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Recommendations for Developing and Implementing a Fire Service Contamination Control Campaign

FINAL REPORT BY:

Jeff Stull (International Personal Protection, Lead Author);
Peg Paul (Peg Paul & Associates);
Julie Reynolds (Peg Paul & Associates);
Marni Schmid (Fortunes Collide Marketing and Business Consulting);
Robert Tutterow (Fire Industry Education Resource Organization)

February 2018

1 Batterymarch Park, Quincy, MA 02169-7417, USA
Email: foundation@nfpa.org   Web: nfpa.org/foundation

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FOREWORD

There has been growing concern among the fire and life safety community that repeated exposures to harmful contamination is likely causing increased rates of cancer in fire fighters. This includes at the fire scene and the subsequent post fire scene exposures to contaminated clothing, tools, apparatus, and stations.

A strong need exists to determine the broad contamination hazards that exist throughout the fire service, and gaps in how contamination is addressed similarly need to be identified. Contamination has broader negative effects on health than just cancer. A number of other chronic health disorders could be related to broad, continuing chemical and biological exposures. This problem has not been resolved and needs to be further addressed.

This report clarifies the strategy and recommendations to address the fire service contamination issue and support the development of tools to adequately address contamination control in fire service. This starts with controlling exposure and the spread of harmful fire ground contaminants, and extends beyond to all aspects of a fire fighters work life. The ultimate goal is to improve the long-term health of today's fire service.

In support of this project, a two day workshop was held on 19-20 July 2017 in Columbus Ohio to address this topic. The results of that specific effort are available in separate Workshop Proceedings. The Workshop discussion and related information are partially reflected within this final project report.

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ACKNOWLEDGEMENTS

The Fire Protection Research Foundation expresses gratitude to the Research Team that worked on this project (indicated alphabetically by last name): Peg Paul (Peg Paul & Associates); Julie Reynolds (Peg Paul & Associates); Marni Schmid (Fortunes Collide Marketing and Business Consulting); Jeff Stull (International Personal Protection); and Robert Tutterow (Fire Industry Education Resource Organization). A special thanks are provided to Jeff Stull who has lead the compilation and authorship of this report.

The Research Foundation appreciates the guidance provided by the Project Technical Panelists, the funding provided by the project sponsor (AFG), workshop participants, and all others that contributed to this research effort.

About the Fire Protection Research Foundation

The Fire Protection Research Foundation plans, manages, and communicates research on a broad range of fire safety issues in collaboration with scientists and laboratories around the world. The Foundation is an affiliate of NFPA.

About the National Fire Protection Association (NFPA)

Founded in 1896, NFPA is a global, nonprofit organization devoted to eliminating death, injury, property and economic loss due to fire, electrical and related hazards. The association delivers information and knowledge through more than 300 consensus codes and standards, research, training, education, outreach and advocacy; and by partnering with others who share an interest in furthering the NFPA mission.

All NFPA codes and standards can be viewed online for free.

NFPA's membership totals more than 55,000 individuals around the world.

Keywords: fire fighter, fire fighter cancer, chronic health disorder, contamination, contamination control, fire service, health risk, SOPs/SOGs, emergency service, equipment, PPE, NFPA 1, NFPA 1500, NFPA 1581, NFPA 1851, NFPA 1989, FPH

Report number: FRPF-2017-27
FPRF Project Manager: Casey Grant

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Project Technical Panel

Stephen Belski, NFPA & Somerville Fire Dept. (MA)
David Bernzweig, Columbus Fire Department (OH)
Ken Block, Edmonton Fire/Rescue & Metro Chiefs Representative
Ken Brown, NVFC & VA State Firefighter’s Association
Paul Erickson, Lemay, Erickson & Willcox Architects (VA)
Beth Gallup, Kent Fire Department (WA)
Bill Haskell, NIOSH NPPTL (MA)
Peter McBride, Ottawa Fire Services (ON)
Ed McCarthy, Boston Fire Department (MA)
Joe Molis, NFPA & Providence Fire Dept. (RI)
Russ Osgood, Firefighter Cancer Support Network (NH) (Alt to Keith Tyson)
Larry Petrick, IAFF (DC)
Jay Petrillo, NFPA & North Providence Fire Dept. (MA)
Jim Riley, Boston Fire Department (MA) (Alt to E. McCarthy)
Molly Riley, Virginia Beach Fire Dept. (VA)
Thomas Smith, FDNY (NY)
Victor Stagnaro, NFFF Fire Service Occupational Cancer Alliance (MD)
Tim Tomlinson, Addison Fire Dept. & Gear Cleaning Solutions (TX)
Keith Tyson, Firefighter Cancer Support Network (FL)
Dick Weise, LA County Fire Dept. (CA)

Project Sponsors

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Summary

This document lays out a strategy and recommendations for establishing increased fire service awareness of and promoting changes in equipment and procedures to minimize the harmful effects from exposure to contaminants from the fireground and other emergency responses. Ample evidence exists that firefighters are frequently exposed to a variety of different types of contamination, ranging from products of combustion to hazardous chemicals to infectious diseases. The persistency for many of these exposures leads to both acute and chronic health issues that can be partly mitigated by implementing a proactive approach that increases firefighter understanding of contamination hazards and by instituting new equipment and response practices that limit, where practical, the exposures to these hazards. Overall, this effort is best enacted in the form of a "campaign" that uses consistent messaging to promote changes in fire service culture, procedures, equipment, and standards for solving contamination issues among firefighters.

The Fire Protection Research Foundation (FPRF) undertook a project funded by the U.S. Department of Homeland Security as part of an Assistance to Firefighter Grants Program for research and development on contamination control. This effort included investigating different sources of information such as existing published literature, past and on-going research, current fire service practices, and standards for addressing the issue of fire service contamination control. This investigation was coupled with a comprehensive workshop designed to elicit commentary from fire service representatives and subject matter experts on different approaches for improving efforts towards controlling contamination. While it was learned that a variety of studies, practices, and requirements have been developed for the purpose of addressing contamination control in the fire service, it was obvious that much more information and direction is needed to ensure that improvements are made in reducing continued firefighter exposures to different types of contamination hazards. In essence, a national strategy is needed to bring together and implement the many elements as part of a fire service contamination control campaign.

The recommended strategy consists of the following recommendations:

1. A centralized organization with strong fire service ties, such as the National Fire Protection Association, should take long-term responsibility for managing a fire service contamination control campaign. This responsibility should provide the fire service with information on the latest research, best practices, and standards as well as promoting forms for communication and outreach. Furthermore, the centralized organization should endeavor to link its efforts to the multitude of other organizations also conducting outreach in this area. Alternatively, organizations that are willing to make long-term commitments to the area of contamination control in the fire service should band together based on areas of strength to provide a forum with appropriate levels of overlap for undertaking the various elements as part of a comprehensive campaign.

2. The campaign should be seated within an easily accessed website that provides a clearinghouse that offers the best and more recent available information on topics related to contamination control within the fire service. The use of the website establishes a forum that can easily be updated and creates a myriad of linkable awareness tools.

3. Key elements of the campaign information should include an overview of the contamination control problem within the fire service, a means for establishing a searchable interactive research and literature database, a database that directs end users to standards promoting their participation within the development process, a synthesized list of available best practices with information describing the evidence available to establish their effectiveness, and other information that can be utilized for addressing the multiple issues associated with contamination control across different facets of the fire service.

4. Information in the contamination control campaign should be positioned to evolve and be updated. It should also permit both use by a wide range of individuals within and outside the fire service with different needs and be accessible through a variety of forums. The information should be provided in an actionable form and create opportunities for increased awareness, adoption of best practices, and the strengthening of standards.

This recommendations document provides detailed proposed steps for the implementation of this strategy and the creation of a national campaign on fire service contamination control.

The Need for a Campaign

Substantial evidence already connects firefighting with increased rates of cancer among fire fighters. A number of prior studies have provided findings indicating specific elevated incidence of certain cancers when fire fighters are compared against the general population. These linkages culminated with a comprehensive epidemiology-based study spanning a detailed review for fire fighters in 3 different major cities over a 50 year period. Moreover, the International Agency for Research on Cancer (IARC) has classified activity of firefighting as being probably carcinogenic to humans. Anecdotal information from across North America has indicated many of these cancers for fire fighters are occurring at younger ages. Statistics have been compiled by a number of organizations including the IAFF and more recently the Firefighter Cancer Support Network. Cancer has become the number one concern among firefighters as an occupational issue. Extensive research continues in this area, including a new study led by the University of Arizona towards recording future trends of firefighter cancers and exposure histories that will further elucidate the patterns of this disease among firefighters and potentially track intervention approaches.

While there is a substantial focus on exposure to cancer-causing substances in the fire service, innumerable other health disorders emanate from both acute and chronic exposures to various hazardous substances that are not specifically carcinogenic, mutagenic, or teratogenic. Long-term exposures to certain chemicals are known to induce a variety of corrosive, toxic and sensitizing effects. Those firefighters that come in contact with the public through victim extrication and transport, as well as the provision of personal medical care are further subject to exposure to a variety of biological contaminants that include common blood-borne pathogens as well as other highly infectious diseases that may be airborne or liquid borne or both. The dynamic nature of emergency response coupled with the persistence for some of these forms of contaminants increases the risk of firefighter exposure and, while not always deadly, still results in significant potential harm, disability, and lost work time.

Firefighting is perhaps one of the few occupations that does not mandate strict occupational safety and health requirements for its members as part of structural and other types of fire exposures. Cultural attitudes towards exposure have been lax for decades, particularly as firefighters are more likely to enter burning structures for longer periods of times due to improved forms of personal protective equipment. However, with the advent of modern building materials, a larger variety of toxic decomposition products of combustion are created to which fire fighters are exposed. Even though personal protective equipment provides extended stay times, it does not protect against smoke, other particulate, fire gases, and on-scene liquids. Moreover, provisions for keeping clothing and equipment clean and maintaining good hygiene have been lacking until very recently. Similarly, firefighters are more likely to come in contact with infectious diseases that result from more active fire service involvement with the public during both the provision of medical care and responses to various disasters such as hurricanes, terrorist events, or other localized emergencies.

Multiple organizations have attempted to increase the awareness of the fire service, including the International Association for Fire Chiefs (IAFC), the International Association for Fire Fighters (IAFF), and the National Volunteer Fire Council (NVFC). These efforts have been supplemented by other fire service-based groups such as the National Fallen Firefighters Foundation, the Firefighter Cancer Support Network, and the Fire Fighter Cancer Foundation. Each user organization has attempted to provide comprehensive information, suggest best practices, and provide reference tools and other resources to improve the understanding of exposure risk as well as ways of mitigating exposure hazards. Often, various recommendations are made in the forms of suggested standard operating procedures for contamination control.

The fire service is being inundated with a wide range of products, suggested practices, and other information that can have varying degrees of credibility, verification, and application for solving or at least addressing contamination control problems. While there are a variety of different research programs that have either been completed or are on-going, the results of this research are just beginning to define the extent of effectiveness for different contamination control approaches.

Key Elements for a Contamination Control Campaign

Based on this review of fire service and industry efforts toward contamination control, the Fire Protection Research Foundation considered a variety of approaches for gathering information that could be useful in promoting a campaign for improving fire service awareness and implementing new technology, practices, and standards to best address the wide ranging issues for firefighter exposure to contamination. The FPEF quickly realized that simply gathering information at the time, while leading to a fuller understanding of the current status of various aspects of contamination issues and possible solution, would be too static to have long lasting effects. Therefore, the original proposed project outputs were transformed into a more flexible and functional platform for presenting information to the fire service and other interested parties. Work undertaken to create this platform included the following efforts:

- Determining the appropriate content for providing and communicating an overview of fire service contamination issues
- Investigating ways for improving how relevant literature including articles, research reports, and other documents could be provided in a more accessible, interactive, and useful way
- Assessing the current status of standards affecting contamination control and defining how a standards resource data base could be created to capture this information
- Synthesizing a set of suggested fire service best practices and the best manner for presenting this information for potential utilization
- Describing a contamination control practices in parallel related industries (vignettes) and indicating their relevance to the fire and emergency services
- Establishing a question/answer forum
- Collecting a list of glossary terms

The efforts in each of these areas were positioned to yield the proposed new project elements that form the foundation of the baseline information content for the contamination control awareness campaign.

For the purposes of executing a campaign, the primary recommended approach was to put the collected information into a series of on-line accessible databases using linkable information for defining a future approach rather than a project report that simply compiles the findings of information collection and analysis effort pursued over the project timetable. Combined with this approach, the primary data content – literature citations, abstracts of research, descriptions of organizations, and information on standards – were collected and placed into various spreadsheets to enable their accessibility and potential linkages to future database programs The FPRF further saw that the recommendation for establishing a centralized web page where each of the information elements could be presented in an easily navigable fashion through the use of tabs and associated links coupled with thematic elements was the most efficient way to gain attention and create continuing awareness. This scheme is shown in Figure 1.

Figure 1 – Specific Graphic Depicting the Key Elements of a Fire Service Contamination Control Plan

The specific recommendations for developing how each campaign element should be defined and implemented are described in the following sections.

Key Element 1 –Describing and Communicating Fire Service Contamination Issues

The opening element is intended to frame the contamination issues in the fire service. For the purpose of this project, the scope of contamination control was defined as all forms of contaminants that may be encountered by firefighters including fire suppression and emergency patient care. This activity is distinguished from highly specialized team functions such as those undertaken by specially-outfitted hazardous materials or special operations teams, though it is recognized that line firefighters do respond to HazMat and other specialty calls.

The purpose of this element is to convey the enormity of the problem and to describe the various forms of contamination that affect firefighter health and how these exposures occur and are exacerbated with the fire service by controllable and non-controllable circumstances. In essence, it was suggested that the baseline information of this element should be presented as a "taxonomy" of contamination issues, indicating the types of contamination, the manner of exposure and continued spread, and the impact and risks associated with contamination. Figures 2 and 3 capture some of the scope elements for a potential white paper.

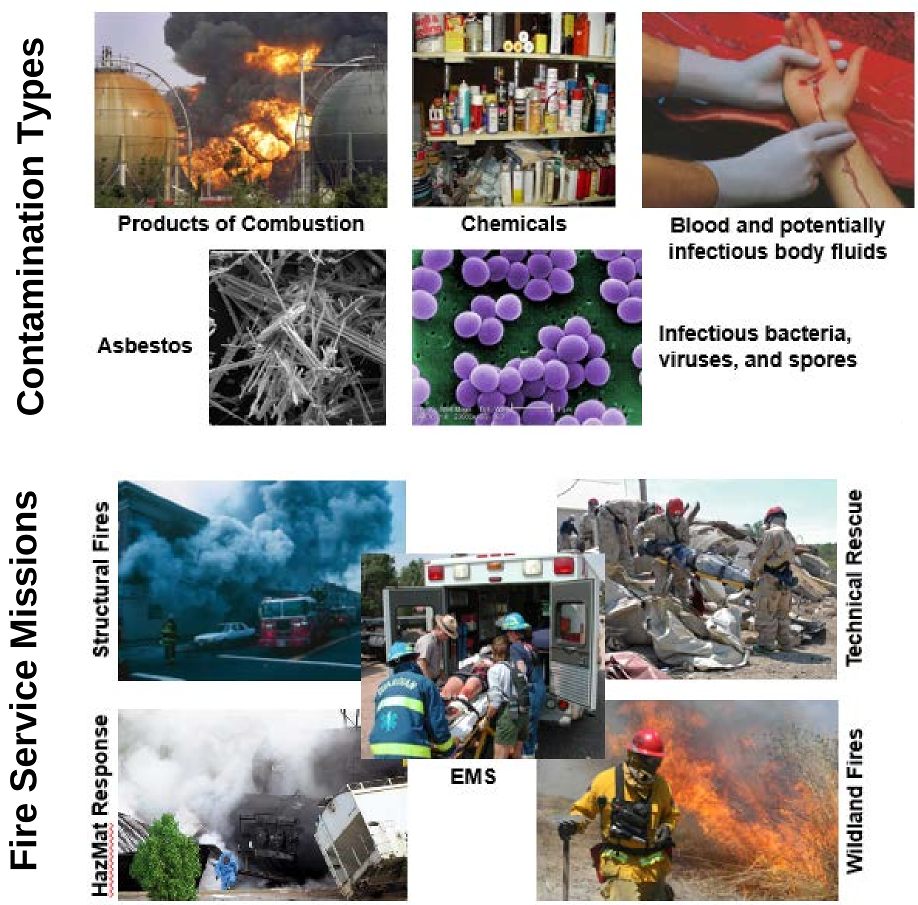


Figure 2 – White Paper Scope Related to Contamination Types and Fire Service Missions

Figure 3 – White Paper Scope Related to Contamination Locations, Items, and Mitigation Methods

The overview document was also imagined to provide a variety of solutions ranging from the simplest approach to the most sophisticated approach that could be undertaken by an organization to begin addressing or enhancing their strategies for contamination control. An outline of key topics for this element are identified in Table 1.

Table 1 – Short Outline for Fire Service Contamination Control Awareness Document

Purpose: raise awareness of fire service on contamination issues

Overall length: 10 to 12 pages

Key messages:

- Broad contamination hazards exist throughout the fire service (more than just cancer concern)
- Gaps in addressing contamination: not all missions, locations, and equipment are being addressed
- Comprehensive approaches are needed to limit exposure to contamination and limit transfer

Content

- The contamination problem in the fire service
- Examples of contamination and how firefighters are being exposed
- Development of contamination control program and application of best practices
  - Recognition of contamination sources
  - Protective measures
  - Isolation of contaminated items
  - Post exposure cleaning and decontamination
  - Maintenance of hygiene for firefighters, apparatus, stations
- State of research in contamination control
- Current gaps in controlling contamination
- Available resources
- References

In a web-based presentation of a contamination control campaign, the opening page or a separate tab should be created for this general information to provide an introduction to and background on the topic to further establish a roadmap for other campaign elements. To be effective in creating content that provides an overview of the contamination control topics, the following attributes are recommended.

- The principal web page should contain the essential narrative that explains the overall contamination control campaign including its importance, relevance, and purpose. This general content should be supplemented by key graphics that can be updated as needed such as photographs of accepted best practices or charts showing statistics in the climbing rates of firefighter reported cancers. The principal web page should also have links to other pages to further explain other elements in the campaign or specific tools that can be provided to the fire service for creating increased awareness.

- A 10- to 12-page downloadable, white paper should be provided as one of the linked tools that defines the primary aspects of contamination control. It is further suggested that different positioned white papers might be needed to address various audiences – a general paper for fire service members, a different white paper that may be aimed at management or decision makers, and perhaps a third white paper that is oriented toward product or service providers in the area of contamination control.

- Another useable tool would be an on-line (and also downloadable) slide presentation that highlights the white paper narrative through the bullets and increased use of graphics for a more visual communication of key messaging topics.

- Additional links should be provided to other organizations' efforts to define contamination issues (e.g., IAFF, IAFC, NVFC, Fire Fighter Cancer Support Network and National Fire Fighter Foundation) as well as links to any general electronically obtainable key overview documents.

Overall this element should be designed to create the initial awareness for the fire service on the different types of contamination and why action is needed on the part of the firefighter, the department, and the community to limit its spread and effects. Workshop participants agreed that an awareness document was a key part of a campaign, but there were varying opinions for how this document should be prepared, maintained, and distributed.

Key Element 2 – Making Articles and Research Reports Accessible

A broad selection of articles and research reports have been collected both prior to and as part of this project. Annex A provides a list of the principal authors, titles, and sources of these documents.

Originally, a key factor for making this collection useful was the consideration for developing an interactive database by which an individual user could search on respective topics through key words. To this end, a format was established for specific fields of information for organizing the content and specific details of these documents in such a database. Specific identified fields included:

- First author
- Secondary author(s)
- Title
- Availability
- Source document
- Citation information
- DOI number, if applicable
- Year of publication
- Type of contamination and target of contamination
- Key words
- Short abstract
- Notes

As part of the project, samples of relevant literature were placed in an Excel spreadsheet (with the exception of the short abstract) to enable use of the information as part of a future database program. This process was undertaken to demonstrate how an interactive database could be developed. This format was partly used in documenting the literature information in Annex A.

It was also proposed that the abstracts associated with the documents be contained in a separate Excel spreadsheet of simpler design. However, given the wide variety of styles and level of detail provided in different types of articles and reports, it was determined that abstract information should be homogenized to provide for a consistent level of content and to be written in a style that would be more fire service friendly as the firefighters and other professional responders were considered the principal audience. Table 2 provides an example for taking a relatively detailed abstract and creating a short version for easier and more consistent reading.

Table 2 – Example for Simplifying Abstract from Academic Article

Full Published Abstract	Simplified Abstract
There is a high incidence of cardiovascular disease and certain cancers in firefighters that may be related to their occupational exposure to hazardous substances. Exposure may result from contaminated personal protective gear, as well as from direct exposure at fire scenes. This study characterized flame-retardant contamination on firefighter personal protective clothing to assess exposure of firefighters to these chemicals. Samples from used and unused firefighter protective clothing, including gloves, hoods and a coat wristlet, were extracted with methylene chloride and analyzed by EPA method 8270D Specific Ion Method (SIM) for polybrominated diphenyl ethers (PBDEs). Until recently PBDEs were some of the most common flame-retardant chemicals used in the US. Fifteen of the seventeen PBDEs for which analysis was performed were found on at least one clothing swatch. Every clothing sample, including an unused hood and all three layers of an unused glove, held a detectable concentration of at least one PBDE. These findings, along with previous research, suggest that firefighters are exposed to PBDE flame retardants at levels much higher than the general public. PBDEs are found widely dispersed in the environment and still persist in existing domestic materials such as clothing and furnishings. Firefighter exposure to flame retardants therefore merits further study. {*203 words*}	The finding of polybrominated diphenyl ethers (PBDEs) on all samples from used and unused firefighter protective clothing that had been extracted with methylene chloride and analyzed by EPA method 8270D Specific Ion Method (SIM) suggests that firefighters' exposure to PBDE flame retardants is much higher than the general public and warrants further study. {53 words}

Moreover, it is anticipated that additional spreadsheets could be created for other database linkages including contact information for obtaining a specific document or separate links for electronically available reports or articles that do not require special permissions.

As a consequence of these considerations, a database design as illustrated in Figure 4 was conceived for the project.

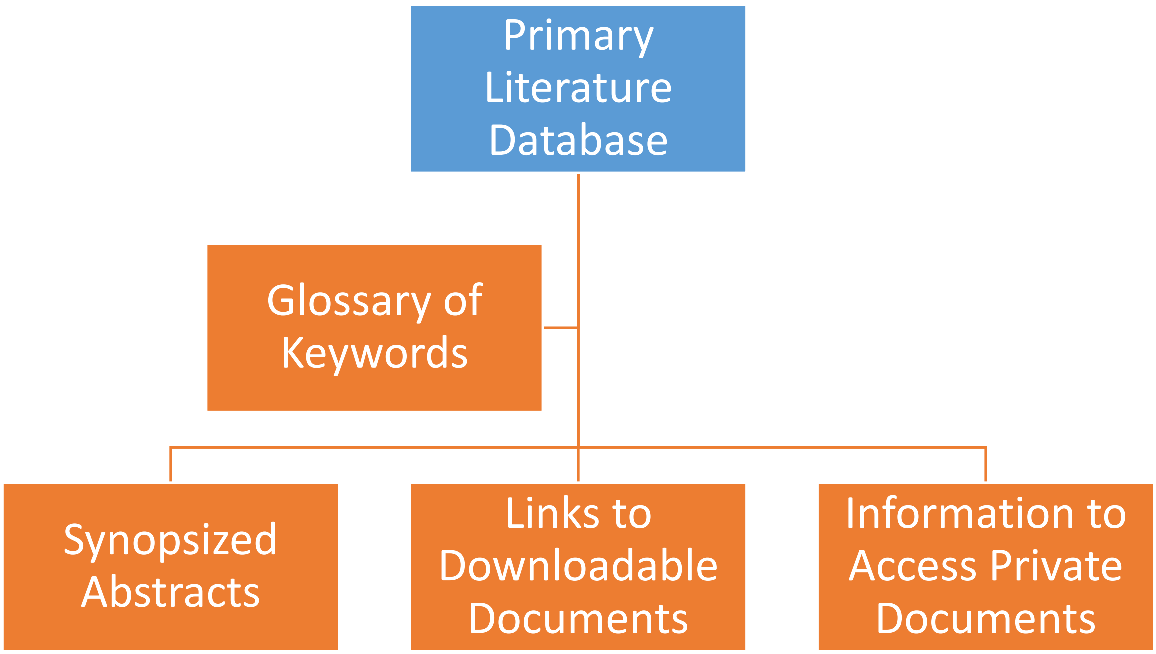


Figure 4 – Recommended Structure of a Contamination Control Document Database

Specific parameters were also considered for creating simple and more complicated searches through the proposed database to enable end users to locate specific articles related to keywords or other chosen information fields. In essence, the provision of a "primer" was recommended for using any ensuing database.

