Firefighting System Cleanout: Lessons Learned from Bench-Scale Treatability Studies and Field-Scale Demonstration

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Background/Objectives. As the United States promulgates increasingly stringent regulations on per- and polyfluoroalkyl substances (PFAS) and to facilitate the transition from fluorine-based aqueous film-forming foam (AFFF) to fluorine-free foam (F3), removal and cleanout of AFFF-impacted firefighting systems has become a critical need for the Department of Defense (DoD) and the Federal Aviation Administration. The current practice of cleaning these systems using the triple potable water rinse methodology is inadequate for removing residual PFAS, generates a large volume of PFAS-impacted waste requiring complex and expensive treatment and disposal, and results in PFAS rebounds, which further complicates the transition from fluorine-based AFFF to F3. Herein, two different cleaning reagents, ***PerfluorAd***® technology and School of Mines' proprietary cleaning solution, and PFAS treatment approaches were interrogated under both laboratory- and field-scale settings as part of two parallel DoD-funded research projects to evaluate the potential for enhanced firetruck cleanout and effective treatment of the PFAS-impacted rinsate, respectively.

Approach/Activities. At the bench scale, a series of batch desorption and flow-through laboratory experiments were performed to determine the nature and extent of PFAS present in stainless-steel pipes from an AFFF delivery and fire suppression system, the effectiveness of PFAS removal using two different cleaning reagents, impacts of heating and air scouring on PFAS removal efficacy, and the potential for and extent of PFAS rebounds following the initial cleanout. In addition, treatment of the PFAS-impacted rinsate generated during cleanout using PerfluorAd and closed-circuit desalination (CCD) using reverse osmosis and nanofiltration was also assessed. Results of the bench-scale treatability studies were incorporated into the design and execution of a field-scale technology demonstration using firetrucks at a DoD military installation in the southeastern United States. As part of the field demonstrations, the effectiveness of PFAS removal from the firetruck using the two different cleaning reagents and the treatment of the PFAS-laden rinsate solutions using two different PFAS treatment techniques were compared. The extent to which PFAS rebounds occur after the firetrucks had been refilled with F3 was also assessed.

Results/Lessons Learned. Following the initial cleanout and regardless of the cleaning reagent used, bench-scale testing results indicate PFAS rebounds are likely to occur due to the difficulty of removing sorbed PFAS from pipe materials. The addition of co-solvents and heating are beneficial during pipe cleaning processes, whereas the benefits of air scouring were inconclusive. In addition, CCD and PerfluorAd, especially when used in conjunction with another coagulant, can be used to effectively treat the PFAS-laden rinsate. Results and lessons learned from the bench and field-scale technology demonstrations, including short- and long-term PFAS removal, life cycle costs associated with firetruck cleaning, and a comparison to the triple rinse methodology, will be presented.