

FIGHTING CANCER RATES WITH BEST PRACTICES & INNOVATION

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INTRODUCTION

The fire service is making strides in its effort to reduce the number of firefighters who are diagnosed with firefighter-related cancers as more information becomes available, but there still is plenty of work to do, as cancer continues to be a leading cause of death for active and retired firefighters.

Chiefs are implementing policies that are based on the latest research on carcinogens to which firefighters are exposed as well as regarding on-scene and preliminary exposure reduction programs. They also are arming themselves with the data, to justify purchasing additional PPE and washers and extractors; to utilize verified ISP's for annual advanced cleanings and inspections; to ensure benefits for firefighters and their loved ones; and to improve health exams to catch cancer earlier.

As photographers submit fireground scenes from across the country, we see an increasing number of firefighters wearing SCBA during suppression and overhaul operations as well as gross decontamination efforts taking place more often.

Research shows that firefighters are exposed to carcinogens not only at fire scenes but also during training burns. It's important that firefighters take part in live-fire training to learn and reinforce critical skills for reading smoke, understanding fire behavior and for fire attack and fireground search operations, particularly as the frequency of fires in many areas is down and the roster of experienced firefighters is dwindling. Basic skills, such as hoseline advancement, and ladder placement can be completed in non-live fire environments, reducing exposures. As fire stations are built and renovated, careful consideration is being put into those facilities to separate work and living spaces to limit exposures.

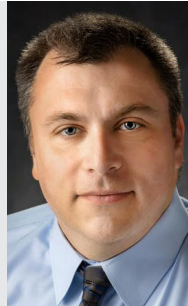


We're happy to present this eBook to help you to navigate the challenges that fire departments face, along with options to help your agency reduce exposures and increase awareness, and education with the goal of reducing firefighter illnesses and deaths from cancers.

They say it takes a generational turnover of about 15–20 years to implement cultural changes, such as fighting cancer while fighting fires, and the fire service is doing great work, but there's plenty left to do to add years to their lives.

AUTHOR

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VOLUNTEER FIRE SERVICE & OCCUPATIONAL CANCER

More research can help to identify chemical exposures at the workplace and to protect the health of women who are in the fire service.

Volunteer firefighters provide life-saving services to local communities throughout the country. Unfortunately, this untiring dedication comes with risks, sometimes known and sometimes unknown. By identifying and understanding these risks, they take the actions that are needed to lessen the hazards that are faced, so they can continue to do the job that they love.

Over the past six years, firematic associations have been adamant about communicating the issues that relate to occupational cancer. Just five years ago, the National Fallen Firefighters Foundation joined forces with national fire service organizations from career, volunteer and wildland to build a foundation of concern about the rising number of firefighters who are diagnosed with cancer. They called it an “epidemic.” It was that word, and that word alone, that brought about the realization that this is a battle for their lives, and this battle wouldn’t be won fighting it alone.

A CHANGE IN ATTITUDE

How can the job that we love give us cancer? What can be done to protect firefighters and to serve the community without this threat looming? It turns out that the culture is perhaps the biggest obstacle. Firefighters are self-determined to define their value and routinely indicate that, as long as they get to decide when to stop being firefighters, they can accept the consequences of the profession.

Unfortunately, so many of those firefighters traded their health for the job. However, it doesn’t have to be this way.

Cancer doesn’t have to be accepted as another consequence of the dangerous profession that



firefighters choose to pursue. It is in departments’ and individuals’ power to take actions that will lessen risks and make it far less likely that anyone will become another statistic. However, to do this requires a change in attitude. Harmful toxins and carcinogens must be mitigated. The days of showing off dirty helmets and gear are over. Pride must be taken in doing everything possible to decontaminate people, gear, equipment and vehicles after a fire call. Taking these actions enables everyone to be there for the next call.

Understand the causes and learn the steps that you can take to mitigate the threats and reduce your risks; doing so will make you feel as if you can take care of yourself and that you are doing what you need to do to be there for your family. It also will make you understand the value of what you have now, both in the station and as you walk through the front door of your home after a call. Attacking the risks that you face when it comes to occupational cancer is something that you never must place on a shelf or in an office drawer and forget.

MY PERSONAL EXPERIENCE

My challenge began on Dec. 24, 2014, when my life changed forever. Being diagnosed with B-cell non-Hodgkin’s lymphoma, which was attributed to my job as a volunteer firefighter, was a message that I had a very difficult time understanding. After 37 years in the volunteer

fire service helping people, why did I feel like a failure?

I was that volunteer firefighter who never washed his hood and very seldomly washed turnout gear and helmet, because it was my badge of courage. Yet, looking back at it now, I would’ve taken the time to do things very differently if I would’ve known the pain that I could have spared myself and my family. (Read McQueen’s Survivor Story profile on page A9.)

Cancer will change you. It will shape you and set your course in directions that you never have imagined. However, in the end, it won’t crush, consume or destroy you. Jim Valvano stated in his famous ESPY speech, “Cancer can take away all my physical abilities. It cannot touch my mind, it cannot touch my heart, and it cannot touch my soul.” My treatments were completed at Memorial Sloan Kettering Cancer Center in New York City. I lived in a hotel five days per week for seven weeks while undergoing the treatments. Laying under the intensity-modulated radiation therapy (IMRT) machine for 45 minutes each day, I wondered whether the cancer would enter into remission and end this horrible nightmare.

What I took from my experience is that I had to do more to raise awareness of the epidemic and work toward preventing my brothers and sisters from going through this experience.

