAAI, IAAI-FIT
Danville, Indiana
January 2022

Part I – Fire Investigator Health and Safety Best Practices

The following best practices are directed to employers and individual investigators. While individual employers may have specific requirements that supersede or provide similar variants to this list, this comprehensive list recommends the processes, procedures, and knowledge that each organization, team, or individual can adopt to reduce the overall health and safety risks to fire investigators. In addition, the following items should be accounted for when formulating policy and while performing duties related to fire investigations.

Section 1.0 Employers *should*:

1.0.1 Develop and implement written policies covering all aspects of fire investigator health and safety, including but not limited to:

1.0.1.1 Work schedules that consider workload vs. hours worked, so they do not increase and hopefully reduce worker stress.

1.0.1.2 A *site safety assessment* before starting every fire scene investigation and at the start of each day it continues that includes:

1.0.1.2.1 A methodology to identify and mitigate environmental, biologic, and chemical/*toxic hazards*, in addition to other possible hazards.

1.0.1.2.2 Air quality monitoring for hot and warm scenes.

1.0.1.2.3 A hazard communications plan[9].

1.0.1.2.4 Personal protective equipment (PPE) ensemble definition, requirements, and user training[10].

1.0.1.2.5 When to use respiratory protection equipment (RPE) and scene placarding to identify areas of required RPE use.

1.0.1.2.6 See Section 2 for additional information regarding vehicles.

1.0.1.3 A respiratory protection program that addresses (U.S.) 29 CFR 1910.134 or similar for other countries.

1.0.1.3.1 See Appendix B for additional information regarding respiratory protection.

1.0.1.4 A requirement that employees do not have facial hair that impedes the effectiveness and protection of respiratory PPE[11].

1.0.1.5 Annual respirator fit testing

1.0.1.6 Parameters on when to use respiratory protection equipment[12].

1.0.1.7 Support mechanisms necessary to have on-site whenever *SCBA* use is required.

1.0.1.8 Control the transportation of contaminated tools/equipment and PPE.

1.0.1.9 Decontamination procedures (See Appendix C) that address:

1.0.1.10 Cleaning of contaminated clothing.

1.0.1.11 Effective personal hygiene practices to reduce contaminant effects, and

1.0.1.11.1 The recommendation is to shower within an hour of concluding the exposure.

1.0.1.12 Regular/annual physicals/health checks by a medical professional aware of the physical demands of fire investigations, including PPE use, and that includes:

1.0.1.12.1 Behavioral health screening.

1.0.1.12.2 Skin screening by a dermatologist.

1.0.1.13 The inclusion of fire investigators in any debriefs, CISM activities, after-action reviews, or similar post-incident analysis activity.

1.0.1.14 A protocol for exposure to occupational stress that includes a time out/hot wash immediately after the event and trauma screening 3-4 weeks after the event[13] **[27]**.

1.0.1.15 The training identified in Section 4.0.

1.0.1.16 *Accident* and *near-miss* investigations, including roles and responsibilities for all parties and

[9] In the U.S., OSHA regulations (29 CFR 1910.1200) requires employers to communicate hazard information to employees.

[10] Rely on known authorities, equipment manufacturers, and industrial hygienists to assist the authority having jurisdiction in generating written procedures addressing replacement, change out, reuse, and controlled disposal of contaminated respirator cylinders, backframe assemblies, face blanks, filtration elements, clothing, gloves, boots, and other human factors PPE.

[11] This is required in 29 CFR 1910.134(g)(1)(i)(A) for most U.S. employers.

[12] While respiratory protection equipment is a part of the full PPE ensemble, because of its importance it is listed separately in this document. What is proper is defined by the situation as found by the fire investigator, using the guidelines established by the employer's competent decision maker or, if self-employed, using the information and resources identified herein.

[13] See the Stress First Aid model for firefighters and EMS personnel for further information https://www.everyonegoeshome.com/training/behavioral-health-training/stress-first-aid-sfa-firefighters-emergency-services-personnel/

behavioral health support for the involved person(s) and team.

1.0.2 Have a program for employee behavioral health awareness and support.

1.0.3 Require that at large-scale investigation scenes, including multi-agency investigations and joint scene exams, a safety officer/manager is designated and following Section 3.1.12 below.

1.0.4 Ensure that all fire investigator training follows the best practices described herein.

1.0.5 Ensure that all live burn training, including burn cell demonstrations, requires all participants and observers in the hot and warm zones to use appropriate PPE, including respiratory protection, and follow the precautions identified in this document and NFPA 1402 **[28]** and NFPA 1403 **[29]**.

1.0.6 Take a proactive approach to managing fire investigator workplace safety and health by having a formal safety and health program. These programs can prevent workplace illnesses, injuries, and death, and the suffering and financial hardship they can cause for workers, their families, and employers.
1.0.6.1 These programs have been linked to:

- Improvements in product, process, and service quality
- Better workplace morale
- Improved recruitment and retention
- A more favorable image and reputation among customers, suppliers, and the community **[22]**

1.0.6.2 Include a safety management system approach as part of the health and safety program.

1.0.7 Objectively investigate every employee-involved *accident* and *near-miss* incident

1.0.8 Provide ballistic protection to fire investigators When advisable for personal safety.

Section 2.0 Vehicles

2.0.1 Vehicles used by fire investigators should support the *clean cab concept* and be able to store and transport tools and materials separately, with contaminated items physically separated from the passenger area.
2.0.1.1 Vehicles should not have carpeting or cloth seats. If a vehicle does have these, they should be covered with something that is easily decontaminated or washed.
2.0.1.2 Vehicle electronics should be off the floor to facilitate cleaning.
2.0.1.3 Vehicles should have a portable or fixed water system for the decontamination of persons and tools and immediate cleaning of injuries or direct contact contamination.
2.0.1.4 Vehicles should be equipped with a pressurized water extinguisher and an ABC dry chemical fire extinguisher.
2.0.1.5 Marked vehicles should conform to or follow the principles of the current version of NFPA 1901 or a similar best practice document that addresses emergency vehicle safety marking, such as the USFA Emergency Vehicle Safety Initiative or the FEMA Emergency Vehicle Visibility and Conspicuity Study.
2.0.1.6 All vehicles equipped to operate as an emergency vehicle should have a noise-reducing headset connected to the vehicle's two-way radio(s) to limit the occupational noise hazard produced by the vehicle's audible emergency notification systems (siren(s), airhorns, etc.) for each seat position.

2.0.2 The vehicle's cab interior should be cleaned regularly, regardless of contamination potential.

2.0.3 Containers of collected evidence and soiled/dirty tools and clothing should be stored in areas other than the vehicle's passenger compartment or trunk/boot to prevent off-gassing and airborne particulate exposure.
2.0.3.1 If this is not possible, all items used and worn at the scene should be placed in tight-sealing tubs/containers or sealed in sturdy plastic bags[14].
2.0.3.2 All evidence containers should be appropriately packaged and sealed before being placed in the vehicle.

[14] Turnout gear PPE should be in a minimum 6-mil plastic bag because thinner bags have been shown to tear. Softer PPE, such as that worn during warm and cold scene exams can be placed in any bag that will effectively contain particulates and off-gassing, and not tear. Both types are to be sealed after being filled. See Section 3.3 for additional information.

2.0.4 Do not enter or allow others to enter your vehicle's passenger compartment unless ALL potentially contaminated clothing has been removed and all exposed skin areas have been cleaned.
2.0.4.1 In an emergency, such as an evacuation or injury, disposable seat covers or similar should be used to minimize cab contamination.

2.0.5 When examining vehicles, all relevant safety precautions and PPE usage noted in other sections of this document, including the use of proper respiratory protection listed in Appendix B, should be followed.

2.0.6 Fire investigators should recognize that special hazards exist when examining alternative fuel vehicles and educate themselves regarding these hazards before beginning any examination of this type of vehicle[15] **[30]**.
2.0.6.1 This includes checking for vehicle type hazards – electric and hybrid vehicles with lithium-ion batteries and similar. These batteries may be prone to reignition and have been known to reignite as much as 22 hours after initial extinguishment.
2.0.6.2 Shock, fire, and explosion hazards can be present.
2.0.6.2.1 50 volts DC is lethal. Many electric vehicles have more than 400 volts DC.
2.0.6.2.2 Disconnecting wires/battery cables does NOT equal a safe working environment.
2.0.6.3 Proper PPE and battery-handling precautions are necessary.
2.0.3.1 Investigators should review the applicable safety information for the model vehicle before starting the investigation. This information is available from the manufacturer's website or the current version of the NFPA Alternative Fuel Vehicles Emergency Field Guide.
2.0.3.1.1 Some owners have self-modified their vehicles to operate on alternative fuel sources. However, because these vehicles likely do not conform to industry standards, special hazards may exist and recommended safety procedures may not apply, thus requiring additional precautions to be taken.

Clean cab examples. Credit: Palm Beach Fire Rescue

[15] There are several applicable cfitrainer.net modules available on this subject.

Section 3.0 Individual Fire Investigators *should*:

3.0.1 Maintain a healthy lifestyle to manage modifiable health risk factors, including:

3.0.1.1 Seven to nine hours of sleep a night.

3.0.1.2 A healthy diet.

3.0.1.3 Regular exercise.

3.0.1.4 Eliminate or limit alcohol intake and tobacco use.

3.0.1.5 Wear a head covering and long clothing as often as possible.

3.0.1.6 Use sunscreen of at least SPF 30.

3.0.2 Be physically fit and able to perform the job, including being fit-tested on assigned respirators and safely wear and doffing an open circuit pressure-demand *SCBA* when necessary.

3.0.3 Not having facial hair that impedes the effectiveness of respiratory protection equipment.

3.0.4 Have an annual physical (see Appendix E).

3.0.5 Have an annual skin check by a dermatologist because the fire investigation profession increases skin cancer risk.

3.0.5.1 If there is, or has been a prior, positive skin exam, these may need to be done more frequently.

3.0.6 Immediately clean and bandage any skin area that gets a cut or abrasion.

3.0.6.1 Any existing cut or abrasion should be bandaged before starting the scene examination.

3.0.6.2 Follow agency/company procedures for documenting any first report of injury.

3.0.7 Maintain a written log of every scene examination that includes, at a minimum:

3.0.7.1 The date, location, and nature of each incident.

3.0.7.2 The number of hours spent at the scene.

3.0.7.3 The presence of any hazardous condition or any injury or unprotected exposure possibility.

3.0.7.4 Use the Personal Exposure Reporter (PER), developed by the University of Miami, to collect this information. See **https://per.miami.edu**

3.07.4.1 This is the only known electronic data collection tool that includes fire investigators.

3.0.8 Self-report all operational exposures and behavioral incidents to a reporting database.

3.1 Before Going, Enroute to and Arriving at the Incident

3.1.1 It is important to know where you are going, the best route of travel, and the weather conditions that may be encountered. It is also important to drive safely so that you can arrive at the incident scene in a timely fashion and do the job in a more relaxed and positive state of mind.

3.1.1.1 It is important to be proactive and be alert to and aware of impending weather conditions as these can affect overall scene safety.

3.1.2 Know about and understand the type of scene you are responding to before going.

3.1.2.1 Ask any necessary questions before going to fully understand the scene, including potential health and safety hazards that may be present.

3.1.3 Locate and plan a route to the closest emergency medical facility from the scene. Have readily available the phone numbers to emergency services for the area you are working.

3.1.4 Ensure that you have and use proper clothing for the current and forecasted weather conditions.

3.1.5 Consider the wind direction and park your vehicle upwind to help keep particulates from entering your vehicle. Ensure that the vehicle's HVAC system is off to keep particulates from being drawn into the vehicle.

3.1.5.1 Vehicle windows should be up, and doors should be kept shut as much as possible to prevent the entry of particulates.

