GUIDE TO CANCER PREVENTION THROUGH PPE

FireRescue1

FIRE CHIEF

GLOBE

ATHLETIC GEAR FOR FIREFIGHTERS™

Protecting firefighters

Improving firefighter health is a broad and complex topic.

There is the monumental task of better understanding the biological mechanisms that make firefighters ill. Added to that mix are fire service cultural issues that may resist beneficial equipment and behavioral changes. And there are political and legal forces at play in the battle to decide what impact firefighting has on our health and when benefits are awarded to those with job-related health problems.

Firefighters can do little to control their exposure to toxic substances that adversely affect health. They can, however, mitigate that exposure through sound practices like wearing SCBA, cleaning PPE after incidents, not smoking, exercising, sleeping better and eating well.

Again, it's a broad and complex topic, yet one that impacts every firefighter to some degree.

In this brief guide, we've zeroed in on firefighter cancer. We begin with a piece that helps explain some of the latest research on firefighter cancer. We follow that up with two pieces on how firefighters can protect themselves with their PPE.

We finish up by looking at another problem area for firefighters: heat-related illness. We've also included several additional resources that delve deeper into these topics.

In the end, we hope this guide helps you achieve better health throughout your firefighting career and well into retirement.

Keep safe and keep healthy.

— Rick Markley, Editor-in-Chief

CONTENTS

3
Firefighting research looks at overhaul risk

4
8 ways to protect against cancer with PPE

6
Cardiovascular & Chemical Exposure Risks in Modern Firefighting Interim Report – Summary

8
How to rid firefighting PPE of contaminants

9
Additional resources

About the Authors

Sara A. Jahnke, Ph.D. is the director of the Center for Fire, Rescue and EMS Health Research at the National Development and Research Institutes Inc. Dr. Jahnke has served as the principal investigator of two large-scale studies of the health and readiness of the U.S. fire service funded by the Department of Homeland Security and a qualitative study of health and wellness with a national sample of fire service representatives from the American Heart Association. She serves as the principal investigator of a study on the health of women firefighters. She also serves as a co-investigator of several studies focused on fitness, nutrition and health behaviors in both firefighters and military populations. She completed her doctorate in psychology with a health emphasis at the University of Missouri – Kansas City and the American Heart Association's Fellowship on the Epidemiology and Prevention of Cardiovascular Disease. You can reach her at Sara.Jahnke@firerescue1.com.

Jeffrey O. and Grace G. Stull are president and vice president respectively of International Personnel Protection, Inc., which provides expertise on the design, evaluation, selection and use of personnel protective clothing, equipment and related products to end users and manufacturers. They are considered amongst the leading experts in the field of personal protective equipment. Send questions or feedback to Jeff or Grace at Jeffrey.O.Stull@firerescue1.com.

Firefighting research looks at overhaul risk

By testing firefighters before and after overhaul activities, researchers hope to quantify their exposure risk to deadly airborne materials

By Sara Jahnke

Several fire departments monitor carbon monoxide after fires to know when it is safe for everyone to remove their SCBAs. Some departments wait until there isn't smoke to sound the all clear.

Research by the Underwriters Laboratory, funded by the Assistance to Firefighters Grant Research and Development program at FEMA, suggests that basing the choice on what you see isn't enough. The UL team conducted a number of large-scale burns in their lab while monitoring the chemicals produced. The news is not good for firefighters who are quick to remove their SCBAs.

In the lab, a number of chemicals were present during fire and overhaul — carbon monoxide, carbon dioxide, hydrogen sulfide, ammonia, hydrogen chloride, nitrogen oxides, phenol, sulfer dioxide, isocyanates, benzene, chromium, formaldehyde and polycyclic aromatic hydrocarbons.

Recommended exposure levels for carbon monoxide, benzene, formaldehyde, hydrogen cyanide and arsenic were exceeded during overhaul. Nearly all, more than 97 percent, of the smoke particulates collected during overhaul were too small to be visible.

So, while it looked like the air was clear, there were actually a multitude of chemicals present.

Work in Illinois

The team also monitored chemical exposures of Chicago Fire Department firefighters and the accumulated chemicals on their hoods and gloves. Field monitoring with Chicago firefighters found gas exposures that were higher than recommended by OSHA standards.