VOLUNTEER CHALLENGES

Volunteer fire departments face some unique challenges in that their budgets might not cover such things as new turnout gear, washer/extractors, second hoods, etc. They also might have responders who carry their gear in their own vehicles. Many departments need to re-examine their SOPs/SOGs to ensure that they are doing all that they can to reduce exposure risks. That is why I worked with the International Association of Fire Chiefs—Volunteer & Combination Officers Section and the National Volunteer Fire Council to develop the first “**Lavender Ribbon Report**.” It was aimed at providing best practices for preventing firefighter cancer, so volunteer departments and individual firefighters would have an action plan that has clear guidance for how they can reduce the risks.

I also realized that we needed to do more to ensure that those of us who do get the diagnosis have financial support. It is a terrible revelation that many states either don't have a cancer presumption law or don't cover volunteer firefighters in their existing law. At the time of my treatment, the state of New York didn't have a law that included volunteers. I joined the ongoing effort to rectify this situation along with the Firemen's Association of the State of New York, the New York State Association of Fire Chiefs, the New York State Fire Coordinators' Association and the Association of Fire Districts of the State of New York.

We built a solid campaign for the passage of the New York State Volunteer Firefighter Cancer Benefit Program, which was signed into law two years ago. Although this law will provide financial assistance to the volunteer firefighters in the state of New York, it can't be the answer to the problem. The mission must be to prevent the use of this financial solution.

Volunteer firefighters must begin early in their fire service careers. They must take lessons from fire departments across the nation that have embedded cancer prevention education in their new recruit classes. You must be vigilant in following NFPA standards and guidelines to properly decontaminate gear on scene and at the station.

ANOTHER PART OF THE BATTLE

Having worked with volunteer firefighters from my county in the formation of the Believe 271 Foundation Inc. to support volunteers in their cancer fights, we now realize the unfortunate issues that are faced with post-traumatic stress (PTS) with a cancer diagnosis. This PTS is one that will be in the forefront of the battle for years to come. Firefighters who are dealing with cancer might have symptoms of PTS at any point from diagnosis through treatment, after treatment is complete or during possible recurrence of the cancer. Family members of firefighter cancer survivors also might have PTS.

Symptoms of PTS usually begin within the first three months after the trauma, but sometimes they don't appear for months or even years afterward. Even though it's been six years since my cancer battle, there still are many nights when I lay awake in bed, praying to God that my cancer never comes back. I look at the ceiling visualizing the IMRT machine making its trek across my body. Sometimes this becomes so

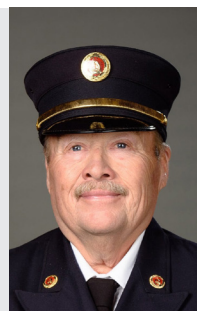
intense that it feels like I am actually living through the event all over again. My wife understands. She asks me quite often if I am OK. She walked the walk with me. Just take a look in the chart at the comparison between occupational cancer and the mental issues that can be faced with PTS. Occupational cancer is such a powerful and painful diagnosis. The more of us who stand up to this terrible disease and do what we can to reduce our risks, the closer that we come to defeating it. For those who do receive that diagnosis, we need to understand the emotional effect that comes with it. So, now, fire service leadership not only is challenged with educating firefighters to the dangers of cancer, they must be even more aware of the mental strains that are placed on occupational cancer survivors when they return to work. Families as well must understand that there is more to beating cancer than the treatments. There has to be a bond of love and understanding for those who are going through this fight. Understand where and when to turn for help.

CANCER	POST-TRAUMATIC STRESS
Exposure to carcinogenic and toxic chemicals	How will I handle the stress related to my fire service and personal life after being diagnosed?
Where do I go from here?	Flashbacks occurring all times of the day Being unable to think clearly
Denial of being diagnosed with occupational cancer	How do I handle the pain associated with treatments?
Annual Checkups	You live in a world filled with anxiety and the unknown.
Terminal Diagnosis	Failing to understand why Avoiding other people
How long will I live after treatments?	Feeling like I failed myself, my family and my friends
Realizing the importance of family and friends	Why Me? Loss of interest in life



AUTHOR

Brian McQueen is past chief of the Whitesboro, NY, Fire Department and past director of the Firemen's Association of the State of New York (FASNY). He serves as a New York director.



UNDERSTANDING CANCER IN WOMEN FIREFIGHTERS

More research can help to identify chemical exposures at the workplace and to protect the health of women who are in the fire service.

A few years ago, a female firefighter who served in a small rural department was diagnosed with breast cancer. After the diagnosis, the firefighter was directed to the department's secretary (who also functioned as the human resources director and the disability officer) to fill out the necessary initial injury paperwork.

Not sure how to answer all of the disability questions and looking for direction, the firefighter asked the secretary, "Do you think my cancer is job-related?" The secretary replied, "No, honey, firefighting didn't cause your breast cancer." The critical box asking whether the injury was work-related was left unchecked. As a result, this firefighter fought many legal battles with her department but never received compensation for her injury.

This case is far from unique and not exclusive to women firefighters but highlights the lack of peer support and isolation that many women firefighters experience when diagnosed with breast cancer. The lack of information and understanding that surrounds breast cancer in a minority population, particularly women in the fire service, is tangible. Could a bit of education and a few resource recommendations help to prevent this outcome from happening to other women firefighters across the nation?