3.1.6 Whenever it may be advisable, wear ballistic protection, if available.

3.1.7 If still an active fire scene, check in with the incident commander first.

3.1.7.1 Public fire investigators arriving at the scene of a working fire should be part of the formal accountability system if it has been implemented.

3.1.7.1.1 If no formal accountability system has been established, checking in with and regular communication with the incident commander will help provide for the accountability of investigators at the fire scene.

3.1.7.1.2 Fire investigators should be included in any on-scene medical screening, including recording vitals on arrival and departure.

3.1.7.1.3 Private fire investigators managing joint scene examinations should employ an accountability management process and ensure the whereabouts of all persons working at the scene and ensure no freelancing is done.
3.1.7.1.4 Fire Investigators should be monitored for any behavioral health signs, symptoms, and exposures while working at fire scenes.
3.1.7.2 Ask about any known safety concerns/issues.
3.1.7.3 Coordinate and communicate all scene activities with the incident commander.
3.1.7.4 Ask if foam was used; if so, see **3.1.8.3** below.
3.1.7.5 Identify the fire suppression tactics that were or are being used to help determine any resulting structural integrity issues, such as the amount of water used and its weight effect on the structure or a portion thereof.

3.1.8 Utilizing a safety management system approach, conduct a hazard survey and risk assessment of the entire scene before beginning any work, at the start of each day thereafter, and any time conditions change.
3.1.8.1 As necessary, identify *safety zones* and escape routes.
3.1.8.2 Check for hazardous materials, including asbestos, and physical and biological hazards, including mold.
3.1.8.3 If firefighters used foam during suppression, determine the type used[16]. Special precautions may be needed, including determining if PFAS may be present at the scene.[17]
3.1.8.4 Identify and implement any hazard elimination methodologies or engineering controls to reduce scene hazards.
3.1.8.5 Determine the need for additional or specialized resources, including but not limited to additional personnel and equipment.

3.1.9 Clearly communicate strategy, tactics, and hazards to all investigation participants.

3.1.10 Ascertain all occupants' medical condition(s) regarding any infectious diseases.

3.1.11 Inspect and verify the status of all utilities before entering any structure.
3.1.11.1 Use a lockout/tagout system and electrical systems/equipment procedures as necessary.[18]
3.1.11.2 In residential structures, leather gloves and rubber-soled footwear should be used to remove electric panel covers and conduct similar activities.[19]
3.1.11.3 Only trained personnel wearing proper arc flash PPE should examine electrical service equipment in commercial structures **[31]**.
3.1.11.4 Ensure that you are wearing proper PPE[20] for the incident before approaching the scene for any reason, including an appropriately selected respirator that is approved by the regulatory authorities of your country for fire scene entry.

3.1.12 Recognize that special hazards exist when examining solar panels, especially when located on the roofs of structures, and educate yourself regarding these hazards before beginning any examination.

3.1.13 Recognize that high voltage batteries in vehicles and solar generators can emit *toxic* gases and fluids when damaged.
3.1.13.1 Lithium-ion battery fires generate intense heat and considerable amounts of gas and smoke, including significant quantities of hydrogen fluoride. This can create an IDLH atmosphere that requires SCBA, especially in a confined or semi-confined space. **[49]**

3.1.14 Recognize that there are special hazards when refrigerants are present. Newer refrigerant blends

[16] This can be easier said than done. Even the SDSs often don't indicate if there is PFAS in the foam so it might be hard to determine quickly.
[17] Class A foams are used to extinguish fires caused by wood, paper, and brush. They generally do not contain per- and polyfluoroalkyl substances (also known as "PFAS"). Class B foams can be divided into two categories: fluorinated foams and fluorine-free foams. Fluorinated foams contain PFAS, and fluorine-free foams do not. Of the fluorinated foams, aqueous film forming foams or "AFFF" are the foams that contain varying amounts and mixtures of PFAS, and of the most concern to human health and the environment. https://www4.des.state.nh.us/nh-pfas-investigation/?page_id=148#:~:text=Class%20A%20foams%20are%20used,known%20as%20%E2%80%9CPFAS%E2%80%9D).
[18] See OSHA regulation 29 CFR 1910.147 for additional information.
[19] Arc flash hazard minimum is 200 volts; however, shock hazard minimum is 50 volts.
[20] Defined as PPE manufactured and evaluated to a known scientific standard of performance (i.e., ANSI, ASTM, ASSE, NFPA, NIOSH, EN, etc.). Specific information regarding respirator selection is found in Appendix B.

are more flammable and produce *toxic* byproducts when burned, and these can remain after the fire is extinguished.

3.1.14.1 Use caution and appropriate respiratory protection when working fire scenes that involve items that may contain or did contain refrigerant chemicals, including refrigerators, air conditioning units (including vehicles), and commercial chillers[21].

3.1.15 Recognize that, in addition to the fire itself, fire suppression activities may have affected all or parts of the structure. This can include unseen ventilation openings, weak areas in floors or ceilings, and weakening from water load.

3.1.16 At large-scale investigation scenes, including multi-agency investigations and joint scene exams, a safety officer/manager should be designated.

3.1.16.1 This person should be familiar with and preferably certified as a fire service Incident Safety Officer and fully understand these best practices and applicable regulatory requirements.

3.1.16.2 This person should be responsible for conducting the *site safety assessment* (see **3.1.7** above), establishing scene PPE use requirements, and monitoring compliance.

3.1.16.3 It can be challenging to maintain situational awareness and follow accepted safety procedures. It is the responsibility of the safety officer/manager to stay on top of this.

3.1.16.4 This person should have the authority to stop work should an immediate safety hazard be identified.

3.2 During the Incident

3.2.1 When available, use air quality monitoring during all examinations[22].

3.2.1.1 Understand monitoring limitations, detection ranges, interferents, maintenance, and sustainment requirements.

3.2.1.2 Monitor CO (*carbon monoxide*), HCN (*hydrogen cyanide*), and *formaldehyde* at a minimum.

3.2.1.3 H_2S (hydrogen sulfide) and LEL (*lower explosive limit*) are also good when possible.

3.2.2 Use powered ventilation fans to physically move ambient air and propel contaminants downwind from the investigation scene. For gases and vapors, ventilation is your friend.

3.2.2.1 However, recognize that this may significantly stir up the particulates, making respiratory protection even more necessary.

3.2.3 Wear appropriate PPE for the incident attended; every scene is somewhat different. This includes:

3.2.3.1 Respiratory protection that meets or exceeds the minimum standards as found in Appendix B.

3.2.3.2 Steel-toed leather or rubber boots/shoes[23] with a puncture-resistant sole, understanding the limitations of each type[24].

3.2.3.3 Protective outer garment(s) appropriate for the scene category type. See Part II and Appendix A.

3.2.3.3.1 The goal is to prevent the skin absorption of hazardous chemicals and particulates.

3.2.3.4 Protective safety helmet that meets or exceeds ANSI Z89.1-2014 Type II[25] for industrial use or its equivalent, with a chin strap and high visibility markings[26].

3.2.3.5 Hearing protection that meets or exceeds ANSI A10.46-2013 or its equivalent.

3.2.3.6 Eye protection that adequately protects the wearer from flying particles and sparks, liquid splashes, and meets or exceeds ANSI standard Z87.1-2015 or its equivalent.

3.2.3.6.1 Gas-proof safety goggles should be worn when wearing a half-mask respirator.

3.2.3.7 Disposable, leather palm, outer gloves or similar, and nitrile[27] inner gloves.

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[21] Fire investigators are encouraged to view the NFPA online training module and materials on this subject at https://www.nfpa.org/refrigerants

[22] Many variables determine how long gas and vapor hazards persist post-fire, however, disturbing the scene in any way and at any time post-incident is known to stir up and make particulates airborne and this may release trapped gases and vapors, thus requiring the use of proper PPE including appropriate respiratory protection.

[23] Rubber boots can pick up static electricity that will attract particulates but are easier to clean. Leather boots may absorb certain chemicals and can be harder to clean. It would be best to have a pair of each and determine appropriate use based on the scene circumstances found.

[24] See also OSHA regulation 29 CFR 1910.132 and 136.

[25] A Type II hard hat is designed to protect workers from blows to the top and side of the head.

[26] See also OSHA regulation 29 CFR 1910.135 and 1926.100

[27] Nitrile has a higher puncture resistance than any other glove material. Nitrile also has a better chemical resistance than latex or vinyl gloves. Latex comes directly from rubber trees. Some people are allergic to Latex.

3.2.4 Ensure that all PPE technologies in use are pre-determined to comply with an existing standards development organization's published technical standard and do not interfere with other PPE in use.

3.2.5 Ensure you have an operable and reliable communication system with you, and if you are working alone, that someone knows where you are and what you are doing.[28]

3.2.6 Conduct all scene examinations with at least two persons unless the status or nature of the scene indicates that it is safe for one person.
3.2.6.1 From a safety perspective, this second person can be anyone capable of calling for help if needed.
3.2.6.2 Whenever a single investigator is present, have a methodology in place where you are checked on regularly but no less frequently than every half hour.

3.2.7 Use a non-contact voltage detector to verify that all circuits that may be interacted with are de-energized before any arc mapping, circuit tracing, or removal of electrical evidence **[32]**.
3.2.7.1 Use electrically insulated tools whenever working on electrical equipment.

3.2.8 Ensure adequate auxiliary lighting is available, especially if working at night, which presents the potential for additional hazards.

3.2.9 Recognize that wearing PPE while performing strenuous work in higher environmental temperatures can lead to heat stress.
3.2.9.1 Heat stress issues vary from scene to scene based on the type of fire, the duration of your work, the kind of work performed, and the environmental conditions **[33]**.
3.2.9.2 You should take regular breaks as needed, well away from the fire scene.
3.2.9.3 If you are going to eat or drink anything, conduct gross decontamination and remove all PPE and wash hands and face with soap and water, decontamination wipes[29] , or a waterless cleaner.
3.2.9.4 All exposed and *transition skin areas* should be cleaned, as noted above, at every break or rehab visit and after final PPE removal.
3.2.9.5 All nitrile gloves and leather/canvas gloves or similar are one use and done. In addition to any evidence collection requirements, these need to be replaced each time they are removed.
3.2.9.5.1 Reusable gloves should be cleaned after each use. The preferred method is to wear nitrile gloves and wash them using running water and soap.
3.2.9.6 The use of *SCBA*, high temperatures, humidity, or extensive digging may necessitate more frequent and/or more prolonged breaks and hydration.
3.2.9.7 Follow rest, hydration, and cooling procedures for your specific environment.
3.2.9.8 To prevent dehydration:
3.2.9.8.1 Ensure that workers pre-hydrate before starting work in the heat.
3.2.9.8.2 Drink a cup of fluid as often as practicable; water is best. Energy drinks with added carbohydrates should not be used. Such beverages may also contain excessive salt and caffeine.
3.2.9.8.3 Do not take salt tablets.
3.2.9.8.4 Avoid alcohol and caffeinated drinks while working.
3.2.9.8.5 Consume fluid-rich foods such as soup or yogurt.

3.2.10 Understand the definition of a confined space and recognize their presence at a fire scene.[30], [31]
3.2.10.1 The typical non-permit confined space encountered by fire investigators is a residential crawl space.

[28] Public fire investigators are encouraged to advise their dispatcher "Note in the CAD, interior examination started" and, when finished, "Note in the CAD, interior examination complete" to have quantitative data to support the length of time personnel are in an IDLH environment.
[29] While there are a variety of decontamination wipes on the market, with some marketed especially to the fire service, they contain a variety of ingredients and there currently is no independent research regarding their effectiveness. Decontamination wipes used by fire investigators should not contain alcohol.
[30] The U.S. Occupational Safety and Health Administration defines a confined space as a one that: "(1) is large enough and so configured that an employee can bodily enter and perform assigned work; and (2) has limited or restricted means for entry or exit and (3) is not designed for continuous employee occupancy." 1910.146(b). These spaces are further divided as permit-required confined spaces and non-permit confined spaces.
[31] See the current edition of NFPA 350 Guide for Safe Confined Space Entry and Work for additional information.