While an interactive database was originally proposed as an essential part of a contamination control campaign, an analysis of this approach revealed certain obstacles that included:

- A key challenge for developing any database is the ability to keep that database up-to-date as a stand-alone database for contamination control. The amount of information in the area of contamination control is rapidly increasing as this area of interest is quickly escalating as a principal fire service topic. Any database manager would have to have a system in place for identifying relevant documents and keying the information into the database. This would be further complicated by the need to rework some of the information, such as abstracts, for maintaining consistency in the style and size of the content.

- A number of referenced articles, particularly those located through multidisciplinary literature database services like Google Scholar, ScienceOpen, and Scientific Information

Database to other more specific databases such as Medline Plus, PubChem, and PubMed are not readily accessible beyond the initial information such as the abstract, and require fees for accessing the full documents.

- There is the potential for infringement of publisher rights in providing some of the information that may appear in portions of the proposed database, particularly abstracts.

The Project Team further investigated how such a database could be implemented by checking with the NFPA library staff. The library staff pointed out that while it maintained general documents associated with the specific needs of the organization, it relies heavily on existing databases for performing searches on general literature among different topics. The staff conveyed that current databases are evolving significantly to result in greater effectiveness in the identification and retrieval of desired documents.

On the basis of investigating different literature database options, the Project Team concluded that a hybrid form would be appropriate. In the hybrid solution, the following two approaches were recommended specifically for the fire service contamination control campaign:

1. Efforts should be made to obtain direct access to specific publications that are referenced in campaign document such as the white paper or suggested best practices. These documents should further be synopsized for ease of understanding and explaining their significance to the contamination control campaign.

2. Specific literature databases should be suggested as sources of potential information on a given range of topics for fire service contamination control. Different guidelines should be offered to instruct interested individuals for how to use these databases for researching specific articles and reports such as providing listed keywords and instructions for accessing suggested databases.

Overall, making key literature accessible can be a significant supporting function of the contamination control campaign. Specifically, articles and research reports can provide the basis for both understanding key contamination topics, as well as offer evidence supporting different best practices. As the amount of information related to fire service contamination grows, the organization(s) undertaking efforts to lead the campaign must be vigilant in seeking new information as it becomes available. Thus, the selection of key documents and making them accessible furthers fire service awareness and creates the confidence in new technologies and procedures that evolve to address the problems of contamination control.

Key Element 3 – Providing an Understanding and Access to Relevant Standards

Standards are perceived to be tools that can allow for the implementation of specific products and practices that result in contamination control. A large part of the initial project effort involving going through the entirety of the NFPA standards and identifying those standards where contamination control is addressed or where the potential for criteria or other information could be included on contamination control topics within the respective standard. That effort resulted in a list of 93 standards out of the over 250 NFPA standards directly or potentially related to fire service contamination control. Annex B provides a list of those standards and their relevance. A number of representative standards are listed in Table 3 below.

Table 3 – Examples of NFPA Standards Relevant to Contamination

Selected NFPA Standards Related to Contamination Control (Abbreviated Titles)	
NFPA 1500 Occupational Safety & Health	NFPA 1901 Fire Apparatus
NFPA 1581 Infection Control Program	NFPA 1937 Care/Maintenance Rescue Tools
NFPA 1584 Member Rehabilitation Process	NFPA 1961 Fire Hose
NFPA 1700 Structural Fire Fighting Guide	NFPA 1971 Structural Fire Fighting PPE
NFPA 1710 Career Fire Dept. Deployment	NFPA 1975 Station/Work Uniforms
NFPA 1720 Volunteer Fire Dept. Deployment	NFPA 1981 Fire Service SCBA
NFPA 1851 Care/Maintenance of Fire PPE	NFPA 1992 HazMat PPE
NFPA 1852 Care/Maintenance of SCBA	NFPA 1999 EMS PPE

It was further recognized that standards from other organizations could have application to fire service contamination control issues and practices. For example, ASTM International writes standards on a variety of product and service areas. Several committees within this organization have developed or are working on different standards that have the potential for application to fire service contamination control. Examples of potentially relevant standards include:

- ASTM D5755-09, *Standard Test Method for Microvacuum Sampling and Indirect Analysis of Dust by Transmission Electron Microscopy for Asbestos Structure Number Surface Loading*
- ASTM E2274, *Standard Test Method for Evaluation of Laundry Sanitizers and Disinfectants*
- ASTM E2967, *Standard Test Method for Assessing the Ability of Pre-wetted Towelettes to Remove and Transfer Bacterial Contamination on Hard, Non-Porous Environmental Surfaces Using the Wiperator*
- ASTM F24, *Standard Test Method for Measuring and Counting Particulate Contamination on Surfaces*
- ASTM G120, *Standard Practice for Determination of Soluble Residual Contamination by Soxhlet Extraction*
- WK55144 (proposed), *New Standard for Evaluating the Transfer of Exterior Contaminants from Protective Clothing During Doffing*

Similarly, standards from other organizations such as those published by specific trade organizations within the United States or standards out of Europe or the International Standards Organization related to contamination control equipment, practices, and guidance can be identified, though the specific availability of those standards and their relevance to fire service applications requires a detailed analysis before any recommendations for their use can be made.

In order to make use of standards information as the basis of a contamination control campaign, a similar approach to the article/report database was examined to determine a database approach might be applied to standards. As with the interactive research and literature database, specific fields of information were identified for each the standards that include:

- Organization
- Document number or reference
- Current edition
- Revision cycle
- Document title
- Applicable sections (related to contamination control) and Category
- Relevancy
- Specific input opportunities
- Criticality rating

Efforts were made to determine how the relevancy, specific input opportunities, and criticality rating for specific standards could be established as it was expected that this information would facilitate searches on given standards.

The thinking behind the standards database was to provide pointers to existing standards where criteria or guidance related to contamination control could be found, or indicate specific standards where additional work could be undertaken to incorporate new requirements to address contamination control. From the perspective of the principal fire service members, the identification of existing standards appeared to be the more relevant purpose for a standards database since the ability to reference standards could address specific needs related to instituting contamination control practices within their organization. On the other hand, an identification of gaps relating to contamination control in the existing spectrum of standards, while considered important, was less relevant to the majority of fire service members than it was to certain individuals that are generally engaged on technical committees for writing standards. As with the analysis of a literature database, the preliminary approach was adjusted for these findings resulting in the following two recommendations:

1. The NFPA should prepare a list of standards, as part of a simple database, which identifies the specific existing requirements for current standards as related to contamination control. This list should indicate the specific areas of contamination control addressed within the referenced standard and how they might be applied for implementing contamination control practices within an organization.

2. The NFPA should develop a comprehensive strategy for addressing contamination control as part of its fire service standards. This strategy should address which standards provide the lead in establishing contamination control practices, identify gaps in the existing standards where contamination control should be addressed, and provide some form of oversight to ensure consistency in requirements and guidelines provided to the fire service.

The latter recommendation was based on the assessment by the Project Team that the NFPA standards were likely to be the most relevant standards applied to the fire service for contamination control given the strong connection between the fire service and wide range of NFPA standards addressing fire operations. However, it was noted that the topic of contamination control was only being addressed in some of those standards and some not at all. This review produced the following observations:

- Contamination control was found to be primarily addressed in standards related to hazardous materials response such as qualification requirements found in NFPA 472.
- The only true contamination control document for the fire service was identified as NFPA 1581, Standard on Fire Department Infection Control Program.
- Limited instances of contamination control requirements were included in the NFPA 1500, Standard on Fire Department Occupational Safety and Health Program, though at the time of the project, significant new modifications within that standard were being prepared.
- Similar existing actions and future activity were found for NFPA 1851, Standard for the Selection, Care, and Maintenance of Protective Ensembles for Structural Firefighting and Proximity Firefighting. Cleaning of turnout clothing was addressed but little information was provided about removal of products of combustion or other forms of persistent contamination. The committee responsible for that standard is also processing significantly revised criteria to address contamination control.
- Few other equipment standards correctly address contamination control, including those for SCBA, rescue tools, and firehose.
- There are currently no requirements in the various standards for fire apparatus to address handling of contaminated PPE, tools, hose, and other equipment on the fireground.
- Other than criteria for infection control at fire stations within NFPA 1581, there were no criteria addressing requirements for fire station design relative to general contamination control.
- In addition, standards for personnel qualifications and training do not directly address contamination control issues for fire service members.

This review of the pertinent NFPA standards revealed several gaps in opportunities for developing criteria that could be applied to fire departments and other organizations related to contamination control. However, it is also apparent that a large degree of coordination is needed to undertake modifications to existing standards for creating a consistent set of practices for controlling or reducing contamination at the fireground and other emergencies. Normally, individual technical committees have responsibilities in a defined scope for addressing particular products or functions. For example, there are separate committees for personal protective equipment versus committees for fire apparatus and rescue tools. Similarly, different committees operate to establish standards on fire service personnel competence, training, and occupational safety and health programs.

While a given committee may seek to coordinate and modify the standards within its jurisdiction, there is no overall coordinating function to oversee and ensure the consistency of all relevant NFPA standards on a given topic. Therefore, it is recommended that NFPA establish a strategy for harmonizing different standards related to first service contamination control. It is imagined that some form of ad hoc committee could provide this oversight function. Figure 5 shows how this approach could be applied within the NFPA for fire service standards.

Figure 5 – Recommended Interrelationship to Establish NFPA Standards on Contamination Control

Another option considered for addressing fire service contamination control through NFPA standards was the formation of a new committee to fully address the topics of contamination control in a single comprehensive document. However, after considering this option, the Project Team rejected the idea since the period of implementation would be relatively long. Instead, using the existing framework of standards, it would be possible to expediently enact new requirements to address contamination control in the short-term. In fact, these actions are already being carried out by the committees responsible for fire service occupational safety and health program and personal protective equipment. An oversight committee would be instrumental in ensuring the use of common terminology and consistent practices from one standard to another while leaving the different technical committees with the responsibility to address contamination control.

It was concluded that the standards element of the contamination control campaign must have two principal parts: (1) a list of standards with appropriate annotations directing end users to the existing requirements that can be applied for contamination control, and (2) a strategy for improving standards, primarily those of the NFPA, for creating new requirements related to contamination control.

It was further realized that, in order for standards development activity to focus on contamination control, efforts would be needed to encourage greater fire service participation in the process and to bring together the appropriate subject matter experts for addressing potential new requirements. This level of support would improve the standards development process and could be further supplemented with activities to solicit fire service participation in the development of standards to the avenues of public input and public comment on relevant contamination control issues as they are proposed as part of new or existing standards. To this end, a final recommendation in the area of standards development was to provide a basis for announcing new proposed requirements for standards on contamination control for gaining feedback from various sectors within the fire service and industry.

Key Element 4 – Reviewing and Suggesting Best Practices

One of the principal output areas for this project was to identify and evaluate the need to support various best practices that can be employed by fire departments and others in the fire service industry for purposes of contamination control. Best practices represent prevailing procedures that have been shown to provide benefits in achieving contamination reduction and control within the fire service as supported by different technologies or operational approaches. Over the past several years, a number of best practices have been promoted for implementation in the fire service specific to controlling contamination. Yet, it was not the intent of the project to create new best practices, rather to assimilate all the different recommendations that have been established over the past several years related to various aspects of contamination exposure and control as well as refinements in best practices that are now emerging.

It was initially envisioned that specific practices would be identified by their category and type of contaminant using the same taxonomy developed for the categorization of baseline literature information. In this approach, various recommended practices (or types of products) would be recommended. These recommendations would include references to whatever source material exists for how the recommendation was created as well as any citations to existing research or literature that supports the viability of the specific recommended practice.

Within this section of the recommended web-based campaign approach, additional links would be provided to organizations offering various specific practices that are identified within the website. This approach would afford the opportunity of broadening the reach of the campaign and to further recognize the efforts and contributions of different outside organizations working in the area of contamination control.

Based on its review of existing or emerging best practices for contamination control, the Project Team identified the following areas as specific targets for implementation or at least further research within the fire service:

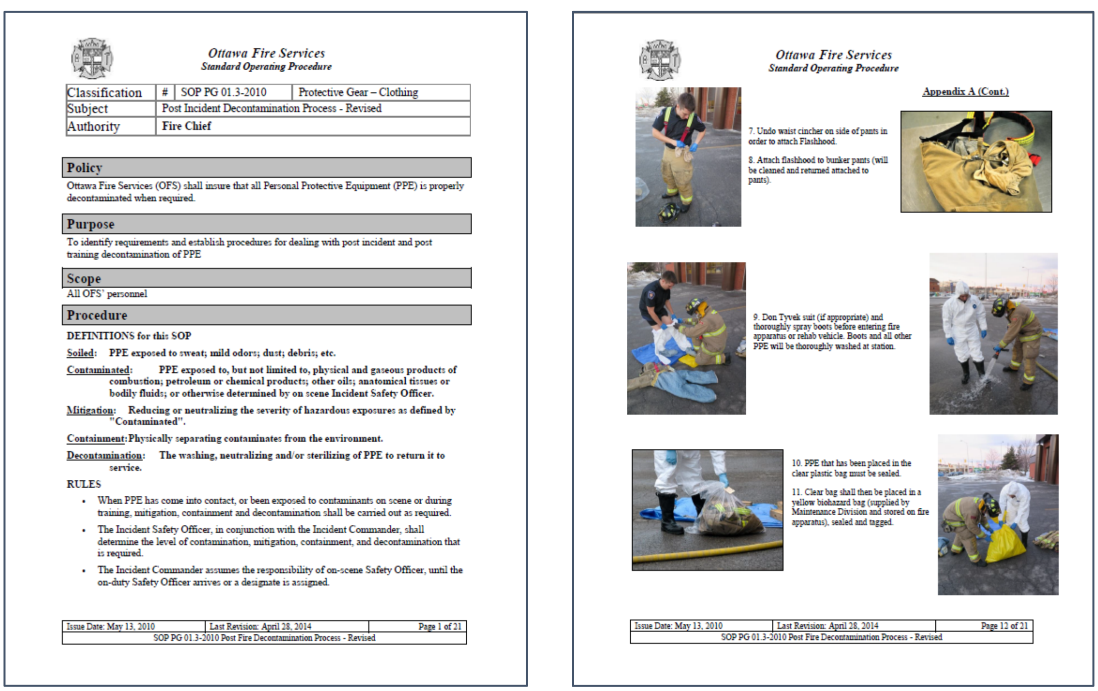
- Contamination avoidance
- Proper wearing of PPE
- Gross decontamination at the emergency scene
- Contaminated item handling
- Cleaning and decontamination

- Personal hygiene
- Wellness and health
- Documentation and recordkeeping
- Apparatus design and cleaning
- Fire station design and maintenance

Further details were defined for each of the best practice areas as shown in Table 4 on page 18.

Several factors were considered for how best practices could be qualified. While it is believed an "intuitive" approach could be used in some cases, participants of the project workshop believed that independent data are needed to validate the benefits of every individual approach. This could be accomplished through studies that show the direct value of specific procedures, through multiple sources that confirm best practices work as intended, or through peer-reviewed research as indicating specific values for the intervention product or process.

To communicate best practices, the Project Team decided that it would be important to use imperative language such as "Do this…" as opposed to "You should do this…" as a more end user friendly method for conveying a specific set of procedures. For each suggested best practice, there was decidedly a need to document current findings and science behind the recommended procedures. Further, it is believed that wherever possible, detailed procedures should be proposed that could be adapted by different organizations in the form of standard operating procedures (SOPs). As an example, certain SOPs provided by different department could be used as models for other department to adopt. An example of these such procedures, which includes photographs to illustrate the practice, are shown in Figure 6.



Ottawa Fire Services
Standard Operating Procedure

Classification	#	SOP PG 01.3-2010	Protective Gear – Clothing
Subject	Post Incident Decontamination Process - Revised		
Authority	**Fire Chief**		

Policy

Ottawa Fire Services (OFS) shall insure that all Personal Protective Equipment (PPE) is properly decontaminated when required.

Purpose

To identify requirements and establish procedures for dealing with post incident and post training decontamination of PPE

Scope

All OFS' personnel

Procedure

DEFINITIONS for this SOP

Soiled: PPE exposed to sweat; mild odors; dust; debris; etc.

Contaminated: PPE exposed to, but not limited to, physical and gaseous products of combustion; petroleum or chemical products; other oils; anatomical tissues or bodily fluids; or otherwise determined by on scene Incident Safety Officer.

Mitigation: Reducing or neutralizing the severity of hazardous exposures as defined by "Contaminated".

Containment: Physically separating contaminates from the environment.

Decontamination: The washing, neutralizing and/or sterilizing of PPE to return it to service.

RULES

- When PPE has come into contact, or been exposed to contaminants on scene or during training, mitigation, containment and decontamination shall be carried out as required.
- The Incident Safety Officer, in conjunction with the Incident Commander, shall determine the level of contamination, mitigation, containment, and decontamination that is required.
- The Incident Commander assumes the responsibility of on-scene Safety Officer, until the on-duty Safety Officer arrives or a designate is assigned.

Issue Date: May 13, 2010	Last Revision: April 28, 2014	Page 1 of 21
SOP PG 01.3-2010 Post Fire Decontamination Process - Revised		

Ottawa Fire Services
Standard Operating Procedure

Appendix A (Cont.)

7. Undo waist cincher on side of pants in order to attach Flashhood.

8. Attach flashhood to bunker pants (will be cleaned and returned attached to pants).

9. Don Tyvek suit (if appropriate) and thoroughly spray boots before entering fire apparatus or rehab vehicle. Boots and all other PPE will be thoroughly washed at station.

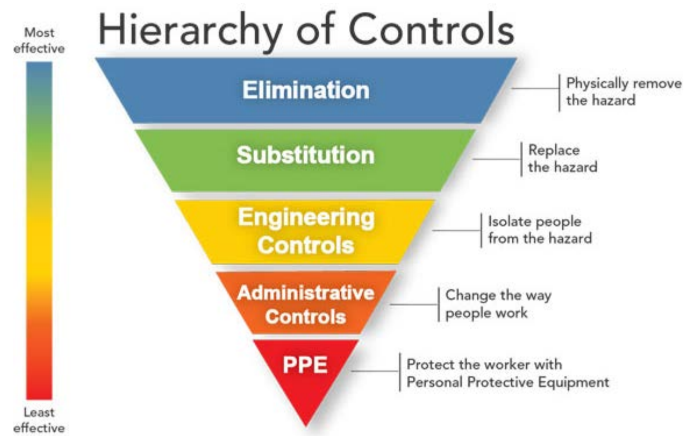
10. PPE that has been placed in the clear plastic bag must be sealed.

11. Clear bag shall then be placed in a yellow biohazard bag (supplied by Maintenance Division and stored on fire apparatus), sealed and tagged.

Issue Date: May 13, 2010	Last Revision: April 28, 2014	Page 12 of 21
SOP PG 01.3-2010 Post Fire Decontamination Process - Revised		

Figure 6 – Example of Best Practice SOP (*Courtesy of Ottawa Fire Services*)

Table 4 – Overview of Recommended Fire Service Best Practices for Contamination Control

Category	Recommended Practices	Level of Validation	Relevant Image(s)
Contamination avoidance	• Teach personnel how to recognize contamination hazards • Delineate hazard zones at emergency scene − Designate HOT, WARM, and COLD zones • Keep unprotected personnel away from contaminated areas	Practices have been successfully used in HazMat responses; Practices expected to require minimal investment on part of organization	
Proper wearing of PPE	• Select appropriate PPE − Conduct thorough hazard assessment • Ensure that selected PPE is properly integrated to provide needed level of protection • Wear PPE according to manufacturer instructions • Continue wearing PPE where hazards still remain	Practices comply with OSHA regulations for proper selection of PPE; Practices also follow current operational doctrine for HazMat response	 For structural firefighting, it is critically important that all items are properly fitted and are in place during all activity where hazards can be encountered including during overhaul; The head, neck, and upper body are especially vulnerable areas

Category	Recommended Practices	Level of Validation	Relevant Image(s)
Gross decontamination at the emergency scene	• Integrate contamination control as part of member rehabilitation procedures • Start cleaning as soon as possible after coming out of the emergency scene – Perform appropriate techniques for gross decontamination (cold weather?) • Maintain protection until principal contamination is removed	Preliminary work at Illinois Fire Service Institute has shown better removal of some contaminants using on scene wet and dry decontamination methods	 Spraying of firefighter at scene removes exterior soils and contamination to limit later transfer Wet decon can be undertaken with simple supplies using water service from apparatus
Contaminated item handling	• Properly remove PPE to avoid contamination transfer • Isolate and bag contaminated PPE • Provide clean clothing for personnel at scene • Avoid transporting contaminated PPE in apparatus or personal vehicles • Apply proper cleaning to other contaminated items	Initial work has been performed to show transfer of contaminants to skin if proper doffing not done; Limited research shows evidence of contaminant transfer to vehicles	 Gear should be bagged and isolated after wet decon for separate transport out of personal areas of apparatus for later advanced cleaning

Category	Recommended Practices	Level of Validation	Relevant Image(s)
Cleaning and decontamination	• Clean all contaminated items – Other items: SCBA, boots, gloves, hoods, hose, tools should be also be cleaned • Subject contaminated items to proper cleaning – Pick effective process • Ensure that items can be safely returned to service	Limited research showing removal of contaminants from garments and hoods; No acceptable levels of residual contamination levels established; Review of cleaning for other items needed especially gloves and footwear needed	 Cleaning of turnout clothing in washer/extractor  Special machine for washing of helmets and self-contained breathing apparatus
Personal hygiene	• Change out of station wear and undergarments as soon as possible following exposure • Take a shower as soon as possible after exposure – Controversies over water temperature and advocating use of steam rooms or sauna • Practice frequent handwashing	No specific studies shown in fire service; however, recommended practices coincide with contamination control in industry and healthcare; No specific data related to shower temperature or use of post-response sauna	

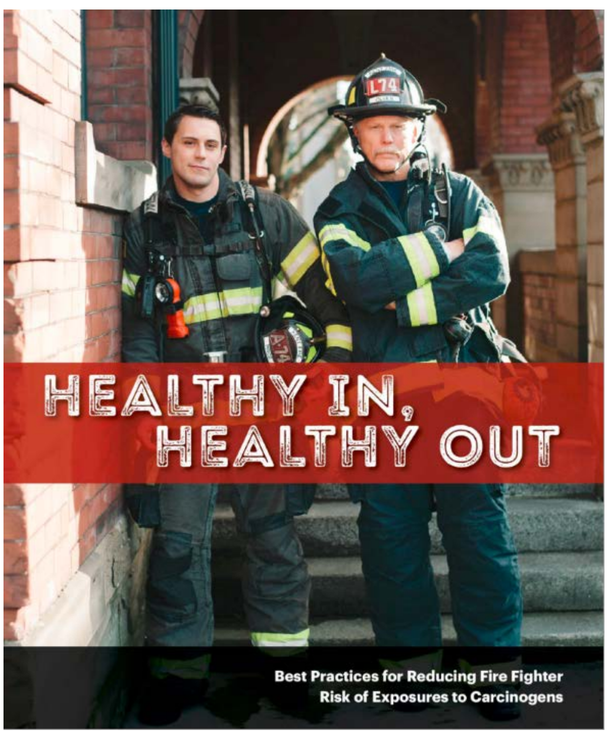
Category	Recommended Practices	Level of Validation	Relevant Image(s)
Wellness and health	• Get baseline physicals with appropriate benchmarking / diagnostic tests • Have follow up annual physicals or as needed • Eat healthy, hydrate frequently, maintain level of fitness • Undertake good lifestyle habits	Multiple studies outside fire service and limited studies within fire service showing benefits of wellness programs to overall health	

Documentation and recordkeeping	• Document all exposures with sufficient detail
	• Provide monitoring where possible
	  – Retain information and link to exposures
	• Maintain records for all personnel
	  – Apply in medical exams
		Provisions already exist for detailed documentation of fire service exposures;
		Specific standards in place for routine firefighter medical examination
			

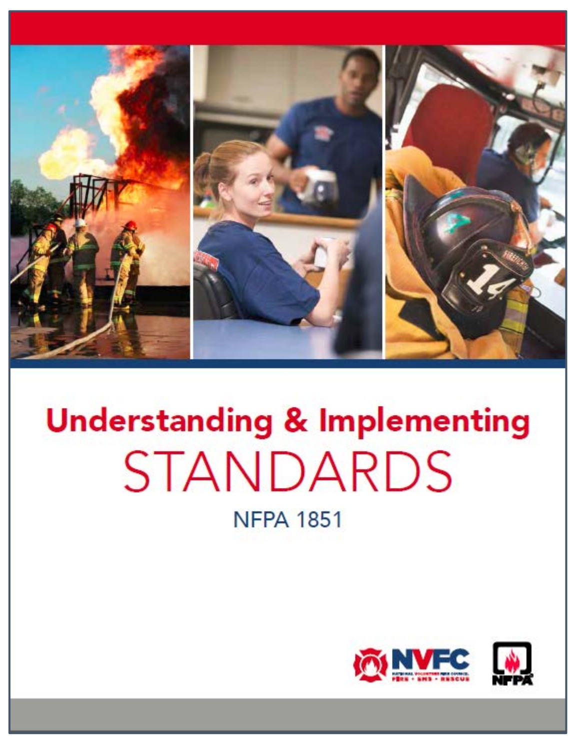
Category	Recommended Practices	Level of Validation	Relevant Image(s)
Apparatus design and cleaning	• Choose apparatus with storage compartments for contaminated items – Alternatively, use separate transport where possible • Apply appropriate cleaning and disinfection to apparatus following use in contamination event	Practices now applied for emergency medical services but not fire apparatus	
Fire station design and maintenance	• Control exposures at fire station – Apply segregation of clean versus contaminated areas – Use transition zones – Ensure separate areas for cleaning contaminated items – Provide for proper storage of PPE and other frequently contaminated items • Practice appropriate station hygiene procedures • Use diesel capture system	Limited requirements for fire stations other than infection control (NFPA 1981); Diesel exhaust systems used but no standard or criteria exist for judging effectiveness	 

Lastly, the cost of implementation should be considered as part of any proposed best practice since resource requirements may negate the potential for its implementation. On the subject, many workshop participants recommended that for certain types of contamination control objectives, there should be a range of low cost to more expensive, higher technology options for implementing a specific best practice. As an example, using a low pressure, low volume hose from the fire truck to perform gross decontamination of individuals in gear at the emergency scene as a minimum resource approach versus having a dedicated portable decontamination vehicle or trailer for representing a higher expense more sophisticated method of implementation.