For the past six years, I have been involved in a study that looks at chemical exposures in women firefighters that are work-related. This work has taught me to respect and understand the power of science as it relates to you and me—our firefighter community.

Because my colleagues were getting sick from



In 2012, a rise in breast cancer diagnosis among San Francisco Fire Department (SFFD) firefighters was noticed. Pictured: SFFD firefighters Julie Mau (left), Heather Buren and Dawn DeWitt.

and dying of cancer, I became interested in cancer as an occupational disease and began working with local scientists and breast cancer advocates to determine why this was happening and what could be done.

Please be advised, the implications for health and wellness outcomes and cancer concerns of particular relevance to women firefighters (and the information that's provided) are relevant for other types of cancer in the fire service and can be used to benefit all.

Women make up less than 10 percent of firefighters across the nation. However, as departments continue to diversify, it is important to understand the extent of chemical exposures in the workplace and to explore tangible ways to protect the health of women firefighters.

A HIGHER CHANCE OF CANCER?

Occupational cancer is a critical issue that the nation's firefighters face. In fact, it is the leading

cause of death in firefighters today. Although we know that some cancers are influenced by a person's behaviors (such as tobacco use and sun exposure without protection), these "lifestyle factors" aren't enough to explain cancer in the fire service. Is it possible that the occupation of firefighting could be causing cancer? The International Agency for Research on Cancer (IARC), which ranks different exposures for their cancer risk based on available science, classifies the occupation of firefighting as class 2B carcinogen, or possibly carcinogenic. In addition, firefighting is the only occupation to be reviewed by the IARC for its cancer risk.

Firefighters are exposed to known carcinogens and hundreds of other chemicals on the fireground and in the station, from diesel exhaust and firefighting foams to even PPE. The fire service's occupational exposures can be described as a chemical soup that contains thousands of chemicals. Some of the chemicals are known or suspected carcinogens, but many others lack toxicity data that make it difficult to

assess the health effects of all of the chemicals to which we are exposed.

Cancer doesn't develop all at once. It happens through a series of changes in body processes that collectively transform normal cells into cancer cells. Many chemicals that can interact with these processes are considered partial carcinogens. They don't cause cancer by themselves, but exposures to high levels of chemicals or to combinations of these substances might overwhelm the body's defenses, which can result in cancer.

Starting in 2012, firefighters noticed an alarming uptick in breast cancer diagnosis among the ranks of the San Francisco Fire Department (SFFD). While searching for information on incidences of cancer in women firefighters, and to better understand chemical exposures with relevance to women's health, I was surprised that I could find no such information. There were many studies about firefighters that documented increased exposures to carcinogenic compounds and elevated rates of certain cancer, but this research focused exclusively on men. I now understand that one of the reasons for this data gap is because of the underrepresentation of women in the profession. The low number of women firefighters makes it difficult for scientists to characterize women's workplace exposures.

To understand how women firefighters are exposed to potential breast carcinogens and other chemicals, it was clear that we needed to create our own data. At approximately 15 percent of the workforce, the SFFD has the largest number of women firefighters of any urban fire department in the country. This makes it the ideal location to conduct a research study that focuses exclusively on women firefighters.

We undertook a community-based participatory biomonitoring project that was funded by the California Breast Cancer Research Program. This partnership of firefighters, environmental health scientists and advocates became the Women Firefighters Biomonitoring Collaborative (WFBC). It sought to address the gap in information on occupational exposures among women

firefighters by examining exposures to environmental chemicals that are linked to breast cancer, including potential carcinogens and chemicals that disrupt the body's normal hormone function.

The WFBC collected biospecimens and interview data from 80 women firefighters and 80 women office workers from San Francisco. The samples were analyzed for perfluorinated chemicals and flame retardants. Study updates and recent publications can be found by visiting biomonitoringcollaborative.org. For a recently published scientific paper on perfluoroalkyl substances (PFAS) in women firefighting, you also can read the article, "Exposure to Perfluoroalkyl Substances in a Cohort of Women Firefighters and Office Workers in San Francisco," which was published in the scientific journal *Environmental Science & Technology*. It will be available for download starting in February 2021.

WARNING SIGNS FOR CANCER?

Because cancer prognosis is better when cancer is caught in its early (incipient) stages, it is recommended that you get tested early and often. Currently, there are reliable screenings for breast, cervical, colorectal and lung cancer. You might need to educate your clinician to consider initiating earlier screening or screening at an increased frequency because you are firefighter.

A national nonprofit, 15-40 Connection is devoted to improving cancer survival rates through the power of early detection. It developed a training program that's particularly for first responders. It teaches firefighters to baseline their good health, to recognize subtle changes to their health that persist for two weeks, which could be symptoms of cancer, and to share those observations with their doctor. No one knows your health like you do, so your awareness, your voice and your actions can help you to recognize cancer symptoms early and to take steps to give yourself a life-saving advantage.

MAKING A DIFFERENCE

Consider participating in clinical research that's uncovering the relationship between chemical exposures and cancer. Join the National



Firefighter Registry (NFR). In 2018, Congress directed the Centers for Disease Control and Prevention to create a database of health and occupational information on firefighters that can be used to analyze and track cancer in the fire service. In addition, this database can help to identify occupational risk factors for cancer at a national level. The information that's collected by the NFR can help the public safety community, researchers, scientists and medical professionals better protect firefighters' health and safety. Registration in the NFR is voluntary.