3.2.10.1.1 Crawl space hazards include but are not limited to:

3.2.10.1.1.1 Poor lighting

3.2.10.1.1.2 Obstacles that impede a quick exit if needed.

3.2.10.1.1.3 Energized electric cabling

3.2.10.1.1.4 Hydrogen sulfide

3.2.10.1.1.5 Gas line leaks

3.2.10.1.1.6 Reduced oxygen levels. A 1 percent drop in oxygen readings means 50,000 parts per million (ppm) of something is filling that void. It is very important to know what that something is.

3.2.10.1.1.6.1 See Section 5 for detection device information.

3.2.10.2 Do not enter a permit-required confined space under any circumstances.

3.2.10.3 Before entering a non-permit confined space, do the following:

3.2.10.3.1 Ensure that the atmosphere within the space is not oxygen deficient.

3.2.10.3.2 Ensure the electrical service to the structure is off.

3.2.10.3.3 If gas service is present, ensure it is off.

3.2.10.3.4 Ensure that the space does not contain any other hazard that could cause death or serious physical harm.

3.2.10.3.5 Wear proper PPE, including appropriate respiratory protection.

3.2.10.3.6 Ensure enough lighting is present to work in the space, to be able to detect potential hazards and to safely exit the confined space in the event a hazard is detected.

3.2.11 Recognize that all post-fire scenes are dynamic; situations can change without notice. Continually conduct a risk assessment of the scene you are working in, and always maintain situational awareness.

3.2.12 Recognize that falls are a leading cause of workplace injuries, and the hazards found at a post-fire scene can increase the chances of this occurring.

3.2.12.1 When possible, use means other than ladders to examine areas where needed.

3.2.12.1.1 Safer alternatives include using small unmanned aerial systems or a properly inspected and functioning hydraulic lift.

3.2.12.2 Use fall protection harnesses or similar devices when working from heights.

3.2.12.3 If using a ladder is the only alternative, practice ladder safety by properly placing it on a clean, solid surface in a location free of overhead and other hazards.

3.3 After the Incident

3.3.1 Following proper doffing/de-robing procedures (see Appendix C), remove all PPE:

3.3.1.1 Place all disposable items in a sturdy plastic bag, seal it with duct tape or similar and dispose of it properly. See also footnote 12 above.

3.3.1.1.1 Do not leave this bag at the scene unless you know that a remediation company will properly dispose of it.

3.3.2 Place all to-be-cleaned clothing items in a sturdy plastic bag and seal it with duct tape or similar or use a tight-sealing container. See also Footnote 12.

3.3.2.1 When this bag is reopened, you should wear nitrile gloves and proper respiratory protection.

3.3.2.1.1 It is best to open this bag in a well-ventilated area or outdoors to allow any volatile substances to evaporate before handling the contaminated items.

3.3.2.2 These items should be decontaminated and washed as soon as possible (see Appendix C for additional information).

3.3.2.3 If you are using a reusable tight-sealing container, it should be cleaned inside and out after every use.

3.3.2.4 Close, seal, and discard all used bags to prevent further exposure or contamination.

3.3.3 Using soap and water or decontamination wipes, clean all skin areas that may have been exposed to soot contamination.

3.3.4 Clean tools and respirator assembly[32] immediately after use with an approved cleaning agent[33] and water before returning them to your vehicle.

3.3.4.1 If this is not possible, store them out of the vehicle's passenger compartment and trunk/boot.

[32] Follow the respirator manufacturer's user instructions for cleaning and maintenance of the respirator. For example, alcohol wipes should not be used as they can degrade the facepiece material over time.

[33] See "An Examination of Decontamination Procedures," Fire and Arson Investigator, July 2017 for additional information.

3.3.5 To avoid off-gassing and airborne particulate exposure, do not transport dirty tools, contaminated clothing, PPE, or evidence containers containing samples in your vehicle's passenger compartment or automobile trunk/boot.
3.3.5.1 Remove all outer clothing using the proper methodology (see Appendix C).
3.3.5.2 Replace contaminated footwear with clean before entering the vehicle, or
3.3.5.3 Thoroughly clean footwear before entering the vehicle (see also Section 2.0.4).
3.3.5.4 If this is not possible, place all items in a sealed container and out of the passenger area.

3.3.6 If you are an ignitable liquid detection canine (ILDC) handler, when deployed at a fire scene, the dog becomes as contaminated as you in the same ways you are and should be decontaminated before being placed back into the vehicle.
3.3.6.1 The dog should be wiped down with a damp cloth that then goes into the contaminated-to-be-washed bag. (Effective ILDC decontamination and cleaning procedures are being researched.)

3.3.7 While disposable coveralls are preferred**,** do not wash contaminated clothing in a personal washing machine if possible **[34]**.
3.3.7.1 Use an extractor-type washing machine (found in many fire stations), or
3.3.7.2 Use a commercial laundry/dry cleaner and tell them the items are contaminated.
3.3.7.3 Do not use local laundromat machines.
3.3.7.4 If a personal/home washing machine must be used, wash fire-contaminated clothing articles by themselves. Then, run an empty, complete wash cycle with soap or bleach when finished.
3.3.7.5 Follow established decontamination procedures for tools, PPE, and other contaminated items.
3.3.7.5.1 See Appendix C for additional information regarding decontamination.
3.3.7.6 As soon as possible, and preferably within an hour of leaving the scene, take a shower to clean any remaining particulates from your hair and skin.
3.3.7.7 Properly dispose of all contaminated and biohazard items.
3.3.7.8 Regularly check all your equipment, including all tools and non-disposable apparel items, to ensure they are in proper working order and good condition.
3.3.7.9 Periodically clean all tools and PPE even if they do not appear to be dirty. [34]

3.3.8 Identifying the causes of *accidents* and *near-miss* incidents is essential to furthering the education of fire investigators.
3.3.8.1 Investigators involved in or aware of an *accident* or near-miss involving a fire investigation are encouraged to report the information at https://per.miami.edu

Section 4.0 Training

4.0.1 All employers should train their employees to recognize fire scene health and safety hazards and issues.
4.0.1.1 New employees should receive respiratory protection and fire scene health and safety training and be equipped appropriately before attending any fire scene.
4.0.1.2 All U.S. employees should receive annual retraining on applicable agency policies and all OSHA-required annual training items. (See the OSHA publication Training Requirements in OSHA Standards for additional information).
4.0.1.2.1 Some U.S. states have different or more restrictive training policies, and those should be followed.
4.0.1.2.2 For entities not covered by OSHA, please refer to your appropriate governing agency for training requirements. Absent any local requirements, the applicable U.S. OSHA training requirements referenced above would be reasonable to follow.

4.0.2 All employees who work at fire scenes and do not have a medical facility, trained personnel, or another treatment methodology in proximity to the scene should be adequately trained to render first aid to others and themselves.
4.02.1 These employees should have adequate first aid supplies readily available.

[34] Per NFPA 1851, ensemble elements (exposed to the hot or warm zones) that have not been cleaned and appear to be unsoiled have been shown to contain numerous fire gas chemicals, including carcinogenic polynuclear aromatic compounds. Periodic cleaning is required to avoid use of ensemble elements that could be contaminated without visible evidence of soiling.

4.0.3 All training should be conducted to allow the trainee access to the trainer to ask questions.

4.0.4 Everyone who develops, designs, manages, or participates in any live burn training, including burn cell demonstrations, should understand and follow the applicable requirements in the current edition of NFPA 1402 Standard on Facilities for Fire Training and Associated Props, including Chapter 14 Fire Investigation Training Structures, Props, Burn Cells and Sets, and NFPA 1403 Standard on Live Fire Training Evolutions, including Chapter 4 General and Chapter 8 Exterior Live Fire Training Props[35].

4.0.4.1 All participants in the hot or warm zones[36] should follow the PPE precautions identified in this document, including the use of appropriate respiratory protection.

4.0.5 Instructors, managers, and trainees should understand that training evolutions/cycles can present unique heat stress-related challenges, especially during repeated evolutions.

4.0.5.1 Instructors should understand the signs and symptoms of heat stress and have appropriate countermeasures and treatments available.

4.0.6 All employees should receive initial and frequent ongoing training on proper PPE donning and doffing procedures that include regular, ongoing practice sessions.

4.0.7 All employees should receive training on properly conducting a fit or seal check on their respiratory protection equipment.

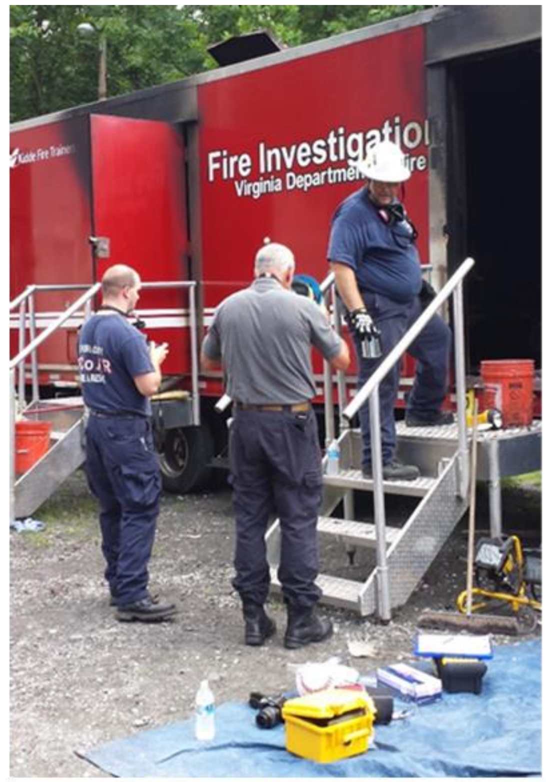
4.0.8 All persons responsible for conducting annual respirator fit tests should be appropriately trained and follow the OSHA-approved or similar procedures.

4.0.9 All persons managing or assisting in gross decontamination (preliminary exposure reduction) activities should be trained in the proper methodologies for conducting those operations.

4.0.10 All employees should receive training about the physiological effects of working in hot and cold conditions, including the signs and symptoms of heat- and cold-related illnesses and injuries, and safe work-rest cycles.

4.0.11 In those instances where a U.S. OSHA-covered fire investigator must enter a scene involving the release of a hazardous substance, that person must first be trained according to §1910.120(q)(6) based on their duties and functions during the response.

4.0.11.1 All fire investigators are discouraged from entering these scenes instead of waiting until the scene has been rendered safe.



New fire investigator training.
Credit: Virginia Department of Fire Programs

Section 5 Equipment

5.0.1 When using a full respirator facepiece, it may be necessary to have a camera with a separate viewer.

5.02 A particulate blocking hood is recommended in the Hot A, Hot B, and Warm fire scenes. When used and properly doffed, particulate-blocking hoods reduce PAH contamination reaching the neck and do not increase heat stress and thermal perception **[48]**.

[35] These standards are included in the NFPA's Emergency Response and Responder Safety Document Consolidation Plan and will be combined into a new consolidated document in the future.

[36] See Appendix A.

5.02.1 Remove your hood using the procedure in Appendix C whenever it's not in use.

5.02.2 **DO NOT** wear your hood around your neck at any time unless it is clean and uncontaminated.

5.02.3 A hood exchange program or ensuring that a used hood is adequately cleaned before the subsequent use is highly recommended.

5.03 Disposable coveralls, such as those made of Tyvek® and similar material, do not protect against gases or vapors and therefore should not be worn in Hot A or B scenes. Their only protection is from particulates and liquids (if the seams are taped).