They also found there were times when carbon monoxide was low but other harmful gasses were high. Smoke particulates contained metals like arsenic, cobalt, chromium, lead and phosphorous. When the team analyzed the gloves and hoods, they found the same chemicals and concentrations were 100 times higher on both.

In July, Dr. Gavin Horn and his colleagues at the Illinois Fire Service Institute in Champaign, Ill., will be conducting a series of tests to learn more about what firefighters are exposed to on the fireground. With funding from FEMA's Assistance to Firefighters Grant Research and Development mechanism, they will run 12 different burn scenarios in a 1,200 square foot ranch style home that was built for the study.

Firefighters' blood, breath, and urine will be tested prior to and after firefighting. Their cardiovascular responses will be monitored by a Holter monitor. This research will shed more light on the physiologic response and exposures firefighters face, which can shape best practices for minimizing exposure.

So why does it matter?

Here's what we know

The chemicals firefighters are exposed to can be inhaled, can stick to gear and can sink in through the skin. We know exposure to these chemicals can increase risk for cardiovascular disease — both morbidity and mortality. We also know there are several cancers that happen at higher rates among firefighters and are likely related to chemical exposures.

While the research is ongoing and the data pouring in, there are prevention strategies to decrease risks of cancer among firefighters. The Firefighter Cancer Support Network has a few suggestions for reducing your risk with a handy CANCER acronym.

Change out your PPE after every fire.

Always shower after every fire.

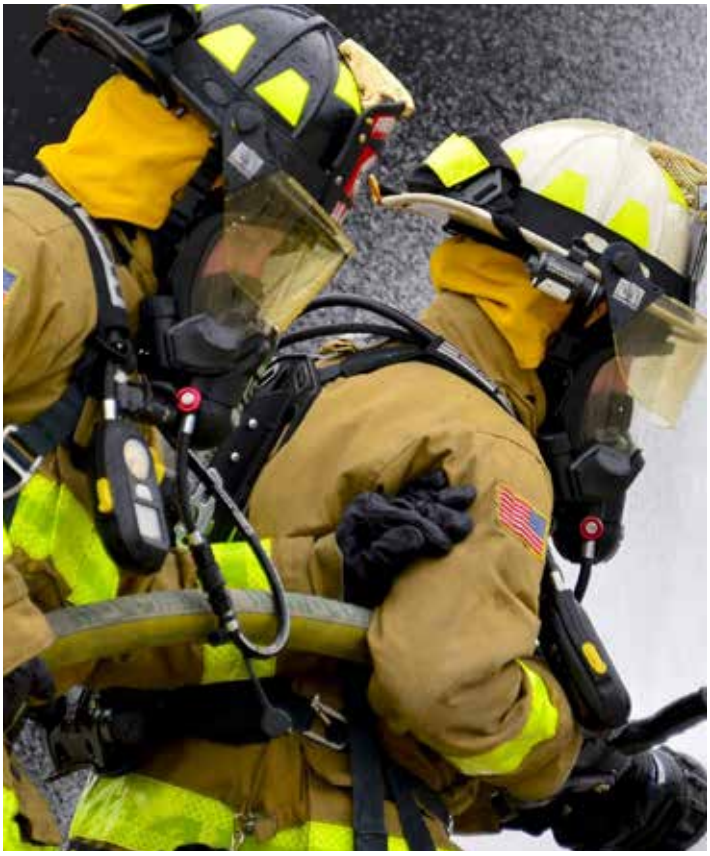
Never place dirty PPE in living areas, including your car.

Clean PPE regularly regardless of appearance.

Exhaust is deadly.

Remember to get annual physicals.

While there are risks inherent to firefighting that cannot be avoided, the increased risk of diseases such as cancer and cardiovascular disease makes prevention and intervention efforts all the more important for firefighters. ■



8 ways to protect against cancer with PPE

Cancer-causing agents can reach a firefighter, even one in full PPE; here are simple steps to reduce your risk

By Jeffrey O. and Grace G. Stull

There was a time when dirty bunker gear was a badge of honor. In fact, firefighters often complained when they were forced to clean their gear and sometimes even became creative in finding ways to avoid having PPE appear newer.