As noted above, many research studies haven't included women or minority career firefighters or volunteer firefighters. However, the NFR hopes to have a broad reach with better participation from these understudied and underrepresented groups. NFR enrollment for firefighters is slated to start soon. This is an opportunity for all women firefighters across the nation to be counted and to make their concerns and numbers in this profession count. For more information on the NFR or to join their newsletter for updates, visit cdc.gov/niosh/firefighters/registry.html.

Support the efforts of cancer prevention organizations locally via a donation. If you're a

firefighter who has cancer, consider reaching out to the **Firefighter Cancer Support Network (FCSN)**. The FCSN aims to support fire/EMS professionals and their families following a cancer diagnosis. The organization offers peer support and gives cancer awareness and prevention training nationwide. The FCSN is a way for women to support each other through this great network.

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Learn about and get involved with policy changes that can improve first responders' health and safety, such as chemicals policy reform. Encourage your local, state and federal representatives to support policies that will better protect workers by reducing exposures that are linked to adverse health outcomes, such as breast cancer. This won't happen without significant and sustained collaborative pressure from local and national firefighting organizations and advocacy groups that's supported by boots on the ground. Presumptive laws are regulations that assume that a given disease is linked to work by default. This means that when someone is diagnosed with an illness that's covered under a presumptive law, he/she

automatically is entitled to disability or workers' compensation, medical expense coverage and medical leave. Many states still lack presumptive cancer laws, and many of the laws that exist are limited. Currently, only 12 states proactively include breast cancer in their presumptive laws.

Science is important, because it can validate exposure experiences, lending evidence to help to build strong presumptive laws in every state. The good news is that firefighters have had success changing laws, particularly with the help of science. A great example of this took place in 2018 in Massachusetts where Boston firefighters/Local 718 were successful with a bill that proposed to include breast and reproductive cancers into the cancer presumption list to protect women firefighters who serve in the state.

PROTECTING YOURSELF ON THE JOB

Efforts to educate firefighters about safe work practices, including proper training, proper use of protective clothing, and proper decontamination steps on the fireground and in the station, have created a groundswell in our profession that is changing the narrative for fire service personnel in regard to cancer. The strong leadership of the IAFF and the work and dedication from many local unions across the nation and Canada have raised awareness of exposure prevention efforts that help local departments to recognize and embrace the need to reduce occupational exposures that are associated with increased cancer risk.

We all swore an oath to protect the lives and property of the residents we serve. We don't get to choose which fires we fight, and we don't turn away because a fully involved fire looks potentially dangerous or toxic. Please, after every fire, tend to our own decontamination, then remind your fellow firefighters to do the same and to follow best practices when possible.

Firefighters don't need science or clinicians or legislators to tell us that this is a dangerous job. We only need to look left and then right when sitting down to a firehouse dinner to notice the missing friends and colleagues who are getting sick and dying of cancer.

5 TIPS TO REDUCE EXPOSURE ON THE FIREGROUND

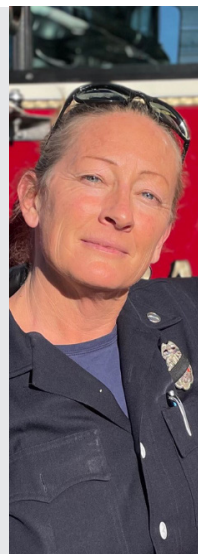
- Use SCBA from the initial attack through the completion of overhaul
- Use wet wipes to clean hands, neck, jaw and face after fire operations
- Do a gross decontamination of PPE and place in a sealed bag in an outside compartment of your vehicle if possible
- Shower immediately upon returning to your station
- Thoroughly clean all PPE, including helmet and SCBA
- Use your station's vehicle exhaust system

5 TIPS TO REDUCE EXPOSURE AT THE STATION

- Store turnouts in closed lockers and gear bags
- Keep doors closed between the apparatus floor and living areas
- Wipe down the vehicle cab interior every day
- Do not sweep the apparatus floor; vacuum with a certified HEPA shop vac and mop
- Use your station's vehicle exhaust system

AUTHOR

Heather Buren has been a member of the San Francisco Fire Department since 1997. She cross-trained as a firefighter/paramedic early in her career, promoting to lieutenant in 2010. She is a co-primary investigator of Women Firefighter Biomonitoring Collaborative Study and The Women Workers Biomonitoring Study and is involved in the Tubbs Fire Research Study. Buren is a long-time member, past president and current board member of the United Fire Service Women.



CLEAN GEAR MATTERS

Researchers review the impact of laundering PPE to reduce exposure to harmful chemicals.

In recent years, cancer in the fire service has become a topic of growing concern, as numerous studies have highlighted firefighters' increased risk for certain cancers. Several numbers appear in fire service discussions regarding this increased risk; however, the most reliable data were published by the National Institute for Occupational Safety and Health (NIOSH) in 2014. This scientific research found a 14 percent increase in all cancer deaths for firefighters' relative to the general population rate. This increase in risk for cancer deaths may be, at least partially, explained by firefighters' occupational exposure to toxic chemicals.

During fire responses, firefighters are routinely exposed to smoke (particulate and gas) that contains a variety of chemicals, including polycyclic aromatic hydrocarbons (PAHs) and flame retardants (FRs).