5.04 Detection Devices

5.04.1 Single and multi-gas meters use these technologies:

5.04.1.1 Catalytic combustion sensor – used for lower explosive limit (LEL).

5.04.1.2 Electrochemical sensors – used for CO, O_2 (oxygen), H_2S (*hydrogen sulfide*).

5.04.2 The typical 4-gas meters cover most fire scene situations. These detect LEL, O_2, CO, and H_2S. Other sensors can be substituted if needed.

5.04.3 Full PPE should always be worn whenever using a detection meter. If it alerts, the user is already in a potentially hazardous area.

5.04.4 Detection monitors and badges are cheaper than meters and can be worn by fire investigators at a scene. However, these are typically for a single substance only.

5.04.5 Persons using these meters and monitors should be appropriately trained in their use and understand their limitations.

Chief Creasy died October 15, 2018. This quote is excerpts from a video he recorded for the IAAI Health & Safety Committee in March 2018 and is used with the permission of his family.

His complete message may be seen at https://www.youtube.com/watch?v=Em-agVK4Ewk

"I spent twenty-three of my fifty years of service managing and conducting fire investigations. Cancer is a devastating disease that may not go away until you go away. I do believe my cancer came from dermal absorption as I was exposed to the toxic byproducts of the fires while often only wearing a t-shirt and no turnout gear. You must change the way you think about cancer – treatments only buy you some time. We need new habits that will protect us while doing our job."

David C. Creasy, Sr.
Retired Fire Marshal
Richmond (Virginia) Fire Department
Retired Sr. Battalion Chief
Chesterfield (Virginia) Fire Department

Part II – Fire Scene PPE Precautions and Protection Categories

All fire scenes can be unsafe in many ways, and the proper use of PPE and following safety procedures can help to mitigate these risks. However, many fire investigators do not fully understand and appreciate the health risks of fire investigation scenes. To help fire investigators understand the precautions that should be taken at the various fire scenes, a hazardous materials-style, time-based scene classification system is provided to denote the various stages of fire scenes from an investigative perspective.

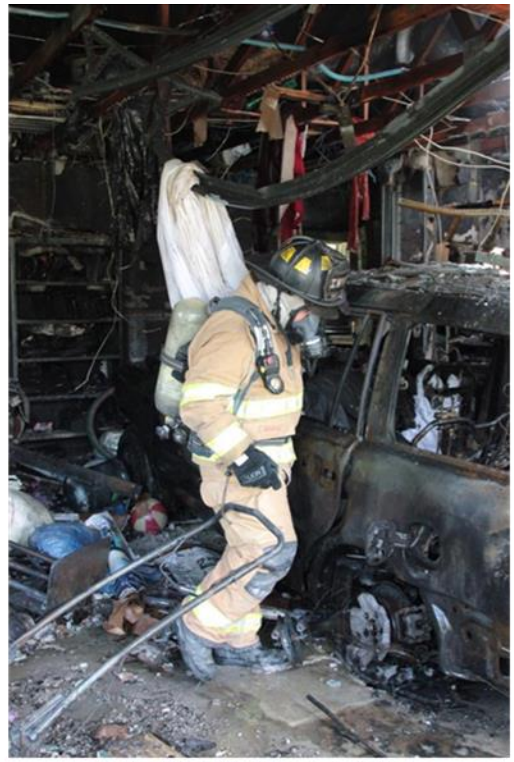
One of the most misunderstood post-fire scene concepts has to do with particulates. Some investigators believe that if they do not see any particulates in the air or the fire has been extinguished for days or weeks, things are OK. However, *nanoparticulates* that the human eye cannot see will likely be present and can be stirred up merely by walking into the scene and can then penetrate deep into unprotected lungs through inhalation. Repeated exposure to *nanoparticulates* could lead to *chronic* health conditions in the future. The graphic on page 35 shows the relative size of various particulate matter.

It should be noted here that the need for PPE use comes only after implementing other control methodologies has been completed or cannot be completed based on the circumstances found at the scene. While the proper use of PPE does offer a level of protection, that protection is not absolute; exposure to the harmful byproducts of fire can still occur.

THE PPE listed here is more fully described in Part I above. Additional respiratory protection equipment information is found in Appendix B.

All fire scenes are divided into four time-based categories:

HOT SCENE A – ***A fire scene where the fire has been extinguished, but overhaul has not yet commenced or is in progress.***



Appropriate Hot Scene A Attire.
Credit Palm Beach County, FL Fire Rescue

In this situation, fire investigators sometimes need to enter the structure or scene after consultation with the incident commander to identify those areas that can be *overhauled* and those areas, usually the probable area of fire origin, where *overhaul* should either be limited or not done at all.

While it is strongly recommended that fire investigators not enter fire scenes during this period, the fire investigator is usually only entering to make a quick, initial determination and possibly take some initial photos and should be wearing the following PPE.

- Structural firefighter turnout gear, including bunker pants and coat, helmet, particulate-blocking hood[37, 38], boots, and gloves over nitrile gloves.

[37] Unless it will be washed before using it again, this hood should be swapped out after each use for a clean one.

[38] Contaminated hoods should never be worn pulled down around the neck.

- Proper respiratory protection equipment offering the below NIOSH (or similar in other countries) awarded protection:
  - SCBA[39, 40, 41] as a primary technology, with the ability to downgrade to *APR* or *PAPR* after site characterization and determination of an accurate maximum hazard ratio, which is often not possible at a working fireground.
- Work duty coveralls or similar underneath turnout gear to aid in self decontamination.

Note 1: Fire investigators should only enter scenes that have not yet been fully extinguished under the most extenuating circumstances, and then only when wearing full structural firefighter PPE, including SCBA.

Note 2: Research has shown potential exposure to *carbon monoxide* (CO) and volatile organic compound (VOC) hazards in the upwind and downwind areas of the fire scene warm zone (defined in Appendix A). The referenced paper states, "Strategies to monitor multigas detection and to implement the use of PPE by firefighters are necessary" and recommends the use of a filtering half-mask (of the type recommended in this paper) in the warm zone **[35]**. This necessarily also applies to fire investigators operating in the warm zone of a hot scene.

HOT SCENE B – *A fire scene that has been fully extinguished and overhauled for less than two hours.*

Regardless of the amount of ventilation, these scenes are hazardous for fire investigators because of the potential for high levels of gases and particulates (e.g., smoldering items). Therefore, it is strongly recommended that fire investigators not enter fire scenes to undertake any investigative actions during this period. If there is a need to enter, fire investigators should limit their activities and time at the scene while following a vetted respirator selection logic (i.e. (U.S.) NIOSH Respirator Selection Logic 2004: https://www.cdc.gov/niosh/docs/2005-100/pdfs/2005-100.pdf) and wearing the below PPE.

- Structural firefighter turnout gear, including bunker pants and coat, helmet, particulate-blocking hood, boots, and gloves over nitrile gloves.
  - Disposable coveralls made of flash spun high-density polyethylene fibers, such as Tyvek® and similar, do not protect against gases or vapors and should not be worn in Hot B scenes. Their only protection is from particulates and liquids (if the seams are taped).
- Respiratory protection
  - *SCBA* (see U.S. OSHA https://osha.gov/Publications/3352-APF-respirators.pdf or
  - Other proper respiratory protection equipment as identified in Appendix B.
- Multi-gas area monitoring that includes VOCs, oxygen enrichment/deficiency, *carbon monoxide*, formaldehyde, and hydrogen sulfide.

See **Note 2** above, which also applies here.

Appropriate Hot Scene B Attire.
Credit: Charlotte, NC Fire Department

[39] See NFPA 1981, 1986 and 1987 for additional information

[40] 2019 research by Stack, Griffin and Burgess at the University of Arizona concluded that a CBRN *APR* is not a substitute for SCBA during the *overhaul* phase due to benzene and *formaldehyde* breakthrough.

[41] At some agencies fire investigators are getting approval to wear lighter industrial *SCBA* for the first 24 hours post-fire, with the ability to step down thereafter.

WARM SCENE – ***A fire scene that has been fully extinguished for at least two hours but less than 72 hours.***

This is the typical period when public investigators conduct fire scene examinations. Some private fire investigations may also be done during this period. It is also when a significant particulate and gas/vapor exposure hazard may still exist. All fire investigators conducting any type of examination within the fire scene during this period should wear the below PPE and be aware of or have immediate access to environmental monitoring data stay times, escape times, and time-weighted averages of *toxic* industrial chemicals while on scene.

- Coveralls (preferably disposable with hood) that completely cover the arms and legs.
- Helmet with chin strap.
- Boots with steel toe and puncture-resistant sole.
- Proper respiratory protection equipment, as identified in Appendix B.
- Disposable leather gloves with nitrile gloves underneath.
- Multi-gas area monitoring, including VOCs, oxygen enrichment/deficiency, *carbon monoxide*, and *hydrogen sulfide*.

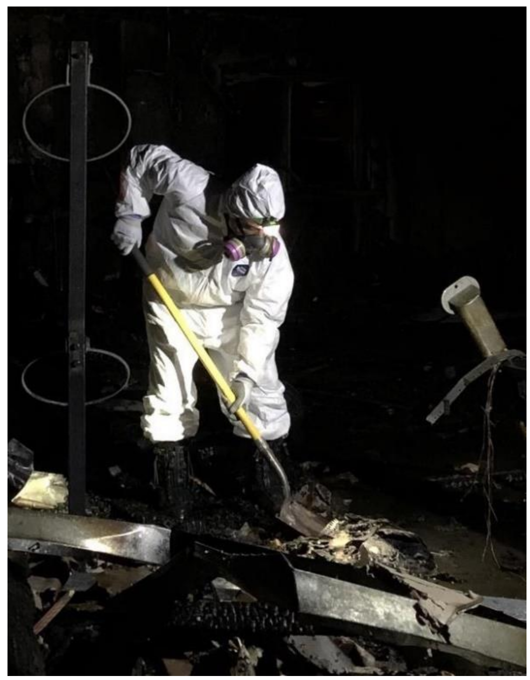
Note 3: The 72-hour threshold is used here because multiple studies **[36] [37] [38]** have shown that some gas residue can be present at many fire scenes for as long as 72 hours.