Similarly, many firefighters delayed wearing SCBA during a structure fire and removed their facepieces as soon as they could get away with it. Fortunately, these practices have diminished significantly.

Yet, the dangers of firefighter exposure to carcinogens and other hazardous materials is still a serious problem. There are several proper PPE use and hygiene practices to reduce these exposures and the risks of cancer.

The fatalities statistics presented annually by the National Fire Protection Association and other organizations indicate that stress-related incidents often are the principal cause of firefighter fatalities. Nevertheless, these statistics do not show the alarming trend for increased incidences of cancer among firefighters.

Know the enemy

Certain types of cancers are prevalent among active firefighters. This is reason enough for focusing serious attention on finding ways to limit exposures during fireground operations, and just as importantly, providing information to firefighters who have been diagnosed with cancer.

To this end, the Firefighter Cancer Support Network was formed. This organization has engaged in a relatively aggressive awareness campaign and has been steadily growing. Its website provides one of the most extensive lists of resources on firefighter cancer issues, including many references related to PPE use and cancer.

A white paper published in August 2013 captures many of the issues facing firefighters and provides specific recommendations involving PPE.

Many firefighters are under the false impression that simply wearing PPE is sufficient to limit exposure to most cancer-causing agents encountered on the fireground. SCBA, when worn, provides respiratory protection. But SCBA is not always worn, particularly during overhaul.

False sense of security

A significant number of chemicals absorb through skin and cause both acute and latent toxic effects. While it is true that gear has evolved extensively over the past several decades, its ability to prevent skin exposure to many fireground contaminants is quite limited. If not removed, contaminated exterior surfaces and inner layers of protective clothing and equipment results in exposure well after the incident.

Structural firefighting protective clothing has a moisture-barrier layer throughout most of the ensemble elements — coats, pants, gloves and footwear are all required to have these materials to prevent liquid penetration. Moisture barriers attenuate many contaminants but do not protect against all chemicals.

Certainly, the helmet shell is relatively impervious for protecting much of the firefighter's head; the SCBA facepiece also protects the majority of the firefighter's face. Still, there are several parts of the ensemble that provide penetration pathways for smoke particulates and vapors to reach the firefighter's skin.

Helmet ear covers and hoods, and coat and glove wristlets all lack any form of barrier material. In addition, while garment closures are designed to be resistant to liquid penetration, they are not airtight. Interface areas between gloves and coat sleeves, footwear and pant trouser ends, the coat and pants, and the face/head/neck area are all relatively open to airborne contaminants.

The science

A December 2013 U.S. Department of Health and Human Services publication examining firefighter exposure to potential carcinogens shows that the neck area is one of the most likely regions to become contaminated.

Other studies have clearly shown that many fireground gases penetrate the clothing and reach the firefighter's skin. For example, work done in Australia showed specific carcinogens to be present on the firefighter's skin after simulated residential and industrial fires.

Many firefighters complain about the amount of soot that gets onto their face and neck areas not covered by the SCBA facepiece or main portion of their coat.

The reality is that firefighters are more likely to be exposed to hazardous materials during structure fires than they are during hazardous materials incidents. Not only are there differences in the manner in which these emergency responses are carried out, but the most important distinction is that most structural fires create large volumes of hazardous gases and particulates, some of which are persistent and remain in the environment after the fire is extinguished.

In contrast, most hazardous material responses involve only a few chemical commodities and the response teams approach these emergencies with a high level of monitoring and caution.

Much of the smoke in a structure fire consists of visible soot particles. However, the large amount of synthetic materials found throughout all structures contributes to a significant number of highly hazardous chemicals when they burn.

Lingering toxins

While most of these chemicals are relatively volatile and dissipate over time, the carbon-based soot particles absorb many of these vapors, holding them in place on surfaces including firefighter clothing and skin. These chemicals initially trapped on the particles, migrate into the surrounding environment and come in contact with the firefighter.

It is not surprising that analyses conducted on contaminated PPE often show a range of different types of chemical substances present. In some cases, these chemicals are not removed by washing.

So if PPE has limitations in preventing exposure to carcinogens and other hazardous substances, how can firefighters reduce their overall exposure? The Firefighter Cancer Support Network and other organizations have offered many specific suggestions for reducing exposures relative to PPE use and care as well as specific hygiene practices. Here are the top eight.

