

**GAO Review of DOD Drinking Water Contaminants (100947)
Follow-up Questions on AFFF Products**

In our prior conversations with Navy officials, we have been told that DOD's AFFF MILSPEC calls for AFFF products to contain PFCs. Based on our review of the AFFF MILSPEC, it appears that the relevant language is as follows (from page 5 of the document): *"Concentrates shall consist of fluorocarbon surfactants plus other compounds as required to conform to the requirements specified hereinafter. The material shall have no adverse effect on the health of personnel when used for its intended purpose."*

1. Is the term "fluorocarbon surfactants" in the MILSPEC interpreted as synonymous with PFCs? If not, how is the term interpreted, and where in the MILSPEC does it require AFFF to contain PFCs?

~~The MILSPEC requires the Class B foam product to have the capability to form an aqueous film layer on the fuel surface. At this point in time, only a fluorocarbon surfactant, which does contain PFC molecules of various chain lengths, is capable of changing the surface tension of the water to enable its film formation at the fuel/foam interface.~~

"PFCs" are "Perfluorinated Chemicals".

From the EPA website on PFCs and PFASs:

"Perfluorinated chemicals is a term that some scientists use to refer to the group of toxic chemicals that includes PFOA and PFOS and other per- and polyfluoroalkyl substances (PFASs). Organizations that have used the abbreviation "PFCs", referring to perfluorinated chemicals, include U.S. EPA, U.S. Centers for Disease Control and Prevention (CDC) and the U.N. Organisation for Economic Co-operation and Development. EPA is now trying to use "per- and polyfluoroalkyl substances (PFASs)" rather than "perfluorinated chemicals (PFCs)" consistently to collectively describe PFOA, PFOS and the other chemicals in this group."

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Yes, the term "fluorocarbon surfactant" is synonymous with PFCs. In the upcoming revision of the Milspec, the term will be modified to be "fluorosurfactant", which includes all PFAS; both fluorocarbon-based (PFC) and polyfluorinated compounds.

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2. To what extent has DOD/Navy considered revising the MILSPEC to remove the requirement for "fluorocarbon surfactants," provided the performance requirements of the MILSPEC could still be met?

Removing the fluorocarbon surfactant requirement would put the foam in the fluorine-free foam (F3) category. To date, there has not been a product without a fluorocarbon surfactant that has been able to meet the Milspec fire performance requirements.

MIL-F-24385F additionally mandates specific chemical and physical requirements to ensure the candidate foam products are compatible with existing military foam proportioning systems and firefighting appliances. The current F3 products have demonstrated problematic issues with regard to their concentrate viscosity, sea water compatibility, their ability to function with non-aspirating nozzles, and will have increased acute toxicity to aquatic life forms, particularly fish, due to their higher levels of hydrocarbon surfactants in comparison to AFFF.

If and when an F3 foam is developed that meets all of the Milspec requirements, including compatibility, the removal of the requirement for fluorocarbon surfactants will be considered.

3. We understand that the Air Force uses high-expansion foam in some of its hangars.
- a. Is high-expansion foam subject to AFFF MILSPEC requirements, or is it subject to other requirements?

No, high-expansion foam is not subject to the AFFF Milspec requirements. There is no other military specification that governs high-expansion foam. High-expansion foam is tested and listed to Underwriters Laboratories Standard, UL-139. Naval Research Laboratory (NRL) testing of multiple UL-139 listed high-expansion foam concentrates in 2004 showed a wide range of extinguishing performance.

It should be noted that high-expansion foam is not an effective fire extinguishing agent for all fire hazards that are protected by AFFF systems. In addition, high-expansion foam systems come with their own set of limitations, including danger to personnel safety.

- b. To what extent does high-expansion foam contain PFCs?

To our knowledge, the Navy has not conducted any testing to determine if high-expansion foam contains PFCs. Available literature on the topic claim that high-expansion foam concentrate do not contain PFCs. It is unknown if this claim applies to all products that have been manufactured in the past.