COLD SCENE – ***A fire scene that has been fully extinguished for at least 72 hours and is not generating detectable or visible dust, fumes, mists,*** particulates***, gases, vapors, or aerosols. ****

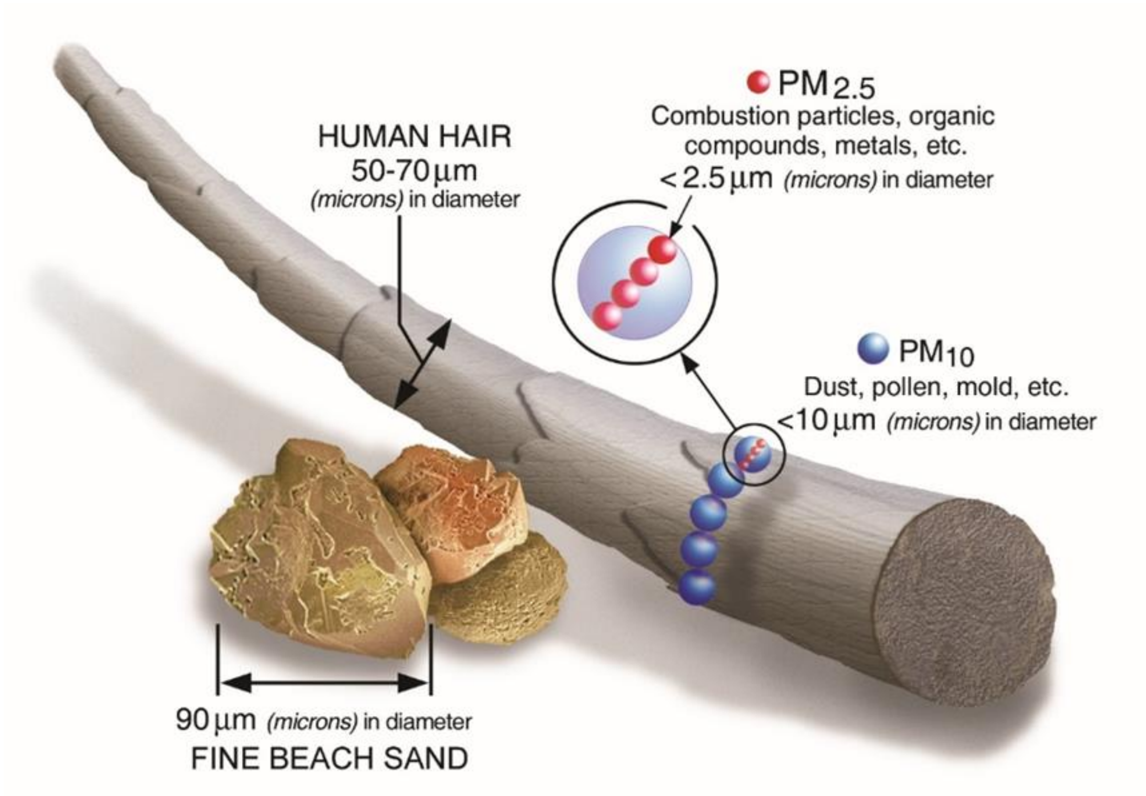
When walking through the scene or moving fire debris or digging occurs, particulates are introduced into the air, and gas pockets may be released, thus creating a health hazard for the fire investigator. Therefore, fire investigators conducting any examination within the fire scene during this period should wear the following PPE and address fire investigators' rehabilitation/recovery needs.

- Coveralls (preferably disposable with hood) that completely cover the arms and legs.
- Helmet with chin strap.
- Boots with steel toe and puncture-resistant sole.
- Proper respiratory protection equipment, as identified in Appendix B.
- Disposable leather gloves with nitrile gloves underneath.

*** Regardless of the time since extinguishment, if the cold scene is still generating visible substances, it becomes a warm scene.**



Appropriate warm or cold scene attire.
Credit: Palm Beach County, FL Fire Rescue



The size of nanoparticulate matter (red circles) in reference to other very small things.
Source: U.S. Environmental Protection Agency

"FIRE INCIDENT RESPONSE STRATEGIES THAT ENCOURAGE AND SUPPORT THE USE OF RESPIRATORY PROTECTION FOR RESPONDERS OPERATING IN THE WARM ZONE ARE NEEDED. . . AND MAY LIMIT EXPOSURE TO CANCER-CAUSING PARTICULATES PRESENT."

Dr. Alberto Caban-Martinez et al
The "Warm Zone" Cases: Environmental Monitoring Immediately Outside the Fire Incident Response Arena by Firefighters

Appendix A – Fire Scene Categories and Zones

Fire Scene Categories

As noted in Part II, post-fire scenes are divided into four time-based categories, with specific PPE recommendations for each, based on the conditions found at the scene. The below graphic summarizes these categories.

HOT SCENE A – *A fire scene where the fire has been extinguished but overhaul has not yet commenced or is in progress.*

HOT SCENE B – *A fire scene that has been fully extinguished and overhauled for less than two hours.*

WARM SCENE – *A fire scene that has been fully extinguished at least two hours but less than 72 hours.*

COLD SCENE – *A fire scene that has been fully extinguished for at least 72 hours and not generating detectable or visible dust, fumes, mists, particulates, gases, vapors or aerosols.*

Fire Scene Zones

Fire scene zones are geographic or distance-based. EVERY post-fire scene has these, regardless of how long the fire has been extinguished.

- The post-fire scene hot zone is the portion of the scene that includes the structure or similar burned area, the potential collapse zone, and any adjacent debris field/area, and to which access is restricted to only those required to enter.
    - It may be visually defined/outlined with red scene tape.
- The post-fire scene warm zone includes that area immediately outside the hot zone of sufficient size and shape to limit exposure to contaminants and shall contain the necessary decontamination areas. Access to this area should be limited to decontamination personnel and those accessing the hot zone. Respiratory protection should always be worn in this area until gross decontamination is completed, and the person immediately moves to the cold zone.
    - As necessary, the warm zone may be defined/outlined with yellow scene tape.
    - When fire smoke cools, it returns particulate matter to the ground. This particulate matter can be harmful when stirred up and then inhaled or absorbed, hence the need for PPE, including respiratory protection in this area. The weather conditions at the time of the fire, especially wind speed and direction, will help determine the size of this zone. The size of this area, also known as

the sootprint, should not be underestimated since the human eye cannot see the nanoparticulate matter.

As this smoke plume cools, particulate matter settles to the ground, creating the sootprint, which must be considered when the warm zone is established. Credit: Summerfield (NC) Fire District

- The smoke plume MUST be considered when the warm zone is defined during suppression. After suppression, weather data from the time of the fire can be used to help determine the warm zone.
  - Rain and snow can, over time, reduce the amount of contaminants on the ground and exterior surfaces, but this is typically the exception rather than the rule.

- The post-fire scene cold zone includes all scene areas outside the warm zone. It is the area immediately outside the boundary of the established warm zone where personnel are relatively safe from the adverse effects of a fire, toxic chemicals, carcinogens, etc.
  - The cold zone typically contains the command post and other support functions deemed necessary to control and manage the incident.
- If the suppression crews have left, the fire investigator in charge of the scene should establish these zones at every fire scene. See the current edition of NFPA 1700, Chapter 11, for additional information.

The fire scene categories and fire scene zones make up the post-fire scene when combined.

Time-based		Distance-based		
Category	+	**Zone**	=	**Post-fire Scene**
Hot Scene A Hot Scene B Warm Scene Cold Scene		Hot Warm Cold		

Appendix B – Respiratory Protection Guidelines

The United States Department of Labor, Occupational Safety and Health Administration's (OSHA) Respiratory Protection Standards[42] establishes OSHA's hierarchy of controls by requiring the use of feasible engineering controls[43] as the primary means to control air contaminants. Respirators are required when "*effective engineering controls are not feasible, or while they are being instituted*." It also requires employers to provide employees with respirators that are "*applicable and suitable*" for the purpose intended "*when such equipment is necessary to protect the health of the employee*." Whether or not an agency or business must follow the OSHA standards, the information contained therein provides valuable guidelines for respiratory protection best practices.

In the U.K., Health and Safety Guide 53 (HSG53, 4th edition, 2013) is the primary document for information regarding the use of respiratory protection equipment (RPE) and says that you should only use RPE after you have taken all other reasonably practicable measures to prevent or control exposure **[39]**.

Fire investigators in other countries should check their similar applicable regulations or follow these if there are none.

OSHA has a tool on its website to assist with proper respirator selection and related information at https://www.osha.gov/SLTC/etools/respiratory/index.html. One of the information subsets provided discusses the employer's responsibility to conduct an exposure assessment. "*Employers must make a 'reasonable estimate' of the employee exposures anticipated to occur as a result of those hazards, including those likely to be encountered in reasonably foreseeable emergencies, and must also identify the physical state and chemical form of such contaminant(s)*." This includes an identification of the respiratory hazards that could be present.

While it is known that some hazards, such as particulates/nanoparticulates, are present at virtually every post-fire scene, we do not know their precise make-up and typically do not know what gas or vapor hazards might be present unless extensive sampling is done. While sampling is the "*gold standard*" of hazard detection, it is often not practical in these situations. There are other alternatives:

- "*You can use data on the physical and chemical properties of air contaminants, combined with information on room dimensions, air exchange rates, contaminant release rates, and other pertinent data, including exposure patterns and work practices, to estimate the maximum exposure that could be anticipated in the workplace.*
- *Data from industry-wide surveys by trade associations for use by their members, as well as from stewardship programs operated by manufacturers for their customers, are often helpful in assisting employers, particularly small-business owners, to obtain information on employee exposures in their workplaces.*"

From https://www.osha.gov/SLTC/etools/respiratory/change_schedule_exposure.html

In the U.K., the law requires you to adequately control exposure to materials in the workplace that cause ill health. This is the Control of Substances Hazardous to Health Regulations (COSHH) and means:

- Identifying which harmful substances may be present in the workplace
- Deciding how workers might be exposed to them and be harmed
- Looking at what measures you have in place to prevent this harm and deciding whether you are doing enough

[42] 29 CFR 1910.134

[43] Fire scene engineering controls includes such things as demolition, shoring, wetting areas to control particulates and the use of positive pressure fans to put fresh air into a scene.

- Providing information, instruction, and training
- in appropriate cases, providing health surveillance [**39**]

And like in the U.S., to select respiratory protection equipment that will protect the wearer, you will need a basic understanding of:

- the hazardous substance and the amount in the air (exposure)
- The form of the substance in the air (e.g., gas, particle, vapour)
- The type of work being carried out
- Any specific wearer requirements, such as other PPE or a need for spectacles/eyeglasses

Regardless of your country, the respiratory protection equipment selected and used must also be adequate for the hazard and reduce exposure to the level required to protect the wearer's health, and suitable for the wearer, task, and environment, such that the wearer can work freely and without additional risks due to the RPE.

Although there is ample information identifying many of the harmful gases and vapors that could be present at a post-fire scene, every scene is different. However, we know that various acid gases, oily vapors, and aldehydes are present in nearly every instance. This means that an accurate reading or measurement at each fire scene is doubtful. In this case, the OSHA website says that *"you should account for potential variation in exposure by using exposure data collected with a strategy that recognizes exposure variability,* ***or by using worst-case assumptions and estimation techniques to evaluate the highest foreseeable employee exposure levels****. The use of safety factors may be necessary to account for uneven dispersion of the contaminant in the air and the proximity of the worker to the emission source* **[40]**." These regulations also assume that there are a small number of known harmful materials/chemicals in the workplace, and that is certainly not the case in the post-fire environment. The information in this document follows the worst-case assumption premise noted here.

Even with this information, deciding on the best respirator solution for fire investigators can be challenging. To use the OSHA respirator selection advisor genius software, you must know several workplace parameters, two of them being the OSHA permissible exposure limit and the maximum exposure level in the workplace of a single contaminant and its physical state: gases, vapors, and particulates. This, of course, requires identifying specific items, which, as discussed above, is very challenging in the post-fire environment.
(See https://www.osha.gov/SLTC/etools/respiratory/advisor_genius_nrdl/work_categories.html)
HSG53 provides similar information, but the hazard must also be known.

Acceptable fire investigator respiratory protection equipment options.

In the U.S., OSHA regulations require that a competent decision-maker determines the best respirator for employees to use based on recognized hazards. Therefore, based on the best information presently available regarding the potential hazards to fire investigators, as discussed elsewhere in this document, the following recommendation is made:

The IAAI-recommended <u>minimum</u> respirator **assembly for all fire investigators while in the hot and warm zone of every warm and cold fire scene is a half-mask facepiece with goggles,[44] or a full facepiece[45], that has a P100 particulate filter with an OV/AG/FM [46] gas/vapor cartridge[47] if following U.S. descriptions OR a half-mask facepiece with eye protection, or a full facepiece, with an A3P3 combination filter if following U.K. descriptions. Filtering facepiece respirators like N95 filter mask or dust mask is not suitable for fire investigation or other scene work under any circumstances.**

Reminder: Zones are geographic – based on the fire situation as found (see Appendix A),
Categories are time-based (see Part II and Appendix A).
EVERY post-fire scene has both.