Exposure to PAHs are especially concerning because some PAHs are known human carcinogens. In a study conducted by Illinois Fire Service Institute (IFSI) and NIOSH, elevated levels of PAH metabolites were identified in firefighters' urine after a live-fire scenario even though SCBA were used throughout, suggesting PAHs may be absorbed through the skin.²

It has been hypothesized that FRs in household products may be released into the environment when they burn and could also present an exposure hazard for firefighters. Some FRs, like the phased-out polybrominated diphenyl ethers (PBDEs), have been associated with altered hormone regulation.³ Some organophosphate flame retardants (OPFRs) have been associated with cell toxicity,⁴ and a few non-PBDE brominated flame retardants (NPBFRs) have been observed to be endocrine disruptors (chemicals



that may interfere with the hormone systems and can produce developmental, reproductive, neurological, and immune effects).⁵ Recent studies have found elevated levels of brominated and organophosphate flame retardants in firefighters' bodies compared to general population levels.⁶

itself will retain fireground products of combustion and be a source of chemical exposure. This dirt or soot has the potential to contain PAHs, FRs and other compounds. Thus, over time, hoods with residual contamination may contribute to firefighters' overall exposure to dangerous chemicals.

FIREFIGHTER HOOD CONTAMINATION

PPE, including protective hoods, helps reduce firefighters' exposure to these toxic substances by reducing skin exposure during a fire response. Protective hoods are characterized by the NFPA as the interface element of the protective ensemble that provides limited protection to the coat/helmet/SCBA face-piece interface area.⁷ This PPE ensemble element is in direct contact with neck and face skin, which is thinner and tends to be more absorptive than skin on most other parts of the body.

Previous studies have characterized chemical exposures on the neck following firefighting. It is often assumed that most of this exposure happened during the firefight (via penetration of chemicals through or around the hoods). However, if hoods are worn for multiple responses, there is a possibility that the hood



LAUNDERING SOCK HOODS

Historically, protective hoods may have been worn for multiple responses without laundering. However, over the past few years, many fire departments have implemented hood exchange and/or laundering programs in an attempt to reduce potential exposure through contaminated hoods. This is a positive step for the fire service and a reasonable solution in light of available evidence. However, we are unaware of any data that tells us just how effective laundering is at removing contamination on hoods, or if there are any unintended consequences of this action. In other industries, it has been suggested that cleaning efficiency will depend on the solubility (fat-soluble compounds are harder to clean) and molecular weight (heavier compounds are harder to clean) of the contaminants.

To address this knowledge gap in the fire service, we set out to determine the effectiveness of laundering to reduce or remove PAHs and FRs from sock hoods. PAHs are fat-soluble but generally lighter than FRs. Brominated FRs are fat-soluble (and persistent in the environment), while OPFRs tend to be water-soluble. So there are materials with a range of different properties that we want to remove in a single-wash cycle.

In a collaborative effort between IFSI, NIOSH and Underwriter Laboratories (UL) Firefighter Safety Research Institute (FSRI), we asked 10 firefighters, who were paired, to complete different fireground job assignments while responding to realistic fire scenarios. For each pair of firefighters, one hood was routinely laundered after every scenario and one was not. The hoods that were cleaned were laundered together in a washing machine following manufacturer and NFPA guidelines. In total, each firefighter responded to four scenarios. At the end of the study, we took samples from five routinely laundered and five unlaundered hoods and analyzed them for PAHs and three classes of FRs—PBDEs, NPBFRs and OPFRs—that were on the surface and embedded in the hoods themselves.⁸

THE RESULTS:

We found that some chemicals were removed fairly well and some were not. For example, concentrations of NPBFRs, OPFRs and PAHs were at least 50 percent lower in the routinely laundered hoods compared to the unlaundered hoods. PAH levels—the most abundant contaminant found on the hoods—were lowered by approximately 80 percent after routine laundering (Figure 2A). These results show that laundering will likely reduce the amount of contamination available for transfer to the skin upon subsequent hood use.

Surprisingly, PBDEs were almost 50 percent higher in the laundered hoods compared to the unlaundered hoods (Figure 2B). A previous study had indicated poor extraction of PBDEs contaminating polyester fabrics into laundry water.⁹ Thus, we were not surprised to find significant residual PBDE contamination on laundered hoods, but we were surprised to find higher contamination. Where did the additional PBDE contamination come from? Because of this finding, we conducted a follow-on study to examine cross-contamination during laundering.

CROSS-CONTAMINATION STUDY

For our follow-on study, we laundered brand new, unexposed hoods and a set of exposed hoods similar to those used in Figure 2 along with a set of heavily contaminated hoods (containing relatively high levels of PAHs and FRs). Altogether, 12 hoods were laundered at one time in a load of laundry representative of what may be done at a fire department where all hoods are gathered and laundered after a structure fire response regardless of contamination level.

After laundering, we collected and analyzed samples from the hoods to evaluate differences before and after laundering. Interestingly, all hoods that were brand new—and had no PBDE, NPBFR or OPFR contamination before laundering—had measurable contamination after laundering (Figure 3). This finding clearly indicates there can be cross-contamination of FRs between hoods during the laundering process. Additionally, some previously exposed hood samples had even higher PBDE levels after laundering than before, corroborating our earlier findings.

