By Laura Aiken

PFAS: Let's talk about it

PHOTO CREDIT: NANCY WING / ISTOCK / GETTY IMAGES.

"I can't talk about that."

Rare is the topic that evokes this response, but it's one I've heard more than once from an inquiry about PFAS, more tongue-twisterly known as per – and polyfluoroalkyls. PFAS comprise thousands of human-made substances. PFAS has had a role in fire as a fluorine based performance additive in turnout gear and foam, but that role has been under re-evaluation for years because there is a burgeoning body of generally accepted evidence that these chemicals are bad for humans and our planet.

PFAS are easy-peasy to detect in people and the environment because they are everywhere (food, air, drinking water, dust, cosmetics, consumer products) and they aren't nicknamed "forever chemicals" for nothing (devilishly persistent, can't be broken down by conventional methods). They are found around the world, even in remote areas, and are routinely measured in samples of air, water, earth and tissue.

ABOVE Dirty gear brought into the fire hall could off-gas and increase exposure to a number of hazards.

"PFAS is not a fire service problem. It's a global problem," said Bryan Ormond, associate professor at the Textile Protection and Comfort Center in the Textile Engineering, Chemistry, & Science Department at Wilson College of Textiles; North Carolina (NC) State University. "They've just been used in way too many places and too many products. Are there any people on the planet that don't have PFAS? Babies are born with PFAS already in their blood."

PFAS can have a tendency to biomagnify, which means they accumulate in larger levels the higher up the food chain you go. This was reported in the Canadian government's updated draft on the state of PFAS, issued in July, that is intended to guide the decision making on PFAS as

a class in Canada.

Canadian specific data on high-risk groups (firefighters, pregnant women, Indigenous and Northern populations) is unavailable. Firefighters internationally have measured higher levels of certain types of PFAS than the general population, reported the Canadian government. At large, diet and water are the main sources of PFAS ingestion and levels in local populations vary. Firefighters potentially have this additional exposure and trying to sort out how much when they are already exposed is difficult.

The federal document looked at recent studies, particularly on PFOA and PFOS, that have shown them to be more hazardous to human health in lower doses than prior research indicated. Studies have shown that PFAS can enter the body easily and exit slowly, accumulating and hanging around for years. Exposure can impact multiple organs and systems, mainly the liver, immune system, kidneys, reproductive system, development, thyroid, nervous system and metabolism. In terms of PFAS' potency as a cancer triggering carcinogen, 26 types were evaluated in a 2020 study by Temkin et. al., and these findings determined they exhibited many key carcinogenic traits (suppressing immunity, changing cell growth), and well-studied PFOA and PFOS carried up to five characteristics. In U.S. firefighters, 2021 research by Goodrich et. al. linked concentration levels with accelerated DNA aging and aberrant gene expression, both biomarkers for diseases, including cancer. The International Agency for Research on Cancer (IARC) classified PFOA as carcinogenic to humans and PFOS as possibly carcinogenic.

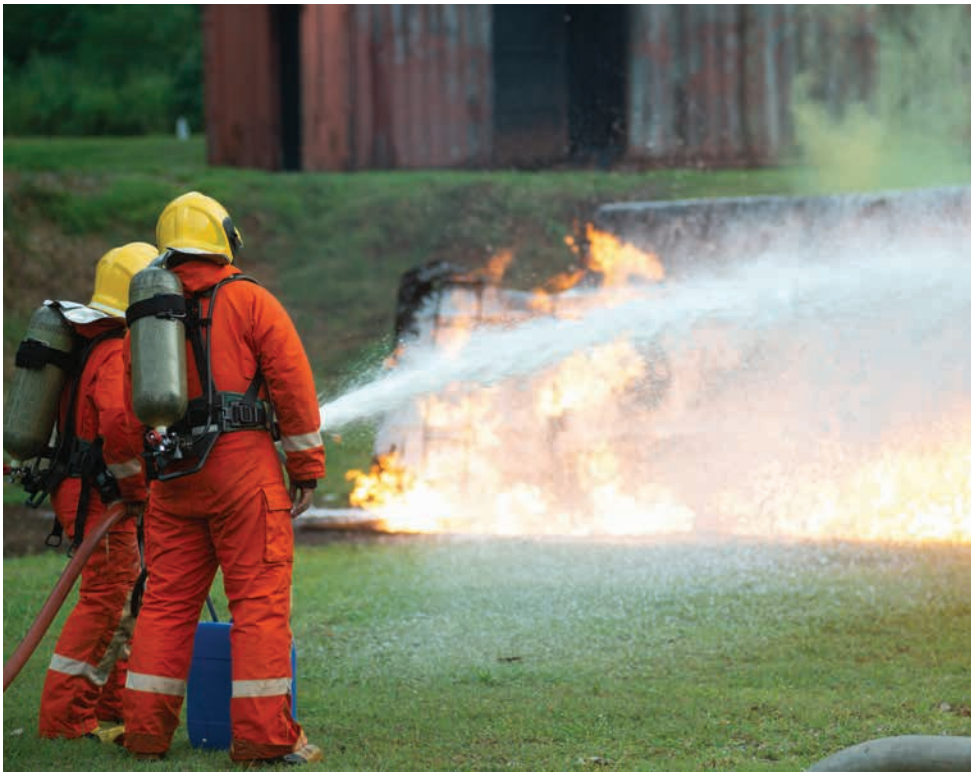
The science is evolving when it comes to PFAS: there are knowns and unknowns. There are multiple considerations for fire departments evaluating turnout gear replacement or foam systems. This article intends to capture the lay of a vast and changing landscape to bring us up to date on the current state and future direction of PFAS in the fire service, beginning with its role in foams, then looking at PPE and the incoming consolidated NFPA 1970 standard on Protective Ensembles for Structural and Proximity Firefighting, Work Apparel, Open-Circuit Self-Contained Breathing Apparatus (SCBA) for Emergency Services, and Personal Alert Safety Systems (PASS).