P100/OV/AG/FM is a respiratory protection filter/cartridge assembly that removes 99.97% of particulates down to .3 microns[48] in combination with protection for organic vapors (OV), acid gases (AG), and *formaldehyde* (FM). Organic vapors typically refer to liquids that evaporate quickly (hence giving off vapors) and are petroleum-based. Examples include solvents in paint, nail polish remover, and gasoline. Acid gas contains significant amounts of acidic gases such as carbon dioxide or *hydrogen sulfide*. Other than using *SCBA*, a P100 filter is the best for protecting fire investigators from particulate inhalation.

There have been adverse respiratory effects while wearing P100/OV/AG cartridges during *overhaul* **[16]**, with a likely cause being *formaldehyde* breakthrough. Therefore, *SCBA* should be used by fire investigators who must enter a fire scene during the *overhaul* phase or within two hours after it has been completed (Hot Scene A & B).

When specified in an agency's policy, CBRN Cap 1 canisters can also be used for fire scene examinations. The incident commander or lead fire investigator approves it and uses it as subcomponents of industrial respirators[49].

In the U.K., based on the information in Health and Safety Executive Guidance 53, the recommendation is the P3 particulate filter and A3 gas/vapour filter in combination. In addition, the U.S. and U.K. require SCBA (an open circuit, pressure-demand, self-contained breathing apparatus respirator) if it is necessary to enter an IDLH (immediately dangerous to life or health) environment, which includes the post-fire *overhaul* phase.

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[44] In instances where *toxic* gases/vapors and/or particulates are likely present in the warm zone, such as during Hot Scene A or B operations, the above minimum recommended respirator assembly should also be worn.
[45] NFPA 1500 Standard on Fire Department Occupational Safety, Health and Wellness Program (2021 ed.) advocates the use of at least a fitted full-face air purifying respirator (*APR*) with protection against fireground contaminants for entry into the post-fire environment before or after *overhaul* (7.10.9) and with the safeguards and criteria identified in Section 14.4.2.1.1. present. As part of NFPA's consolidation plan, this document will be incorporated into the new NFPA 1550.
[46] *Formaldehyde* (FM) protection has been added in this edition as an additional minimum protection requirement.
[47] 29 CFR 1910.134 (OSHA) and 42 CFR 84 (NIOSH)
[48] This is essentially the same as a High Efficiency Particulate Air (HEPA) filter, which is used in mechanical equipment ratings, and the U.K.'s high efficiency rating.
[49] CBRN Cap 1 canisters can be used as a subcomponent of an industrial respirator if the configuration is NIOSH approved. The NIOSH approved configurations can be found on the approval label.

In the U.S., to meet the IAAI minimum protection guideline, the respirator must have a P100 particulate filter and gas and vapor protection, including organic vapors, acid gases, and *formaldehyde*, **at a minimum**. NIOSH requires P100 filters to be magenta or have a magenta label. A cartridge with the above gas and vapor protection has an olive-colored band on the label. The filter and gas/vapor cartridge can come as one complete assembly or combined before being attached to either a half-facepiece or a full-facepiece.

There are numerous other respiratory protection masks on the market that are not NIOSH or HSE approved or do not meet the IAAI minimum respiratory protection guidelines. Readers are cautioned that these masks are not suitable for use during fire investigations.

In the U.K., filters are color-coded according to the HSE. The particulate filter is white. The A filter for Organic gases and vapours with a boiling point above 65 ºC is brown. This filter/cartridge combination assembly meets the IAAI minimum respiratory protection guideline.

Maintenance and Cleaning

Masks cannot be altered or changed after being issued or purchased. Cartridges, filters, and masks get old. After each use, they must be cleaned with mild soap and water, properly stored, and replaced when necessary to maintain effectiveness, in addition to following all of the manufacturers recommendations. If the filter cartridges are outdated, have been open to the air, or are damaged, you may not be protected. Cartridges that contain charcoal or other chemicals for filtering the air should be kept in air-tight packages until use. If cartridges are open or not packed in air-tight packaging, they should not be used. Even cartridges in original packaging have expiration dates that should be checked before use. Also, over time your mask can get old and break down. Keep your facepiece in a clean, dry place, away from extreme heat or cold, and in a sealed container. Inspect it before and after use according to the manufacturer's instructions. Cartridges also have a finite service life and must be changed periodically. Users should consult the manufacturer’s recommendations regarding filter and cartridge service life.

How long a filter or cartridge lasts typically depends on how much filtering capacity the respirator has and the amount of hazard in the air at each scene – the more hazards in the air (higher concentration), the shorter the time a filter may last. There is no absolute time limit, and it varies by each respirator model's capacities, the concentration of the hazard, and the manufacturer’s recommendation **[41]**. At the very least, filters and cartridges should be replaced after 40 hours of use, when you can sense outside air or when breathing becomes slightly labored. Tracking this is another reason keeping a scene examination log is essential. The use of an *SCBA* eliminates the concern for filter saturation and the possibility of contaminants getting through a filter or cartridge.

Program Administration

U.S. respirator users and competent decision-makers should read the relevant literature and information available on the website of the NIOSH National Personal Protection Technology Laboratory (https://www.cdc.gov/niosh/npptl/) regarding respirator approval standards, respirator recognition, and access to the NIOSH certified equipment list when developing procedures to validate a written respiratory protection program based on U.S. Department of Labor, OSHA requirements. HSG53 has similar requirements.

Workplace administrators charged with writing and managing written respiratory protection programs play a vital role in working with management personnel on the use of engineering controls to eliminate the airborne respiratory hazards, and if not able to eliminate them, control them by implementing feasible engineering controls, workplace environmental sampling and monitors, administrative signage/area restrictions and as necessary introducing workplace-specific personal protective technologies and equipment designed to lower the potential or actual exposure of assigned workers.

A field sample of a written industrial respiratory protection program is found at the following link: http://www.radford.edu/content/dam/departments/administrative/ehs/Respiratory%20Protection%20Program.pdf. This is an evolving document that is tailored to a specific workplace and demonstrates a concerted effort to address all the known and implied variables present. However, it also shows how perishable the information is/can be if the document's responsibilities are not revisited, reevaluated, improved, and republished over a known period.

A properly attired private fire investigation team working in the post-fire environment.
Credit: Kevin Hays Fire Consulting, LLC

Appendix C – Decontamination Procedures

Crime Scene Decontamination and PPE Doffing Procedures

In addition to cleaning and decontaminating tools and PPE after every scene exam, it is also sometimes necessary to decontaminate investigative personnel at some fire scenes. In addition to the gross decontamination noted below, there are two special types of decontamination situations that fire investigators must be aware of:

1. Persons entering the scene who may contaminate it (IN)
2. Persons leaving the scene and are contaminated by the scene contents (OUT)

These recommended procedures or similar should be implemented when investigating all fatal fires, arson fires, other crime scenes, and any other fire scene dictated by the circumstances of the incident. The incident commander or lead fire investigator should determine when these procedures are necessary and implement them accordingly. Because these situations may not be initially known, first-arriving public fire investigators should consider the implementation of these procedures for any initial scene investigation.

It may also be necessary to establish a no-entry zone in these situations. This is a control area designated to keep out responders due to the presence of dangers such as imminent hazard(s), potential collapse, or the need to preserve the scene.

IN Procedures

Each person entering the fire scene hot zone[50] must wear new gloves, approved clean outerwear, and any other necessary pristine PPE as further defined elsewhere in this document. In addition, in those instances where the possibility of scene contamination exists, all persons entering the scene should clean their boots, using the below procedures, immediately before entering. The lead investigator/scene manager is responsible for determining if this procedure is necessary and, if so, ensuring that the decontamination station is in place and properly used before anyone enters to ensure that all items are either new or thoroughly cleaned to prevent any cross-contamination. (If this procedure is used, it must be documented in the investigation report and photographed.)

- Set up two buckets or similar containers filled with water if the ground is dry. To the first bucket, add the recommended amount of cleaning solution[51]. Then, using a poly-fiber, long-handle brush, or similar, each person cleans their boots in the first bucket, rinses them in the second one, and then enters the scene.
  - It may be necessary to rinse and refresh one or both buckets regularly.
- If the ground is wet, it may be necessary to place a tarp under these buckets and add a pre-rinse bucket in the first position. However, the wet tarp may be slippery if used, and users need to exercise caution.

OUT Procedures

The decontamination procedures to be used after exiting a fire scene vary depending on the situation and weather conditions.

A decontamination station should be established at the hot zone exit point at crime scenes, including all fatal fires. This process often requires the assistance of additional personnel who should be wearing PPE and respiratory protection because of off-gassing and particulate dispersal. While there are specific methodologies for this process in HazMat literature, a detailed discussion of this process is outside the scope of this document.

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[50] See Appendix A

[51] See M. Evans and S. Trimber, "An Examination of Decontamination Procedures," Fire and Arson Investigator, July 2017, pp 10-15 for additional information regarding effective cleaning products.

Knowledge vs. Practice

A 2018 study of 482 firefighters from four south Florida fire departments showed that while firefighter attitudes were overwhelmingly favorable towards cleaning gear (knowledge), their actual decontamination and cleaning behaviors (practice) did not follow at the same level.

As a fire investigator, is there a gap between your decontamination and cleaning knowledge and practice?

Tyler R. Harrison, Jessica Wendorf Muhamad, Fan Yang, Susan E. Morgan, Ed Talavero, Alberto Caban-Martinez & Erin Kobetz (2018) Firefighter attitudes, norms, barriers, and behaviors towards post-fire decontamination processes in an era of increased cancer risk, Journal of Occupational and Environmental Hygiene, 15:4, 279-284, DOI:10.1080/15459624.2017.1416389

Hot Scene A & Hot Scene B PPE Gross Decontamination, Doffing, and Cleaning

Gross decontamination is a preliminary exposure reduction methodology used to remove many contaminants from the wearer's PPE while still at the scene. When wearing the PPE referenced in Part II above for hot zone post-fire scene examinations, decontamination and doffing/de-robing should be done in the warm zone, downwind from one's vehicle, and as soon as practical after completing work in the hot zone, in the following order.

1. Tools (**BEFORE** removing any PPE):
    a. Wash tools using a bucket of clean water containing the recommended amount of cleaning solution, scrubbing with a poly-fiber or similar brush for at least 30 seconds, and then rinsing in a bucket of clean water or with a hose, **OR**
    b. Rinse them thoroughly with water, **OR**
    c. Wipe them down with a damp cloth*
    d. Allow tools to air dry
    e. Properly dispose of the dirty water and avoid runoff contaminating other things
    f. If available, this can be done by another team member wearing full PPE, including respiratory protection
2. If available, after loosening *SCBA* straps, use a low-pressure hose to rinse off the turnout coat, pants, and boots, including soles, starting at the neck, and working down. If water is not available or the weather does not permit, use a poly brush to lightly brush off the turnout coat, pants, and boots, including soles, starting at the neck, and working down.
    a. This procedure is done by a second person wearing full PPE, including respiratory protection (*SCBA* or *APR*) and downwind of any personnel, equipment, or vehicles.
3. Remove structural gloves and place them in the bag**
    a. If your agency has a glove or hood on-scene replacement program, follow those procedures after removal
    b. If you are wearing nitrile gloves under the structural gloves, leave them on for now
4. Take off the helmet, clean off any debris, and place it in a bag
5. Holding your breath, pull the hood over your head and place it in the appropriate bag
6. Remove the SCBA
7. Remove turnout coat and put it in bag
8. Gently fold down the turnout pants
9. Remove boots and pants and place them in the bag
10. Remove nitrile gloves and place them in the disposables bag

11. Close and seal the bags
12. Clean all exposed and transition skin areas with decontamination wipes or soap and water
13. Put on clean/dry clothing and footwear
14. Place tools and bags in the vehicle's utility or storage area
15. Shower within the hour or as soon as practical
16. While wearing nitrile gloves and respirator, and in an open area, remove items from the bag, separate the outer shell from the liner, and place them in the washing machine/extractor in separate loads
17. Wash all apparel items as noted elsewhere in this document
18. Clean helmet+, boots, *SCBA* and mask, and similar items with water and mild soap tools. If the helmet liner or neck cover is removable, add it to the washing machine/extractor

NOTES:
- The 2020 edition of NFPA 1851 Standard on Selection, Care, and Maintenance of Protective Ensembles for Structural Fire Fighting and Proximity Fire Fighting, Chapter 7 Cleaning and Decontamination, and the 2021 edition of NFPA 1700 Guide for Structural Firefighting, Chapter 11 Exposure and Hygiene Considerations, contain additional information regarding this subject.
- Structural fire gloves may need to be cleaned more often than other PPE. The preferred method is to wear nitrile gloves and wash them like your hands using running water and soap.

