White Paper

The Truth about Cancer Hazards and Turnout Gear

Awareness of cancer clusters among firefighters has increased recently as more information becomes available. Over the last decade, three key studies have shown elevated risks of certain types of cancer among firefighters relative to the general population [1,2,3]. The amount of increased risk is difficult to determine exactly, but it is apparent that the risk is associated with the number of fire calls, indicating that exposure to fire smoke is a major contributor [4].

The effects of exposure to carcinogens (cancer-causing compounds) can often take many years to show up as cancer clusters. This makes it very difficult to quantify the risk, as well as see results of changes that are made to procedures and equipment. A large, long-term study is underway that is focused on carcinogen exposures and effects in firefighters [5].

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Studies show elevated risk of cancer among firefighters...

The Fire Fighter Cancer Cohort Study (FFCCS) includes evaluation of exposures, building a matrix of cancer-causing agents, and studies of epigenetic biomarkers (individual susceptibility to carcinogens). Although this major study will take more than a decade to conclude, it should answer many of the outstanding questions related to the disproportionate risk of cancer faced by firefighters. This article will attempt to summarize the current thinking on the major contributors to cancer clusters, and the role that firefighter's personal protective equipment plays.

What role does the firefighter's personal protective equipment play in health hazard exposure?

All fires, including modern building fires, produce toxic chemicals, including many chemicals that are either known, or suspected carcinogens (cancer causing chemicals). Carcinogenic chemicals such as benzene, PAH's (polyaromatic hydrocarbons such as napththalene and benzopyrene), PCB's (polychlorinated biphenyls), aldehydes, asbestos, and toxic metal compounds such as arsenic, cadmium, and lead have all been detected in fire smoke [6, 7,8]. Some reports also speculate that the toxicity of structural fires has increased over the years due to changes in building materials [9]. Decades ago, building materials and interior furnishings were made from natural products such as wood, cotton, and wool. Today, modern materials such as plastics, synthetic foams, and engineered lumber are thought to produce a higher concentration of toxic materials when burned. Firefighters are now being trained to treat fires as hazardous material events in order to limit exposure to the toxic gases and particulates that can increase the risk of cancer, as well as other respiratory diseases [10].

Personal protective equipment plays an important role in protecting firefighters from exposures to dangerous heat as well as inhalation of smoke/toxic outgas of fires. Firefighter communities, manufacturers, and health organizations are using the newly available information to educate firefighters, and to help design and engineer equipment. As part of a firefighter protective equipment ensemble, thermal protective clothing (turnout gear) covers and protects the majority of a firefighter's body area. There have been ongoing studies and questions about turnout gear contamination, decontamination, cleaning, and the role turnout gear plays in carcinogen/health hazards exposure.

A new study, which is running concurrently to the cohort study, conducted jointly by the Fire Protection Research Foundation and the NFPA, in underway to identify the best practice in cleaning of protective equipment, including turnout gear. The goals of the study are to identify the best methods for measuring cleaning effectiveness (how clean is "clean"), determine best cleaning methods, decontamination, and disinfection to reduce firefighter exposures to contaminants [11].

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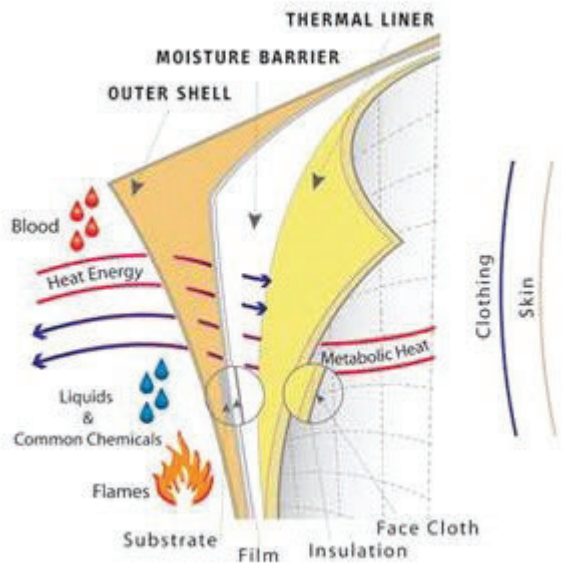

Fabric illustration courtesy of Honeywell First Responder Products

The current turnout coat and pant design is based on a three-layer system that was developed and patented in 1918. It consists of a thermal liner against the skin to provide insulation from extreme heat, a moisture barrier to prevent water and contaminants from penetrating the garment, and a heat resistant shell fabric that provides protection from flame, chemical, and thermal hazards.

The outer shell of turnout gear is made from a blend of flame resistant, high-strength fibers. These fibers do not melt, are highly resistant to fire, and retain their high strength even at elevated temperatures. The outer surface of the shell may be treated with a repellent finish to prevent absorption of water, other fluids, and contaminants. Recently, there has been some concern that the synthetic materials used to construct this protective composite may be contributing to the exposure hazards faced by firefighters [12]. The concern is driven mostly by the widely-known issues surrounding a chemical known as PFOA (perfluorooctanoic acid) [13].