THE FACTS ON FOAM

Typically, Class A foam that is used to battle Class A fires, like forest fires and structure fires, never included PFAS (fluorine) as an ingredient.

PFAS surfactants and polymers have many practical applications, but their ability to repel oil, make a film and supress vapours, have made them a suitable ingredient in Class B aqueous film forming foam (AFFF) and alcohol-resistant AFFF (AR-AFFF) used for class B fires, like oil, diesel, and alcohol fires since the 1960s.

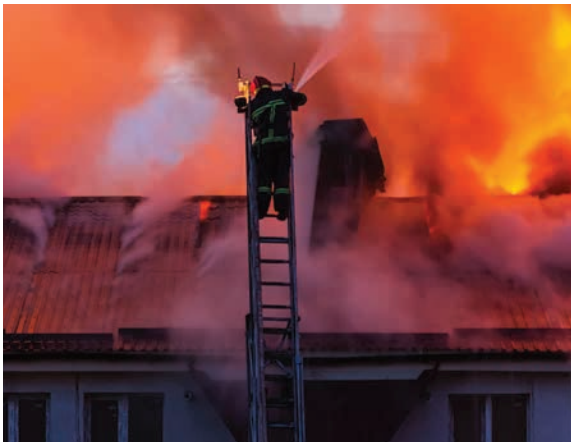
Canada has "hot spots" where higher levels of PFAS are measured in areas where AFFF foam was used to fight fires, or for training or equipment maintenance at airports and military buildings. However, contamination



is found throughout Canada, not just these concentrated areas.

There has been an ongoing phase-out of PFAS in foams, with regulations currently being revised under the proposed Prohibition of Certain Toxic Substance Regulations 2022. Implemented by the Canadian government, these regulations will further restrict any exemptions to the point where there would be a "phase-out of the use of AFFF containing PFOA and/or LC-PFCAs as early as 2025."

PFAS molecules are still used in some Class B applications today, but over the last 10 years, the need for this material is slowly going away as technology continues to improve. Misconceptions, however, continue about which foams have PFAS, and which do not. It is always best to consult your foam manufacturer, said Mark Biernat, president of Biernat Fire Feu Inc., a representative in the industry since 1993. Most Class A foams are like strong dish soaps and they have never contained PFAS, he said. In the past, some B foams with PFAS were also recommended for use on A fires, branding themselves as A/B foam, so he said it is understandable why this product segment is not always clear.



Above Using less water at a structure fire reduces the risk of structure collapse.

"When you say the word 'foam', you really need to clarify what kind of foam or agent you're talking about, which one is the threat to the environment and which one isn't, and which one has never really been a threat," said Biernat.

There is always an environmental risk; even an "environmentally friendly" fire fighting foam without any PFAS, or a pail of your favorite soap may leak into a creek, and this could potentially have a negative impact on fish. But the benefits of being equipped with a foam that can extinguish flammable liquids seems to be the responsible path; like using soap for personal hygiene, he said.

