Engineered Technologies for Management of PFAS on Army Installations

6.4 Program Overview and Current Results

Objectives:

The main objective of the 6.4 Program - Engineered Technologies for Management of Per- and Polyfluoroalkyl Substances (PFAS) on Army Installations is to provide the Army with cost effective technologies and implementation guidance for characterization, removal, and destruction of PFAS-contaminated materials. The program provides critical information and current data on vetted technologies through internal demonstrations that showcase the destruction of PFAS with an overall emphasis on future incorporation at Installations (Figure 1). The main technologies demonstrated are Supercritical Water Oxidation (SCWO) and Hydrothermal Alkaline Treatment (HALT).

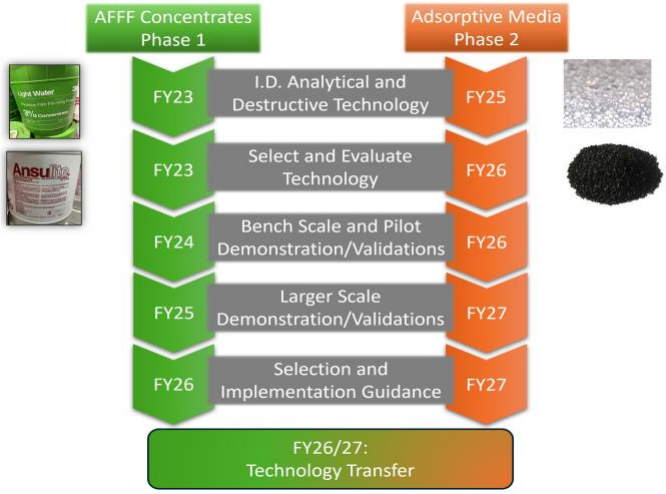

Figure 1. Schematic showing the project design and deliverables by year.

Partners:

Army: ODASA IE&E, IMCOM HQ, USACE-EMCX
Non-Army: SERDP-ESTCP, NAVFAC, USAF-AFCEC, USEPA-ORD
Academic: Colorado School of Mines, University of Surrey

Performers:

Industry: General Atomics, 374 Water, Aquagga, Arcadis, US NAVY NRL

Background / Problem Statement:

Disposal of AFFF concentrate presents a challenging issue to land managers on military installations due to the toxic and recalcitrant nature of PFAS. Stockpiles derived from aqueous film-forming foam usage containing PFAS create significant liabilities with no approved, cost-effective technologies for destruction. However, destruction of PFAS represents an attractive option that may have benefits over disposal given successful performance of destructive technologies available. Demonstration/validation of technologies at scale will enable accurate, near real-time analysis of PFAS and the safe destruction/disposal of PFAS containing materials.

Approach:

The main demonstration/validation efforts are to determine the (1) effectiveness of selected technologies for the destruction of PFAS in an AFFF concentrate mixture, (2) establish controls on the mass balance of fluorine (F) in the influent/effluent/gaseous phase, (3) estimate costs associated with each technology for implementation across different locations in the U.S., (4) and provide implementation guidance for selecting technologies. Each selected technology was tasked with destroying 100 gallons of a pre-mixed, pre-characterized AFFF mixture and monitoring destruction in the effluent stream (Figure 2) and partitioning in gaseous stack emissions. Additionally, operational costs from each technology and life cycle analyses were estimated.

Figure 2. Collection of treated effluent for PFAS analysis.

- *Task 1: Analytical Technologies*
- *Task 2: Destruction Technologies*
- *Task 3: Guidance, Support, and Planning*

Benefit to the Army / Return on Investment:

Per- and polyfluoroalkyl substances represent a burden for the Department of Defense (DOD) due to aqueous firefighting foam (AFFF) trainings on military bases. Providing the Army with cost-effective technologies that can destroy PFAS will aid to decrease overall burden and provide implementation guidance for characterization, removal, and destruction of PFAS contaminated materials.

Results: HALT Dem/Val with Aquagga

HALT implements high pressure, high temperature, and high pH conditions to transform PFAS into relatively inert fluoride salts. This technique is generally considered cost-effective considering the high costs for disposal of PFAS-contaminated material and also can be scaled to from low to high concentrations of PFAS. This is a closed-loop technology meaning the effluent can be cycled back into the destruction unit.

The Aquagga HALT demonstration occurred on 20-23 May 2024 where AFFF concentrate was continuously processed with no stack emissions associated. An overall 99.9% reduction in PFAS substances was achieved (Figure 3).