Figure 2A. Average concentrations of PAHs on unlaundered and routinely laundered hoods

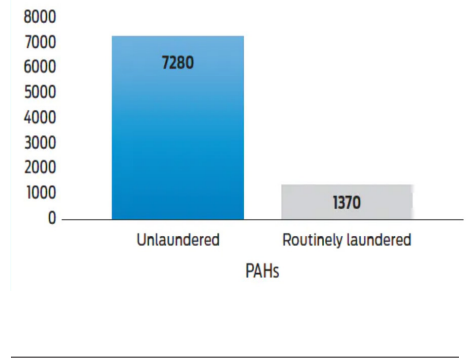
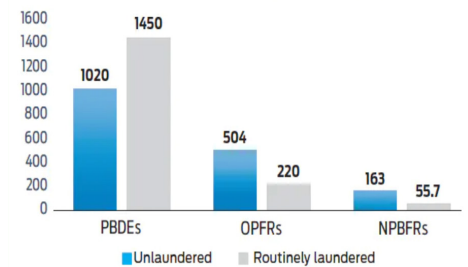


Figure 2B. Average concentrations of PAHs on unlaundered and routinely laundered hoods



PAH concentrations were low on the brand new hoods after laundering, and PAH contamination on the exposed hoods were significantly reduced after laundering. This finding is of particular importance because PAHs are the only known human carcinogens in the class of chemicals analyzed in this study. Overall, cross-contamination of hoods during laundering appears to occur for FRs, and is less of a concern for PAHs.



ONGOING HOOD SWEAT EXTRACTION STUDY

Our study on laundering hoods highlighted some interesting findings regarding cross-contamination of FRs. These findings may be important because protective hoods can come in direct contact with the skin of the neck and head. However, it is not clear just how much of this contamination could transfer to the skin. On the one hand, some of the cross-contamination may be embedded in the inner layer of the sock hood that touches the skin. On the other hand, if the FRs are not readily extracted in laundry water (containing detergents), will they be extracted in human sweat? And if some contamination did transfer to the skin, how much would be absorbed into a firefighter's body?

To begin addressing these remaining questions, we have embarked on a study to determine the amount of residual contamination on hoods that can be extracted in synthetic sweat solution. Importantly, the sweat solution contains both water and lipids (fats) and other properties that are characteristic of actual human sweat. Routinely laundered hood samples from our previous study will be placed in the sweat solution for a period that represents how long firefighters may wear hoods before, during and after an emergency fire response. Hood and sweat samples will then be analyzed for a variety of FRs. This experiment will increase our understanding of how hood contamination relates to dermal exposure and potential for absorption.

IMPLICATIONS FOR OTHER FIREFIGHTER PPE

Our findings may have implications for other components of the turnout gear ensemble. If chemicals are capable of cross-contaminating hoods during laundering, then cross-contamination may also happen during the laundering of turnout jackets or trousers, gloves or helmet liners. It is possible that some contamination on exterior materials could transfer to interior materials that are in direct contact with the skin if outer shells and liners are not separated during laundering as recommended by NFPA and others. Certainly, further research is needed. Studies are underway by fellow

researchers to determine “How Clean Is Clean?”

Further, NIOSH, IFSI, and UL recently completed the field experiments for the “PPE Cleaning Study” to examine residual contamination with repeated laundering. Importantly, this study also aims to understand how repeated laundering affects the protective properties of turnout gear, including tear resistance, flame resistance and thermal protection performance. These studies, as well as the aforementioned sweat-extraction study, should provide further insight into how laundering firefighter PPE impacts firefighters' potential exposure to chemicals. These results, along with previous research projects, will be made available to the fire service through our websites at [cdc.gov/niosh/firefighters](https://www.cdc.gov/niosh/firefighters) and [fsi.illinois.edu/CardioChemRisks](https://www.fsi.illinois.edu/CardioChemRisks).

FINAL THOUGHTS

While the potential for cross-contamination of FRs during laundering is something that should be explored further, the preponderance of evidence suggests that it is still prudent to launder contaminated hoods after fire responses to reduce the potential for exposure upon subsequent use. Based on our study findings, laundering will remove a large proportion of the PAHs from hoods, and it is likely that other hazardous or potentially carcinogenic compounds will also be removed. Also important are other measures to minimize skin exposure, such as careful removal of hoods and gloves to limit the amount that transfers to the skin (see videos at [youtube.com/watch?v=QyAt5WHf5uM](https://www.youtube.com/watch?v=QyAt5WHf5uM) and [youtube.com/watch?v=9uYp0ZQP158](https://www.youtube.com/watch?v=9uYp0ZQP158)), on-scene cleaning of skin (e.g., skin cleansing wipes), and showering as soon as possible at the station.



KEY TAKE-HOME MESSAGES

Laundering hoods is effective at removing a large portion of PAH contamination, which is by far the most abundant contaminant found on the hoods and is an important part of firefighter hygiene and PPE cleaning.

Consider segregating firefighter hoods by contamination level to reduce the potential for cross-contamination. If a firefighter responds to a call but is exposed to low levels of contamination compared to the rest of the crew, it may be beneficial to avoid washing with other crewmembers' hoods.

Do not launder hoods with base layers or station wear to reduce the risk for cross-contamination to these pieces of clothing that may directly contact skin.

This study suggests the possibility that some contamination on turnout gear outer shells might transfer to inner liner materials that are in direct contact with the skin if they are not separated during laundering as recommended by NFPA and others.

AUTHOR

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15 TIPS TO MINIMIZE RISK

Frank Leeb challenges firefighters to make the commitment toward reducing their exposure risks on the fireground and at the station.

There has been a great deal of emphasis on reducing occupational exposure to fireground contamination.

Firefighters are at an increased risk for cancer and other diseases that scientific research has linked to firefighting. The reality is that firefighting is a dirty job, and we will never eliminate all of the hazards we face. We can, however, minimize and manage these hazards.