Biernat believes there are many advantages to using Class A foam, including faster knockdown and less total water used. There is also one less water tanker shuttle, less fuel used for the tanker, less risk of an accident, less time at the fire scene for firefighters, less water damage to citizen property, and less time exposing firefighters to a superheated environment. When less water is used to fight a structure fire, it reduces the risk of building collapse, and the number of rekindle situations. In a metro area with hydrants many of these benefits remain true, especially the reduction of potable water used on fires.

Another area that requires further research is the possibility that using Class A foam could reduce the likelihood of cancer in firefighters by mitigating harmful vapours at the scene, lowering benzene levels typically found inside the structure after a fire, and creating a cleaner environment during any follow-up operations.

Communities have been placed under incredible pressure to find a quick solution to this "PFAS foam environmental crisis" and maintain a healthy workplace. In the rush to a solution, it's possible to overlook the performance of a foam. It is not only important to ask questions about the environment – we need to know if the foam performs and to what standard. With so many new products out there, it is important to understand the difference between performance tests.

What is the difference between a Class B fire NFPA 18 wetting agent test, and a Class B fire UL 162 test? What criteria are used to meet each of these standards? To explain this difference in broad terms, the quantity of fuel burning in a 50 sq. ft. pan is the same for each test. The difference is that the NFPA

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"We're trying to make sure our crews only wear bunker gear when it's absolutely necessary."

18 wetting agent test uses 10 gallons of foam, and 50 gallons of water to extinguish, while UL 162 only uses only three gallons of foam and six gallons of water and includes burn-back tests. The UL 162 test is a much more rigorous test to pass.

"You have many choices for fire fighting agents, but they may not offer the performance you are expecting for the type of fire you are facing. NFPA 18 is simply a much easier test to pass," said Biernat. UL 162 products can pass the NFPA 18 Class B fire test but not all NFPA 18 tested products can pass UL 162.

When considering a non-PFAS or fluorine-free Class B foam there are several other terms used to refer to this type of foam: SFFF (Synthetic Fluorine Free Foam) or FFF (Fluorine Free Foam). The term "no intentionally added PFAS" is also used to emphasize the fact that PFAS are not intentionally added to the formulations but that trace amounts could be seen from incoming raw materials and the water that's used to make the product. Extremely low levels (<1ppm) of PFAS do not provide any fire fighting benefit, such as oleophobicity and a vapour barrier, to the formulation.

It is also important to understand some of the subtle differences between the use of traditional AFFF and SFFF. Some SFFF will work only with freshwater not saltwater. Some may be thicker, so knowing the foam viscosity is important, and if your existing foam system is ready for it. For example, the popular FoamPro 2001 and 2002 series can pump foams up to 2000Cps (centipoise). The FoamPro Accumax with a Trident Pump can pump foams with viscosities up to 3500Cps. AFFF Foam uses a film to supress vapours, while SFFF uses a bubble blanket. There are subtle differences that should be addressed before the foam is put into service. A whole new skillset will not be required, just more awareness of seeing the bubbles, and understanding that filling the gaps is more important than with AFFF, because the bubble blanket is really doing all the work with SFFF.

There are many foams, gels, or agents that emulsify or encapsulate and are all legitimate tools to be considered for your community. It is important understand how they work. AFFF and SFFF foams are for Class B fires, which represent about seven per cent of all fires. If your Class B flammable liquid fire is deep or shallow it may influence what type of agent is best for the risk you are facing. Know how much agent you need, and the strategy it employs, as this varies significantly depending on the product. The rest of the 93 per cent of fires fall into the Class A category, including tires.

PFAS AND PPE

PFAS is such a high performing class of chemicals that it's been easy, up until recent times, to performance boost many things with it. The challenges of removal face many industries. PFAS are a big player in the creation of semiconductors (there is even a Semiconductor PFAS Consortium). For the fire service, there are now non-PFAS finishes for turnout gear on the market from a number of suppliers. For example, Stedfast created a moisture barrier in StedAir Clear with non-fluorinated membrane technology and is UL certified to NFPA 1971 ed. 2018. Safety Components PF Zero non-fluorinated finish for PPE fabrics is another example of innovation. PF Zero fabrics were certified by UL as a replacement finish for fabrics sold by Safety Components under NFPA 1971/1951.

The new finishes being applied to turnout gear were already on the market in consumer finishes for sports gear and are, for the most part, based on hydrocarbon wax or silicone, said Ormond, whose expertise in textiles and PFAS made him a knowledgeable and memorable speaker at Ontario Association of Fire Chiefs' annual conference this year.