Hot Scene A & B Gross Decon Examples

Credit: UL FSRI

Credit: Palm Beach Fire Rescue

Warm and Cold Scene PPE Gross Decontamination, Doffing, and Cleaning

Gross decontamination is a preliminary exposure reduction methodology used to remove many contaminants from the wearer's PPE while still at the scene. When wearing the PPE referenced in Part II above for warm and cold post-fire scene examinations, decontamination and doffing/de-robing should be done in the warm zone, downwind from one's vehicle, and as soon as practical after completing work in the hot zone, in the following order.

1. Tools (**BEFORE** removing any PPE:
   a. Wash tools using a bucket of clean water containing the recommended amount of cleaning solution, scrubbing with a poly-fiber or similar brush for at least 30 seconds, and then rinsing in a bucket of clean water or with a hose, **OR**

    b. Rinse them thoroughly with water, **OR**
    c. Wipe them down with a damp cloth*
    d. Allow tools to air dry
    e. Properly dispose of the dirty water and avoid runoff contaminating other things
2. Brush off any visible debris and particulates from outer clothing
3. Do an initial rinse of boots, including soles
4. Remove outer gloves and place them in the proper disposable trash bag**
5. Take off the helmet and wipe it off with a damp cloth*
6. Gently remove the hood portion of the disposable outer garment***
7. Gently unzip the suit and pull your arms out. Roll down the suit with the inside out to the top of the boots
    a. If wearing another type of protective outer garment, follow the same procedure
8. Remove boots and set them aside
9. Remove suit and outer gloves and place them in the disposables bag
10. Clean boots using the same procedures as for tools
11. Remove goggles and then respirator, taking care not to cross-contaminate facial areas in the removal, and wipe them off with a damp cloth*
12. Remove inner gloves and place them in the bag
13. Close and seal bag all bags
14. Clean all exposed and transition skin areas with decontamination wipes or soap and water. Place used wipes in the disposables bag
15. Put on clean, dry clothing to travel
16. Place tools, boots, and sealed bags in the vehicle's utility area
17. Shower within the hour or as soon as practical
18. While wearing nitrile gloves and respirator, and in an open area, remove items from the bag and place them in the washing machine/extractor
19. Wash all apparel following the instructions noted elsewhere in this document
20. Clean tools, helmet[+], boots, goggles, and respirator with warm water and mild soap. If the helmet liner or neck cover is removable, add it to the washing machine/extractor

* If you are going to dispose of these used cloths, they go in the disposables bag. If you are going to wash and reuse them, place them in a separate bag that is then sealed and put in your vehicle's utility area. Follow the best practices, storage, and cleaning information.

** Contaminated items that are going to be disposed of should be placed in a sturdy plastic bag that is then sealed. Items that are going to be cleaned later should be placed in a sturdy plastic bag and sealed or in a container with a tight-fitting lid. See footnote 11 on page 14 for additional information.

*** If wearing something else, such as coveralls or long pants and a long-sleeved shirt, substitute as appropriate following the same steps.

[+] The helmet needs to be cleaned inside and out. Repeated exposure to accumulated *nanoparticulates* on the headband can lead to skin cancer presenting around the headband area. Therefore, regular change-out of disposable sweatbands is recommended on all helmets or hard hats that are equipped or can be retrofitted with a sweatband.

All persons opening sealed containers containing items contaminated at a fire scene should wear proper respiratory protection as defined in Appendix B and nitrile gloves.

Appendix D – Risk Assessment and Analysis

Whether done informally by one or a small group of fire investigators at a scene or as part of a formal process at a more extensive investigation, conducting a risk assessment and analysis is a critical step that should be taken at the beginning of every scene exam and, if necessary, daily after that. It should also be done any time during the investigation should conditions change. This appendix provides a detailed overview of this risk assessment process. In addition, there are many literature sources available to provide additional information.

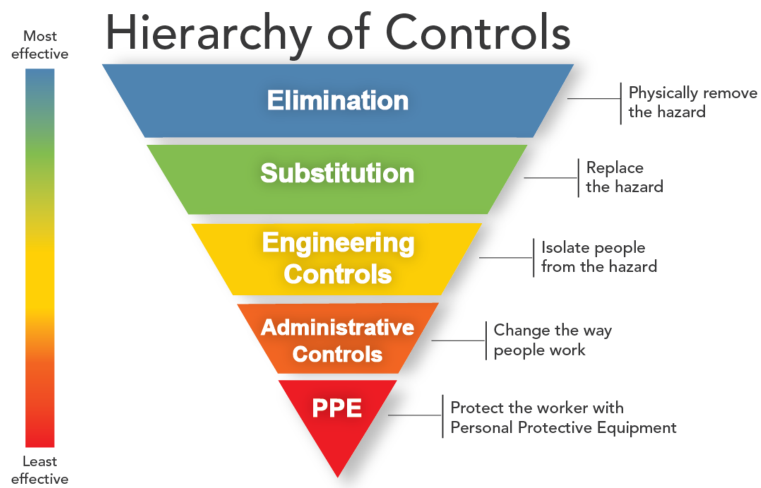
There can be many hazards at a post-fire scene; therefore, the first step in the process is to survey the scene and conduct interviews to identify the potential hazards. Interviews can be with fire personnel, property owners/tenants, neighbors, or anyone else who may know the incident location. The important thing for the fire investigator to remember when interviewing these people is to ask "what" questions, i.e., What hazards did you see while you were inside? Or what hazards are you aware of? This information, combined with the on-scene observations, provides the risk assessment data. It also is key to having situational awareness while working at the scene.

Scene hazards include but are not limited to:

- Electrical power supply/energized systems, Storage batteries
- Water and sewer/septic
- Other utilities (natural gas, propane, heating oil)
- Chemical reactions
- Viral, bacterial, fungal exposures
- Environmental/weather conditions
- Falling objects
- Flammable/combustible materials
- Inadvertent motion
- Fatigue
- Ergonomics
- Accessibility
- Explosive liquids, gases, or vapors
- Post-fire gases and particulates
- Combustible materials
- Temperature extremes
- Pipe/vessel rupture
- Structural integrity
- Emergency egress
- Stairs and railings
- Lighting
- Refrigerants
- Confined spaces
- PPE availability
- First aid availability and training

The risk assessment and analysis process involves looking at each identified potential hazard and making a judgment decision regarding the likelihood of something bad happening and, if it did, the *acute* consequences. Using the matrix and criteria below, each hazard can be scored. This process is accomplished by conducting a what-if analysis to identify risks, hazardous situations, or specific event sequences that could produce an undesirable outcome —for example, looking at a possibly unstable wall section and saying, what would happen if that wall fell over? Associated with this is an assessment of the likelihood that it will fall and the consequence or impact thereof. For example, there would likely be a minimal impact if the wall section is well away from the work area. However, if it fell into the work area, there would be a significant impact.

Once all the actual and potential hazards have been identified, the next step is to determine the level of risk and the likelihood of occurrence associated with each. This will help determine how likely each hazard is to occur and how much damage would result and help understand the relationship between the cause of the hazard and any subsequent effect. Using the chart below, each hazard can be categorized based on the likelihood and possible consequences. The consequence ratings are based on the four objectives categories listed. The risk evaluation matrix is then used to rate each hazard. Anything other than green requires utilizing the hierarchy of controls (see below) to mitigate the hazard to an acceptable level of risk.



Source: National Safety Council

Once this is done, the results are compared with known standards, and mitigation strategies can be initiated using the hierarchy of controls. Of course, not every hazard can be eliminated by the very nature of the post-fire scene, but they can be made as low as reasonably practicable (ALARP).[52]

Hazard mitigation should then be done before the scene examination starts. The identified hazards and mitigation actions should be documented in the investigation report. The hierarchy of controls should be considered when implementing risk reduction strategies. Eliminating a hazard is most effective. Wearing PPE is regarded as the least effective control; however, it may be the only available control measure due to the nature of fire investigations **[1]**.

The post-fire scene presents some unique situations that traditional methods cannot easily control. Substitution is not a control method typically used in the post-fire environment. Administrative controls like training and up-to-date policies and procedures are effective control methods for many hazards encountered in the post-fire environment. However, these must be in place well before the scene exam. In some instances, it will be possible to use engineering controls or hazard elimination controls to make the scene safer. This could include removing hazardous structural members to permit safe passage, pushing down masonry chimneys, constructing reinforced walkways within the structure to protect workers, or cordoning off areas from access. Safely removing a hazard is usually the best course of action. In most instances, risk acceptance is an individual decision made by the fire investigator based on the unique hazards found at the scene.

Likelihood:

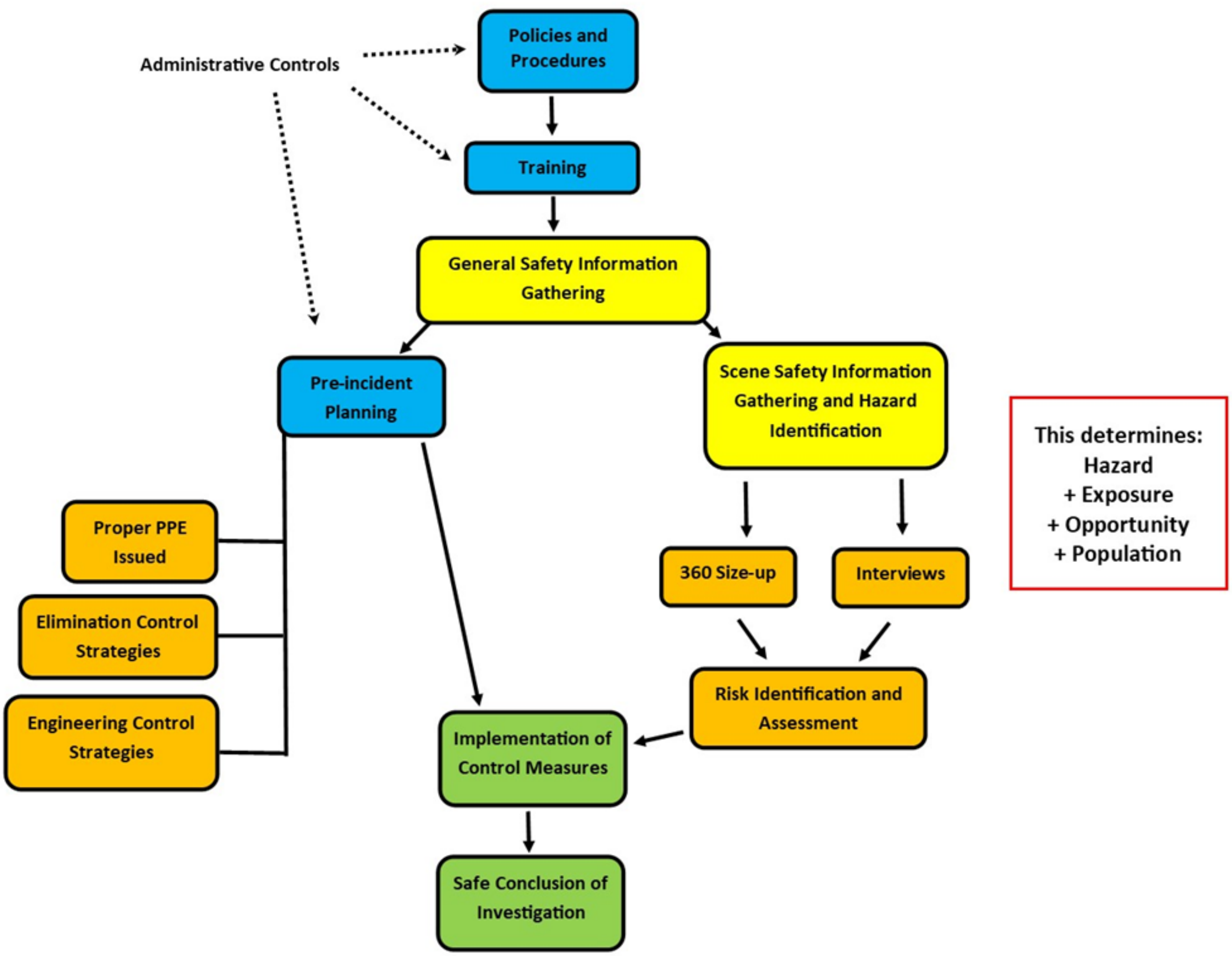
1. Unlikely. The hazard is extremely rare, with a less than 10% chance it will occur.
2. Seldom. Those hazards occurring 10% to 35% of the time.
3. Occasional. A hazard that will occur between 35% and 65% of the time.
4. Likely. A hazard that has a 65% to 90% probability of occurring
5. Definite. These hazards will occur 90% to 100% of the time.