Individuals must make their own commitment to their health and well-being. Collectively, we must apply the same smart, aggressive approach that we already use with firefighting and extend that mindset to reduce our risk.

AUTHOR

Frank Leeb has served the FDNY since 1992, currently serving in the rank of deputy chief.



1

Always use your SCBA, including when operating at car fires, dumpster fires and during overhaul. The SCBA provides the best respiratory protection from inhalation hazards.



2

Take a shower and change into clean station wear as soon as possible after returning from a fire. This should be done prior to cleaning tools. The concept is to “place the firefighter back in service first” to minimize time spent exposed to harmful contaminants.



3

Wash off bunker boots after a working fire. Boots contribute significantly to cross-contamination.



5

Thoroughly wash your hands after every response, as well as before and after using the bathroom. This will minimize cross-contamination to highly absorptive areas of the body.



4

Keep hard surfaces inside the crew cab of the apparatus clean. Contaminants are known to settle on these areas, contributing to cross-contamination.



6

Remove PPE—such as hoods and gloves—in a manner that minimizes cross-contamination. Think of contaminated firefighting gloves as you would blood-soaked medical gloves.



7

Don't overlook your helmet. Wash the inside liner of your helmet with soap and water.



9

Wash your dirty gear. Dirty gear demonstrates that you are naïve to the risks posed by fire-ground contaminants.



10

Don't use a contaminated hood or leave one around your neck following a fire. This greatly increases exposure around the neck, one of the most absorptive areas of the body.



8

Use gear bags when transporting PPE to minimize cross-contamination. Do not store bunker gear in your car or home.



11

Practice healthy lifestyle choices. Exercise regularly; limit or avoid alcohol, tobacco products and red meat intake; and always use sunscreen.



14

Shower prior to leaving the firehouse after your tour ends, regardless of the amount of firefighting activity during the tour. This minimizes the risk of cross-contamination.



12

Ensure diesel exhaust capture systems are working properly and used. Diesel is a known carcinogen.



13

Perform on-scene decontamination of contaminated gear and equipment following a working fire to remove soot, which is composed of harmful compounds that can cause cancer and other illnesses.



15

Maintain and strictly enforce "no bunker gear zones" in all living areas of the firehouse.

PARTICULATE-BLOCKING GEAR

At its most basic level, we all know that turnout gear is designed to protect structural firefighters from an Immediate Danger to Life and Health (IDLH) environment. But fire scenes today aren't just IDLH environments. There are dangers lurking in the smoke and soot that may not affect you now, but instead, in the future. That's why the fire service has begun taking steps to reduce exposure to these harmful toxins contained in products of combustion.



There are several different ways in which the body can be exposed to products of combustion; inhalation, dermal absorption, and ingestion. The best ways to reduce these exposures are to avoid the exposure altogether or to remove it. Many departments have started stressing the importance of clean air, clean bodies, and clean gear. Staying on air at a fire scene, staging upwind, or adding diesel exhaust capture systems in stations are a few good ways to keep the air around you clean. Training with digital equipment or cleaner burning training fires is another good way to reduce exposure.

Based on input from experts in the fire service drawing on scientific research, the NFPA has recently adopted in the latest revision of the 1851 Standard the requirement that structural firefighters engage in preliminary exposure reduction, washing hands, face, and neck while on-scene, and showering within the hour after an event. A hood exchange program coupled with using NFPA 1851-compliant cleaning procedures to keep ensembles clean is essential too.

But what about substantially reducing or even eliminating contact of smoke particulate with the body altogether? That's where particulate blocking gear comes into play.

In conjunction with the Department of Homeland Security (DHS) Science and Technology Directorate (S&T) and the North Carolina State University Textile Protection and Comfort Center (TPACC), LION developed a structural turnout with enhanced protection from hazardous particulates contained in smoke and soot that may infiltrate the ensemble interfaces.

In a DHS press release, S&T First Responders Group Program Manager Bill Deso said, "We worked with TPACC and LION to develop turnout ensemble garments that afford firefighters the same level of fit, functionality and comfort as their existing turnout gear with added protection from particulate infiltration at garment interfaces." This particulate blocking gear is known as RedZone™ today.

RedZone substantially reduces particulate ingress at key PPE interface areas as confirmed by the fluorescent aerosol screen test (FAST), performs consistently with existing turnout standards, and requires little to no change in donning/doffing procedures. The ensemble protects the areas around the wrists, upper calf, chest, stomach, and neck where gaps in traditional PPE interfaces allow infiltration of particulates into the existing ensemble and does so in a way that is easy for the firefighter,

meaning the parts and pieces don't require additional steps to engage the features.

To accomplish this, the coat and pants utilize Dupont's Nomex Nano particulate blocking material at the wrists and calves, and in an internal core guard that helps block particulates from entering the waist area. Nomex Nano resists greater than 95% of particulates less than 1.0 microns in size.

What LION, DHS, and NC State learned through the development process is that it's not the fact that there is a particulate blocking material in the gear, but instead how it is strategically placed to interface with other PPE elements like the gloves, boots, hood, and the coat and pant itself, that results in the true benefit. This conclusion was drawn through multiple design concepts and robust, thorough testing.

AUTHOR

Alysha Gray is LION's PPE Product Marketing Director. She also assisted in the development of the innovative RedZone particulate-blocking gear.



Over the last 20 years, an increasing body of scientific research has provided increasing evidence that firefighting causes an elevated risk of certain types of cancer. In 2021, one study supported by NIOSH showed significantly elevated levels in firefighters of Polycyclic Aromatic Hydrocarbons (PAHs), a highly carcinogenic product of combustion, when measured directly after structural fires.