The PPE with non-fluorinated finishes may look the same but they are not quite the same. PFAS' fluorinated side chains stand up on the fabric, causing a surface tension that's highly repellent. When substitutions are made, there are trade-offs, and the risks of substitutions are often not sorted until later. There is no solution that ticks all the boxes and has no trade-offs. Some of the challenges lies in tackling both water and oil repellency.

"We know when you switch to some of these other ones, just as a matter of chemistry, we are not going to have all the repellency anymore, with the current technologies and chemistries that are out there...We don't know what level of exposure you're actually getting from the fabrics – we don't know a lot of things...Is wearing the turnout gear a significant dermal exposure to PFAS? We don't have an answer for that," said Ormond.

Most oils are hydrocarbons, he said, and you can't repel something with the same type of chemistry, but you can get quality water repellency, and one that is relatively durable to aging. Water repellency is key because water conducts heat well and burn injuries could result from gear getting soaked through.

Firefighters are also exposed to many flammable oils from motor vehicle accidents, auto body shop fires or restaurant fires and they will burn at different rates. Christian Dubay, vice president of engineering and research and chief engineer for the NFPA, spoke with *Fire Fighting in Canada* on the incoming new 1970 standard. He said one case the committee has proposed is a reporting test around the flammability of the outer shells, and this is based on significant research done through NC State University on non-PFAS and with PFAS outer shells to compare how they perform. It was observed that non-PFAS gear could pose a potential flammability hazard when exposed to diesel.

Burn protection and making sure firefighters aren't experiencing heat stroke are also

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Fighting vehicle fires is inherently dangerous, but electric and hybrid vehicles pose additional challenges to responding crews.

As per NFPA guidelines and EV manufacturers' Emergency Response Guides, firefighters are instructed to deliver copious amounts of water directly onto the battery case to prevent thermal runaway and aid in extinguishing the fire. But with the majority of EV batteries located underneath the vehicle, it's extremely difficult and demanding on manpower to achieve using the nozzles currently available to the fire service.
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factors. Turnout gear consists of three layers: outer shell, moisture barrier and thermal barrier. There are two key tests to understand with turnout. One is thermal protective performance (TPP) to measure the thermal insulation of all three layers together to assess how long it takes to receive a second-degree burn. The current minimum is 35, and this means it takes 17.5 seconds to get a second-degree burn in a flash fire situation. All composites are also tested for total heat loss (THL), an indication of the product's ability to allow heat and moisture vapour escape from the wearer (current minimum is 205). Attaining a greater TPP will result in less THL ability.

MAKING CHANGES

Ideally, when making significant changes to PPE, you'd have all the desired data, but the existence of some lesser knowns doesn't mean no one should act. PFAS build-up is cumulative, acting is a form of taking precautions. Science takes time to catch up, and in the meantime, it's key for the fire service and industry to acknowledge knowns and unknowns.

ABOVE Which gear is essential for which calls? Reducing PFAS exposure calls for, perhaps, a re-evaluation.

"The transition has happened too slow for some people and way too fast for others," said Ormond. "It's important to consider in the transition that we are not changing things that are going to cause other problems. It's important to acknowledge that the gear will be different and understand those differences, whether it's the repellency or breathability of the moisture barrier... it's going to be different. We have to make sure firefighters, before they ever put on a set of non-PFAS gear, are trained thoroughly on the differences, the limitations and how does it look and feel different from the gear that they have been using."

It will be noticeable, he said, that some liquids that splashed and ran off PFAS treated gear, will soak through non-PFAS gear. Repellency issues need to be understood through all the layers. There are also many different fluids to consider for first responders – such as blood and saliva – on scene. Is there a difference with those fluids on these finishes?

"Biological hazards are much more complicated sometimes than chemical hazards are."

If unclean gear hangs in the station, it's potentially off-gassing other hazardous materials. There's been several studies looking at dust in various environments and some of the dust contains a lot of PFAS, he said. It's very individualized trying to understand the actual exposure happening from these routes and sources. Last May, NIST researchers published a paper analyzing the prevalence of PFAS in firefighter gear. Researchers looked at 20 new textile samples used for one of the three layers of turnout gear – outer shell, moisture barrier and thermal liner. Analysis was difficult because PFAS are so externally prevalent that the risk of contamination during the study was high, but researchers noted it was mitigated. The least amount of PFAS was found in the thermal layer next to the skin, with PFAS concentrations being up to 400 times higher in the moisture barrier and outer shell. NIST is continuing its research by examining effects of wear and tear on the gear and what it means for PFAS concentrations over time. If a significant amount of the PFAS wears off after the first few washes, that significantly changes the thought process around it and risk assessment, said Ormond. It also raises the question of where all the

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"wash-off" is going. Consider also that you can wash non-PFAS gear and it can pick up PFAS from the water if the water is contaminated.