The idea of having a best practices database was considered by the Project Team. In this approach, a summary of best practices would be covered in a comprehensive document covering the span of contamination control procedures. It was believed that an NFPA standards development-like process could be used for developing the best practices with the predominate participation by end user representatives. These practices that could then be separately referenced by different NFPA standards. As an alternative, it was also thought that a more efficient and effective way of addressing best practices would be simply to highlight those different breast practices from existing organizations that already promote specific procedures such as the Firefighter Cancer Support Network or other organizations. Figure 7 provides examples of best practice guides developed by two different organizations related to fire service contamination control.



Comprehensive guide on best practices developed by Washington State Council of Fire Fighters, with support from the State of Washington



Specific guide for promoting awareness and use of standard for care and maintenance of turnout clothing by National Volunteer Fire Council & NFPA

Figure 7 – Examples of Existing Organization Best Practice Guides

Incumbent in the development of best practices of the specific needs for addressing new products and services that are emerging to address various contamination control issues. Foremost among these are different products for cleaning gear or firefighter skin such as disposable wipes. As with any highlighted need within the fire service, there are multiple claims about efficacy yet these claims should be validated based on some form of standardized testing. Unfortunately, standards do not exist in all areas with one example being the efficacy of disposable wet wipes touted as providing an efficient way of cleaning firefighter skin following structural fires. The generation of specific efficacy criteria would fall to certain standards, some being perhaps outside the NFPA process. Thus, some best practices might be considered generic until more data is collected. The ability to prescribe what could seem a certain best practice would be limited by a general understanding of effectiveness rather than a certainty of applicability or efficacy for broad recommendation to the fire service.

As an additional approach, which looks to take advantage of other government resources, is the System Assessment and Validation for Emergency Responders (SAVER). This program could provide a basis for the independent evaluation of specific product types. SAVER provides a Consumer Products guide-like approach for assessing specific features and performance of different types of existing or new technologies. This program has been applied to several forms of first responder technologies where the assessments rely on a set of uniform evaluation procedures, quantified methods of rating products or approaches, and full disclosure of methodology and findings available on-line through the Department of Homeland Security website. The Project Team advocates that this resource be considered for aiding in the validation of best practice technologies where recognized procedures can be applied. A sample report is shown in Figure 8 where firefighter gloves and practices regarding their use were evaluated and surveyed.

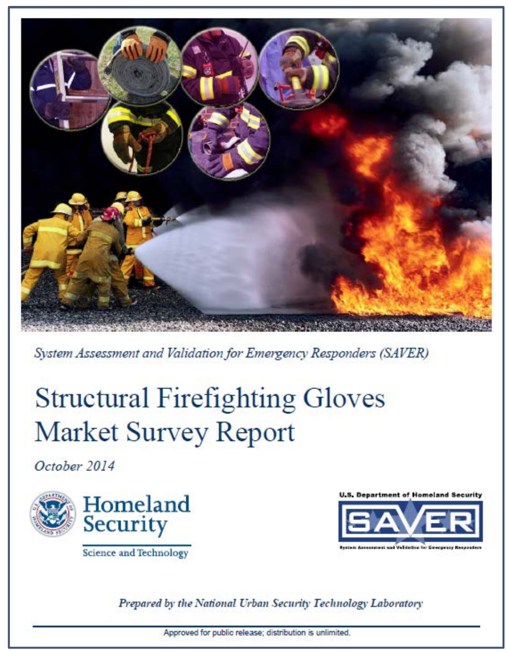


Figure 8 – Example SAVER Report

As another example of product/service qualification, it was noted that a separate DHS AFG research project being conducted by the Fire Protective Research Foundation has focused on the validation of cleaning processes for turnout gear. Experiments have been carried out using a kit-like approach for determining the effectiveness of different advanced cleaning procedures as illustrated in Figure 9.

Ultimately, best practices should be promoted to the fire service for addressing immediate concerns related to contamination control. As best practices are further defined, they can become part of existing voluntary standards to be used by the fire service. Yet, to properly address the specific key element within a contamination control campaign, it is necessary to create the awareness and tools for the fire service adoption of specific procedures, which can limit exposure to contamination.

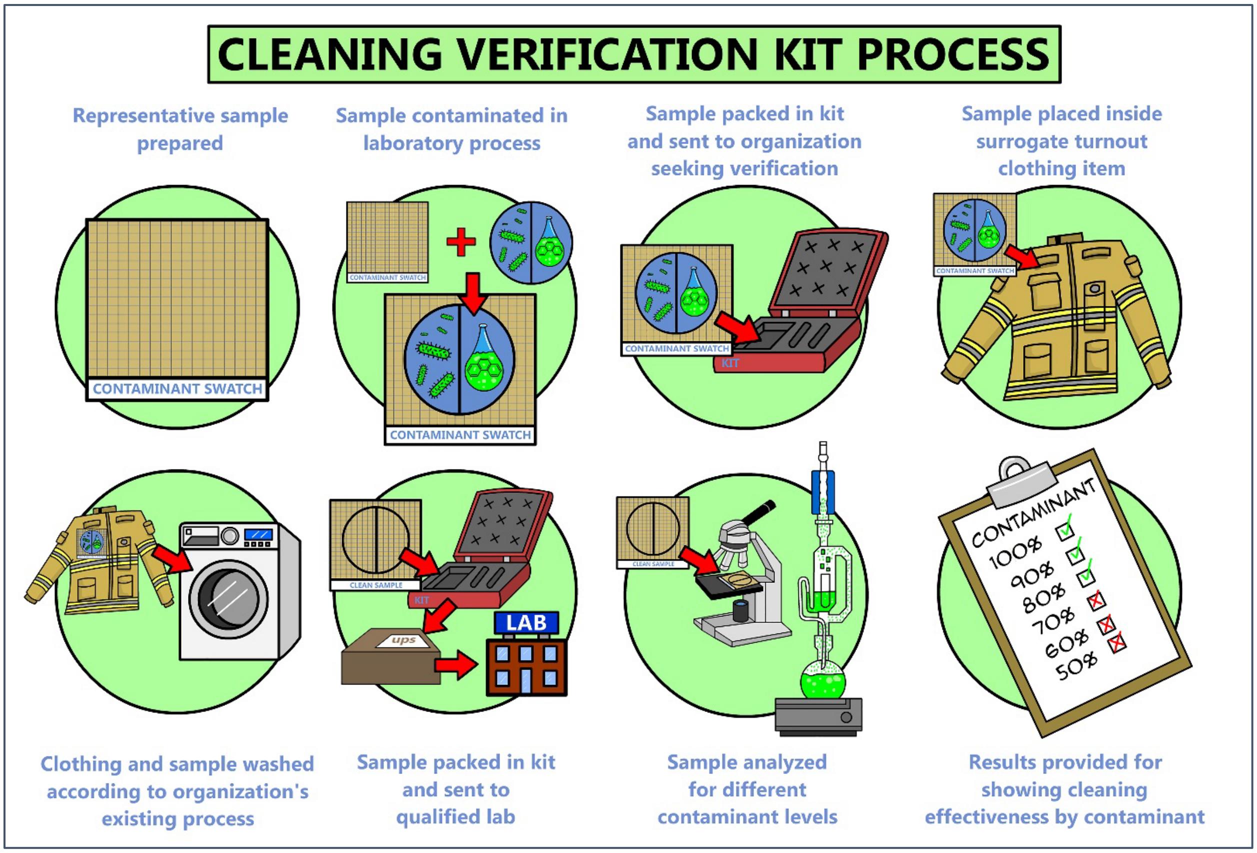


Figure 9 – Validation Approach Being Developed to Evaluating Turnout Gear Cleaning

Key Element 5 – Assessing the Utility of Other Information and Resources

A number of other types of information resources were considered as part of a proposed fire service contamination control campaign. While this element was intended to be mostly a "catchall" for areas not explicitly covered as part of the other elements, it was recommended to provide a number of tools and other resources that are interconnected with other parts of the overall baseline information.

As part of the content for this element, the following sub-elements were proposed:

- A list of different organizations and their relation to contamination control
- An evolving list of unmet research needs to support various contamination control efforts
- Descriptions of contamination control practices used in other related industries (3 examples will be given including HazMat, healthcare, and the nuclear power industry)
- A glossary
- A forum for online questions and answers (likely through a blog)
- Specific social media connections

As previously pointed out, there are several organizations that are already working in the area of contamination control. These include a variety of fire service trade groups, unions, and other independent organizations, A campaign for fire service contamination control must recognize the value of these organizations and create links from the central group (if promoted through a website) to these other organizations. Linkages to these organizations should be created with permission and include a short description of the resources that are available within each organization.

While not within the scope of this project, an additional area of information that can be helpful not just to the fire service but all to the larger industrial community that interfaces with the fire service is an evolving list of unmet research needs. This information becomes useful being associated with a contamination control campaign because it provides a location on a contamination-control site that does not become generalized with other topics. There are on-going efforts for identifying research needs by several organizations including the National Fallen Firefighters Foundation and the Interagency Board for First Responder Equipment Interoperability and Standardization. The lists produced by these groups are broad in scope and are not always directly communicated to the overall research community. Therefore, identifying specific research needs, especially those that arise from the examination of proposed best practices, provides a pathway for linking the current state-of-the-art with technology or service gaps to be developed or validated.

In the course of this project it was understood that other professions also have to deal with various forms of contamination and have evolved practices to control worker exposure. It was further recognized that the specific practices developed for these industries could have potential application as applied to the fire and emergency services. For these reasons, contamination control approaches were examined in three different industries:

- Healthcare
- Nuclear power generation
- Hazardous materials response

The specific analyses that were conducted are provided in Annex C. However, some key takeaways included the findings that are provided in Table 5.

Certainly, it is possible for the fire service to learn or to adapt potential best practices for contamination control from other industries, but a substantial part of this transformation has to include changes in the attitudes by firefighters towards controlling contamination. It has only been in the last generation of firefighters, that the culture of the fire service towards maintaining clean gear has evolved. Prior to this transition, a substantial portion of the fire service believed that dirty clothing was a “badge of honor” indicative of experience where the principal hazards were either thermal or physical in nature. The alarming rates of cancer have changed the culture, but some attitudes still persist based on traditional practices and procedures.

To overcome residual tradition or cultural obstacles, continuing efforts are needed to promote awareness and answer questions for ensuring that exposure to persistent contaminants are considered a serious hazard. Among the different tools that can be used for awareness. One suggested way of creating dialogue in this area is to run a “blog.” Another is the use of social media to push out information as it becomes available. Finally, unifying the fire service with a consistent terminology on this subject could be further achieved by assembling a glossary of key terms.

Table 5 – Overview of Contamination Control Practices from Related Industries

Industry	Principal Concern	Primary Strategy	Examples of Best Practices
Healthcare	To limit spread of infectious diseases	• Application of infection control program • Awareness emphasized • Apply sterile procedures • Isolation of infected patients • Extensive use of disinfectants and sanitizers • Infection control practitioners	• Extensive hand washing policy • Application of standard, universal precautions • Clear facility infection control practices • Environmental management procedures • Large degree of oversight by Center for Disease Control (CDC) and U.S. Food & Drug Administration (FDA) as well as World Health Organization (WHO)
Nuclear power generation	To provide full control of ionizing radiation	• ALARA (as low as reasonably achieving) • Hierarchy of exposure controls (engineering, administrative, and PPE) • Strict control of entry into hazard areas • Practicing health physicists	• Extensive use of engineering and administrative controls, site segregation • Limitation of exposure (time x proximity = dose) • Extensive monitoring of affected sites; us of dosimetry for individual exposures • Oversight by Nuclear Regulatory Commission
Hazardous materials response	To prevent exposure to and transfer of hazardous materials	• Classification of events by types of hazards presented • Methodological approach to response • Assumption that hazards exist during response	• Establishment of hazard control zones • Use of defined levels of PPE • Comprehensive training of all personnel in operational procedures to minimize exposure and limit contamination spread • Extensive size up of situation before response • Governed by applicable OSHA regulations

Overall Direction

Through this project, a detailed approach has been suggested for creating a long-term campaign for fire service contamination control. It was apparent at the beginning of the project that a single examination of this topic would be insufficient to create the needed features of a campaign to credibly inform and advance the fire and emergency services into the needed cultural, operational, and technological changes that are needed to appropriately address persistent contamination and its spread to individual firefighters, other emergency responders, their equipment, their facilities, and the public.

A campaign can only be achieved by a multifaceted, concerted effort aimed at reaching all levels of the fire emergency services, as well as related industries. The proposed elements in the campaign, based on recommendations provided in this report, are intended to set the framework for such an effort. Ideally, a central coordinating organization would champion the campaign and work closely with other organizations, which are also undertaking various endeavors towards contamination control. Further, there is the need for an adaptable platform, such as a website, which can be used to create the necessary linkages to the variety of different information and resources available in this area.

Ultimately, the fire service will be seeing a number of changes in how they pursue their responsibilities in the consideration of controlling contamination. These changes will be fostered by new attitudes and consideration of the hazards of contamination, modifications to operations for minimizing contamination transfer, and effects, and a range of new technologies and services that will affect stations, vehicles, and various types of equipment.

In order to implement the necessary actions for individual organizations or for industry groups to adopt specific approaches to affect contamination control, the Project Team has drafted a sample resolution provided in Annex D, which can be the basis for the organization's work group's commitment to addressing contamination control.

Contamination control is not a new concept for worker protection; however, in relation to certain types of contaminants, particularly products of combustion, serious changes are needed for fire and emergency services to overcome years of neglect and to aggressively reverse disturbing trends in the rise of cancer and other chronic diseases that are now being associated with exposure to persistent contaminants. A campaign is truly an effort that is needed to ensure that these changes continue well into the future.

ANNEX A

Sample Literature Survey Results for Fire and Emergency Services Contamination Issues

Table A-1: Sample Literature Survey Results For Fire And Emergency Services Contamination Issues (as of August 2017)

First Authors	2nd Authors	Title	Available Free?	Source	Citation	DOI #	Year	Type of Contamination	Target of Contamination	Key Words	Abstract	Other
Adetona, O.	Simpson, C. D., G. Onstad, and L. P. Naeher	Exposure of Wildland Firefighters to Carbon Monoxide, Fine Particles, and Levoglucosan	No	n/a	*Annals of Occupational Hygiene* 57.8 (2013): 979-991.	10.1093/annhyg/met024	2013	Chemical – CO, PM	personal	carbon monoxide, levoglucosan, particulate matter, prescribed burn, wildland firefighting		
Adetona, O.	Reinhardt, T. E., J. Domitrovich, G. Broyles, A. M. Adetona, M. T. Kleinman, R. D. Ottmar, and L. P. Naeher	Review of the Health Effects of Wildland Fire Smoke on Wildland Firefighters and the Public	No	n/a	*Inhalation Toxicology* 28.3 (2016): 95-139.	10.3109/08958378.2016.1145771	2016	Chemical – PM	personal	cardiovascular effects, respiratory effects, wildfire, wildland firefighter		
Adetona, O.	Simpson, C.D, Z. Li, A. Sjodin, A. M. Calafat, and L. P. Naeher	Hydroxylated Polycyclic Aromatic Hydrocarbons as Biomarkers of Exposure to Wood Smoke in Wildland Firefighters	No	n/a	*Journal of Exposure Science and Environmental Epidemiology* 27.1 (2017): 78-83.	10.1038/jes.2015.75	2017	Chemical – PAH	personal	wildland firefighting, PAHs, polycyclic aromatic hydrocarbons, biomarker		
Al-Malki, Abdulrahman L.	None	Serum Heavy Metals and Hemoglobin Related Compounds in Saudi Arabia Firefighters	Yes	https://occup-med.biomedcentral.com/articles/10.1186/1745-6673-4-18		10.1186/1745-6673-4-18	2009					
Alexander, Barbara M.	Baxter, C. Stuart	Plasticizer Contamination of Firefighter Personal Protective Clothing–A Potential Factor in Increased Health Risks in Firefighters	No	n/a	*Journal of Occupational and Environmental Hygiene* 11.5 (2014): D43-D48.	10.1080/15459624.2013.877142	2014	Chemical – DEHP, PAH	PPE – glove, hood, wristlet	DEHP, firefighters , exposures, phthalates, polycyclic aromatic hydrocarbons, PAH		
Alexander, Barbara M.	Brooks, A. A. and J. A. Srigley	Postexposure Management of Healthcare Personnel to Infectious Diseases	Yes	https://www.researchgate.net/profile/Mazen_Bader/publication/273066103_Postexposure_management_of_healthcare_personnel_to_infectious_diseases/links/55a4cd8508aef604aa03facb.pdf	Hospital Practice. 2015 Apr 3;43(2):107-27	10.1080/21548331.2015.1018091	2015					
Alexander, Barbara M.	Baxter, C. Stuart	Flame-retardant Contamination of Firefighter Personal Protective Clothing - A Potential Health Risk for Firefighters	No	n/a	*Journal of Occupational and Environmental Hygiene* 13.9 (2016): D148-D155.	10.1080/15459624.2016.1183016	2016	Chemical – PBDE	PPE – gloves, hood, wristlet	flame retardants, firefighters, PBDE		
Alrazeeni, Daifallah	Al Sufi, Mohammed S.	Nosocomial Infections in Ambulances and Effectiveness of Ambulance Fumigation Techniques in Saudi Arabia: Phase I Study	Yes	https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4362147/	*Saudi medical journal 35.11 (2014): 1354.*		2014					

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First Authors	2nd Authors	Title	Available Free?	Source	Citation	DOI #	Year	Type of Contamination	Target of Contamination	Key Words	Abstract	Other
Alves, Donald W.	Bissell, Richard A.	Bacterial Pathogens in Ambulances: Results of Unannounced Sample Collection	No	http://www.academia.edu/download/32906586/BactPathogensInAmbulances.pdf	Prehospital emergency care 12.2 (2008): 218-224.	10.1080/10903120801906721	2008					
Amlot, Richard	Larner, Joanne, Hazem Matar, and David R. Jones	Comparative Analysis of Showering Protocols for Mass-Casualty Decontamination	Yes	http://www.academia.edu/download/45835206/Comparative_analysis_of_showering_protoc20160521-20512-13oy3v2.pdf	Prehospital and disaster medicine 25.5 (2010): 435-439.	10.1017/S1049023X00008529	2010					
Amster, E. D.	Fertig, S. S., U. Baharal, S. Linn, M. S. Green, Z. Lencovsky,and R. S. Carel	Occupational Exposures and Symptoms among Firefighters and Police during the Carmel Forest Fire: the Carmel Cohort Study	Yes	https://www.ima.org.il/FilesUpload/IMAJ/0/65/32805.pdf	*Israel Medical Association Journal* 15.6 (2013): 288-92		2013	Chemical – smoke	personal	wildfire, firefighters, police, smoke exposure		
Anderson, B. M.	Rasch, M., K. Hochlin, F-H. Jensen, P. Wismar, and J .E. Fredriksen	Decontamination of Rooms, Medical Equipment and Ambulances Using an Aerosol of Hydrogen Peroxide Disinfectant	Yes	https://www.researchgate.net/profile/Bjorg_Andersen/publication/7433015_Decontamination_of_rooms_medical_equipment_and_ambulances_using_an_aerosol_of_hydrogen_peroxide_disinfectant/links/5547ed8e0cf2e2031b384bfc/Decontamination-of-rooms-medical-equipment-and-ambulances-using-an-aerosol-of-hydrogen-peroxide-disinfectant.pdf	Journal of Hospital Infection 62.2 (2006): 149-155.	10.1016/j.jhin.2005.07.020	2006					
Anthony, T. Renée	Joggerst, Philip, Leonard James, Jefferey L. Burgess, Stephen S. Leonard, and Elizabeth S. Shogren	Method Development Study for APR Cartridge Evaluation in Fire Overhaul Exposures	Yes	https://academic.oup.com/annweh/article/51/8/703/204803/Method-Development-Study-for-APR-Cartridge#2119700	*Annals of Occupational Hygiene* 51.8 (2007): 703-716.	10.1093/annhyg/mem048	2007	Chemical – PAH, PM, smoke	PPE – SCBA	firefighter, respiratory protection, irritants, hydrocarbons, smoke		
Aufderheide, Tom P.	White, Susie M., William J. Brady, Harlan A. Stueven	Inhalational and Percutaneous Methanol Toxicity in Two Firefighters	No	n/a	*Annals of Emergency Medicine* 22.12 (1993): 1916-1918.	10.1016/S0196-0644(05)80423-8	1993	Chemical – MeOH	personal	firefighter, methanol		
Austin, Claire	None	Municipal Firefighter Exposures to Toxic Gases and Vapours	Yes	http://www.nlc-bnc.ca/obj/s4/f2/dsk2/ftp02/NQ36954.pdf	Dissertation, McGill University, 1997.		1997	Chemical, VOC, diesel, CO	PPE – SCBA; Fire Station	carbon monoxide, VOCs, diesel, benzene, fire station, structural firefighting	This thesis assessed firefighter exposures to diesel emissions in firehalls (CO), to chemicals via contaminated self-contained breathing apparatus (SCBAs) and VOCS at fires.	