<https://pubmed.ncbi.nlm.nih.gov/33654270/>



Products of combustion can become trapped inside the layers of turnout gear. Without timely and effective cleaning, smoke deposits, condensed residues and lingering hydrocarbons in grease, soot, and oil may not only reduce the protective properties of the clothing but put firefighters at risk of secondary exposure to carcinogenic products of combustion after firefighting operations are completed.

While effective in removing a substantial amount of contaminants, infrequent, conventional water-based cleaning of fire PPE cannot thoroughly penetrate & remove 100% of all contaminants from all layers of protective fabric. The residual PAHs embedded in the fabric create a risk of exposing firefighters to these contaminants through inhalation and/or dermal absorption (unlike some chemicals, PAHs in particular have a high rate of dermal absorption) if they become released from the clothing while wearing.

Laundry operations in the fire service have thus far been built upon an assumption that water-based cleaning is the most appropriate process for achieving cleanliness. The 2020 edition of the NFPA 1851 Standard was updated to include cleaning requirements for ISP verification. One of those requirements was a

minimum of a 50% average reduction in PAHs, which are known carcinogenic chemicals found at typical structural fires. The average reduction of PAH contamination by standard water washing, following NFPA 1851 guidelines, is between 50%-55%. Until now, there has not been a solution for removing all but a small percentage of PAHs and volatile organic compounds (VOCs) while not using large amounts of water and energy.

WHAT IS CO2 CLEANING AND HOW DOES IT WORK?

Liquid carbon dioxide (LCO2) outperforms water on multiple fronts.

Cleans more Thoroughly – LCO2 ensures a deeper clean without the use of harsh chemicals, allowing for garments to experience less agitation and fiber disruption for a longer-lasting product.

Saves Natural Resources and Conserves Energy – By eliminating the use of water and heat, CO2 cleaning drastically reduces the consumption of natural resources and energy, allowing for a more sustainable process that prioritizes the environment.

Lowers Carbon Footprint – By utilizing liquid CO2 via a closed-loop cleaning process, we can

contribute to a circular economy that effectively reduces the carbon footprint associated with the creation and release of carbon emissions.

How does a CO2 washing machine work? The simple explanation is this: CO2 cleaning leverages CO2's natural affinity for common contaminants found on and in turnout gear. The pressure in the machine is raised, first by injecting gaseous CO2, then liquid CO2. The pressurized CO2 molecules are significantly smaller than a water molecule, allowing them to easily penetrate all layers of turnout gear, lifting these contaminants up and out of the garment. These particulates are then transported to a sludge tank in the machine from where it's removed and disposed of as a hazardous waste. Because the process does not use water, garments come out of the machine dry.



REDZONESM CO2 CLEAN (POWERED BY TERSUS SOLUTIONS): ADVANCING TEXTILE INNOVATION

How does a CO2 washing machine work? The simple explanation is this: CO2 cleaning leverages CO2's natural affinity for common contaminants found on and in turnout gear. The pressure in the machine is raised, first by injecting gaseous CO2, then liquid CO2. The pressurized CO2 molecules are significantly smaller than a water molecule, allowing them to easily penetrate all layers of turnout gear, lifting these contaminants up and out of the garment. These particulates are then transported to a sludge tank in the machine from where it's removed and disposed of as a hazardous waste. Because the process does not use water, garments come out of the machine dry.

95%+ removal of PAHs and VOCs

In third-party testing, RedZone CO2 cleaning removed over 95% of polycyclic-aromatic hydrocarbons (PAHs) – contaminants produced by combustion that are increasingly linked to higher rates of cancer in firefighters.

No harsh mechanical action or chemicals

Due to the superior cleaning properties of CO2, the machinery does not need aggressive mechanical agitation to dislodge soils and stains. The result is gentler, no-gravity action while using no detergent and no harsh chemicals, thus preserving the tensile strength of fibers and fabrics.

One process for All PPE

The unique features of the RedZone CO2 cleaning process allow us to put essentials such as helmets, boots and gloves in the machine to receive the same level of cleaning as turnout pants and coats, prolonging the life of firefighter PPE from head to toe.

Superior oil-based contaminant removal capabilities

Because of its low surface tension, Liquid CO2 seamlessly removes oil-based contaminants by bonding with the contaminant molecules. Liquid CO2 has exceptional oil contaminant removal capabilities and other non-polar properties ideal for treating unique technical gear.

No drying time required

RedZone CO2 cleaning is a waterless cleaning technique. Garments come out of the CO2 machine dry and ready for shipment back to the department, saving valuable turnaround time so that gear can be returned to service faster.



LION TotalCare's RedZone CO2 cleaning is another component of the LION RedZone family that offers firefighters the ability to reduce risk and help protect your long-term well-being, health, and safety.

To learn more about LION TotalCare's RedZone CO2 Clean, [contact your nearest LION TotalCare facility](#) or [visit the RedZone CO2 webpage](#).

AUTHOR

Anna Lones is the Senior Product Marketing Manager for LION TotalCare®, which provides high-performance verified PPE inspection, cleaning and repair services.



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DHS PRESS RELEASE (Nov 1, 2017) -

New Turnout Ensemble Aims to Reduce Firefighter Cancer Risk

DHS FACT SHEET (Oct 6, 2017) -

Smoke and Particulate Resistant Structural Turnout Ensemble Fact Sheet



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