1 Wear SCBA through all stages of the fire, including overhaul.

2 Remove as much of the bulk contamination as possible while still at the fire scene by performing gross decontamination.

3 Wipe soot from your head, neck, jaw, throat, underarms and hands using wet wipes immediately after the fire.

4 Change and wash station, work and other clothing right after returning to the station or leaving the fireground.

5 Shower after the fire.

6 Ensure that all gear is properly cleaned right after the fire.

7 Do not transport or take contaminated clothing home or store in a vehicle.

8 Keep all gear out of living and sleeping areas.

In addition to these recommendations, it is important to always wear gear properly. This includes wearing the hood, deploying ear flaps, extending the collar fully and making sure that all interface areas are properly secured with sufficient overlap.

This is a start and there are certainly other practices that can reduce your risks that are not PPE-related. ■

Cardiovascular & Chemical Exposure Risks in Modern Firefighting

INTERIM REPORT – SUMMARY

Purposes of the Study

This study was designed to better understand how operating in a modern fire environment is related to the two leading health issues facing firefighters; namely cardiovascular events and chemical exposures related to carcinogenic risk. We investigated the impact of different tactics (traditional interior attack vs a transitional attack) and different firefighting location/assignment (interior attack, outside operations, outside command, overhaul) as well as measures such as skin cleaning and gross on scene decon to affect these risks.

Motivation for Study

Significant advances have been made in our understanding of the hazards associated with structural firefighting.

- Research has provided a greater understanding of the development, propagation and dangers of modern residential fires. The fire service has been provided with important tactical guidance that may potentially increase firefighter effectiveness while decreasing risk.
- Sudden cardiac events are the leading cause of duty-related deaths among firefighters and they are far more likely to occur after fire suppression activity. Substantial evidence suggests that firefighting leads to significant cardiovascular strain.
- Firefighters have an increased risk for several types of cancer. Fires produce hundreds of toxic compounds. Some are carcinogenic like benzene and certain polycyclic aromatic hydrocarbons (PAHs).

Despite these advances in understanding, important questions remain.

- What is the physiological and chemical impact of the different exposures experienced by firefighters employing differing tactics and conducting various job assignments on the fireground?
- How do factors related to firefighting effect cardiovascular responses under realistic modern fire environments? How effectively does the body recover over the 12 hours following a response?
- How — and at what levels — do toxic combustion products get into a firefighter's body? How much of the absorbed dose comes from skin absorption versus inhalation?

Methodology

In order to safely and reliably conduct typical firefighting operations and tactics with 12 person crews, we designed and built a structure that had all of the interior finishes, fuel loads and features common in the 21st century, yet contained safety systems and hardened construction techniques that ensured our participants' safety.

- During this study, we measured 1) the production and transfer of thermal energy as well as the magnitude and composition of gasses and particles in the fire environment, 2) contamination of firefighters' personal protective equipment and skin, 3) absorption of that contamination into the firefighters' bodies and 4) how these variables were influenced by tactical decision

(interior only vs. transitional attack) and operating location (interior fire suppression vs. exterior operations vs. interior overhaul). Specifically:
  - o Temperature, heat flux, oxygen, carbon monoxide and carbondioxide were measured throughout the structure to characterize risks for firefighters as well as potentially trapped occupants.
  - o A variety of chemical compounds were evaluated in the air surrounding firefighters during the fires, as well as in the fireground. Firefighters wore SCBA when inside the structure, but did not always wear SCBA when on the fireground.
  - o The chemical compounds (or their metabolites) found in urine, blood, or breath were characterized before and after firefighting. This tells us what was absorbed into the firefighters' bodies.
  - o Contamination on neck and hand skin was assessed after firefighting. We also determined the effectiveness of using commercial skin wipes to clean the neck area.
  - o Volatile and non-volatile contamination on turnout gear was measured after firefighting and after three types of field-based decontamination methods.
- We assessed cardiovascular responses to firefighting and to specific tactics and operating location by assessing 1) ECG responses, 2) blood chemistry and coagulatory measures and 3) vascular responses during and up to 12 hours following firefighting.