Table A-1: Sample Literature Survey Results For Fire And Emergency Services Contamination Issues (as of August 2017)

First Authors	2nd Authors	Title	Available Free?	Source	Citation	DOI #	Year	Type of Contamination	Target of Contamination	Key Words	Abstract	Other
Austin, Claire C.	Ecobichon, D. J., et al.	Carbon Monoxide and Water Vapor Contamination of Compressed Breathing Air for Firefighters and Divers	Yes	https://www.researchgate.net/profile/Claire_Austin2/publication/13840600_Carbon_monoxide_and_water_vapor_contamination_of_compressed_breathing_air_for_firefighters_and_divers/links/544d4ccf0cf2d6347f45c55a.pdf	*Journal of Toxicology and Environmental Health* 52.5 (1997): 403-423.		1997	Chemical – CO, PM	PPE – SCBA	CO, carbon monoxide, carboxyhemoglobin, compressed air contamination, SCBA, SCUBA	Elevated levels of carbon monoxide (CO) and water vapor in compressed breathing air are consistent with carboxyhemoglobin (COHb) poisoning and freezing of the user's regulator on the breathing apparatus. At maximum exercise, the COHb ranged from 6.0 to 17% with the use of 1 to 4 SCBA cylinders contaminated by 250 ppm CO.	
Austin, Claire C.	Wang, D., D. J. Ecobichon, and G. Dussault	Characterization of Volatile Organic Compounds in Smoke at Municipal Structural Fires.	Yes	https://www.researchgate.net/profile/Claire_Austin2/publication/11859896_Characterization_of_volatile_organic_compounds_in_smoke_at_municipal_structural_fires/links/544d47ad0cf2bcc9b1d8e955.pdf	*Journal of Toxicology and Environmental Health Part A* 63.6 (2001): 437-458.	10.1080/15287390130034 3470	2001	Chemical – VOC	personal	structural firefighting, VOC, volatile organic compounds, benzene, products of combustion, biomarker		
Austin, Claire C.	Wang, D., D. J. Ecobichon, and G. Dussault	Characterization of Volatile Organic Compounds in Smoke at Experimental Fires	Yes	http://s3.amazonaws.com/academia.edu.documents/35484254/Austin_CC_2011_Characterization_of_VOCs_in_smoke_at_experimental_fires.pdf?AWSAccessKeyId=AKIAIWOWYYGZ2Y53UL3A&Expires=1498769356&Signature=j4U0XSrgGTAWJWRaoLf3luLnpJA%3D&response-content-disposition=inline%3B%20filename%3DCharacterization_of_volatile_organic_com.pdf	*Journal of Toxicology and Environmental Health Part A* 63.3 (2001): 191-206.	10.1080/15287390151101 547	2001	Chemical – VOC	personal	structural firefighting, experimental fire, VOC, volatile organic compounds, benzene, products of combustion		
Averhoff, Francisco M.	Moyer, Linda A., Bradley A. Woodruff, Adeline M. Deladisma, Joni Nunnery, Miriam J. Alter, and Harold S. Margolis	Occupational Exposure and Risk of Hepatitis B Virus Infection among Public Safety Workers	No	n/a	Journal of occupational and environmental medicine 44.6 (2002): 591-596.		2002					

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Bacidore, Jeffrey	None	Considering Health and Safety in Fire Station Design	Yes	http://www.firehouse.com/article/12319662/considering-health-and-safety-in-fire-station-design-firefighter-news	Firehouse,		2017					
Baird, Colleen P.	DeBakey, Samar, Lawrence Reid, Veronique D. Hauschild, Bruno Petruccelli, and Joseph H. Abraham	Respiratory Health Status of US Army Personnel Potentially Exposed to Smoke from 2003 Al-Mishraq Sulfur Plant Fire	No	n/a	Journal of Occupational and Environmental Medicine 54.6 (2012): 717-723.	10.1097/JOM.0b013e3182572e37	2012					
Baker, David	None	Improving Decontamination procedures: a Priority for Chemical Incident Management	No	n/a	Prehospital and disaster medicine 25.5 (2010): 440-441.	10.1017/S1049023X00008530	2010					
Baldwin, T. N.	Hales, T. R. and M. T. Niemeier	Controlling Diesel Exhaust Exposure Inside Firehouses	Yes	http://www.fireengineering.com/articles/print/volume-164/issue-2/features/controlling-diesel-exhaust-exposure-inside-firehouses.html	Fire Engineering 2011; 164(2):		2011					
Baxter, C. Stuart	Ross, Clara Sue, Thomas Fabian, Jacob L. Borgerson, Jamila Shawon, Pravinray D. Gandhi, James M. Dalton, and James E. Lockey	Ultrafine Particle Exposure during Fire Suppression--Is It an Important Contributory Factor for Coronary Heart Disease in Firefighters?	yes	http://media.cygnus.com/files/base/FHC/document/2010/09/firefightersandheartdisease_10466452.pdf	Journal of occupational and environmental medicine 52.8 (2010): 791-796.	10.1097/JOM.0b013e3181ed2c6e	2010					
Baxter, C. Stuart	Hoffman, Joseph D., et al.	Exposure of Firefighters to Particulates and Polycyclic Aromatic Hydrocarbons	Yes	https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4653736/	Journal of occupational and environmental hygiene 11.7 (2014): D85-D91.	10.1080/15459624.2014.890286	2014					
Bay, Austin	None	Fire Truck Exhaust Removal: What to Know Before You Buy	yes	https://www.firerescue1.com/station-design/articles/152210018-Fire-truck-exhaust-removal-What-to-know-before-you-buy/	FireRescue1. Fire Rescue1/Fire Chief, 14 Dec. 2016. Web. 05 Aug. 2017.		2016					
Beaumont, J. J.	Chu, G.S., J. R. Jones, M. B. Schenker, J. A. Singleton, L. G. Piantanida, and M. Reiterman	An Epidemiologic Study of Cancer and Other Causes of Mortality in San Francisco Firefighters	No	n/a	Am J Ind Med. 1991;19(3):357-72		1991					
Bell, T.	Smoot, J., J. Patterson, R. Smalligan, and R. Jordan	Ebola Virus Disease: The Use of Flourescents as Markers of Contamination	Yes	http://www.sciencedirect.com/science/article/pii/S2214250914000468	IDCases. 2015 Dec 31;2(1):27-30	10.1016/j.idcr.2014.12.003	2015					

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		for Personal Protective Equipment										
Berendt, Andrea E.	Turnbull, LeeAnn, Donald Spady, Robert Rennie, and Sarah E Forgiand	Three Swipes and You're Out: How Many Swipes Are Needed to Decontaminate Plastic with Disposable Wipes?	No	n/a	American journal of infection control 39.5 (2011): 442-443.	10.1016/j.ajic.2010.08.014	2011					
Berger, Peter S.	Moulin, Gregory	Cancer in the Fire Service - A Public Policy Risk Analysis	Yes	https://content.govdelivery.com/attachments/USDHSFACIR/2016/05/19/file_attachments/553656/ifsta_spring_2016_cancer_in_the_fire_service_jxJubGL.pdf#page=3	EXECUTIVE DIRECTOR'S RAMBLINGS (2016). (Fire Protection Publications, OK State University, Spring 2016, p 3-4.)		2016				Cancer is overtaking heart attack as the primary cause of firefighter death. Common carcinogens and modes of exposure (inhalation, dermal, and ingestion) as well as action plans for reducing exposures are discussed.	
Bielawska-Drózd, A.	Cieślik, P., B. Wlizło-Skowronek, I. Winnicka, L. Kubiak, J. Jaroszuk-Ściseł, D. Depczyńska, J. Bohacz, T. Korniłłowicz-Kowalska, E. Skopińska-Różewska, and J. Kocik	Identification and Characteristics of Biological Agents in Work Environment of Medical Emergency Services in Selected Ambulances	Yes	https://pdfs.semanticscholar.org/d193/84ff26d7440f404b934d219b8ef26ba357d2.pdf	International Journal of Occupational Medicine and Environmental Health 30.4 (2017): 617-627.	10.13075/ijomeh.1896.00816	2017					
Birch M. E.	Cary, R. A.	Elemental Carbon-Based Method for Monitoring Occupational Exposures to Particulate Diesel Exhaust	Yes	http://www.tandfonline.com/doi/pdf/10.1080/02786829608965393	Aerosol Science and Technology. 1996 Jan 1;25(3):221-41	10.1080/02786829608965393	1996					
Birch, M. E.	None	Analysis of Carbonaceous Aerosols: Interlaboratory Comparison	Yes	http://lib3.dss.go.th/fulltext/Journal/analyst/Analyst1998/no.5/1998v123n5p851-857.pdf	Analyst. 1998;123(5):851-7		1998					
Boal, Winifred L.	Hales, Thomas and Clara Sue Ross	Bloodborne Pathogens among Firefighters and Emergency Medical Technicians	No	n/a	Prehospital Emergency Care 9.2 (2005): 236-247.	10.1080/10903120590924915	2005					
Bolstad-Johnson, D. M.	Burgess, J. L., C. D. Crutchfield, S. Storment, R. Gerkin, and J. R. Wilson	Characterization of Firefighter Exposures during Fire Overhaul	No	n/a	AIHAJ. 2000 Sep-Oct;61(5):636-41		2000					

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Braue Jr, Ernest H.	Smith, Kelly H., Bryce F. Doxzon, Horace L. Lumpkin, and Edward D. Clarkson	Efficacy Studies of Reactive Skin Decontamination Lotion, M291 Skin Decontamination Kit, 0.5% Bleach, 1% Soapy Water, and Skin Exposure Reduction Paste against Chemical Warfare Agents, Part 2: Guinea Pigs Challenged with Soman	No	n/a	Cutaneous and ocular toxicology 30.1 (2011): 29-37.	10.3109/15569527.2010.515281	2011					
Brown, F.R.	Whitehead, T. P., J. S. Park, C. Metayer, and M. X. Petreas	Levels of Non-Polybrominated Diphenyl Ether Brominated Flame Retardants in Residential House Dust Samples and Fire Station Dust Samples in California	Yes	https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4262617/	Environmental research. 2014 Nov 30;135:9-14	10.1016/j.envres.2014.08.022	2014					
Brown, Robert	Minnon, Julianne, Stephanie Schneider, and James Vaughn	Prevalence of Methicillin-Resistant *Staphococcus aureus* in Ambulances in Southern Maine	No	n/a	*Prehospital emergency care 14.2 (2010): 176-181.*	10.3109/10903120903564480	2010					
Burgess, J. L.	Nanson, C. J., D. M. Bolstad-Johnson, R. Gerkin, T. A. Hysong, R. C. Lantz,, D. L. Sherrill, C. D. Crutchfield,, S. F. Quan, A. M. Bernard, and M. L. Witten	Adverse Respiratory Effects Following Overhaul in Firefighters	No	n/a	J Occup Environ Med. 2001 May;43(5):467-73		2001					
Cantrell, Bruce K.	Watts, Winthrop F.	Diesel Exhaust Aerosol: Review of Occupational Exposure	No	n/a	Applied occupational and environmental hygiene 12.12 (1997): 1019-1027.	10.1080/1047322X.1997.10390643	2011					
Capleton, A. C.	Levy, L. S.	An Overview of Occupational Benzene Exposures and Occupational Exposure Limits in Europe and North America	No	n/a	Chem Biol Interact. 2005 May 30;153-154:43-53		2005					
Carballo, Leyenda B.	Rodríguez-Marroyo, J.A., J. López-Satué, C. Avila Ordás, R. Pernía Cubillo, and J. G. Villa Vicente	[Exposure to Carbon Monoxide in Wildland Firefighters during Wildfires Suppression]	No	n/a	Rev Esp Salud Publica. 2010 Nov-Dec;84(6):799-807		2010					Spanish
Carvalho, Ferdando P.	Oliveira, João M. and Margarida Malta	Exposure to Radionuclides in Smoke from Vegetation Fires	No	n/a	Science of the Total Environment 472 (2014): 421-424.	10.1016/j.scitotenv.2013.11.073	2014					

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Caux, C.	O'Brien, C. and C. Viau	Determination of Firefighter Exposure to Polycyclic Aromatic Hydrocarbons and Benzene during Fire Fighting Using Measurement of Biological Indicators	No	n/a	Appl Occup Environ Hyg. 2002 May;17(5):379-86		2002					
Centers for Disease Control and Prevention	None	Pseudo-Outbreak of Antimony Toxicity in Firefighters - Florida, 2009	No	n/a	MMWR: Morbidity and mortality weekly report 58.46 (2009): 1300-1302.		2009					
Centers for Disease Control and Prevention (CDC)	None	Injuries and Illnesses among New York City Fire Department Rescue Workers After Responding to the World Trade Center Attacks	No	n/a	MMWR Morb Mortal Wkly Rep. 2002 Sep 11;51 Spec No:1-5		2002					
Centers for Disease Control and Prevention (CDC)	None	Pseudo-Outbreak of Antimony Toxicity in Firefighters – Florida, 2009	No	n/a	MMWR Morb Mortal Wkly Rep. 2009 Nov 27;58(46):1300-2		2009					
Centers for Disease Control and Prevention (CDC)	None	Outbreak of Cryptosporidiosis Associated with a Firefighting Response-Indiana and Michigan, June 2011	Yes	https://www.cdc.gov/mmwr/preview/mmwrhtml/mm6109a2.htm	MMWR. Morb Mort Wkly report. 2012 Mar 9;61(9):153-6.		2012					
Chernyak, Yury I.	Shelepchikov, Andrey A., Efim S. Brodsky, and Jean A. Grassman	PCDD, PCDF, and PCB Exposure in Current and Former Firefighters from Eastern Siberia	Yes	https://www.researchgate.net/profile/Andrey_Shelepchikov/publication/51699161_PCDD_PCDF_and_PCB_exposure_in_current_and_former_firefighters_from_Eastern_Siberia/links/02e7e51d077e190c61000000.pdf	Toxicology letters 213.1 (2012): 9-14.	10.1016/j.toxlet.2011.09.021	2012					
Chilcott, Robert P	None	An Overview of the Health Protection Agency's Research and Development Programme on Decontamination.	Yes	http://www.npis.org/PHE/15_HPA_CHaPR_Sept_2009_small.pdf#page=26	Chemical hazards and poisons report 15 (2009): 26-28.		2009					
Chilcott, Robert P	None	Managing Mass Casualities and Decontamination	No	n/a	Environment international 72 (2014): 37-45.	10.1016/j.envint.2014.02.006	2014					

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Chilcott, Robert P.	None	CBRN Contamination	No	n/a	Textbook of Environmental Medicine. London: Hodder Arnold (2010): 475-486.		2010					
Cinnamon, M. L.	None	Post Use Analysis of Firefighter Turnout Gear-Phase III	Yes	http://uknowledge.uky.edu/cgi/viewcontent.cgi?article=1004&context=mat_etds	Master's thesis, Univ of Kentucky, Theses and Dissertations--Retailing and Tourism Management. 4.		2013					
Cone, David C.	MacMillan, Dan, Vivek Parwani, and Carin Van Gelder	Threats to Life in Residential Structure Fires	No	n/a	*Prehospital Emergency Care 12.3 (2008): 297-301.*	10.1080/10903120802104029	2008					
Cooper, Moogega	Fridman, Gregory, David Staack, Alexander F. Gutsol, Victor N. Vasilets, Shivanthi Anandan, Young I. Cho, Alexander Fridman, and Alexandre Tsapin	Decontamination of Surfaces from Extremophile Organisms Using Nonthermal Atmospheric-Pressure Plasmas	Yes	https://www.researchgate.net/profile/Alexander_Gutsol/publication/224374551_Decontamination_of_Surfaces_From_Extremophile_Organisms_Using_Nonthermal_Atmospheric-Pressure_Plasmas/links/00b4951c6273ff0846000000.pdf	IEEE transactions on plasma science 37.6 (2009): 866-871.	10.1109/TPS.2008.2010618	2009					
Cordner, A.	Brown, P.	Moments of Uncertainty: Ethical Considerations and Emerging Contaminants	No	n/a	Sociol Forum (Randolph N J). 2013 Sep;28(3)	10.1111/socf.12034	2013					
Currie, J.	Caseman, D. and T. R. Anthony	The Evaluation of CBRN Canisters for Use by Firefighters During Overhaul	Yes	https://academic.oup.com/annweh/article/53/5/523/206847	Ann Occup Hyg. 2009 Jul;53(5):523-38	10.1093/annhyg/mep025	2009					
Daniels, R. D.	Bertke, S., M. M. Dahm, J. H. Yiin, T. L. Kubale, T. R. Hales, D. Baris, S. H. Zahm, J. J. Beaumont, K. M. Waters, and L. E. Pinkerton	Exposure-Response Relationships for Select Cancer and Non-Cancer Health Outcomes in a Cohort of U.S. Firefighters from San Francisco, Chicago and Philadelphia (1950-2009)	No	n/a	Occup Environ Med. 2015 Oct;72(10):699-706	10.1136/oemed-2014-102671	2015					
Datta, S. Deblina	Armstrong, Gregory, L., Aaron J Roome, and Miriam J Alter	Blood Exposures and Hepatitis C Virus Infections among Emergency Responders	Yes	http://jamanetwork.com/journals/jamainternalmedicine/fullarticle/216388	Archives of internal medicine 163.21 (2003): 2605-2610.	10.1001/archinte.163.21.2605	2003					
de Perio, Marie A.	Durgam, Srinivas, Kathleen L. Caldwell, and Judith Eisenberg	A Health Hazard Evaluation of Antimony Exposure in Fire Fighters	No	n/a	Journal of occupational and environmental medicine 52.1 (2010): 81-84.	10.1097/JOM.0b013e3181c7514a	2010					

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Dia, A.	Verret, C., V. Pommier de Santi, M. Tanti, C. Decam, R. Migliani, X. Deparis	Blood and Body Fluid Exposures in the French Military	No	n/a	Occup Med (Lond). 2012 Mar;62(2):141-4	10.1093/occmed/kqr179	2012					
Diab-Elschahawi, Magda	Assadian, Ojan, Alexander Blacky, Maria Stadler, Elisabeth Pernicka, Jutta Berger, Helene Resch, and Walter Koller.	Evaluation of the Decontamination Efficacy of New and Reprocessed Microfiber Cleaning Cloth Compared with other Commonly Used Cleaning Cloths in the Hospital	No	n/a	*American journal of infection control 38.4 (2010): 289-292.*	10.1016/j.ajic.2009.09.006	2010					
Dick, T.	None	Not on Your Watch: Just Try a little Windex	No	n/a	JEMS. 37.4 (2012): 24		2012					
Dietrich, James	Yermakov, Michael, Tiina Reponen, Pramod Kulkarni, Chaolong Qi, and Sergey A. Grinshpun	Protection of Firefighters against Combustion Aerosol Particles: Simulated Workplace Protection Factor of a Half-Mask Respirator (Pilot Study)	yes	https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4610121/	Journal of occupational and environmental hygiene 12.6 (2015): 415-420.	10.1080/15459624.2015.1006637	2015					
Domingues-Ferreira, Maurício	Saddi-Rosa, Pedro and André Luis dos Santos	May Ingestion of Leachate from Decomposed Corpses Cause Appendicitis? A Case Report	yes	http://downloads.hindawi.com/journals/crim/2011/467137.pdf	Case reports in medicine 2011 (2011)	10.1155/2011/467137	2011					
Dost, F. N.	None	Acute Toxicology of Components of Vegetation Smoke	No	n/a	Rev Environ Contam Toxicol. 1991;119:1-46		1991					
Driscoll, T. R.	Carey, R. N., S. Peters, D. C. Glass, G. Benke, A. Reid, and L. Fritschi	The Australian Work Exposures Study: Prevalence of Occupational Exposure to Formaldehyde	No	n/a	Ann Occup Hyg. 2016 Jan;60(1):132-8	10.1093/annhyg/mev058	2016					
Dufay, Sarah K.	Archuleta, Melecita	Comparison of Collection Efficiencies of Sampling Methods for Removable Beryllium Surface Contamination	Yes	http://pubs.rsc.org/-/content/articlehtml/2006/em/b601526n	Journal of Environmental Monitoring 8.6 (2006): 630-633.		2006					
Dunn, K. H.	Devaux, I., A. Stock, and L. P. Naeher	Application of End-exhaled Breath Monitoring to Assess Carbon Monoxide Exposures of Wildland Firefighters at Prescribed Burns	No	n/a	Inhal Toxicol. 2009 Jan;21(1):55-61	10.1080/08958370802207300	2009					
Dunn, K. H.	Shulman, S., A. L. Stock, and L. P. Naeher	Personal Carbon Monoxide Exposures among Firefighters at Prescribed Forest Burns in the Southeastern United States.	No	n/a	Arch Environ Occup Hea	10.1080/19338244.2011.633126	2013					
Easter, Elizabeth	Lander, Deborah and Tabitha Huston	Risk Assessment of Soils Identified on Firefighter Turnout Gear	No	n/a	Journal of occupational and environmental hygiene 13.9 (2016): 647-657.	10.1080/15459624.2016.1165823	2016			Contaminants, fire fighter, risk assessment, turnout gear, soil		

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Edelman, P.	Osterloh, J., J. Pirkle, S. P. Caudill, J. Grainger, R. Jones, B. Blount, A. Calafat, W. Turner, D. Feldman, S. Baron, B. Bernard, B. D. Lushniak, K. Kelly, and D, Prezant	Biomonitoring of Chemical Exposure among New York City Firefighters Responding to the World Trade Center Fire and Collapse	Yes	http://web.a.ebscohost.com/ehost/viewarticle/render?data=dGJyMPPp44rp2%2fdV0%2bnjisfk5Ie46bVNt6u1TLSk63nn5Kx95uXxjL6urU2tqK5JtZawUrCuuEi3ls5lpOrweezp33vy3%2b2G59q7RbGrr0m0rq5KpOLfhuWz44ak2uBV4ePjfOuc8nnls79mpNfsVa%2bqtEyyrLRNpNztiuvX8lXu2uRe8%2bLqbOPu8gAA&vid=7&sid=4238fcac-bae5-4506-a306-9eb55de01211@sessionmgr4008	Environ Health Perspect. 2003 Dec;111(16):1906-11		2003					
Edwards, R.	Johnson, M., K. H, Dunn, and L. P. Naeher	Application of Real-time Particle Sensors to Help Mitigate Exposures of Wildland Firefighters	No	n/a	Arch Environ Occup Health. 2005 Jan-Feb;60(1):40-3		2005					
Eibicht, S. J.	Vogel, U.	Meticillin-Resistant *Staphylococcus aureus* (MRSA) Contamination of Ambulance Cars after Short Term Transport of MRSA-Colonised Patients Is Restricted to the Stretcher			Journal of Hospital infection 78.3 (2011): 221-225.		2011					
Eskierka, J. A.	None	Developing a Policy for Decontamination of Firefighter Personal Protective Equipment in the Saint Paul Fire Department.	No	n/a	Capstone paper, The College of St. Scholastica, ProQuest Dissertations Publishing, 2014. 1570367		2014					
Evans, D. E.	Fent, K. W.	Ultrafine and Respirable Particle Exposure during Vehicle Fire Suppression	No	n/a	Environ Sci Process Impacts. 2015 Oct;17(10):1749-59	10.1039/c5em00233h	2015					
Fabian, Thomas Z.	Borgerson, Jacob L., et al.	Firefighter Exposure to Smoke Particulates	Yes	https://pdfs.semanticscholar.org/157e/6dc272dba2e5fcc4e77212fca302ab96e28f.pdf	(Underwriters Laboratories)		2010				Gases and particulates were analyzed from the combustion in three scales of fires: residential structure and automobile fires; simulated real-scale fire tests; material based small-scale fire tests.	