PFOA, also abbreviated as “C8” because it has an 8 carbon backbone, is a building block used to make repellent coatings for all sorts of products. It was used to make stain and water repellent finishes for carpet and home furnishings, non-stick cookware, and apparel. Unfortunately, PFOA does not break down easily in the environment, nor is it metabolized quickly (removed from the body). Detectable amounts began to show up in the tissues and blood of workers in factories that manufactured the materials and in members of the surrounding communities [14]. In individuals with high concentrations, PFOA has been associated with a variety of health concerns [15]. In addition to repellent finishes, PFOA was used as a component in firefighting foams and as a processing aid in some industrial manufacturing. As analysis techniques improved and even trace amount of PFOA could be detected, lower concentrations were found in many other geographic areas. It is believed today that 98% of all Americans have detectable levels of PFOA in their body [16].

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Due to its persistence in the environment, and the possibility that it can cause health issues at high concentrations, PFOA has been phased out in North America over the last decade. Repellent material and coatings are now made from different fluorine building blocks. Most commonly, an intermediate material with 6 carbons, termed “C-6”, is used. These new materials have been shown to be significantly less persistent, and less harmful [17]. The short-chain building blocks have shown to metabolize in mammals 20 times faster than PFOA, in addition, these C-6 monomers are non-carcinogenic, and are at least 10 times less toxic than the PFOA counterparts that they replaced. Due to the concerns raised from PFOA, the shorter chain building blocks have been well studied and found to be extremely safe [18,19].

Studies have shown that turnout gear can be contaminated with toxic and carcinogenic chemicals that are generated in fires [20,21,22]. Some of the carcinogenic and suspected carcinogen chemicals, such as PAH’s and PCB’s, can absorb through human skin (dermal absorption). In addition, skin permeation to chemicals generally increases significantly with increases in temperature and humidity (skin hydration level, or amount of moisture on skin). These conditions are very prevalent for firefighters. Heat stress and perspiration under a thermal protective clothing are likely to exacerbate the potential dermal exposure to hazardous chemicals. Therefore, keeping hazardous chemicals from adhering to the fabric of the gear, and allowing for easy decontamination are good practices in limiting exposure to carcinogens.

The repellent coating in turnout gear is a key feature of the equipment. Currently, fluoropolymers, including C-6-based polymers, are the best materials available to form durable coatings that reduce water absorption (a requirement of turnout gear as specified in the NFPA 1971 Standard), reduce absorption of contaminants, repel greases, oils and other hydrocarbons, and provide easy decontamination. As a result, most turnout gear certified to NFPA 1971 will contain some form of fluoropolymer. When selecting protective equipment, fire departments should choose comfortable turnout gear with the necessary level of thermal protection, and low heat stress burden. A low heat stress burden can not only reduce heat stress related injuries, but also can minimize potential chemical exposure risks. Innovative manufacturers of turnout gear fabrics are continually searching for new materials, constructions, and processes that provide the maximum protection to firefighters while ensuring that the components remain safe for end-users, manufacturing associates, and the environment.

All turnout gear certified to NFPA 1971 will contain some form of fluoropolymer, a coating that reduces water and contaminates.

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About the Authors

Andrew Child

Drew has been with Milliken & Company for nearly 25 years holding roles in Research, product development, development management, and program management. An inventor on 24 issued US patents in areas of textile coating and chemistry.

Drew earned his B.S. in Chemistry and Ph.D. in Applied Chemistry (polymer specialty) from the University of Texas at Arlington. He also holds a Project Management Professional certification from Project Management International.

Shulong Li

Shulong has more than 20 years of productive industrial research experience with Milliken & Company. He is responsible for developing successful commercial technologies and products in a broad range of markets including military, flame resistant specialty Apparel, Fiber Reinforced Composites and Automotive textiles. He is an inventor on 55 issues US patents. Shulong holds degrees of B.S. in Applied Chemistry and a M.S. in Polymer Physics from the University of Science and Technology of China ('85 and '88) and a Ph. D. in Materials Science from University of Minnesota ('93). In 2008, he obtained a MBA degree from University of South Carolina, Moore School of Business.

Shulong Li (Continued)
Shulong serves on the ASTM D13 (Textiles), F18, F23 and E05 technical committees. He is a member of ACS (American Chemical Society), the Fiber Society, and NFPA (National Fire Protection Association).

Milliken & Company is the leading textile manufacturer in United States with 40 manufacturing locations. Milliken has long led the way for "knowledge-based" investment, employing over 100 PhDs, and has accumulated over 2,200 U.S. patents - and more than 5,000 patents worldwide - since our founding in 1865. Manufacturing sustainably is a core value of Milliken. We are an ISO 14001 (Environmental Management) company, participate in the Responsible Care program, and are certified by the Leonardo Academy as a carbon negative manufacturer.

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