[52] The ALARP principle is based on reasonable practicability, which simply means that hazard controls are implemented to reduce residual risk to a reasonable level of practicality. For a risk to be considered ALARP, it must be demonstrated that the cost in reducing the residual risk further would be grossly disproportionate to the benefit gained.

Acute (Immediate) Consequences:
A. Negligible. An event that does not result in injury or system damage and does not affect the mission.
B. Minor. An event that may cause a minor injury or minor damage to equipment being used but does not adversely affect the mission.
C. Critical. An event that may cause significant injury to anyone at the scene and has an impact on the mission by temporarily stopping it.
D. Catastrophic. An event that may cause death or serious injury to anyone at the scene and significantly impacts the mission by stopping it for an extended period.

Unlikely (1)				
Seldom (2)				
Occasional (3)				
Likely (4)				
Definite (5)				
	Negligible (A)	**Minor (B)**	**Critical (C)**	**Catastrophic (D)**

The Post-fire Scene Investigation Safety Management Process



Credit: Jeff Pauley

Appendix E – Additional Resources

The following resource documents are available on the IAAI website's Health and Safety Resource page. This material can be accessed at www.iaaiwhitepaper.com and is not password protected. These may be updated, and additional items may be added. Only the latest version of any document is here.

- Behavioral Health Survey results
- Health and Safety Infographic
- Fire Investigation Respiratory Protection Fact Sheet
- Fire Investigator Best Practices Quick Facts
- Fire Investigator Physical Exam Letter
- Health and Safety Resolution
- Health and Safety Top Tips
- Health & Safety Committee Benchmark Survey Results
- Health & Safety Committee Benchmark Survey Results Data
- Health & Safety Committee SOP

Or you can use this QR code to get there

Appendix F - Some Common Plastics and Their Fire Behavior

Some Common Plastics and Their Fire Behavior

Plastic	Commonly Found Products	Beginning Temperature of Quantitative Decomposition	Emissions During Quantitative Decomposition	Beginning Temperature During Ignition	Emissions During Ignition*
Polyvinyl Chloride (PVC)	Plasticized: Wire insulation, wall covering, leather-look upholstery	464 - 536°F (240 - 280°C)	Hydrogen chloride[1], phthalate[3]	1,110°F (600°C)	Carbon monoxide[2], benzene[3], organics[3]
	Rigid: Electrical conduit, plumbing pipe, molded furniture	480°F (250°C)	Hydrogen chloride[1]	1,110°F (600°C)	
Urethane Foam	Flexible: Pillows, mattresses, soft furniture stuffing	212 - 390°F (100 - 200°C)	Large quantities of organics[3] (50% weight of foam), hydrogen cyanide[1]	750 - 840°F (400 - 450°C)	Nitrogen oxides[1], benzene[3], carbon monoxide[2], organics[3]
	Rigid: Building insulation, some wood-looking furniture	300 - 390°F (150 - 200°C)	Organics[3], hydrogen cyanide[1]	840°F (450°C)	
Acrylonitrile-butadiene-styrene (ABS)	Plumbing pipe, upholstry, computer casing, luggage	570°F (300°C)	Hydrogen cyanide[1], organics[3]	930°F (500°C)	Nitrogen oxides[1], benzene[3], carbon monoxide[2], and other organics[3]
Polystyrene	Hot/cold drinking cups, fast food packaging, other food packaging, insulation	390 - 570°F (200 - 300°C)	Styrene[3], phenyls[3], diphenyls[3]	840°F (450°C)	Carbon monoxide[2], phenols[3], other organics[3]
Teflon	Plasticized: Wire insulation, cabling	570°F (300°C)	Hydrogen flouride[1], phthalate[3], flourinated organics[3]	1,110 - 1,290°F (600 - 700°C)	Carbon monoxide[2], benzene[3], other organics[3]
	Rigid: Credit cards, cookware, protective liners	930 - 1,110°F (500 - 600°C)	Hydrogen flouride[1], flourinated organics[3]	1,290 - 1,470°F (700 - 800°C)	
Nylon	Carpets, upholstery, clothing, gears	660 - 750°F (350 - 400°C)	Hydrogen cyanide[1,2], ammonia[1]	930°F (500°C)	Carbon monoxide[1], nitrogen oxides[1], organics[3]

* Emissions in addition to those begun during quantitative decomposition

[1] These chemicals are corrosive irritants

[2] These chemicals are asphyxiants

[3] Organic chemicals usually affect the nervous system

Glossary

Accident - an undesired event that causes harm to people, damage to property, or an interruption of the work process **[42]**.

Acute – in this context, an illness having a sudden onset, sharp rise, and short course. [Merriam-Webster Dictionary]

Aerosol - NIOSH defines an aerosol as an airborne suspension of tiny particles, fibers, or droplets – such as dust, mists, fogs, fibers, smokes, or fumes. Inhalation of skin contact or ingestion of aerosols can adversely affect workers' health because aerosols are a significant source of hazardous agents. In addition, aerosols often lead to complex toxicological interactions in the human body. Because of their various sizes and characteristics, aerosols tend to affect different areas of the lungs in different ways **[43]**.

APR - An elastomeric air-purifying respirator that utilizes a particulate filter, cartridge, or canister. Filters can be either N, R, or P series. N = Not resistant to oil, R = Resistant to oil, P = oil proof. Only P filters should be used when working in the post-fire environment. See Appendix B for additional information.

Carbon monoxide - a colorless, odorless, toxic flammable gas formed by incomplete combustion of carbon.

Carcinogens – substances capable of causing cancer in living tissue. [Oxford Dictionary]

Chronic – in this context, a continuing illness or one that repeatedly occurs for a long time. [Merriam-Webster Dictionary]

Clean Cab Concept – Employing preliminary exposure reduction efforts (at-scene decontamination) to minimize fireground contaminants entering the vehicle's passenger area.

Formaldehyde - A common contaminant of indoor air. It is found in many manufactured wood products, including particle boards and ceiling tiles, carpets, and urea-formaldehyde foam. It irritates the skin and the mucous membranes. High levels of formaldehyde "off-gassing" can occur in new buildings, particularly in hot weather, causing eye, nose, and throat irritation **[44]**.

Hydrogen cyanide - a highly poisonous gas or volatile liquid with a slight odor of bitter almonds, made by the action of acids on cyanides. [Oxford Dictionary]

Hydrogen sulfide – a colorless chalcogen-hydride gas, and is poisonous, corrosive, and flammable, with trace amounts in the ambient atmosphere having a characteristic foul odor of rotten eggs. [Wikipedia]

Hydrogen fluoride – a colorless gas or liquid is the principal industrial source of fluorine, often as an aqueous solution called hydrofluoric acid. It is an important component in the preparation of many important compounds, including pharmaceuticals and polymers, e.g., polytetrafluoroethylene (PTFE). Hydrogen fluoride is a highly dangerous gas, forming corrosive and penetrating hydrofluoric acid upon contact with moisture. The gas can also cause blindness by rapid destruction of the corneas. [Wikipedia]

International Agency for Research on Cancer (IARC) - The specialized cancer agency of the World Health Organization. See https://www.iarc.who.int/cards_page/about-iarc/ for additional information. The objective of the IARC is to promote international collaboration in cancer research.

Lower explosive limit – the minimum concentration of a combustible vapor required to facilitate its combustion in air.

Nanoparticulates - Particulates that are less than 5 micrometers or microns in size. These are invisible to the naked eye and can penetrate deep into the lungs through inhalation, where clearance mechanisms are less effective, and inflammation and systemic absorption can occur. They can also introduce chemicals into the body through dermal absorption. In most instances, references in this paper to particulates include nanoparticulates. The graphic on page 37 identifies the various particulate sizes by comparison.

Near-miss - an unplanned event that did not result in injury, illness, or damage; but had the potential to do so. Only a fortunate break in the chain of events prevented an injury, fatality, or damage; in other words, a miss that was nonetheless very nearly an accident. Also known as a close call, narrow escape, near-collision, near hit, etc.

Overhaul – A firefighting term involving the process of final extinguishment after the main body of the fire has been knocked down. All traces of fire must be extinguished at this time **[1]**.

PAPR – An elastomeric powered air-purifying respirator that can utilize a full-facepiece, half-facepiece, or loose-fitting head covering and can be used with either a HE (high-efficiency) filter or gas and vapor cartridge or canister. See also APR.

Safety Zone - An area within the post-fire scene free of hazards from wall and floor collapse, falling debris/objects, etc., where a person can find temporary refuge within the scene.

SCBA – Self-contained breathing apparatus.

Site Safety Assessment - An exterior and interior evaluation conducted to identify physical, toxicological, and biological hazards (structural stability, *toxic* substances, electrical hazards, etc.).

Situational awareness - A mental state of alertness that involves perceiving, processing, and predicting the event to prevent an unexpected incident from happening. It is always better to err on the side of safety than to let a bad situation grow worse **[45]**.

Sootprint – the area on the ground where cooled smoke particles (particulates) will likely be. The area is defined by the wind speed and direction and the quantity of smoke produced by the fire.

Take-home exposures - exposures to *toxic* contaminants inadvertently brought home from a family member's work.

Toxic - having the characteristic of producing an undesirable or adverse health effect at some dose **[46]**.

Toxicity - the quality, state, or relative degree of being poisonous. [Merriam-Webster Dictionary]

Toxin/toxins - a poisonous substance that is a specific product of the metabolic activities of a ***living organism*** and is usually very unstable, notably *toxic* when introduced into the tissues, and typically capable of inducing antibody formation. https://www.merriam-webster.com/dictionary/toxin. Poisons produced within living cells or organs of plants, animals, and bacteria. https://discardstudies.com/2017/09/11/toxins-or-toxicants-why-the-difference-matters/

Toxicant - any synthetic (human-made) substance that causes a harmful (or adverse) effect when in contact with a living organism at a sufficiently high concentration.

Transition skin area – where apparel items overlap, e.g., at the wrist or neck.

Upper Exposure Limit – The maximum concentration of a chemical, radiation, or sound to which workers may be exposed continuously for a short period, usually 15 minutes, without any danger to health, organ damage, injury, or work efficiency.

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