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Fabian, Thomas Z.	Borgerson, Jacob L. Pravinray D. Gandhi, C. Stuart Baxter, Clara Sue Ross, James E. Lockey, and James M. Dalton.	Characterization of Firefighter Smoke Exposure	No	n/a	Fire Technology 50.4 (2014): 993-1019.	10.1007/ s10694-011-0212-2	2014		exposure assessment	Firefighter, overhaul, products of combustion, gases, smoke, smoke particulate, inhalation, size distribution, polycyclic aromatic hydrocarbons, PAHs, metals, respiratory protection	Exposures were monitored during knockdown and overhaul and search rescue operations with direct-reading gas monitors and personal cascade impactors.	
Fent, K. W.	Eisenberg, J., J. Snawder, D. Sammons, J. D. Pleil, M. A. Stiegel, C. Mueller, G. P. Horn, and J. Dalton	Systemic Exposure to PAHs and Benzene in Firefighters Suppressing Controlled Structure Fires	Yes	https://academic.oup.com/annweh/article/58/7/830/157036	Ann Occup Hyg. 2014 Aug;58(7):830-45	10.1093/ annhyg/ meu036	2014					
Fent, K. W.	Evans, D. E.	Assessing the Risk to Firefighters from Chemical Vapors and Gases during Vehicle Fire Suppression.	No	n/a	J Environ Monit. 2011 Mar;13(3):536-43	10.1039/ c0em00591f	2011					
Fent, K. W.	Evans, D. E., D. Booher, J. D Pleil, M. A. Stiegel, G. P. Horn, and J. Dalton	Volatile Organic Compounds Off-gassing from Firefighters' Personal Protective Equipment Ensembles after Use	No	n/a	J Occup Environ Hyg. 2015;12(6):404-14	10.1080/ 15459624.2015.1025135	2015					
Fent, Kenneth W.	Alexander, Barbara, Jennifer Roberts, Shirley Robertson, Christine Toennis, Deborah Sammons, Stephen Bertke, Steve Kerber, Denise Smith, and Gavin Horn	Contamination of Firefighter Personal Protective Equipment and Skin and the Effectiveness of Decontamination Procedures	No	n/a	Journal of occupational and environmental hygiene just-accepted (2017): 00-00.	10.1080/ 15459624.2017.1334904	2017					
Fent. K. W.	Eisenberg, C.J., D. Evans, D. Sammons, S. Robertson, C. Striley, J. Snawder, C. Mueller, V. Kochenderfer, J. Pleil, and M. Stiegel	Evaluation of Dermal Exposure to Polycyclic Aromatic Hydrocarbons in Fire Fighters	Yes	https://interagencyboard.org/system/files/resources/Eval%20of%20Dermal%20Exposure%20to%20Polycyclic%20Aromatic%20Hydrocarbons%20in%20FFs.pdf	Health Hazard Evaluation Report. 2013 Dec(2010-0156):3196		2013					

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Fernando, S.	Shaw, L., D. Shaw, M. Gallea, L. VandenEnden, R. House, D. K. Verma, P. Britz-McKibbin, and B. E. McCarry	Evaluation of Firefighter Exposure to Wood Smoke during Training Exercises at Burn Houses	No	n/a	Environmental science & technology. 2016 Jan 20;50(3):1536-43	10.1021/acs.est.5b04752	2016					
Fertmann, Regina	Tesseraux, Irene, Michael Schümann, and Hermann Neus	Evaluation of Ambient Air Concentrations of Polycyclic Aromatic Hydrocarbons in Germany from 1990 to 1998	No	n/a	Journal of Exposure Science and Environmental Epidemiology 12.2 (2002): 115.		2002					
Fitzgerald, E. F.	Standfast, S. J., L. G. Youngblood, J. M. Melius, and D. T. Janerich	Assessing the Health Effects of Potential Exposure to PCBs, Dioxins, and Furans from Electrical Transformer Fires: the Binghamton State Office Building Medical Surveillance Program	No	n/a	Arch Environ Health. 1986 Nov-Dec;41(6):368-76		1986					
Fitzgerald, E. F.	Weinstein, A. L., L. G. Youngblood, S. J. Standfast, and J. M. Melius	Health Effects Three Years after Potential Exposure to the Toxic Contaminants of an Electrical Transformer Fire	No	n/a	Arch Environ Health. 1989 Jul-Aug;44(4):214-21		1989					
Forrester, Mathias B.	None	Firefighter Exposures to Potentially Hazardous Substances Reported to Texas Poison Centers	yes	http://journals.lww.com/joem/Citation/2016/12000/Firefighter_Exposures_to_Potentially_Hazardous.23.aspx	Journal of occupational and environmental medicine 58.12 (2016): e375.	10.1097/JOM.0000000000000896	2016					
Froines, J. R.	Hinds, W.C., R. M. Duffy, E. J. Lafuente, and W. C. Liu	Exposure of Firefighters to Diesel Emissions in Fire Stations	No	n/a	The American Industrial Hygiene Association Journal. 1987 Mar 1;48(3):202-7	10.1080/15298668791384634	1987					
Gagas, D. F.	None	Characterization of Contaminants on Firefighter"s[sic] Protective Equipment A Firefighter's Potential Exposure to Heavy Metals During a Structure Fire	Yes	http://encompass.eku.edu/etd/261?utm_source=encompass.eku.edu%2Fetd%2F261&utm_medium=PDF&utm_campaign=PDFCoverPages	Master's thesis, Eastern Kentucky Univ, Online theses and dissertations, 261		2015					
Garza, M.	None	MRSA-Contaminated Ambulance	No	n/a	JEMS: a journal of emergency medical services 32.11 (2007): 20.		2007					

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Gaughan, D. M.	Piacitelli, C. A , B. T. Chen, B, F. Law, M. A. Virji, N. T. Edwards, P. L. Enright, D. E. Schwegler-Berry, S. S. Leonard, G. R. Wagner, L. Kobzik, S. N. Kales, M. D. Hughes, D. C. Christiani, P. D. Siegel, J. M. Cox-Ganser, and M. D. Hoover	Exposures and Cross-Shift Lung Function Declines in Wildland Firefighters	No	n/a	J Occup Environ Hyg. 2014;11(9):591-603	10.1080/15459624.2014.895372.	2014					
Ghilarducci, D. P.	Tjeerdema, R. S.	Fate and Effects of Acrolein	No	n/a	Rev Environ Contam Toxicol. 1995;144:95-146		1995					
Gold, Kathryn M.	Hitchins, Victoria M.	Cleaning Assessment of Disinfectant Cleaning Wipes on an External Surface of a Medical Device Contaminated with Artificial Blood or *Streptococcus pneumoniae*	Yes	http://www.thejpd.org/article/S0196-6553(13)00192-2/fulltext	*American journal of infection control 41.10 (2013): 901-907*	10.1016/j.ajic.2013.01.029	2013					
Golden, Anne L.	Markowitz, Steven B. and Phillip J. Landrigan	The Risk of Cancer in Firefighters	No	n/a	Occupational medicine (Philadelphia, Pa.) 10.4 (1995): 803-820.		1995					
Groß, Raoul	Hübner, Nils, Ojan Assadian, Bethany Jibson, Axel Kramer, and Working Section for Clinical Antiseptic of the German Society for Hospital Hygiene	Pilot Study on the Microbial Contamination of Conventional vs. Silver-Impregnated Uniforms Worn by Ambulance Personnel During One Week of Emergency Medical Service	Yes	https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2951103/	*GMS Krankenhaushygiene interdisziplinär 5.2 (2010).*	10.3205/dgkh000152	2010					
Guidotti, T. L.	None	Occupational Mortality among Firefighters: Assessing the Association.	No	n/a	J Occup Environ Med. 1995 Dec;37(12):1348-56		1995					
Guidotti, T. L.	None	Toxic Hazards	No	n/a	Health Risks and Fair Compensation in the Fire Service. 2016:63-92		2016					
Haas, Nelson S.	Gochfeld, Michael, Mark G. Robson, and Daniel Wartenberg	Latent Health Effects in Firefighters	No	n/a	International journal of occupational and environmental health 9.2 (2003): 95-103.	10.1179/oeh.2003.9.2.95	2003					
Hall, Alan H.	Maibach, Howard	Water Decontamination of Chemical Skin/Eye Splashes: a Critical Review	Yes	http://www.prevor.com/images/docs/en/cot_2006_water_review.pdf	*New Solutions: A Journal Of Environmental And Occupational Health Policy. 18,1 (2008); 87-101.*	10.1080/15569520600695520	2006					

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Hall, H. Irene	Dhara, V. Ramana, Patricia A. Price-Green, and Wendy E. Kaye	Surveillance for Emergency Events Involving Hazardous Substances--United States, 1990-1992	Yes	https://www.cdc.gov/mmWR/preview/mmwrhtml/00033505.htm	MORBIDITY AND MORTALITY WEEKLY REPORT: CDC Surveillance Summaries (1994): 1-6.		1994					
Harrison, R.	Materna, B. L. and N. Rothman	Respiratory Health Hazards and Lung Function in Wildland Firefighters	No	n/a	Occup Med. 1995 Oct-Dec;10(4):857-70		1995					
Hoffman, J. D.	None	Firefighters' Exposure to Fine Particles and Polycyclic Aromatic Hydrocarbons	Yes	https://etd.ohiolink.edu/!etd.send_file?accession=ucin1282061833&disposition=inline	Master's thesis, Univ of Cincinnati		2010					
Holland, M. G.	Cawthorn, D.	Personal Protective Equipment and Decontamination of Adults and Children	No	n/a	Emergency medicine clinics of North America 33.1 (2015): 51-68.	10.1016/j.emc.2014.09.006	2015					
Horton, D. Kevin	Burgess, Paula, et al.	Secondary Contamination of Emergency Department Personnel from o-Chlorobenzylidene Malononitrile Exposure, 2002	Yes	https://www.researchgate.net/profile/Wendy_Kaye/publication/7802482_Secondary_Contamination_of_Emergency_Department_Personnel_from_o-Chlorobenzylidene_Malononitrile_Exposure_2002/links/0c9605183c4c56c75c000000.pdf	Annals of emergency medicine 45.6 (2005): 655-658.	10.1016/j.annemergmed.2005.01.031	2002				ED personnel experienced secondary contamination with a tear gas and riot-control agent, o-chlorobenzylidene malononitrile, during a hazmat event.	
Horton, D. Kevin	Berkowitz, Zahava and Wendy E. Kaye,	Secondary Contamination of ED Personnel from Hazardous Materials Events, 1995–2001	Yes	http://s3.amazonaws.com/academia.edu.documents/42794456/Secondary_contamination_of_ED_personnel_20160218-12863-11ui6a.pdf?AWSAccessKeyId=AKIAIWOWYYGZ2Y53UL3A&Expires=1496858658&Signature=0jjbaMxnP1MJKnR30gGCsKb%2BAsQ%3D&response-content-disposition=inline%3B%20filename%3DSecondary_contamination_of_ED_personnel.pdf	The American journal of emergency medicine 21.3 (2003): 199-204.		2003				Data for six hazmat events in 19 states from 1995 to 2001 (from the Agency for Toxic Substances and Disease Registry's Hazardous Substances Emergency Events Surveillance System) indicated that 15 ED personnel received injuries (primarily respiratory and eye irritation) via secondary contamination from treating contaminated victims.	

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Horton, D. Kevin	Orr, M., T. Tsongas, R. Leiker, and V. Kapil	Secondary Contamination of Medical Personnel, Equipment, and Facilities Resulting from Hazardous Materials Events, 2003–2006	Yes	https://www.researchgate.net/profile/D_Kevin_Horton/publication/51401656_Secondary_Contamination_of_Medical_Personnel_Equipment_and_Facilities_Resulting_From_Hazardous_Materials_Events_2003-2006/links/556c9ed608aeab777223181a.pdf	Disaster medicine and public health preparedness 2.02 (2008): 104-113.	10.1097/DMP.0b013e318166861c	2008			hazardous materials events, chemically contaminated victims, medical personnel, secondary contamination	Data from the ATSDR Hazardous Substances Emergency Events Surveillance system revealed that 0.05% of these events involved secondary contamination of medical personnel, equipment, and facilities, with respiratory irritation the common injury.	
Hoskins, J. A.	Brown, R. C.	Contamination of the Air with Mineral Fibers Following the Explosive Destruction of Buildings and Fire	No	n/a	Drug Metab Rev. 1994;26(4):663-73		1994					
Hsu, Jing-Fang	Guo, How-Ran, Hsueh Wen Wang, Chin-Kun Liao, and Pao-Chi Liao	An Occupational Exposure Assessment of Polychlorinated Dibenzo-p-dioxin and Dibenzofurans in Firefighters	No	n/a	Chemosphere 83.10 (2011): 1353-1359.	10.1016/j.chemosphere.2011.02.079	2011					
Hunter, A. L.	Unosson, J., J. A. Bosson, J. P. Langrish, J. Pourazar, J. B. Raftis, M. R. Miller, A. J. Lucking, C. Boman, R. Nyström, K. Donaldson, A. D. Flapan, A. S. Shah, L. Pung, I. Sadiktsis, S. Masala, R. Westerholm, T. Sandström, A. Blomberg, D. E. Newby,and N. L. Mills	Effect of Wood Smoke Exposure on Vascular Function and Thrombus Formation in Healthy Fire Fighters	No	n/a	Part Fibre Toxicol. 2014 Dec 9;11:62	10.1186/s12989-014-0062-4	2014					
Huston, Tabitha N.	None	Identification of Soils on Firefighter Turnout Gear from the Philadelphia Fire Department	Yes	http://uknowledge.uky.edu/mat_etds/8/	Master's Thesis, University of Kentucky, 2014		2014					
Jahnke, S. A.	Poston, W. S., N. Jitnarin, and C. K. Haddock	Health Concerns of the U.S. Fire Service: Perspectives from the Firehouse.	No	n/a	Am J Health Promot. 2012 Nov-Dec;27(2):111-8	10.4278/ajhp.110311-QUAL-109	2012					
Jankovic, J.	Jones, W., J. Burkhart, and G. Noonan	Environmental Study of Firefighters	No	n/a	Ann Occup Hyg. 1991 Dec;35(6):581-602		1991					

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Jia, De-sheng	Qian, W. H., Z. C. Wang, W. L. Tan, Y. P. Cao, J. Zheng, Z. J. Han, N. H. Lu, and C. J. Wang	Biological efficacy of the individual decontamination equipment for medicinal rescue of bioterrorism attack [J]	No	n/a	Chinese Journal of Hygienic Insecticides & Equipments 6 (2011): 007.		2011					
Jinadatha, C.	Simmons, S., C. Dale, N. Ganachari-Mallappa, F. C. Villamaria, N. Goulding, B.Tanner, J. Stachowiak, and M. Stibich	Disinfecting Personal Protective Equipment with Pulsed Xenon Ultraviolet as a Risk Mitigation Strategy for Health Care Workers	Yes	http://www.sciencedirect.com/science/article/pii/S0196655315000310	American journal of infection control. 2015 Apr 1;43(4):412-4	10.1016/j.ajic.2015.01.013	2015			Environmental disinfection; Ebola, personal protective equipment, doffing process, outbreak control, ultraviolet		
Jones, L.	Lutz, E.A., M. Duncan, and J. L. Burgess	Respiratory Protection for Firefighters- Evaluation of CBRN Canisters for Use during Overhaul	No	n/a	J Occup Environ Hyg. 2015;12(5):314-22	10.1080/15459624.2014.989363	2015					
Josse, Denis	Barrier, G., C. Cruz, M. C. Ferrante, and N. Berthelot	Delayed Decontamination Effectiveness Following Skin Exposure to the Chemical Warfare Agent VX	No	n/a	Toxicology Letters 205 (2011): S163.	10.1016/j.toxlet.2011.05.570	2011					
Josse, Denis	Wartelle, Julien and Catherine Cruz	Showering Effectiveness for Human Hair Decontamination of the Nerve Agent VX	Yes	https://www.researchgate.net/profile/Denis_Josse/publication/273779384_Showering_effectiveness_for_human_hair_decontamination_of_the_nerve_agent_VX/links/57ac99af08ae42ba52b247e3.pdf	Chemico-biological interactions 232 (2015): 94-100.	https://doi.org/10.1016/j.cbi.2015.03.010	2015					
Kales, S. N.	Polyhronopoulos, G. N., J. M. Aldrich, P. J. Mendoza, J. H. Suh, and D. C. Christiani	Prospective Study of Hepatic, Renal, and Haematological Surveillance in Hazardous Materials Firefighters	No	n/a	Occup Environ Med. 2001 Feb;58(2):87-94		2001					
Kaufman, J. D.	Morgan, M. S., M. L. Marks, H, L. Greene, L. Rosenstock	A Study of the Cardiac Effects of Bromochlorodifluoromethane (Halon 1211) Exposure during Exercise	No	n/a	Am J Ind Med. 1992;21(2):223-33		1992					
Kehde, Christopher	None	Going Vertical	Yes	http://www.firehouse.com/document/12352174/firehouse-fire-station-design-supplement-august-2017	Firehouse, August, 2017, pp A12-A16.		2017					

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Kei, Jonathan	Richards, John R.	The Prevalence of Methicillin-Resistant Staphylococcus on Inanimate Objects in an Urban Emergency Department	Yes	https://www.utoledo.edu/med/gme/em/pdfs/MRSA_Inanimate_Objects.pdf	The Journal of emergency medicine 41.2 (2011): 124-127.	10.1016/j.jemermed.2008.08.002	2011					
Kingsland, Casandre	None	Analysis of Soil Removal from Firefighting Turnout Gear: an Evaluation of Care and Maintenance Procedures	No	n/a	Dissertation, University of Kentucky, 2003.		2003					
Kirk, Katherine M.	Logan, Michael B.	Structural Fire Fighting Ensembles: Accumulation and Off-Gassing of Combustion Products.	Yes	http://www.tandfonline.com/doi/abs/10.1080/15459624.2015.1006638?journalCode=uoeh20	Journal of occupational and environmental hygiene 12.6 (2015): 376-383.	10.1080/15459624.2015.1006638	2015			Acid gases, deposition, firefighters, off-gassing, PAHs, polycyclic aromatic hydrocarbons, protective clothing, structural fire fighting ensembles, volatile organic compounds	Deposition of PAHs onto structural fire fighting ensembles and the off-gassing from ensembles after multiple exposures to structural attack fire responses were characterized. Laundering returned off-gassing levels of most compounds to pre-exposure levels.	
Kirk, Katherine M.	Logan, Michael B.	Firefighting Instructors' Exposures to Polycyclic Aromatic Hydrocarbons during Live Fire Training Scenarios	No	n/a	J Occup Environ Hyg. 2015;12(4):227-34	10.1080/15459624.2014.955184	2015		exposure assessment	dermal exposure, firefighters, live fire training, PAHs, polycyclic aromatic hydrocarbons, protective clothing		
Kirkham, T. L.	Koehoorn, M,W., H. Davies, and Demers, P. A.	Characterization of Noise and Carbon Monoxide Exposures among Professional Firefighters in British Columbia	No	n/a	Ann Occup Hyg. 2011 Aug;55(7):764-74	10.1093/annhyg/mer038	2011					
Kishi, T.	Arai, M.	Study on the Generation of Perfluorooctane Sulfonate from the Aqueous Film-Forming Foam	No	n/a	J Hazard Mater. 2008 Nov 15;159(1):81-6		2008					
Klaponski, Natasha	Cutts, Todd, Diane Gordon, and Steven Theriault	A Study of the Effectiveness of the Containment Level-4 (CL-4) Chemical Shower in Decontaminating Dover Positive-Pressure Suits	Yes	http://journals.sagepub.com/doi/pdf/10.1177/153567601101600207	Applied Biosafety 16.2 (2011): 112-117.		2011					
Koussiafes, P. M.	None	Evaluation of Fire Scene Contamination by Using Positive-Pressure Ventilation Fans	No	n/a	Forensic Science Communications 4.4 (2002).		2002				Contamination of a fire scene by a gas-powered positive-pressure ventilation fan was studied.	

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Lacey, S.	Alexander, B. M. and C. S. Baxter	Plasticizer Contamination of Firefighter Personal Protective Clothing-a Potential factor in Increased Health Risks in Firefighters	No	n/a	J Occup Environ Hyg. 2014;11(5):D43-8	10.1080/15459624.2013.877142	2014					
Laitinen, J.	Mäkelä, M., J. Mikkola, and I. Huttu	Firefighters' Multiple Exposure Assessments in Practice	No	n/a	Toxicol Lett. 2012 Aug 13;213(1):129-33	10.1016/j.toxlet.2012.06.005	2012					
Lake, William A.	Fedele, Paul D. and Stephen M. Marshall	Guidelines for mass casualty decontamination during a terrorist chemical agent incident	Yes	http://www.sygdoms.com/pdf/casualty/8.pdf	Report for Edgewood Chemical Biological Center		2000					
Landrigan, P. J.	Lioy, P. J., G. Thurston, G. Berkowitz, L. C. Chen, S. N. Chillrud, S. H. Gavett, P. G. Georgopoulos, A. S. Geyh, S. Levin, F. Perera, S. M. Rappaport, C. Small, and NIEHS World Trade Center Working Group	Health and Environmental Consequences of the World Trade Center Disaster	No	n/a	Environ Health Perspect. 2004 May;112(6):731-9		2004					
Lang, T.	Dixon, B. M.	The Possible Contamination of Fire Scenes by the Use of Positive Pressure Ventilation Fans	No	n/a	Canadian Society of Forensic Science Journal 33.2 (2000): 55-60.	10.1080/00085030.2000.10757503	2000	Canadian Society of Forensic Science Journal, 33(2): 55-60			Gasoline vapor was found on samples placed at various interior distances from a gasoline-powered positive pressure ventilation fan placed outside the door during fire suppression.	
Lee, J. B.	Levy, M. and A. Walker	Use of a forensic technique to identify blood contamination of emergency department and ambulance trauma equipment.	Yes	https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2564139/	Emergency medicine journal 23.1 (2006): 73-75.	10.1136/emj.2005.025346	2006					Note: article was corrected. See Emerg Med J. 2006 February; 23(2): 163.
Lee, J. B.	Levy, M. and A. Walker	A1 Use Of A Forensic Technique To Detect Occult Blood Contamination Of Emergency Department And Ambulance Trauma Equipment	No	n/a	Emergency Medicine Journal 22 (2005): 1.							

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Lees, P. S.	None	Combustion Products and Other Firefighter Exposures	No	n/a	Occupational medicine (Philadelphia, Pa.) 10.4 (1995): 691-706		1995					
Leonard, S. S.	Castranova, V., B. T. Chen, D. Schwegler-Berry, M. Hoover, C. Piacitelli, and D. M. Gaughan	Particle Size-Dependent Radical Generation from Wildland Fire Smoke	No	n/a	Toxicology. 2007 Jul 1;236(1-2):103-13		2007					
Lin, J. F.	Huang, Y. C.	A Booster Shot to Promote Doffing Safety	No	n/a	Journal of Acute Medicine 2.5 (2015): 51	10.1016/j.jacme.2015.05.002	2015					
Lowe, John J.	Hewlett, Angela L.,Peter C. Iwen, Philip W. Smith, and Shawn G. Gibbs	Evaluation of Ambulance Decontamination Using Gaseous Chlorine Dioxide	Yes	http://cleanhospital.com/pdfs/ambulance_decon.pdf	Prehospital Emergency Care 17.3 (2013): 401-408.	10.3109/10903127.2013.792889	2013					
Luksamijarulkul, Pipat	Pipitsangjan, Sirikun	Microbial Air Quality and Bacterial Surface Contamination in Ambulances during Patient Services	Yes	https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4412456/	Oman medical journal 30.2 (2015): 104.	10.5001/omj.2015.23	2015					
MacGuire-Wolfe, Christine	Donna Haiduven and C. Duncan Hitchcock	A Multifaceted Pilot Program to Promote Hand Hygiene at a Suburban Fire Department	Yes	https://www.researchgate.net/profile/C_Mcguire-wolfe/publication/51638932_A_multifaceted_pilot_program_to_promote_hand_hygiene_at_a_suburban_fire_department/links/02e7e53097afde5583000000.pdf	American journal of infection control 40.4 (2012): 324-327.	10.1016/j.ajic.2011.06.003	2012			Hand hygiene; Handwashing; Emergency medical services; Firefighters; Hand hygiene compliance; Hand hygiene intervention	Firefighters' attitudes, practices, and beliefs were evaluated by questionnaires before and after training on hand hygiene.	
Maglio, M. A.	Scott, C., A. L. Davis, J. Allen, and J. A. Taylor	Situational Pressures that Influence Firefighters' Decision Making about Personal Protective Equipment: A Qualitative Analysis.	No	n/a	Am J Health Behav. 2016 Sep;40(5):555-67	10.5993/AJHB.40.5.2	2016					
Manns, Robert	None	Anatomy of the apparatus bay	Yes	http://www.firehouse.com/document/12352174/firehouse-fire-station-design-supplement-august-2017	Firehouse, August, 2017, pp A4-A11.		2017					
Markowitz, Jeffrey S.	Gutterman, Elane M., Sharon Schwartz, Bruce Link, and Sheila M. Gorman	Acute Health Effects Among Firefighters and Emergency Medical Technicians	No	n/a	American Journal of Epidemiology 129.5 (1989): 1023-1031.	10.1093/oxfordjournals.aje.a115206	1989					