"PFAS-free is solely a marketing term. We cannot measure zero. We can't say something is free of anything, just limited by the sensitivity of the instrumentation."

Ormond has two main takeaways: "If our fire service can make this transition, it has to be accompanied by training, acclimation and an understanding of how the new gear or products perform differently. The second is for firefighters to understand that removing PFAS is not a cure for the epidemic of cancer in the fire service. It's not a singular cause. Firefighters need to be diligent in all their decon and leave as much contamination at the fire scene as they can so it's not back at the station as a secondary source of exposure. And there are the non-fire related things – diet, nutrition, sleep. These are all factors."

Rob Grimwood, president of the Ontario Association of Fire Chiefs and deputy chief with Mississauga Fire and Emergency Services, concurs: "We look at the totality of the cancer problem in the fire service and that's really complex — multifaceted."

Grimwood is also the management co-chair on the 12 person-fire services Section 21 committee as it pertains to the Occupational Health and Safety Act, appointed by the Minister of Labour, to whom the committee advises. Grimwood's been on the committee since 2015. The committee has developed about 80 guidance notes on health and safety for firefighters and fire chiefs.

He cited a combination of inhalation hazards, absorption hazards, and studies that show that shift work and sleep deprivation are part of the picture when it comes to cancer in the fire service. Lifestyle choices should be considered. And, he said, PFAS are part of it, an emerging part they are trying to learn as much as they can about.

Grimwood is optimistic things are trending in the right direction in terms of foams and gear that do not intentionally add PFAS but acknowledges this also creates challenges for fire departments in terms of budgetary impact and long-term replacement plans. Considering his own department, he said that means considering 800 staff that are issued two sets of bunker gear. There's the impact of that, plus where the garment manufacturers are at in their R&D process, as well as meeting NFPA standards.

"It kind of feels like there is a lot of balls in the air," he said. Fire chiefs need to learn as much as they can and reduce exposures where they can.

"In the short term, what we're encouraging fire departments to do as part of their cancer prevention programs — and we hope that they have these multifaceted programs — is to focus on clean bunker gear and proper storage of bunker gear and health and lifestyle. And as

"Biological hazards are much more complicated sometimes than chemical hazards are."

part of that, we're encouraging them to learn as much as they can about PFAS and try and reduce the exposure."

In practice, for Mississauga, that means a move away from wearing bunker gear to events that don't require it, such as pub ed appearances and calls like checking for gas leaks.

"We're trying to make sure our crews only wear bunker gear when it's absolutely necessary."

As part of this move towards removing intentionally added PFAS, the fire service and industry are closely watching the arrival of the new consolidated 1970 standard, which combines standards NFPA 1971, NFPA 1975, NFPA 1981, and NFPA 1982. The NFPA is at the end of its process with 1970. By the first week of September, or beginning of the second week of September, all actions of the council from this last meeting are expected to be publicly available, said Dubay.

"The committee has considered a path on what they term restricted substances. This includes a proposed avenue for manufacturers to label gear as not containing more than 'X' parts per million of PFAS," he said.

Fire service members can head to nfpa.org/1970next to follow the finalization as the council decisions will go there. Departments can also enlist resources from Firefightergearsafety.org. There is also a new standard, NFPA 1585, that is now available and covers contamination control. This was started in 2020 and it was on the overall exposure first responders face from various contaminants, the vast majority being chemicals, but looking at it from a more holistic and proactive approach that considers what happens at the scene, in training, at the stations and in the vehicles, said Dubay.

"It's so vitally important they are looking at all the ways they are exposed to whatever all the contaminations are."

The Fire Protection Research Foundation has done extensive work around how to clean PPE and that resource is available for free at nfpa.org/education-and-research/research/fire-protection-research-foundation.

TALKING ABOUT IT

PFAS: We talked about it, and in truth, many, many people are talking about it, though there are good reasons for a careful tread. Litigation over the dangers of PFAS has erupted in America and, to a lesser extent, Canada. Those cases continue to play out.

Importantly, and overall, there is a shared passion for the importance of firefighter safety in firefighters, chiefs, and industry alike, one that I believe will continue to make being part of the fire service safer on many fronts. Innovation in PPE, products and training have all come a long way from days of yore to ensure firefighters go home at night and are healthier overall. A question to ask, would be, have the high performance of the PFAS gear actually been causing firefighters to place themselves in more danger than they should be? Food for thought, and perhaps more to talk about too.