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PPE Update

Update: Firefighter PPE cleaning initiative

Researchers are gaining ground on the holy grail of determining how much contamination remains in PPE after cleaning

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As previously reported, the [Fire Protection Research Foundation](#), the standards research arm of the National Fire Protection Association, is working toward a project that has the short title, "How Clean is Clean?"

This project is directed toward carrying out the research to understand the levels of contamination in firefighter clothing and how to properly clean that clothing. Here's an update on where the project is going and some of the initial findings.

To understand the significance of the project, it is necessary to recount the reasons that clothing contamination has become such a concern. For many, cancer in the fire service has reached a problem of epidemic proportions. Statistics clearly show that firefighters have an increased risk of certain cancers above the general population.

Part of that risk is due to structural fires exposing firefighters to combustion products that include myriad of carcinogens. Most fire service organizations have adopted an aggressive posture to address ways to reduce risk through proper hygiene and other practices.

Smoke particulates and fire gases easily penetrate turnout clothing and the clothing picks up and retains many of these contaminants. Thus, one way to mitigate continued exposure of firefighters to carcinogens and other harmful substances is to ensure that clothing is clean, a trend on the increase over the past two decades.

Yet, despite the general improved practices, the industry still lacks any certainty if cleaning is effective and what approaches are the best to ensure that dirty or inadequately cleaned clothing does not

become another way of creating firefighter exposure to carcinogens.

Several studies show that firefighters are exposed to a variety of chemicals on the fireground. This has been confirmed by blood and urine samples, skin wipe samples and the analysis of short- and long-term health monitoring.

While this in itself is not a direct link to cancer, it does show that chronic exposures in some cases can accumulate over a firefighter's career.

Other research shows that different contaminants retained in firefighter clothing can transfer to the apparatus, station and wearer's body. Thus, examining personal protective equipment as one source of firefighter exposure is both relevant and critical to addressing the broader problem.

Fire departments, manufacturers and service providers have been washing PPE for decades but it is difficult to make a claim that all contaminants are removed. Often people use the "sniff test" or wipe a piece of tissue paper on the exterior of the clothing. But these techniques do not prove that the clothing is clean.

Cleaning validation

We need a way to determine whether clothing is clean and if a cleaning and decontamination process has removed all contaminants. This is a significant part of the foundation's effort as it works with government and commercial partners to conduct a thorough investigation. More importantly, it hopes to provide industry guidance and create changes in how the fire service cleans clothing to show effectiveness.

The principal effort is to create a cleaning-validation technique. The idea is that this technique can be applied to any location, cleaning process, detergent, machine or overall technology to determine if contamination is removed.

The research is being directed to first find ways to contaminate samples similar to how the contamination occurs on the fireground. This is important because in order for cleaning efficiency to be determined, you have to know the level of contaminants in the clothing at the start and how much remains or has been removed.

Measuring contaminant levels in the rinse water is insufficient to answer this question. The ability to contaminate clothing with known amount of chemicals and particulates provides the basis for offering a methodology that can create surrogate samples.

Once consistent contaminated samples can be generated, they can be inserted into clothing, subjected to the cleaning process, then removed and analyzed for contaminant levels. The percentage of specific contaminants can be determined by comparing the levels before and after washing.

Separate samples have to be used for this because the technology does not exist to nondestructively evaluate all contaminant levels. This is what makes having a consistent laboratory contamination method so critical — ordinary fireground contaminant is highly variable and cannot be evaluated without cutting out large sections of clothing and subjecting the samples to destructive evaluations.

A complex problem

As simple as the process sounds, the research is exceedingly complex. Turnout clothing consists of a variety of materials that have different affinities for absorbing and retaining contamination. There is vast range of contaminants to which firefighters are exposed; even when priority compounds are selected, the number of different types of chemicals is enormous.

There is no universal extraction or analysis method for this range of contaminants. Various methods have to be used for isolating different groups of chemicals and most contaminants employ unique analytical techniques for determining the presence and quantities of these substances.

Moreover, extraction methods do not mimic how firefighters might be exposed to a substance. In some cases, a strong acid is used to dissolve the material while aggressive solvents also remove normal clothing additives that make analyses difficult. And, interpreting the results of the testing should not require a chemistry degree.

To address these problems, the team is considering a kit that includes a surrogate clothing fabric system contaminated with known amounts of priority chemicals representing a range of hazards. The contaminated sample would then be sent to the cleaning facility in a kit with instructions for placing the sample inside the full clothing and subjecting both to the prescribed washing.

The cleaned sample would be removed, repackaged and sent to the laboratory for analysis where the results would show an index of cleaning in one or more areas. This would show how well cleaning works.

Parallel work is aimed at determining if there are any acceptable levels for certain contaminants if the cleaning is not 100 percent efficient.

Most of the project feedback is that the proposed technique should be applied to the makers of detergents and cleaning equipment to qualify their products and processes. It has also been suggested that this technique also pertain to clothing manufacturers and to verify the cleaning capabilities of independent service providers.

This technique will become the basis for evaluating emerging cleaning technologies and assess practices like gross decontamination as part of field activity. The research group plans to recommend cleaning validation as part of the **NFPA 1851** standard.

Best practices

Another part of the research is focused on developing guidelines for how to set up proper cleaning capabilities and provide recommendations more specific than what is usually offered for how turnout clothing should be cleaned and decontaminated.

For example, NFPA 1851 only indicates not to exceed certain washer and dryer temperatures, to keep the detergent in a certain pH range, minimize the speed at which the machine drum turns and not use bleach. The proposed best practices using the cleaning validation measuring tool will set standard procedures that can be used to generally remove fireground soils and contaminants.

In essence, the guidelines will offer a primer on effective cleaning that is based on validated procedures as well as address other issues such as removing certain forms of contamination, including biological contamination and asbestos.

Overall, the largest challenge is to realize that improvements can be attained in successive steps by not only measuring contamination levels, but also in applying the measurement technique widely to ensure complete cleaning.

The provision of both an industry yardstick and best practices will hopefully lead to the reduced chronic exposure of firefighters resulting from contaminated or inadequately cleaned clothing.

About the author

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Jeffrey and Grace Stull are president and vice president, respectively, of International Personnel Protection, Inc. They are members of several NFPA committees on PPE as well as the ASTM International committee on protective clothing. Mr. Stull was formerly the convener for international work groups on heat/thermal protection and hazardous materials PPE as well as the lead U.S. delegate for International Standards Organization Technical Committee 94/Subcommittees on Protective Clothing and Firefighter PPE. They participate in the Interagency Board for Equipment Standardization and Interoperability and have authored the book, "*PPE Made Easy*." Send questions or feedback to the Stulls via [email](#).

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