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Masik, Jan	Jost, P., R. Pavlikova, E. Vodakova, J. Cabal, and K. Kuca	A Comparison of Decontamination Effects of Commercially Available Detergents in Rats Pre-Exposed to Topical Sulphur Mustard	No	n/a	Cutaneous and ocular toxicology 32.2 (2013): 135-139	10.3109/15569527.2012.730087	2013					
McNamara, M. L.	Semmens, E. O., S. Gaskill, C. Palmer, C. W. Noonan, and T. J. Ward	Base Camp Personnel Exposure to Particulate Matter during Wildland Fire Suppression Activities	No	n/a	J Occup Environ Hyg. 2012;9(3):149-56	10.1080/15459624.2011.652934	2012					
Michalak, G.	None	Diesel emissions in fire stations	Yes	http://www.richter-foundation.org/pdf/case-study1.pdf	Resource Information Center for Health, Technology, and Environmental Recovery Foundation (2004).		2004					
Milham, S.	None	Most Cancer in Firefighters Is Due to Radio-Frequency Radiation Exposure Not Inhaled Carcinogens	Yes	https://www.researchgate.net/profile/Samuel_Milham/publication/26236427_Most_cancer_in_firefighters_is_due_to_radio-frequency_radiation_exposure_not_inhaled_carcinogens/links/00b7d526747090e5ea000000/Most-cancer-in-firefighters-is-due-to-radio-frequency-radiation-exposure-not-inhaled-carcinogens.pdf	Medical hypotheses 73.5 (2009): 788-789.	10.1016/j.mehy.2009.04.020	2009					
Minnich, G.	None	A Clean Ride. Building EMS Vehicles for Easier Cleaning and Decontamination	No	n/a	EMS: a journal of emergency medical services 28.5 (2003): 104-115.		2003					
Miranda, Ana I.	Martins,Vera, Pedro Cascão, Jorge Humberto Amorim, Joana Valente, Carlos Borrego, António Jorge Ferreira, Carlos Robalo Cordeiro, Domingos Xavier Viegas, and Roger Ottmar	Wildland Smoke Exposure Values and Exhaled Breath Indicators in Firefighters	No	n/a	Journal of Toxicology and Environmental Health, Part A 75.13-15 (2012): 831-843.	10.1080/15287394.2012.690686	2012					

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Misik, Jan	Pavlikov, R., D. Josse, J. Cabal, and K. Kuca	In Vitro Skin Permeation and Decontamination of the Organophosphorus Pesticide Paraoxon under Various Physical Conditions–Evidence for a Wash-In Effect	No	n/a	Toxicology mechanisms and methods 22.7 (2012): 520-525.	10.3109/15376516.2012.686535	2012					
Moen, Bente E.	Øvrebø, Steinar	Assessment of Exposure to Polycyclic Aromatic Hydrocarbons during Firefighting by Measurement of Urinary 1-Hydroxypyrene	No	n/a	*Journal of occupational and environmental medicine 39.6 (1997): 515-519.*		1997					
Moore, G.	Griffith, C.	A laboratory Evaluation of the Decontamination Properties of Microfibre Cloths	Yes	http://www.tscswabs.co.uk/uploads/images/PDF-Downloads/Sterile-Culture-and-Transport-Swabs-Brochure/TS6-A_Microfibre_Cloth_Study2006.pdf	Journal of Hospital Infection 64.4 (2006): 379-385.	10.1016/j.jhin.2006.08.006	2006					
Muscat, J. E.	Wynder, E. L.	Diesel Exhaust, Diesel Fumes, and Laryngeal Cancer	No	n/a	Otolaryngol Head Neck Surg. 1995 Mar;112(3):437-40		1995					
Naeher, Luke P.	Achtemeier, G. L., J. S. Glitzenstein, D. R. Streng, and D. Macintosh	Real-time and Time-Integrated PM2. 5 and CO from Prescribed Burns in Chipped and Non-Chipped Plots: Firefighter and Community Exposure and Health Implications	Yes	http://eds.a.ebscohost.com/eds/pdfviewer/pdfviewer?sid=f1aa64c4-f811-4ae5-a628-484a0321080c%40sessionmgr4006&vid=0&hid=4113	Journal of Exposure Science and Environmental Epidemiology 16.4 (2006): 351-361.	10.1038/sj.jes.7500497	2006			prescribed burn, forest fire, firefighter, PM2.5, CO, air quality, mechanical chipping	Smoke exposures from prescribed burns of chipped plots are lower than those from non-chipped plots based on real-time and time-integrated PM25 and CO concentrations.	
Navarro, K. M.	Cisneros, R., E. M. Noth, J. R. Balmes, and S. K. Hammond	Occupational Exposure to Polycyclic Aromatic Hydrocarbon of Wildland Firefighters at Prescribed and Wildland Fires	No	n/a	Environmental science & technology 51.11(2017): 6461-6469.	10.1021/acs.est.7b00950	2017					
Neitzel, R.	Naeher, L. P., M. Paulsen, K. Dunn, A. Stock, and C. D. Simpson	Biological Monitoring of Smoke Exposure among Wildland Firefighters: a Pilot Study Comparing Urinary Methoxyphenols with Personal Exposures to Carbon Monoxide, Particular Matter, and Levoglucosan	No	n/a	J Expo Sci Environ Epidemiol. 2009 May;19(4):349-58	10.1038/jes.2008.21	2009					
Nigam, Y.	Cutter, J.	A Preliminary Investigation into Bacterial Contamination of Welsh Emergency Ambulances	Yes	http://emj.bmj.com/content/20/5/479.full.pdf+html	Emergency medicine journal 20.5 (2003): 479-482.	10.1136/emj.20.5.479	2003					

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First Authors	2nd Authors	Title	Available Free?	Source	Citation	DOI #	Year	Type of Contamination	Target of Contamination	Key Words	Abstract	Other
Noh, Hyun	Shin, Sang Do, Nam Joong Kim, Young Sun Ro, Hyang Soon Oh, Se Ik Joo, Jung In Kim, and Marcus Eng Hock Ong	Risk Stratification-Based Surveillance of Bacterial Contamination in Metropolitan Ambulances	Yes	https://synapse.koreamed.org/search.php?where=aview&id=10.3346/jkms.2011.26.1.124&code=0063JKMS&vmode=FULL	Journal of Korean medical science 26.1 (2011): 124-130.	10.3346/jkms.2011.26.1.124	2011					
O'Keefe, P.W.	Silkworth, J. B., J. F. Gierthy, R. M. Smith, A. P. DeCaprio, J. N. Turner, G. Eadon, D. R. Hilker, K. M. Aldous, L. S. Kaminsky, et al.	Chemical and Biological investigations of a Transformer Accident at Binghamton, NY	No	n/a	Environ Health Perspect. 1985 May;60:201-9		1985					
Oliveira, M.	Slezakova, K., M. J. Alves, A. Fernandes, J. P. Teixeira, C. Delerue-Matos, M. do Carmo Pereira, and S. Morais	Polycyclic Aromatic Hydrocarbons at Fire Stations: Firefighters' Exposure Monitoring and Biomonitoring, and Assessment of the Contribution to Total Internal Dose	Yes	https://bibliotecadigital.ipb.pt/bitstream/10198/13519/1/Firefighters_JHM_2016.pdf	Journal of hazardous materials. 2017 Feb 5;323:184-94.	10.1016/j.jhazmat.2016.03.012	2017			firefighters, exposures, PAH, OH-PAH, 1-hydroxyprene		
Oliveira, Marta	Slezakova, Klara, Adília Fernandes, João Paulo Teixeira, Cristina Delerue-Matos, Maria do Carmo Pereira, and Simone Morais	Occupational Exposure of Firefighters to Polycyclic Aromatic Hydrocarbons in Non-Fire Work Environments	No	n/a	Science of The Total Environment 592 (2017): 277-287.	10.1016/j.scitotenv.2017.03.081	2017					
Oliveira, Marta	Slezakova, Klara, Carlos Pires Magalhães, Adília Fernandes, João Paulo Teixeira, Cristina Delerue-Matos, Maria do Carmo Pereira, and Simone Morais.	Individual and Cumulative Impacts of Fire Emissions and Tobacco Consumption on Wildland Firefighters' Total Exposure to Polycyclic Aromatic Hydrocarbons	No	n/a	Journal of hazardous materials 334(2017): 10-20.10-20.	10.1016/j.jhazmat.2017.03.057	2017					
Organtini, Kari L	Myers, Anee L., Karl J. Jobst, Eric J. Reiner, Brian Ross, Adam Ladak, Lauren Mullin, Douglas Stevens, and Frank L. Dorman	Quantitative Analysis of Mixed Halogen Dioxins and Furans in Fire Debris Utilizing Atmospheric Pressure Ionization Gas Chromatography-Triple Quadrupole Mass Spectrometry	No	n/a	Analytical chemistry 87.20 (2015): 10368-10377.	10.1021/acs.analchem.5b02463	2015					
Park J. S.	Voss, R. W.,S. McNeel, N. Wu, T. Guo, Y. Wang, L. Israel, R. Das, and M. Petreas	High Exposure of California Firefighters to Polybrominated Diphenyl Ethers	No	n/a	Environmental science & technology. 2015; 49(5): 2948–2958	10.1021/es5055918	2015					

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Park, Huiju	Park, Juyeon, Shu-Hwa Lin, and Lynn M Boorady	Assessment of Firefighters' Needs for Personal Protective Equipment	Yes	https://link.springer.com/article/10.1186/s40691-014-0008-3	Fashion and Textiles. 1.8 (2014): n.p.		2014					
Parker, R. J.	Ashby, L.	Rural Firefighter Exposure to Fireground Gases with Relevance to Physiological Workload and Fire Suppression Productivity	Yes	http://www.scionresearch.com/__data/assets/pdf_file/0020/30809/Rural-firefighter-exposure-to-fireground-gases-with-relevance-web.pdf	New Zealand Fire Service Commission research report no. 108		2010					
Patel, N. D.	Fales, W. D. and R. N. Farrell RN	The Use of a Photoionization Detector to Detect Harmful Volatile Chemicals by Emergency Personnel	Yes	https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4806818/	Open access emergency medicine: OAEM. 2009;1:5		2009					
Payne, R. L.	Alaves,V. M., R. R. Larson, and D. K. Sleeth	An Evaluation of Diesel Particulate Matter in Fire Station Vehicle Garages and Living Quarters	No	n/a	Journal of Chemical Health and Safety. 2016 Aug 31;23(4):26-31	10.1016/j.jchas.2015.10.020	2016					
Pleil, J. D.	Stiegel, M. A. and F. W. Fent	Exploratory Breath Analyses for Assessing Toxic Dermal Exposures of Firefighters during Suppression of Structural Burns	No	n/a	J Breath Res. 2014 Sep;8(3):037107.	10.1088/1752-7155/8/3/037107	2014					
Pronk, A.	Coble J. and P. A. Stewart	Occupational Exposure to Diesel Engine Exhaust: A Literature Review	Yes	http://www.nature.com/jes/journal/v19/n5/full/jes200921a.html	Journal of exposure science and environmental epidemiology. 2009 Jul 1;19(5):443-57	10.1038/jes.2009.21	2009					
Radford, E. P.	Levine, M. S.	Occupational Exposures to Carbon Monoxide in Baltimore Firefighters	No	n/a	J Occup Med. 1976 Sep;18(9):628-32		1972					
Reichard, Audrey A.	Jackson, Larry L.	Occupation Injuries among Emergency Responders	Yes	https://www.researchgate.net/profile/Audrey_Reichard/publication/38071630_Occupational_Injuries_Among_Emergency_Responders/links/56e0278e08aec4b3333d0075.pdf	American journal of industrial medicine 53.1 (2010): 1-11.	10.1002/ajim.20772	2010					
Reifenrath, William G.	Mershon, Millard M., Floyd B. Brinkley, George A. Miura, Clarence A. Broomfield, and H. Bruce Cranford	Evaluation of Diethyl Malonate as a Simulant for 1, 2, 2-Trimethylpropyl methylphosphonofluoridate (Soman) in Shower Decontamination of the Skin	Yes	http://jpharmsci.org/article/S0022-3549(15)46348-8/pdf	Journal of pharmaceutical sciences 73.10 (1984): 1388-1392.	10.1002/jps.2600731016	1984					

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First Authors	2nd Authors	Title	Available Free?	Source	Citation	DOI #	Year	Type of Contamination	Target of Contamination	Key Words	Abstract	Other
Reinhardt, T. E.	Ottmar, R. D.	Baseline Measurements of Smoke Exposure among Wildland Firefighters	No	n/a	J Occup Environ Hyg. 2004 Sep;1(9):593-606		2004					
Reisen, F.	Brown, S. K.	Australian Firefighters' Exposure to Air Toxics during Bushfire Burns of Autumn 2005 and 2006	No	n/a	Environ Int. 2009 Feb;35(2):342-52	10.1016/j.envint.2008.08.011	2009					
Reisen, F.	Hansen, D. and C. P. Meyer	Exposure to bushfire smoke during prescribed burns and wildfires: firefighters' exposure risks and options	No	n/a	Environ Int. 2011 Feb;37(2):314-21	10.1016/j.envint.2010.09.005	2011					
Rinnert, Kathy J.	None	A review of Infection Control Practices, Risk Reduction, and Legislative Regulations for Blood-Borne Disease: Applications for Emergency Medical Services	No	n/a	Prehospital Emergency Care 2.1 (1998): 70-75.	10.1080/10903129808958844	1998					
Rischitelli, G.	McCauley, L., W. E. Lambert, M. Lasarev, and E. Mahoney	Hepatitis C in Urban and Rural Public Safety Workers	No	n/a	J Occup Environ Med. 2002 Jun;44(6):568-73		2002					
Rischitelli, G.	Lasarev, M. and L. McCauley	Career Risk of Hepatitis C Virus Infection among U.S. Emergency Medical and Public Safety Workers	No	n/a	J Occup Environ Med. 2005 Nov;47(11):1174-81		2005					Erratum in: J Occup Environ Med. 2006 Mar;48(3):234-5
Rischitelli, Gary	Harris, James, Linda McCauley, Robyn Gershon, and Tee Guidotti	The Risk of Acquiring Hepatitis B or C among Public Safety Workers: A Systematic Review	No	n/a	American journal of preventive medicine 20.4 (2001): 299-306.	doi.org/10.1016/S0749-3797(01)00292-6	2001					
Ro, Young Sun	Shin, Sang Do, Hyun Noh, and Sung-Il Cho	Prevalence of Positive Carriage of Tuberculosis, Methicillin-Resistant *Staphylococcus aureus*, and Vancomycin-Resistant Enterococci in Patients Transported by Ambulance: A Single Center Observational Study	Yes	https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3374967/	Journal of preventive medicine and public health 45.3 (2012): 174.	10.3961/jpmph.2012.45.3.174	2012					
Roberts, D.	Senarathna, L.	Secondary Contamination in Organophosphate Poisoning	Yes	https://academic.oup.com/qjmed/article/97/10/697/1553170	Qjm 97.10 (2004): 697-698.	10.1093/qjmed/hch114	2004					

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Roberts, M. C.	Soge, O. O., D. No, N. K. Beck, and J. S. Meschke	Isolation and Characterization of Methicillin-Resistant Staphylococcus aureus from fire stations in two northwest fire districts	Yes	http://lni.wa.gov/safety/GrantsPartnerships/SHIP/awardees/UWMRSA/CaseStudy.pdf	American journal of infection control. 2011 Jun 30;39(5):382-9.	10.1016/j.ajic.2010.09.008	2011			USA300, CA-MRSA, HA-MRSA, environmental surfaces		
Roberts, M. C.	No, D. B.	Environment Surface Sampling in 33 Washington State Fire Stations for Methicillin-Resistant and Methicillin-Susceptible *Staphylococcus aureus*	Yes	https://www.researchgate.net/profile/Marilyn_Roberts/publication/262423460_Environment_surface_sampling_in_33_Washington_State_fire_stations_for_methicillin-resistant_and_methicillin-susceptible_Staphylococcus_aureus/links/53fe55030cf21edafd150dfe.pdf	American journal of infection control. 2014 Jun 30;42(6):591-6	10.1016/j.ajic.2014.02.019	2014			MRSA, MSSA, staphyloccocal sample kit, fire station disinfection protocol		
Robinson, M. S.	Anthony, T. R., S. R. Littau, P. Herckes, X. Nelson, G. S. Poplin, J. L. Burgess	Occupational PAH Exposures during Prescribed Pile Burns	No	n/a	Ann Occup Hyg. 2008 Aug;52(6):497-508	10.1093/annhyg/men027	2008					
Roegner, Kevin W.	Sieber, W. Karl and Alan Echt	Evaluation of Diesel Exhaust Controls	No	n/a	*Applied occupational and environmental hygiene 17.1 (2002): 1-7.*	10.1080/10473220275330 6050	2002					
Roline, C. E.	Crumpecker, Christina and Thomas M. Dunn	Can Methicillin-Resistant *Staphylococcus aureus* Be Found in an Ambulance Fleet?	No	n/a	*Prehospital emergency care 11.2 (2007): 241-244.*	10.1080/10903120701205125	2007					
Rom, W. N.	Oppenheimer, K. Berger, R. Goldring, D. Harrison, and D. Prezant	Emerging Exposures and Respiratory Health: World Trade Center Dust	No	n/a	Proc Am Thorac Soc. 2010 May;7(2):142-5	10.1513/pats.200908-092RM	2010					
Rosénstock, L.	Demers, P., N. J. Heyer, and S. Barnhart	Respiratory Mortality among Firefighters	No	n/a	Br J Ind Med. 1990 Jul;47(7):462-5		1990					
Rotander, A.	Toms, L. M., L. Aylward, M. Kay, and J. F. Mueller JF	Elevated levels of PFOS and PFHxS in Firefighters Exposed to Aqueous Film Forming Foam (AFFF)	No	n/a	Environ Int. 2015 Sep;82:28-34	10.1016/j.envint.2015.05.005	2015					
Ruhman, Nicholas	Grantham,Vesper and Chris Martin	The Effectiveness of Decontamination Products in the Nuclear Medicine Department	Yes	http://tech.snmjournals.org/content/38/4/191.full	Journal of nuclear medicine technology 38.4 (2010): 191-194.		2010					
Salazar, Mary K.	None	Hepatitis C among Public Safety Workers – Assessment of Risk and Strategies for Prevention	No	n/a	AAOHN Journal; Thorofare51.8 (Aug 2003): 333-335.		2003					

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First Authors	2nd Authors	Title	Available Free?	Source	Citation	DOI #	Year	Type of Contamination	Target of Contamination	Key Words	Abstract	Other
Sattar, Syed A.	None	Promises and Pitfalls of Recent Advances in Chemical Means of Preventing the Spread of Nosocomial Infections by Environmental Surfaces	Yes	http://www.ajicjournal.org/article/S0196-6553(10)00419-0/fulltext	American journal of infection control 38.5 (2010): S34-S40.	10.1016/j.ajic.2009.09.007	2010					
Sattar, Syed A.	Maillard, Jean-Yves	The Crucial Role of Wiping in Decontamination of High-Touch Environmental Surfaces: Review of Current Status and Directions for the Future	Yes	http://www.ajicjournal.org/article/S0196-6553(13)00015-1/fulltext	American journal of infection control 41.5 (2013): S97-S104.	10.1016/j.ajic.2012.10.032	2013					
Sattar, Syed A.	Bradley, C., R. Kibbee, Rebecca Wesgate, MAC Wilkinson, T. Sharpe, and Jean-Yves Maillard	Disinfectant Wipes Are Appropriate to Control Microbial Bioburden from Surfaces: Use of a New ASTM Standard Test Protocol to Demonstrate Efficacy	Yes	http://orca.cf.ac.uk/84572/2/0appropriate%2520to%2520control%2520microbial%2520bioburden%2520from%2520surfaces-%2520Use%2520of%2520a%2520new%2520ASTM%2520standard%2520test%2520protocol%2520to%2520demonstrate%2520efficacy%5B1%5D.pdf	Journal of Hospital Infection 91.4 (2015): 319-325.	10.1016/j.jhin.2015.08.026	2015					
Scarborough, C. K.	Doell, L. D.	Safeguarding our First Responders: Infection Control and Prevention for Firefighters	No	n/a	American journal of infection control 34.5 (2006): E69	10.1016/j.ajic.2006.05.133	2006					
Schneider, Thomas	Cherrie, John W., Roel Vermeulen, and Hans Kromhout	Dermal Exposure Assessment	Yes	https://academic.oup.com/annweh/article-pdf/44/7/493/9739974/493.pdf	Annals of Occupational Hygiene 44.7 (2000): 493-499.	10.1093/annhyg/44.7.493	2000					
Schwartz, D. M.	Hurst, C. G., M. A Kirk, S. JD Reedy, and E. H Braue	Reactive Skin Decontamination Lotion (RSDL) for the Decontamination of Chemical Warfare Agent (CWA) Dermal Exposure	No	n/a	Current pharmaceutical biotechnology 13.10 (2012): 1971-1979.	10.2174/138920112802273191	2012					
Sepkowitz, Kent A.	Eisenberg, Leon	Occupational Deaths among Healthcare Workers	Yes	https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3371777/	Emerging infectious diseases 11.7 (2005): 1003.	10.3201/eid1107.041038	2005					
Sexton, J. D.	Reynolds, K. A.	Exposure of Emergency Medical Responders to Methicillan-Resistant *Staphylococcus aureus*	No	n/a	American journal of infection control 38.5 (2010): 368-373.	10.1016/ajic.2010.01.004	2010					

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Shaw, S. D.	Berger, M. L., J. H. Harris, S. H. Yun, Q. Wu, C. Liao, A. Blum, A. Stefani, and K. Kannan	Persistent Organic Pollutants Including Polychlorinated and Polybrominated Dibenzo-p-dioxins and Dibenzofurans in Firefighters from Northern California	No	n/a	Chemosphere. 2013 Jun;91(10):1386-94	10.1016/j.chemosphere.2012.12.070	2013					Erratum in: Chemosphere. 2014 May;102:87
Shen, Beverly	Whitehead, Todd P. Sandra McNeel, F. Reber Brown, Joginder Dhaliwal, Rupali Das, Leslie Israel, June-Soo Park, and Myrto Petreas	High Levels of Polybrominated Diphenyl Ethers in Vacuum Cleaner Dust from California Fire Stations	No	n/a	Environmental science & technology 49.8 (2015): 4988-4994.	10.1021/es505463g	2015					
Shin, D. M.	None	Prevention and Decontamination of Chemical, Biological, Radiological, and Nuclear Contaminants for the Emergency Medical Personnel During Ambulance Services	Yes	https://synapse.koreamed.org/DOIx.php?id=10.7599/hmr.2015.35.3.146	Hanyang Medical Reviews 35.3 (2015): 146-151.	doi.org/10.7599/hmr.2015.35.3.146	2015					
Simon, E.	Choi, S. D. and M. K. Park	Understanding the Fate of Polycyclic Aromatic Hydrocarbons at a Forest Fire Site Using a Conceptual Model Based on Field Monitoring	No	n/a	J Hazard Mater. 2016 Nov 5;317:632-9	10.1016/j.jhazmat.2016.06.030	2016					
Slaughter, J. C.	Koenig, J. Q. and T. E. Reinhardt	Association between Lung function and Exposure to Smoke among Firefighters at Prescribed Burns	No	n/a	J Occup Environ Hyg. 2004 Jan;1(1):45-9		2004					
Stacey, R.	Stacey, R., D. Morfey, and S. Payne	Secondary Contamination in Organophosphate Poisoning: Analysis of an Incident	Yes	https://academic.oup.com/qjmed/article/97/2/75/1547690	Qjm 97.2 (2004): 75-80.	10.1093/qjmed/hch020	2004					
Stang, A.	Jöckel, K. H., C. Baumgardt-Elms, and W. Ahrens	Firefighting and risk of testicular cancer: results from a German population-based case-control study	No	n/a	Am J Ind Med. 2003 Mar;43(3):291-4		2003					
Stevenson, M.	Alexander, B., C. S. Baxter, and Y. K., Leung	Evaluating Endocrine Disruption Activity of Deposits on Firefighting Gear Using a Sensitive and High Throughput Screening Method	Yes	http://europepmc.org/articles/pmc4672464	Journal of occupational and environmental medicine. 2015 Dec;57(12):e153-7	10.1097/JOM.0000000000000577	2015					