Preliminary Results

The results presented in this summary of the interim report are a small subset of the data that was collected. We cannot make any definitive conclusions until we perform a comprehensive analysis of ALL the data. These results are provided to alert the fire service of the study and its complexities, provide a glimpse of what we are finding, and to prepare the fire service for future publications and other outputs. For example, results from skin and biological exposure monitoring (blood, urine, and breath) are still pending. The results provided below are only examples of data from one or two scenarios, but we believe them to be fairly representative of the typical study results.

- For the first time, the variability in interior structure temperatures, heat flux and gas concentrations that result from different, yet common, fireground operations (different crews and two separate tactics in the same fire scenario) have been quantified in a controlled manner.
- The impact of tactics on exposures of trapped occupants has also been quantified to better understand the risks and benefits of firefighter activities on the potential victims.
- Firefighters' core temperatures and skin temperatures were strongly affected by the fireground job assignment. Activities such as outside vent and overhaul resulted in elevated temperatures even though the firefighters were not operating on the interior of the structure while the fire was burning.
- Blood clotting potential appears to be strongly related to fireground job function.
- We detected a variety of flame retardants in the fuel package materials used for all fires and in the air inside the structure.
- Air sampling from within the structure during active fire on one day showed hydrogen cyanide levels that were nearly 7 times the Immediately Dangerous to Life and Health (IDLH) level and benzene levels that were up to 15 times exposure limits. These and other volatile compounds were also detected inside the structure during overhaul and on the fireground, but at levels below applicable exposure limits.
- Based on two days of sampling, two important sources of particulate were identified on the fireground: (1) smoke plume from the fire and (2) diesel exhaust from the fire apparatus. The contribution of both sources is dependent on the wind direction.
- Several flame retardants and PAHs were detected on turnout gear items after use in a fire. Gross on-scene decon with water/detergent and scrubbing was effective in bringing the PAH contamination to pre-fire levels.
- Volatile compounds like hydrogen cyanide and benzene were measured off-gassing from turnout gear after use, but at levels below applicable exposure limits. Off-gas levels returned to background within an hour regardless of whether or not the turnout gear were decontaminated.

Next steps

Again, these results presented in this interim report are only a snapshot of what has been collected and is currently being analyzed. A detailed fire service toolkit is scheduled to be released in 2017 with a comprehensive overview of the information available and tactical considerations. The toolkit will be freely available to firefighters and fire officers around the globe. You can keep up to date with information being released through:

- IFSI: https://www.fsi.illinois.edu/content/research/ or on Twitter @IFSIresearch
- UL FSRI: http://ulfirefightersafety.com/, https://www.facebook.com/ULfirefightersafety or on Twitter @UL_FSRI

Download the full report here.

How to rid firefighting PPE of contaminants

What you can't, and can, see on your PPE will hurt you; follow these steps to avoid exposure to cancer-causing agents

By Jeffrey O. and Grace G. Stull

Every emergency response represents a possible contamination event. If there is exposure to gases or vapors, liquids, or particles, these substances will get onto clothing. In many cases, they will remain on the clothing until adequately cleaned.

We have previously described the manner in which this contamination occurs, but there are some subtleties worth going over.

Gases and vapor generally easily penetrate any textile component. Coated or laminated materials such as trim or moisture barriers together with hard surface items such as helmet shells will physically retard gases and vapors, but many of the substances can still permeate materials on a molecular basis.

This is also true for leather and rubber materials. While leather is porous like fabric, many chemicals are soluble in rubber.

Point of entry

Liquids will enter any gap in the material or clothing, particularly through interface areas. For textile fabrics, once the outer surface is wet, the liquid will penetrate.

Moisture barriers, coated materials, and rubber prevent liquid penetration, but many non-water liquids will penetrate gaps more easily than water. Liquid that soaks a material will spread to other areas of the clothing by wicking, spreading contamination beyond the point of entry.

Particulates can range from asbestos fibers to drywall dust, but the largest contributor of particulate contamination at the fire scene is the carbon particles from incomplete combustion. Carbon particles adsorb and hold fire gases, making them more dangerous than plain carbon.

While many particles are visible, many are submicron sized and easily get into any porous surface or gaps in the clothing ensemble where there is no barrier.