Navy officials have also told us there are currently no PFC-free AFFF products that meet the performance requirements laid out in the AFFF MILSPEC. We have reviewed the websites of some manufacturers that are on DOD's AFFF QPL, and it appears that some of those manufacturers (e.g., Solberg, ICL Performance Products) claim to sell firefighting foam products that may not contain PFCs (e.g., "fluorosurfactant-free" and "fluorine-free").

4. Has the Navy tested any available PFC-free firefighting foam products (or products that claim to be PFC-free) from these or other manufacturers to determine whether they can meet the performance requirements in the AFFF MILSPEC?
- a. If so, what were the results?

NRL is well aware of the Solberg® (formerly 3-M Australia) Re-Healing™ foam products, which are non-fluorinated foam with polysaccharide thickeners, which are designed to have mechanical properties to compensate for the lack of film formation. Under a previous Cooperative Agreement with 3-M Australia and with the current Non-Disclosure Agreement between NRL and Amerex Corporation, NRL has been conducting fire testing and laboratory studies to help further investigate the potential possibilities for developing a fluorine-free product that could meet the MILSPEC AFFF fire performance requirements. Although the Solberg® products are superior to other F3 foams tested at NRL, they still fail to meet the MIL-F-24385F 28 ft² fire performance test at full strength. Since the products have not been successful at the 28 ft² fire performance test at full strength, NRL has not pursued more demanding test requirements that include the 28 ft² ½ strength testing, 28 ft² testing (full and ½ strength) with aged concentrate, 28 ft² testing (full and ½ strength) with aged solutions, 28 ft² testing for cross-compatibility, 28 ft² quintuple strength test or the requisite 50 ft² fire

performance test. In addition, the AFFF MILSPEC has several other key requirements that must be considered, including compatibility among vendors, dry chemical compatibility, burn back, and viscosity. Integration and compatibility with existing installed AFFF systems and equipment will also be a factor.

Although Solberg® has been somewhat successful in the commercial market; the western foreign Navies, USCG military vessels, and the FAA still rely on MILSPEC AFFF and require its use for Class B (flammable liquid) fire applications where rapid extinguishing performance is mandated.

- b. If not, why has testing not occurred? N/A. See testing discussion in 4.a.
5. To what extent has the Navy funded (or plans to fund) any research into developing PFC-free AFFF products?

In FY17, the Strategic Environmental Research and Development Program (SERDP) released a solicitation to develop a fluorine-free surfactant formulation for use in Aqueous Film Forming Foam (AFFF) fire-suppression operations. Three projects were selected for funding including a proof of concept project led by Naval Air Warfare Center Weapons Division (\$200K for one year), a multi-year project led by the Naval Research Laboratory (\$1.8M over four years), and by National Foam (\$0.532M over three years). These projects will be initiated over the next few months.

In addition to the FY17 NRL SERDP program, the NRL Core 6.2 Research Program has also contributed (\$2.1M, FY17-20) Science & Technology (S&T) funding to further assist with the development of environmentally-friendly surfactants for firefighting foams, which accounts for the desired low fuel permeability capability that is inherent with the current AFFF formulations.

6. What implications, if any are known, would selecting a PFC-free firefighting foam product (or product that claims to be PFC-free) have on the current infrastructure and systems used to store and use AFFF?

The current commercially available PFC-free F3 products have demonstrated problematic issues with regard to their concentrate viscosity, sea water compatibility, their ability to function with non-aspirating nozzles, and will have increased acute toxicity to aquatic life forms, particularly fish, due to their higher levels of hydrocarbon surfactants in comparison to AFFF. Viscosity is a characteristic that is critical in the ability for foam concentrates to work in current AFFF systems and equipment. Even disregarding the known difference in fire extinguishing effectiveness, no existing PFC-free firefighting foam product is known to be a viable drop-in replacement that would be compatible with existing MILSPEC AFFF proportioning systems. Navy research into developing PFC-free AFFF will include integration and compatibility with existing installed AFFF systems and equipment. Any F3-product would need to be compatible with existing fluorinated Milspec AFFF products.