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Törngren, Staffan	Persson, S-A, A. Ljungquist, T. Berglund, M. Nordstrand, L. Hagglund, L. Rittfeldt, K. Sandgren, and E. Soderman	Personal Decontamination after Exposure to Simulated Liquid Phase Contaminants: Functional Assessment of a New Unit.	No	n/a	Journal of Toxicology: Clinical Toxicology 36.6 (1998): 567-573.	10.3109/15563659809028050	1998					
Treitman, R. D.	Burgess, W. A. and A. Gold	Air Contaminants Encountered by Firefighters	No	n/a	Am Ind Hyg Assoc J. 1980 Nov;41(11):796-802		1980					
Tsai, Naoky C. S.	Severino, Richard, Angie Coste, Steven Buto, Robert Jao, and Linda Wong	The Prevalence Rate of Positive HCV-Ab in Firefighters of the City and County of Honolulu-an Increased Risk with the Length of Service	No	n/a	Gastroenterology 120.5 (2001): A367-A368.	10.1016/S0016-5085(08)81827-6	2001					
Tubbs, R. L.	None	Occupational Noise Exposure and Hearing Loss in Fire Fighters Assigned to Airport Fire Stations.	No	n/a	Am Ind Hyg Assoc J. 1991		1991					
Tuladhar, Era	Hazeleger, Wilma C., Marion Koopmans, Marcel H. Zwietering, Rijkelt R. Beumer, and Erwin Duizer	Residual Viral and Bacterial Contamination of Surfaces after Cleaning and Disinfection	Yes	http://aem.asm.org/content/78/21/7769.long	*Applied and environmental microbiology78.21 (2012): 7769-7775.*	10.1128/AEM.02144-12	2012					
Valdez, Melissa K.	Sexton, Jonathan D., Eric A. Lutz, and Kelly A. Reynolds	Spread of Infectious Microbes during Emergency Medical Response	No	n/a	American journal of infection control 43.6 (2015): 606-611.	10.1016/j.ajic.2015.02.025	2015					
Valenzuela, T. D.	Hooten, T. M., E. L. Kaplan, and P. Schlievert	Transmission of 'Toxic Strep' Syndrome from an Infected Child to a Firefighter during CPR	No	n/a	Annals of emergency medicine 20.1 (1991): 90-92.	10.1016/S0196-0644(05)81129-1	1991					
Varona-Barquin, Aketza	Ballesteros-Peña, Sendoa, Sergio Lorrio-Palomino, Guillermo Ezpeleta, Verónica Zamanillo, Elena Eraso, and Guillermo Quindós	Detection and Characterization of Surface Microbial Contamination in Emergency Ambulances	No	n/a	*American journal of infection control 45.1 (2017): 69-71.*	10.1016/j.ajic.2016.05.024	2017					
Varone, J. Curtis	Warren, Thomas N., Kevin Jutras, Joseph Molis, Joseph Dorsey, and Mary Lee Dunn	Report of the Investigation Committee into the Cyanide Poisonings of Providence Firefighters	No	n/a	New Solutions: A Journal Of Environmental And Occupational Health Policy. 18,1 (2008); 87-101.	10.2190/NS.18.1.f	2008					

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Vikke, Heidi S.	Giebner, Matthias	POSAiDA: Presence of *Staphylococcus aureus*/MRSA and Enterococcus/VRE in Danish Ambulances. A cross-Sectional Study	Yes	https://bmcresnotes.biomedcentral.com/articles/10.1186/s13104-016-1982-x	BMC research notes 9.1 (2016): 194	10.1186/s13104-016-1982-x	2016					
Vogt, Barbara M.	Sorenson, John H.	How Clean is Safe?: Improving the Effectiveness of Decontamination of Structures and People Following Chemical and Biological Incidents	Yes	https://www.researchgate.net/profile/John_Sorensen7/publication/252569804_How_Clean_is_Safe_Improving_the_Effectiveness_of_Decontamination_of_Structures_and_People_Following_Chemical_and_Biological_Incidents/links/57e00e3b08aebe7a63efd0fc/How-Clean-is-Safe-Improving-the-Effectiveness-of-Decontamination-of-Structures-and-People-Following-Chemical-and-Biological-Incidents.pdf	report for US Department of Energy, Chemical and Biological National Security Program		2002					
Waldman, J. M.	Gavin, Q., M. Anderson, S. Hoover, J. Alvaran, H. S. Ip, L. Fenster, N. T. Wu, G. Krowech, L. Plummer, L. Israel, R. Das, and J. She	Exposures to environmental phenols in Southern California firefighters and findings of elevated urinary benzophenone-3 levels	No	n/a	Environ Int. 2016 Mar;88:281-7	10.1016/j.envint.2015.11.014	2016					
Walker, Stewart	Stull, Jeffrey O.	Evaluation of the Cleaning Effectiveness and Impact of Esporta and Industrial Cleaning Techniques On Firefighter Protective Clothing Technical Report	Yes	http://site-media.net/marken/CleaningEffectivenessOfFirefighterProtectiveClothing.pdf	(technical report)		2006	technical report	laundering study	Esporta, decontamination	The Esporta cleaning process was compared to a conventional industrial process for laundering firefighter protective clothing. In general the Esporta process showed less reduction of protective performance.	
Weber, David J.	Sickbert-Bennett, Emily, Maria F. Gergen, and William A. Rutala	Efficacy of Selected Hand Hygiene Agents Used to Remove *Bacillus atrophaeus* (a Surrogate of *Bacillus anthracis*) from Contaminated Hands	Yes	http://jamanetwork.com/journals/jama/fullarticle/196118	Jama 289.10 (2003): 1274-1277.	10.1001/jama.289.10.1274	2003					

Table A-1: Sample Literature Survey Results For Fire And Emergency Services Contamination Issues (as of August 2017)

First Authors	2nd Authors	Title	Available Free?	Source	Citation	DOI #	Year	Type of Contamination	Target of Contamination	Key Words	Abstract	Other
Weiss, D. C.	Miller, J. T.	A study on Chemicals Found in the Overhaul Phase of Structure Fires Using Advanced Portable Air Monitoring Available for Chemical Speciation.	Yes	http://cerexms.com/pdfs/Air%20Monitoring%20Report%20-%20Final.pdf	(report presented to the Oregon Fire Chiefs Association, Safety Committee)		2011					
Wepler, M.	Stahl, W., H. von Baum, S, Wildermuth, B. Dirks, M. Georgieff, and S. Hafner	Prevalence of Nosocomial Pathogens in German Ambulances: The SEKURE Study	Yes	http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.831.82&rep=rep1&type=pdf	*Emerg Med J 32.5 (2015): 409-411.*	10.1136/emermed-2013-202551	2015					
Wisnivesky, J. P.	Teitelbaum S.L., A. C. Todd, P. Boffetta, M. Crane, L. Crowley, R. E. de la Hoz, C. Dellenbaugh, D. Harrison, R. Herbert, H. Kim, Y. Jeon, J. Kaplan, C. Katz, S. Levin, B. Luft, S. Markowitz, J. M. Moline, F. Ozbay, R. H. Pietrzak, M. Shapiro, V. Sharma, G. Skloot, S. Southwick, L. A. Stevenson, I. Udasin, S. Wallenstein S, and P. J. Landrigan.	Persistence of Multiple Illnesses in World Trade Center Rescue and Recovery Workers: a Cohort Study	No	n/a	Lancet. 2011 Sep 3;378(9794):888-97	10.1016/S0140-6736(11)61180-X.	2011					
Wolfe, M. I.	Mott, J. A., R. E. Voorhees, C. M. Sewell, D. Paschal, C. M. Wood, P. E. McKinney, and S. Redd	Assessment of Urinary Metals Following Exposure to a Large Vegetative Fire, New Mexico, 2000	No	n/a	J Expo Anal Environ Epidemiol. 2004 Mar;14(2):120-8		2004					
Xu, Y.	J. Li, Q. Zheng, S. Pan, C. Luo, H. Zhu, L. Nizzetto, and G. Zhang	Polychlorinated Naphthalenes (PCNs) in Chinese Forest Soil: Will Combustion Become a Major Source?	No	n/a	Environ Pollut. 2015 Sep;204:124-32	10.1016/j.envpol.2015.04.014	2015					

Table A-1: Sample Literature Survey Results For Fire And Emergency Services Contamination Issues (as of August 2017)

First Authors	2nd Authors	Title	Available Free?	Source	Citation	DOI #	Year	Type of Contamination	Target of Contamination	Key Words	Abstract	Other
Zeitz, P.	Berkowitz, Zahava, Maureen F. Orr, Gilbert S. Haugh, and Wendy E. Kaye.	Frequency and Type of Injuries in Responders of Hazardous Substances Emergency Events, 1996 to 1998.	Yes	https://www.researchgate.net/profile/Perri_Ruckart/publication/12232699_Frequency_and_Type_of_Injuries_in_Responders_of_Hazardous_Substances_Emergency_Events_1996_to_1998/links/541733250cf2218008bedc78.pdf	Journal of occupational and environmental medicine 42.11 (2000): 1115-1120.		2000					
Zellmer, C.	Van Hoof, S. and N. Safdar	Variation in Health Care Worker Removal of Personal Protective Equipment	Yes	http://www.medicine.wisc.edu/sites/default/files/variation_in_health_care_worker_removal_safdar.pdf	American journal of infection control. 2015 Jul 1;43(7):750-1	10.1016/j.ajic.2015.02.005	2015			Emerging pathogens; healthcare associated infection		
Zhang, Y. Z.	Wang, B., W. Wang, W. C. Li, J. Huang, S. B. Deng, Y. J. Wang, and G. Yu	Occurrence and Source Apportionment of Per- and Poly-fluorinated Compounds (PFCs) in North Canal Basin, Beijing	No	n/a	Sci Rep. 2016 Nov 15;6:36683	10.1038/srep36683	2016					

ANNEX B

NFPA Codes and Standards with Applicability for Emergency Responder Contamination Control

Table B-1: NFPA Codes and Standards with Applicability for Emergency Responder Contamination Control

	A Doc #	B Ed- ition	C Rev Cycle	D Document Title	E Applicable Sections	F Category	G Relevancy	H Specific Input opportunities	I Criticality (1 - 5)
1	471	2002	N/A	Recommended Practice for Responding to Hazardous Materials Incidents	Chap 4, 7, 9, 10	HazMat	Not relevant – Incorporated into 472 and 473		5
2	472	2013	Annual 2017	Standard for Competencies for Responders to Hazardous Materials / Weapons of Mass Destruction Incidents	All	HazMat	Fire ground operations and contamination control in relation to those operations		5
3	475	2017	Fall 2021	Recommended Practice for Organizing, Managing, and Sustaining a Hazardous Materials/Weapons of Mass Destruction Response Program	Chap 5, 7, 9, 10	HazMat	Fire ground operations and contamination control in relation to those operations		4
4	405	2015	Annual 2019	Standard for the Recurring Proficiency of Airport Fire Fighters	Chap 7,8, 9,11,12	ProQual	Training of contamination control and equipment SCAM		3
5	473	2013	Annual 2017	Standard for Competencies for EMS Personnel Responding to Hazardous Materials/Weapons of Mass Destruction	All	ProQual	Fire ground operations and contamination control in relation to those operations		3
6	1001	2013	Fall 2017	Standard for Fire Service Professional Qualifications	All	ProQual	Fire fighter training, which can include contamination control training		5
7	1002	2017	Fall 2021	Standard for Fire Apparatus Driver/Operator Professional Qualifications	Chap 4	ProQual	Fire fighter training, which can include contamination control training		3
8	1003	2015	Fall 2018	Standard for Airport Fire Fighter Qualifications	All	ProQual	Fire fighter training, which can include contamination control training		3
9	1005	2014	Fall 2018	Standard for Professional Qualifications for Marine Fire Fighting for Land-Based Fire Fighters	All	ProQual	Fire fighter training, which can include contamination control training		3
10	1006	2017	Fall 2021	Standard for Technical Rescue Personnel Professional Qualifications	Chap 6, 16, 17, 18, 19, 20, 21, 22	ProQual	Fire fighter training, which can include contamination control training		3

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	A Doc #	B Ed-ition	C Rev Cycle	D Document Title	E Applicable Sections	F Category	G Relevancy	H Specific Input opportunities	I Criticality (1 - 5)
11	1021	2014	Fall 2019	Standard for Fire Officer Professional Qualifications	All	ProQual	Fire fighter officer training, which can include contamination control training		5
12	1026	2014	Fall 2017	Standard For Incident Management Personnel Professional Qualifications	Chap 4, 5, 8, 9, 10, 11, 12, 13, 14, 15, 20, 21, 24, 25, 29	ProQual	Fire fighter training, which can include contamination control training		3
13	1041	2012	Fall 2018	Standard for Fire Service Instructor Professional Qualifications	All	ProQual	Fire fighter training, which can include contamination control training		3
14	1051	2016	Fall 2019	Standard for Wildland Firefighting Personnel Professional Qualifications	All	ProQual	Fire fighter training, which can include contamination control training		3
15	1071	2016	Fall 2019	Standard for Emergency Vehicle Technician Professional Qualifications	All	ProQual	Fire fighter training, which can include contamination control training		3
16	1072	2017	Fall 2021	Standard for Hazardous Materials/Weapons of Mass Destruction Emergency Response Personnel Professional Qualifications	All	ProQual	Fire fighter training, which can include contamination control training		3
17	1081	2012	Fall 2017	Standard for Industrial Fire Brigade Member Professional Qualifications	All	ProQual	Fire fighter training, which can include contamination control training		3
18	1404	2013	Fall 2017	Standard for Fire Service Respiratory Protection Training	All	Training	Fire fighter training, which can include contamination control training		4
19	1405	2016	Fall 2019	Standard for Land-Based Fire Departments that Respond to Marine Vessel Fires	Chap 16	Training	Section on Post-incident activities can include contamination control awareness and training		2
20	1407	2015	Fall 2019	Standard for Training Fire Service Rapid Intervention Crews	Chap 8	Training	Fire fighter training, which can include contamination control training		3

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	A Doc #	B Ed-ition	C Rev Cycle	D Document Title	E Applicable Sections	F Category	G Relevancy	H Specific Input opportunities	I Criticality (1 - 5)
21	1410	2015	Fall 2019	Standard on Training for Emergency Scene Operations	Chap 6	Training	Fire ground operations and contamination control in relation to those operations		4
22	1451	2013	Fall 2017	Standard for a Fire and Emergency Service Vehicle Operations Training Program	Chap 10	Training	How to clean apparatus and equipment, important for contamination control		2
23	402	2013	Annual 2017	Guide for Aircraft Rescue and Fire-Fighting Operations	Chap 13	Ops & Manage-ment	Fire ground operations and contamination control in relation to those operations		3
24	403	2014	Annual 2017	Standard for Aircraft Rescue and Fire-Fighting Services at Airports	Chap 5, 6, 8, 9	Ops & Manage-ment	Fire ground operations and contamination control in relation to those operations		3
25	600	2015	Fall 2019	Standard on Facility Fire Brigades	All	Ops & Manage-ment	Fire ground operations and contamination control in relation to those operations		3
26	1143	2014	Annual 2017	Standard for Wildland Fire Management	Chap 4, 5, 7, 8	Ops & Manage-ment	Fire ground operations and contamination control in relation to those operations		3
27	1500	2013	Annual 2017	Standard on Fire Department Occupational Safety and Health Program	All	Ops & Manage-ment	Concerns fire fighter health and safety management		5
28	1521	2015	Fall 2019	Standard for Fire Department Safety Officer Professional Qualifications	All	Ops & Manage-ment	Fire fighter officer training, which can include contamination control training		5
29	1561	2014	Fall 2019	Standard on Emergency Services Incident Management System and Command Safety	Chap 8	Ops & Manage-ment	Fire ground operations and contamination control in relation to those operations		4
30	1581	2015	Fall 2020	Standard on Fire Department Infection Control Program	All	Ops & Manage-ment	Fire ground operations and contamination control in relation to those operations		4
31	1582	2013	Fall 2017	Standard on Comprehensive Occupational Medical Program for Fire Departments	All	Ops & Manage-ment	Concerns fire fighter health and safety management		4

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	A Doc #	B Ed-ition	C Rev Cycle	D Document Title	E Applicable Sections	F Category	G Relevancy	H Specific Input opportunities	I Criticality (1 - 5)
32	1584	2015	Fall 2020	Standard on the Rehabilitation Process for Members During Emergency Operations and Training Exercises	All	Ops & Manage-ment	Concerns fire fighter health and safety management		5
33	1700			Guide for Structural Fire Fighting		Ops & Manage-ment	Fire ground operations and contamination control in relation to those operations		
34	1710	2016	Annual 2019	Standard for the Organization and Deployment of Fire Suppression Operations, Emergency Medical Operations, and Special Operations to the Public by Career Fire Departments	Chap 6	Deploy-ment	Fire ground operations and contamination control in relation to those operations		3
35	1720	2014	Annual 2019	Standard for the Organization and Deployment of Fire Suppression Operations, Emergency Medical Operations and Special Operations to the Public by Volunteer Fire Departments	Chap 5	Deploy-ment	Fire ground operations and contamination control in relation to those operations		3
36	414	2017	Annual 2019	Standard for Aircraft Rescue and Fire-Fighting Vehicles	All	Appar-atus	Development and SCAM of apparatus		3
37	1901	2016	Annual 2020	Standard for Automotive Fire Apparatus	All	Appar-atus	Development and SCAM of apparatus		5
38	1906	2016	Annual 2020	Standard for Wildland Fire Apparatus	All	Appar-atus	Development and SCAM of apparatus		3
39	1911	2017	Fall 2021	Standard for the Inspection, Maintenance, Testing, and Retirement of In-Service Automotive Fire Apparatus	All	Appar-atus	Development and SCAM of apparatus		4
40	1912	2016	Fall 2020	Standard for Fire Apparatus Refurbishing	All	Appar-atus	Development and SCAM of apparatus		5
41	1915	2000	N/A	Standard for Fire Apparatus Preventive Maintenance Program	Chap 7, 8, 9	Appar-atus	Development and SCAM of apparatus		3

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	A Doc #	B Ed-ition	C Rev Cycle	D Document Title	E Applicable Sections	F Category	G Relevancy	H Specific Input opportunities	I Criticality (1 - 5)
42	1917	2016	Annual 2018	Standard for Automotive Ambulances	Chap 4, 5	Appar-atus	Development and SCAM of apparatus		5
43	1925	2013	Fall 2017	Standard on Marine Fire-Fighting Vessels	Chap 7, 20	Appar-atus	Development and SCAM of apparatus		3
44	1931	2015	Fall 2019	Standard for Manufacturer's Design of Fire Department Ground Ladders	Chap 4	Appar-atus	Development and SCAM of apparatus		2
45	1801	2013	Annual 2017	Standard on Thermal Imagers for the Fire Service	Chap 6	Equip-ment	Training of contamination control and equipment SCAM		3
46	1932	2015	Fall 2019	Standard on Use, Maintenance, and Service Testing of In-Service Fire Department Ground Ladders	Chap 4, 6	Equip-ment	Training of contamination control and equipment SCAM		2
47	1936	1936	Annual 2019	Standard on Powered Rescue Tools	Chap 6	Equip-ment	Training of contamination control and equipment SCAM		2
48	1937			Standard for the Selection, Care, and Maintenance of Rescue Tools		Equip-ment	Training of contamination control and equipment SCAM		3
49	1961	2013	Annual 2018	Standard on Fire Hose	Chap 4	Equip-ment	Training of contamination control and equipment SCAM		3
50	1962	2013	Fall 2017	Standard for the Care, Use, Inspection, Service Testing, and Replacement of Fire Hose, Couplings, Nozzles, and Fire Hose Appliances	All	Equip-ment	Training of contamination control and equipment SCAM		5
51	1963	2014	Fall 2018	Standard for Fire Hose Connections	All	Equip-ment	Training of contamination control and equipment SCAM		2
52	1964	2013	Fall 2017	Standard for Spray Nozzles	All	Equip-ment	Training of contamination control and equipment SCAM		2
53	1965	2014	Fall 2018	Standard for Fire Hose Appliances	All	Equip-ment	Training of contamination control and equipment SCAM		2
54	3	2015	Annual 2017	Recommended Practice for Commissioning of Fire Protection and Life Safety Systems	Chap 6	Exting. Agents	Possible fire fighter contamination risk		1
55	11	2016	Fall 2020	Standard for Low-,Medium, and High-Expansion Foam Systems	All	Exting. Agents	Possible fire fighter contamination risk		1

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	A Doc #	B Ed- ition	C Rev Cycle	D Document Title	E Applicable Sections	F Category	G Relevancy	H Specific Input opportunities	I Criticality (1 - 5)
56	11a	2004	N/A	Standard for Medium- and High-Expansion Foam Systems	All	Exting. Agents	Possible fire fighter contamination risk		1
57	11c	1995	N/A	Standard for Mobile Foam Apparatus	Not Active Document	Exting. Agents	Possible fire fighter contamination risk		1
58	12a	2015	Fall 2017	Standard of Halon 1301 Fire Extinguishing Systems	All	Exting. Agents	Possible fire fighter contamination risk		1
59	13e	2015	Fall 2019	Recommended Practice for Fire Department Operations in Properties Protected by Sprinkler and Standpipe Systems	All	Exting. Agents	Possible fire fighter contamination risk		1
60	16	2015	Fall 2018	Standard for Installation of Foam-Water Sprinkler and Foam-Water Spray Systems	All	Exting. Agents	Possible fire fighter contamination risk		1
61	17	2017	Fall 2021	Standard for Dry Chemical Extinguishing Systems	All	Exting. Agents	Possible fire fighter contamination risk		1
62	17a	2017	Fall 2021	Standard for Wet Chemical Extinguishing Systems	All	Exting. Agents	Possible fire fighter contamination risk		1
63	18	2017	Fall 2020	Standard on Wetting Agents	All	Exting. Agents	Possible fire fighter contamination risk		1
64	18a	2017	Fall 2021	Standard on Water Additives for Fire Control and Vapor Mitigation	All	Exting. Agents	Possible fire fighter contamination risk		1
65	298	1994	N/A	Standard on Foam Chemicals for Wildland Fire Control	All	Exting. Agents	Possible fire fighter contamination risk		1
66	770			Standard on Hybrid (Water and Inert Gas) Fire Extinguishing Systems	All	Exting. Agents	Possible fire fighter contamination risk		1
67	1145	2017	Annual 2021	Guide for the Use of Class A Foams in Fire Fighting	All	Exting. Agents	Possible fire fighter contamination risk		1
68	1150	2017	Fall 2021	Standard on Foam Chemicals for Fires in Class A Fuels	All	Exting. Agents	Possible fire fighter contamination risk		1
69	2001	2015	Fall 2017	Standard on Clean Agent Fire Extinguishing Systems	All	Exting. Agents	Possible fire fighter contamination risk		1
70	2010	2015	Fall 2019	Standard for Fixed Aerosol Fire-Extinguishing Systems	All	Exting. Agents	Possible fire fighter contamination risk		1

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	A Doc #	B Ed-ition	C Rev Cycle	D Document Title	E Applicable Sections	F Category	G Relevancy	H Specific Input opportunities	I Criticality (1 - 5)
71	1408	2015	Fall 2019	Standard for Training Fire Service Personnel in the Operation, Care, Use, and Maintenance of Thermal Imagers	Chaps 5,6,7	PPE SCAM	Possible required education for fire service personnel on contamination hazards		5
72	1851	2014	Fall 2018	Standard on Selection, Care, and Maintenance of Protective Ensembles for Structural Fire Fighting and Proximity Fire Fighting	Chaps 7,8,9	PPE SCAM	Procedures for cleaning and decontamination of firefighter protective clothing and equipment		5
73	1852	2013	Annual 2018	Standard on Selection, Care, and Maintenance of Open-Circuit Self-Contained Breathing Apparatus (SCBA)	Chaps 5,6,7	PPE SCAM	Procedures for cleaning and decontamination of SCBA		5
74	1855	2013	Annual 2017	Standard for Selection, Care, and Maintenance of Protective Ensembles for Technical Rescue Incidents	Chaps 5,6,7,8,9	PPE SCAM	Procedures for cleaning and decontamination of technical rescue PPE		5
75	1858		Fall 2017	Standard on Selection, Care, and Maintenance of Life Safety Rope and Equipment for Emergency Services		PPE SCAM	Procedures for cleaning and decontamination of rope, harness, and related equipment		5
76	1877		Annual 2019	Standard on Selection, Care, and Maintenance of Wildland Fire Fighting Clothing and Equipment		PPE SCAM	Procedures for cleaning and decontamination of wildland PPE		5
77	1951		Annual 2017	Standard on Protective Ensembles for Technical Rescue Incidents	Chap 6	PPE	Specific requirements for contamination resistance and provision of use instructions		5
78	1952	2015	Annual 2020	Standard on Surface Water Operations Protective Clothing and Equipment	Chap 6	PPE	Specific requirements for contamination resistance and provision of use instructions		5
79	1953	2016	Annual 2020	Standard on Protective Ensembles for Contaminated Water Diving	Chap 6	PPE	Specific requirements for contamination resistance and provision of use instructions		5