Like a magnet

Longer exposures produce higher levels of contamination. Yet the extent of contamination is also heavily dependent on the nature of the substances involved. For example, oily, tarry substances created by high heat will tend to bond to clothing materials more readily, particularly as the clothing cools.

Soiled clothing picks up more contamination. Clean clothing may offer more surfaces for contamination, but many forms of contamination on clothing offer compromised materials that can become more soiled or readily pick up other forms of contamination.

This is most often seen when soot in fabrics continues to pick up gases and vapors from the fire environment. In essence, it is easy for dirty clothing to be more soiled than clean clothing.

The soils on clothing often negate whatever repellent properties a clothing fabric might have. The finishes placed on clothing fabrics and some other components can also wear down over time, making soiling more likely to occur.

Routine cleaning

After being exposed it is essential to clean your gear before continuing to use it. This is not the easiest process as firefighters are generally tired from the response and just want to move on. Also, unless your department provides a second set of gear, this approach can be difficult if you still need your gear and it is wet.

NFPA 1851, which is the standard that governs selection, care, and maintenance of turnout clothing prescribes "routine cleaning," which is principally hand washing. Some organizations will hose down gear after an incident; others have employed the Hazmat decon showers at the site to get rid of the worst of the contamination.

Of course, these processes require time for the gear to dry. However, the alternative is equally problematic — wearing dirty gear continues your exposure to whatever stays on and in your gear.

So, to avoid exposure, some cleaning has to take place as soon as possible after the event and preferably before you have to wear the gear again. Remember, it not just your clothing that has to be cleaned, but also gloves, helmets (including the ear covers), footwear and especially hoods.

Station wear

It is important to recognize that your station uniform and underclothes also have become contaminated by any substance that may have bypassed your turnout clothing. This clothing must be removed and cleaned.

Generally, use the cleaning methods prescribed by the clothing label unless some known substance has penetrated to your work clothing. Nevertheless, in all cases wash this clothing separate from other personal items to prevent cross contamination.

Lastly, while your skin is a good barrier to many substances, it too will be contaminated. Unfortunately, wearing of heavy clothing under hot, humid conditions only enhances how some chemicals can be absorbed through your skin.

Thus, taking a shower immediately after the fire event is critical in getting totally clean and preventing any continued contamination exposure.

Advanced cleaning

NFPA 1851 also defines advanced cleaning as form of clothing care. This type of cleaning must be done at least once a year and whenever gear is exposed to soiling at a fire. The frequency for cleaning is a judgment call, but if the clothing is visibly soiled or contaminated, then it must be cleaned.

In addition, if your clothing has been exposed where there is any concern about continued contamination, it must be cleaned. Laundering is not necessarily decontamination, but most laundering processes specified by clothing manufacturers are designed to remove soils, which include soot particles and many chemicals.

This does not mean that all chemicals will be removed. There is active work to learn just how effective current procedures are, but prior research has shown that a great deal of contamination can be removed using appropriate washing procedures or an independent service.

In some cases, fire departments realize that they have encountered particularly hazardous substances and specialized cleaning is needed. This form of cleaning is not defined. It may be a presoak, spotting treatment, or special detergent. It also may be an entirely different process altogether.

Current research

Here, the matter becomes even more difficult because industry offers very little guidance on this topic. Such decisions for how to clean and whether the cleaning itself will be effective are made on a case-to-case basis. In some cases, the knowledge of the contaminant and the potential dangers for reuse will warrant disposal.

But the problem in making that decision is how to assess the cleaning as providing decontamination. This problem has existed for some time and is now being addressed through current NFPA committee work and related research.

Firefighters find themselves in the most dangerous of conditions. While the most obvious hazards are burns and physical injuries, the more incipient hazard of exposure to contaminants that include carcinogens is an equally serious threat. Hopefully, the fire service, with the assistance of groups like the Firefighter Cancer Support Network, can consistently apply these practices and promote other forms of protective clothing design and care technology improvements to further create reductions for cancer-causing agent exposures. ■

ADDITIONAL RESOURCES

- NFPA 1851: Standard on Selection, Care, and Maintenance of Protective Ensembles for Structural Fire Fighting and Proximity Fire Fighting
- New research: How clean is firefighting gear?
- Cardiovascular and Chemical Exposure Risks in Modern Firefighting Interim Report