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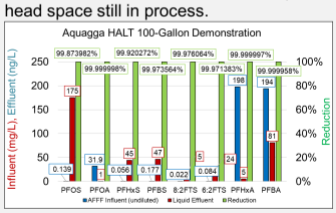
Aquagga HALT
100-gallon demonstration

Aquagga continuously process 100 gal of AFFF concentrate
- Feed Rate AFFF (undiluted) = 0.198 to 0.215 L/min
  - Feed Rate AFFF (diluted) = 0.378 to 0.410 L/min
- Energy required per L of AFFF (undiluted) treated = 0.693 kWh/L
  - Energy required per L of AFFF (diluted) treated = 0.183 kWh/L

No stack emissions associated with system, volatile analysis on effluent tote head space still in process.



	Influent (mg/L)	LE (ng/L)	Reduction
PFOS	0.139	175	99.873982%
PFOA	31.9	1	99.999998%
PFHxS	0.056	45	99.920272%
PFBS	0.177	47	99.973564%
8:2 FTS	0.022	5	99.976064%
6:2 FTS	0.084	24	99.971383%
PFHxA	198	5	99.999997%
PFBA	194	81	99.999958%

Bench Scale Optimization
100 gal AFFF Processing
Larger volume field demonstration

Figure 3. Results from the Aquagga HALT dem/val showing overall destruction capabilities and % PFAS destroyed.

Figure 4. Team on-site (top) and setup of the HALT dem/val (bottom).

Results: SCWO Dem/Val with General Atomics

Supercritical water oxidation is a destruction technique capable of destroying PFAS using oxidation at temperatures and pressures above the critical point of water.

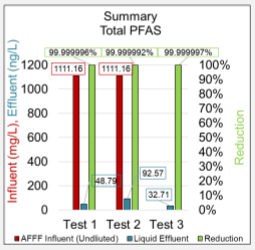
The General Atomics SCWO 100 gallon demonstration occurred on 13-17 May 2024 where AFFF concentrate destruction was achieved at 99.9% for the measured PFAS compounds (Figure 5) and rapid screening tool for PFAS detection was measured in-line (Figure 6).

General Atomics (iSCWO)
100-gallon demonstration

GA iSCWO performed 3 test
1) AFFF concentrate feed at 0.195 L/min
2) AFFF concentrate feed at 1 L/min
3) Reprocessing of test 1 & 2 effluent at 7.7 L/min
- Achieving 99.999997% reduction in PFAS in final liquid effluent.
- Analysis of stack emissions suggest some potential loss of volatiles, but results may be confounded as a consequence of moisture in sampling stream.

	Test 1		
	Influent (mg/L)	LE (ng/L)	Reduction
PFOS	0.139	4.09	99.997060%
PFOA	31.9	1.99	99.999994%
PFHxS	0.056	1.97	99.996488%
PFBS	0.177	3.02	99.998296%
8:2 FTS	0.022	2.27	99.989692%
6:2 FTS	0.084	7.10	99.991552%
PFHxA	198	8.93	99.999995%
PFBA	194	2.60	99.999999%

	Test 2		
	Influent (mg/L)	LE (ng/L)	Reduction
PFOS	0.139	4.38	99.996847%
PFOA	31.9	1.27	99.999996%
PFHxS	0.056	1.24	99.997779%
PFBS	0.177	3.21	99.998184%
8:2 FTS	0.022	4.92	99.977621%
6:2 FTS	0.084	6.85	99.991844%
PFHxA	198	11.56	99.999994%
PFBA	194	6.51	99.999997%



Bench Scale Optimization
100-gal field demonstration
Larger volume field demonstration

Figure 5. Results from the General Atomics SCWO dem/val showing overall destruction capabilities and % PFAS destroyed.

Figure 6. Implementation of a rapid screening method for PFAS detection, direct analysis in real-time (DART).

Current and Future Work:

The main focus of the current work is evaluation of the dem/vals and rapid analytical technology, development of implementation guidance, and incorporation of life cycle analyses/cost benefit information. Future work revolves around incorporation of spent PFAS-contaminated absorptive media. Main deliverables from this effort are field deployable analytical techniques, methodologies for monitoring volatile emissions, technical guidance for disposal of legacy AFFF stockpiles, and planning/guidance documents for Installations.

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