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	A Doc #	B Ed-ition	C Rev Cycle	D Document Title	E Applicable Sections	F Category	G Relevancy	H Specific Input opportunities	I Criticality (1 - 5)
80	1971	2013	Annual 2017	Standard on Protective Ensembles for Structural Fire Fighting and Proximity Fire Fighting	All	PPE	Specific requirements for contamination resistance and provision of use instructions		5
81	1975	2014	Fall 2018	Standard on Emergency Services Work Clothing Elements	All	PPE	Specific requirements for contamination resistance and provision of use instructions		5
82	1976	2000		Standard on Protective Ensemble for Proximity Fire Fighting	All	PPE	Specific requirements for contamination resistance and provision of use instructions		5
83	1977	2016	Fall 2020	Standard on Protective Clothing and Equipment for Wildland Fire Fighting	All	PPE	Specific requirements for contamination resistance and provision of use instructions		5
84	1981	2013	Fall 2017	Standard on Open-Circuit Self-Contained Breathing Apparatus (SCBA) for Emergency Services	All	PPE	Specific requirements for contamination resistance and provision of use instructions		5
85	1984	2016	Fall 2020	Standard on Respirators for Wildland Fire Fighting Operations	All	PPE	Specific requirements for contamination resistance and provision of use instructions		5
86	1986	2017	Fall 2021	Standard on Respiratory Protection Equipment for Tactical and Technical Operations	All	PPE	Specific requirements for contamination resistance and provision of use instructions		5
87	1987			Standard on Respiratory Protection Equipment for Tactical and Technical Operations	All	PPE	Specific requirements for contamination resistance and provision of use instructions		5
88	1989	2013	Annual 2018	Standard on Breathing Air Quality for Emergency Services Respiratory Protection	All	PPE	Specific requirements for contamination resistance and provision of use instructions		5
89	1991	2016	Fall 2020	Standard on Vapor-Protective Ensembles for Hazardous Materials Emergencies	All	PPE	Specific requirements for contamination resistance and provision of use instructions		5
90	1992	2012	Annual 2017	Standard on Liquid Splash-Protective Ensembles and Clothing for Hazardous Materials Emergencies	All	PPE	Specific requirements for contamination resistance and provision of use instructions		5

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	A Doc #	B Ed-ition	C Rev Cycle	D Document Title	E Applicable Sections	F Category	G Relevancy	H Specific Input opportunities	I Criticality (1 - 5)
91	1994	2012	Annual 2017	Standard on Protective Ensembles for First Responders to CBRN Terrorism Incidents	All	PPE	Specific requirements for contamination resistance and provision of use instructions		5
92	1999	2013	Annual 2017	Standard on Protective Clothing and Ensembles for Emergency Medical Operations	All	PPE	Specific requirements for contamination resistance and provision of use instructions		5
93	2112	2012	Annual 2017	Standard on Flame-Resistant Garments for Protection of Industrial Personnel Against Flash Fire	All	PPE	Specific requirements for contamination resistance and provision of use instructions		5
94	2113	2015	Annual 2019	Standard on Selection, Care, Use, and Maintenance of Flame-Resistant Garments for Protection of Industrial Personnel Against Short-Duration Thermal	All	PPE	Specific requirements for contamination resistance and provision of use instructions		5

KEY

A – Doc #: Refers to document number provided by the National Fire Protection Association
B – Edition: The year the standard was more recently promulgated
C – Rev Cycle: The cycle set by NFPA for the revision of the standard. Most NFPA standards are reviewed and revised every five years. Some standards may be short cycled or have extended period before revision are made. NFPA uses both a Fall and an Annual cycle that refers to a set of fixed dates for public input, public comment, and processing according to a standard revision schedule.
D – Document Title: Self-explanatory
E – Applicable Sections: Refers to the section in the standard, which may be impacted by contamination control issues
F – Category: Type of fire service product or operations affected by standard
G – Relevancy: Manner in which standard applies for addressing contamination control issues or practices
H – Specific Input Opportunities: Left blank; intended to provide area for indicating portions of standard that could be modified to affect contamination control issues or practices
I – Criticality: Project team assignment of potential impact of standard on fire service contamination control issues and practices

ANNEX C

Overview of Contamination Control Practices in Selected Related Industries

Overview of Contamination Control Practices in the Healthcare Industry

Contamination control in healthcare settings is focused on limiting the transmission of infectious diseases. Infectious agents of particular concern in the healthcare industry include human immunodeficiency virus (HIV), hepatitis B and C viruses, *Clostridium difficile*, *Mycobacterium tuberculosis* (in particular, multidrug resistant TB, MDR-TB), *Neisseria meningitidis* (meningococcal meningitis), the coronavirus causing SARS, methicillin-resistant *Staphylococcus aureus* (MRSA), Vancomycin-resistant *enterococci* (VRE), and multiple species of *Acinetobacter*. Acts of bioterrorism may involve other infectious agents such as *Bacillus anthracis* (anthrax), *Clostridium botulinum* (botulism), *Yersinia pestis* (plague), *Variola* virus (smallpox), arenaviruses and bunyaviruses (viral hemorrhagic fevers such as caused by Marburg and Ebola viruses), *Francisella tularensis* (tularemia) and others. Other situations requiring contamination control include radiation and chemical emergencies.

Infection control is accomplished through a progression of administrative, environmental and PPE measures. Administrative measures include actions such as developing and implementing agent-specific plans, ensuring the cleaning, disinfecting, and sterilizing of items as appropriate, and training healthcare workers. Environmental controls are used to remove an infectious agent from the healthcare area, for example by using exhaust ventilation to remove contaminated air or using HEPA filters to clean air. Use of personal protective equipment such as respirators further reduces risk.

Infection control practices implemented by the individual healthcare provider include handwashing, use of personal protective clothing and equipment (PPE), and appropriate handling of specimens, sharps, waste, and contaminated garments and PPE. These practices are designed to minimize transmission of infectious agents through airborne, droplet, and contact routes when used in conjunction with the effective decontamination of surfaces, equipment and clothing. Infection control practices implemented by the facility address the cleaning and disinfecting of instruments (endoscopes, etc.), the hard surfaces in patient rooms and wards (rails, IV poles, etc.), and fabric surfaces (drapes, curtains, etc.). Contamination control comprises not only cleaning to removal of surface soils and organic matter but also disinfecting with agents or technologies to kill most microbes (except for spores) and sterilizing with agents or technologies to destroys microbes including spores).

Cleaning, whether performed manually or mechanically, typically entails use of water with detergents or enzyme-based products. Friction and fluidics remove surface soils. Mechanical cleaning of instruments or equipment may be accomplished with ultrasonic machines or washer-sterilizers (steam sterilizers modified to include a cleaning cycle before the sterilizing cycle).

Chemical disinfectants include alcohols (isopropanol and ethanol), chlorine and chlorine compounds such as sodium hypochlorite and “superoxidized water” (electrolyzed saline), formaldehyde and formalin (37% formaldehyde by weight), glutaraldehyde, hydrogen peroxide, iodophors, ortho-phthalaldehyde (OPA), peracetic acid, peracetic acid and hydrogen peroxide, phenolics, and quaternary ammonium compounds (quats). The appropriateness of a particular chemical disinfectant depends on the makeup of the materials being disinfected and the intended use of the materials. For example, alcohols are not suitable for surgical materials but are acceptable for disinfecting the exterior of medication bottles.

Sterilization is accomplished with steam, ethylene oxide gas, hydrogen peroxide gas plasma, peracetic acid immersion, or ozone. Some liquid chemicals (glutaraldehye, hydrogen peroxide, peracetic acid, and peracetic acid/hydrogen peroxide) are also FDA-cleared for sterilization of medical devices. Steam sterilization in an autoclave is most common. Pressure is used to obtain high temperatures (typically 121℃ or 132℃). Exposure times vary depending on type of item and whether the autoclave is a gravity displacement or high-speed prevacuum model. "Flash" steam sterilization (132 ℃ for 3 minutes at 27-28 lb pressure) is sometimes used on clean patient-care items when the regular methods are not possible. Sterilization can be accomplished at lower temperatures with agents such as ethylene oxide. The ethylene oxide method is more expensive, requires more time, and has potential hazards than the steam methods, but it can be used for sterilizing heat and moisture sensitive items. Newer technologies include gas plasma systems using hydrogen peroxide gas or peracetic acid-acetic acid-hydrogen peroxide vapor. Other sterilization technologies include immersion in peracetic acid, radiation, dry heat sterilization (requires higher temperatures and long cycle times), and ozone.

A scenario involving tuberculosis serves as an example of contamination control in a healthcare setting. The Centers for Disease Control and Prevention provides guidelines specific to TB. The healthcare facility has already in place a general infection control program to identify potentially infectious patients, to take precautions to limit the transmission of the infectious agent, and to treat the patient. Within this plan are the TB-specific administrative and environmental controls that the facility has instituted to help control the risk of infection from a patient with TB. Some of the administrative measures include charging designated employees with assessing the TB risk for various healthcare workers; ensuring availability of resources such as laboratory testing; identifying and implementing practices to minimize risk to health care workers tending the patient; educating, training, and counseling those who might have contact with the patient; and ensuring that possibly contaminated equipment is appropriately cleaned, disinfected, and sterilized. Because airborne transmission of *Mycobacterium tuberculosis* is of particular concern, environmental controls to address this include using devices such as hoods and tents that provide local exhaust ventilation in addition to general ventilation. The flow of contaminated air from an isolation room to nearby areas is minimized by using HEPA filters or ultraviolet germicidal irradiation to clean the air. A third control measure is the implementation of a respiratory protection protocol including use of personal respiratory protective equipment (such as a NIOSH-approved particulate filtering facepiece respirator like the N95 disposable respirator) with appropriate training of health care workers and educating the patient in respiratory hygiene including "cough etiquette."

Administrative measures include determining appropriate protocols for procedures in which the possibility is high for aerosol formation. For example, extra precautions are needed in bronchoscopy suites and during autopsy and embalming, particularly when saws are used. Environmental controls include special attention to ventilation and air cleaning. While a major concern is transmission of airborne *M. tuberculosis*, contaminated equipment, for example a contaminated bronchoscope, can spread *M. tuberculosis*. Administrative measures include identifying contamination procedures for patient care equipment and ensuring that these procedures are followed.

Noncritical medical instruments or devices (e.g., blood pressure cuff) that are contaminated with blood or bodily fluids are cleaned with a hospital -grade, EPA-registered germicide disinfectant with tuberculocidal activity. Minimally soiled noncritical items and surfaces like floors are cleaned with low-level disinfectants. During cleaning of an occupied patient room, workers follow precautions against airborne particulates; however, because environmental surfaces do not transmit TB, PPE is not needed during cleaning of the room of a discharged patient, provided that the room has been ventilated appropriately. Semi-critical medical instruments (e.g., bronchoscopes) are cleaned meticulously and then disinfected with a high level disinfectant or, preferably, sterilized. Critical medical instruments (e.g., surgical instruments) are cleaned and sterilized.

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Overview of Contamination Control Practices in the Nuclear Power Industry and Other Industries Using Radiation

The major types of radiation that are generally encountered include alpha, beta, gamma ray, and x-ray radiation. However, one encounters neutron radiation in nuclear power plants and some industrial settings.

Alpha particles are helium nuclei. Examples of alpha emitters are radium, radon, and uranium. While even a sheet of paper or the top layer of dead skin cells are sufficient to block them, alpha particles can be very harmful if inhaled, ingested, or absorbed into the bloodstream through non-intact skin. Beta particles are ejected electrons or positrons. Sources include tritium and carbon-14. These can penetrate skin to the germ layer and cause severe skin damage. Beta particles are also harmful if absorbed internally. Gamma rays and x-rays are high energy electromagnetic radiations that readily penetrate may materials including several inches into human tissue. Gamma ray sources include iodine-131, sesium-137, radium-226, and cobalt-60. X-rays are typically produced by firing an electron beam from a cathode at a metal target. Gamma and x-rays cause severe health effects including acute radiation syndrome. Neutrons are neutral particles emitted during nuclear fission. They are indirectly ionizing and so can make other materials radioactive. Radiation with neutrons can have devastating effects on the whole body. Table 1 summarizes characteristics of different types of radiation.

Table C1 – Characteristics of Different Types of Radiation

Type	Penetration of skin	Shielding	Hazard mode	Detector	Possible health effects
Alpha particles	Virtually non-penetrating	Sheet of paper; layer of clothing	Ingestion, inhalation, absorption into blood through wound	Thin-window Geiger-Meuller (GM) probe	cancer; DNA damage; acute radiation syndrome (rarely)
Beta particles	Moderately penetrating	Thin layer of aluminum or clothing (several mm thick)	Direct exposure to skin, ingestion, inhalation, absorption through wound	Thin-window Geiger-Meuller (GM) probe	Skin damage with severe sunburn effect; cancer or other damage internally
X-rays	Highly penetrating	Dense material like lead (many cm) or concrete (meter or more)	Direct exposure to skin	Sodium iodide detector probe	Skin damage, cancer, ARS

Type	Penetration of skin	Shielding	Hazard mode	Detector	Possible health effects
Gamma rays	Highly penetrating	Dense material like lead (many cm) or concrete (meter or more)	Direct exposure to skin	Sodium iodide detector probe	Acute radiation syndrome (ARS), cancer, DNA damage
Neutrons	Highly penetrating	Concrete or water (meter or more)	Direct exposure to skin, ingestion, inhalation, absorption through wound	Gas proportional detectors	Acute radiation syndrome (ARS), cancer, DNA damage

In addition to nuclear power generation, radiation has applications in medicine, academia, and industry. Common medical applications of radiation include:

- X-rays used for imaging, including CAT scans;
- Irradiation of medical equipment to kill microbes;
- Nuclear medicine, using radioactive isotopes therapeutically, such as iodine-131 for treatment of thyroid disease.

Academic institutions use radiation for a range of applications including:

- Carbon dating using C-14;
- Elucidation of chemical reaction pathways using radioactive isotopes as tracers;
- Identification of compounds such as components of petroleum products with low energy radioactive sources in gas chromatography.

Industrial uses encompass a broad range of application including:

- Irradiation of food to kill microbes;
- Irradiation to remove certain toxic pollutants such as electon bean radiation to remove sulfur and nitrogen oxides from exhaust gases;
- Agricultural applications such as pest control;
- Radiography using x-rays to locate defects in metallic casings;
- Radioactive sources in detection equipment used in oi and gas exploration.

Controlling time, distance, and shielding are the main ways to limit personal exposure to external radiation. The dose of radiation received is directly related to the exposure time. Similarly, the distance from the individual to the radiation source affects the dose, as the intensity of the exposure falls exponentially with distance from the source. Depending on the extent of exposure control possible through time and distance, shielding with a material appropriate for the type of radiation is necessary. The "stay time" (maximum time that an individual can stay in a area before exceeding a prescribed exposure limit) is equal to the limit (in mrem) divided by the dose rate (mrem/hr). External radiation exposure is monitored with different types of personal monitoring devices including film badges and dosimeters, such as thermoluminescent (TDL), optically stimulated luminescent (OSL), or pocket dosimeters. OSL dosimeters are commonly used in the United States.

Internal radiation exposure occurs through inhalation of dusts or aerosolized particles, ingestion of contaminated water or other materials by mouth, absorption through intact skin, or enty into the body through wounds or puncture with a contaminated object. Limiting internal exposures is accomplished by isolating the radiation sources (sealing samples, using fume hoods, etc.), having separate radioactive and nonradioactive work areas, implementing contamination control zones, and scrupulously using protective clothing, monitors, etc. Good work practices such as proper labeling of containers of radioactive material is vital. Internal radiation exposures are monitored with bioassays including biological samples and partial or whole body counting.

To contain radiation hazards to certain areas and limit contamination to other areas, access must be controlled and protocols such as changing clothing and footwear may be implemented. Ventilation control can also help to control hazards. A HEPA filter can remove radioactive particles from the air. Charcoal filters are used for some isotopes. Keeping negative pressure in areas with the potential for contamination and controlling air flow rates also limit exposures. Exit monitoring can include frisk monitors, hand contamination monitors and whole body monitors. Workers should use step-off pads to reduce the chance of bringing contamination into other areas.

In the event of contamination of objects or surfaces, the scope of decontamination depends on the radiological conditions and the cost. Decontamination does not get rid of the radiactive materials; rather the radioactive material is removed to another controlled area. Thus, the benefit of decontamination of objects must outweigh the cost and the hazards involved in the the decontamination. Radioactive contamination of surfaces is “fixed” or “free”. Fixed contamination cannot be spread although the radioactivity is measurable. Free contamination can be spread to other surfaces or into the air. A contaminated surface may be decontaminated in different ways. A concrete surface might be shaved to remove the contamination. Transferable radioactive contaminants can be fixed to a surface with certain products, or a strippable film or decontamination gel can be applied to trap the contaminants. Wipes must be used with care to avoid recontaminating a surface. Decontamination methods should be chosen to limit the chance of spreading radioactive particles to the air.

Decontamination of workers depends on the type of radiation and the exposure mode. Mild soap and lukewarm water are used to decontaminate intact skin. Scrubbing and using harsher cleansers and hot or cold water could actually result in internal exposures as cold water may open pores, vigorous scrubbing may abrade skin, and harsher cleansers and cold water may chap the skin. Internal radiation exposures may be treated with different chemicals depending on the type of exposure. For example, potassium iodide is used to keep the thyroid gland from absorbing as much radioactive iodine. Prussian blue binds with radioactive cesium and thallium and then the body excretes them. Diethylenetriamine pentaacetic acid binds to radioactive plutonium, americium, and curium.

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Overview of Contamination Control Practices in the Hazmat Industry

Contamination control in the hazardous materials remediation comprises protecting the personnel and the environment both during the response activities and afterwards during decontamination. HazMat responses are mostly regulated by the Environmental Protection Agency (EPA), the Occupational Health and Safety Administration (OSHA), the Department of Transportation (DOT), and the Pipeline and Hazardous Materials Safety Administration (PHMSA). Recommendations are also provided through the National Institute for Occupational Safety and Health (NIOSH).

To control contamination of personnel during response activities, protocols are designed to limit contact with hazardous materials and adherence to these is enforced. The site is first characterized by reviewing available information about what substances are or suspected to be present, identifying the risks associated with those substances, developing a site control plan and a Health and Safety Plan for performing the work safely, and notifying workers of dangers.

Specific protocol recommendations depend on the particular hazardous substances known or suspected to be present. These protocols include use of engineering controls, protective clothing and equipment, etc. to limit exposure. OSHA provides guidance for Standard Operating Procedures including examples for specific practices described in Table C-2.

Table C-2: Examples of Standard Operating Procedures to Minimize Contamination by Hazardous Materials
(summarized from: "Decontamination." *Hazardous Waste*. United States Department of Labor, Occupational Safety and Health Administration.)

Standard Operating Procedure	Example
Use appropriate PPE for the situation	Use disposable outer garments and disposable equipment where appropriate
Choose work practices to minimize contact with hazardous materials	Avoid walking through areas of obvious contamination
Use remote sampling and handling techniques	Use devices such as drum grapplers and pneumatic impact wrenches
Protect scientific instruments from contamination	Bag monitoring and sampling instruments with minimal bag openings made for sample ports or sensors
Protect tools and equipment from contact with hazardous materials	Use strippable coatings that are removable during decontamination
Encase contamination source	Use plastic sheeting or overpacks

The response site is divided into work zones with the goal to contain contamination. The specific zones can vary by situation but typically three zones are observed:

- The exclusion zone (hot zone) includes the actual hazardous substances; the chance of contamination is high.
- The contamination reduction zone (CRZ or warm zone) is the point of access to and egress from the hot zone; decontamination occurs here (except for final wash and redressing which occurs in the support zone).
- The support zone (cold zone) is the planning and staging area; it is free of contamination.

The contamination reduction zone contains decontamination stations whose number and layout depends on the particular hazards and the level of personal protection required. This zone also contains areas for emergency response (for example, if responders are injured), sampling supplies, equipment resupply (air tanks, additional PPE), and rest areas for workers.

Decontamination begins at the Hot Line. Each site has at least two lines: one for personnel and one for heavy equipment. The location of the lines depends on site characteristincs such as the physical layout of the site, drainage, and proximity to combustible gases. The Contamination Control line separates CRZ from the support zone and is located at the interface between the support zone and the area of the CRZ which has the lowest levels of contamination.

The equipment and materials required for decontamination depends on the particular hazards and level of PPE. Decontamination can be accomplished through physical means (rinsing, wiping, etc.) or chemical means (inactivation via chemical reaction, sterilization, or disinfection), or through a combination of both. Common decontamination types are listed in Table C-3.

Table C-3: Common Decontamination Methods
(based on Table 10-1, "Some Decontamination Methods," in *Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities*).

Physical Decontamination Methods	Water rinse (gravity or pressurized flow) Pressurized air jets Scrubbing or scraping Evaporation or vaporization
Chemical Decontamination Methods	Halogen stripping Neutralization Oxidation/Reduction reactions Thermal degradation
Disinfection/Sterilization Methods	Chemical disinfection Steam sterilization Dry heat or steam sterilization Gas or vapor sterilization Irradiation
Other methods	Removal and disposal of deeply permeated clothing, protective coatings, etc.

Impermeable PPE is decontaminated before doffing and procedures are followed to minimize exposure to contaminants during doffing. The worker removes the permeable clothing before showering in the warm zone. Depending on the level of PPE required, the decontamination line contains up to 19 stations, each of which entails completion of an action focused on a particular aspect of the decontamination process, ranging from placing used tools or equipment in designated containers at Station 1 to dressing in clean clothes at Station 19. Typical stations for decontamination when Level A PPE is used are described in Table C-4. Appropriate containment and disposal methods are identified and used for contaminated or partially decontaminated clothing, equipment, spent cleaning solutions, washwater, etc.

Table C-4: Decontamination Stations for Level A Protection

(based on the table "*Maximum Decontamination Layout - Level A Protection*" *in* "Decontamination." *Hazardous Waste*. United States Department of Labor, Occupational Safety and Health Administration.

STATION(S)	ACTION(S)
1	Deposit equipment, tools, etc. into designated containers
2,3	Wash and then rinse boot covers and gloves
4	Remove tape
5,6	Remove boot covers and then outer gloves
7,8	Wash and then rinse suit and safety boots
9 (skip if not re-entering hot zone)	If re-entering hot zone: change air tank and dress with fresh boot covers and outer gloves
10, 11, 12	Remove in this order: safety boots, then fully encapsulating suit and hard hat, then SCBA backpack
13, 14	Wash and then rinse inner gloves
15, 16, 17	Remove in this order: facepiece, then inner gloves, and then inner clothing
18, 19	Field wash (in the Support Zone) and then dress in clean clothing.

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ANNEX D

Possible Organizational Resolution Text for Fire Service Contamination Control

Possible Organizational Resolution Text for Fire Service Contamination Control

Background: This is a draft resolution for consideration by organizations interested in supporting and/or promoting the concepts of contamination control by the fire service. This has been generated as a supporting element for the AFG funded project "Campaign for Fire Service Contamination Control".

[ORGANIZATION NAME]

Resolution Text for Fire Service Contamination Control

[Date Adopted]; Version [1.0]

Whereas the profession of fire fighting regularly faces chemical and biological contaminants that are dangerous to the health and wellness of fire fighters;

Whereas there is an immense spectrum of harmful contaminants in typical fires and other emergency events faced by fire fighters;

Whereas the average fire fighter is exposed to harmful contaminants in every event requiring use of an SCBA for an IDLH atmosphere;

Whereas fire ground contaminants are easily spread beyond the fire ground, by contamination to PPE, equipment, hose, apparatus, and other conveyors, and ultimately become deposited at fire stations and beyond;

Whereas today's fire service is seeing increased occurrences of cancer among its fire fighters, along with impact on younger members and occurrence of rare forms of cancer; and

Whereas that dirty gear in no longer recognized as a badge of experience or honor; now, therefore, be it

Resolved, that the [ORGANIZATION NAME]:

1. Urges all members at all levels of the organization support the concepts of contamination control at all times, with appreciation that failure to do so jeopardizes the health and wellness of themselves, their fellow members, and their families,

2. Urges the establishment, use and maintenance of credible and relevant best practices for use by all members;

3. Urges the on-going revision of all applicable codes and standards to fully address the concepts of fire service contamination control,

4. Urges special consideration be given to promoting contamination control concepts for fire stations because of the long durations of exposures to members, and

5. Urges that more research be conducted to support all aspects of this issue where knowledge gaps exist, with deliverables that will contribute to the literature on this topic, and will have relevant impact on making fire fighters safer.