

SERDP AFFF Challenge – PFAS-Free Firefighting Foam Guidance

Disclaimer: This challenge is inherently dangerous. If the submitter does not have the correct protective equipment, test materials or facilities, DO NOT PROCEED. Any submission that shows inadequate equipment or hazardous conditions, will be disqualified. In addition, SERDP assumes no responsibility for damage or injuries that may occur when performing this challenge.

Submission Due Date: 30-September-2021

Please direct any questions or concerns to AFFFChallenge@noblis.org

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AFFF CHALLENGE

2021 ♦ PFAS-Free Firefighting Foams

All submissions will be held in confidence in accordance with the Federal Trade Secrets Act (18 USC 1905). Submissions including Non-Disclosure Agreements will not be accepted.

We strongly suggest that before you initiate any fire testing, you practice mixing/aerating and pouring or spraying foam.

Overview

Legacy Aqueous Film Forming Foam (AFFF) used by the Department of Defense (DoD) as a firefighting foam is facing increasing regulatory scrutiny throughout the world due to environmental and human health concerns associated with per- and polyfluoroalkyl substances (PFAS). PFAS are persistent in the environment and the DoD will be requiring PFAS-free firefighting agents in the near future. The DoD's Strategic Environmental Research and Development Program (SERDP) & Environmental Security Technology Certification Program (ESTCP) are tasked with developing and demonstrating PFAS-free firefighting agents for use as a replacement for legacy AFFF.

This challenge provides an opportunity for individuals and firms of various sizes to contribute to the development of an AFFF alternative by submitting innovative formulations that can approach and match the capabilities of legacy AFFF. These capabilities will be initially demonstrated by the submitter, by performing a small pan fire extinguishing test as described later in this document and in the supporting videos.

Safety Requirements

All fires pose an inherent risk, even in controlled environments. All video submissions should follow a clear safety protocol, which includes (at a minimum):

- Two test participants in proper personal protective equipment
 - flame resistant face shield
 - flame resistant lab coat
 - flame resistant gloves
- Testing shall be done in a well-ventilated area with at least 10 ft ceilings or outdoor testing.
- Testing shall be done in an area clear of flammable materials (10 ft radius).
- If outdoors, testing shall be done in no/low wind conditions (less than 5 mph).
 - concrete or asphalt pad
- Testing shall not be done:
 - in a fireplace
 - on a wooden or other flammable surface
 - in an area with overhanging trees
 - other non-compliant locations
- Gasoline shall be stored in appropriate containers
- A back-up means of extinguishing the fire shall be readily available prior to starting any test.
 - ABC Dry Chemical or CO₂ Fire Extinguisher

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Current AFFF Characteristics

Firefighting foams (including AFFF) extinguish fires by containing the fuel vapors below a blanket of bubbles, preventing these vapors from mixing with air and burning. In the case of AFFF, the bubble blanket is enhanced by a surfactant film that forms on the fuel surface which also contributes to the containment of the vapors. The current foams used throughout DoD are produced by mixing a foam concentrate with water at specified proportions (either 3% or 6% concentrate by volume in most cases). During this exercise, the target ratio is 97% water and 3% concentrate by volume.

Goal

The goal is to identify and test PFAS-free firefighting foam formulations as a replacement for existing AFFF that would meet performance requirements to ensure mission readiness and firefighter safety while also reducing adverse environmental impacts. Non-foaming formulations may be considered but must provide a level of reignition suppression. Desired formulation attributes and desired fire performance are listed below.

Desired formulation attributes:

- does not contain any added PFAS ingredients,
- biodegradable,
- contains only environmentally sustainable chemicals,
- non-toxic,
- supplied as a concentrate designed to be dissolved in water at ratios of 3% concentrate and 97% water by volume,
- a liquid with a viscosity similar to water,
- low corrosivity,
- compatible with fresh water and salt water, and
- produces a foamy solution when discharged from a nozzle.

Desired Fire Performance:

- provides rapid control and extinguishment of liquid fuel fires including gasoline and
- minimizes the release of flammable vapors above the fuel surface after extinguishment and prevents reignition and fire spread (burnback).

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Prize and Next Steps

Three tiers of awards are available:

1. Cash Awards up to but not to exceed \$10,000 will be made to entrants who achieve an acceptable level of performance on fire extinguishment, physical properties, and environmental impact.
2. Entries meriting further investigation will be invited to submit 100 milliliters (ml) of their formulation as a concentrate to the Naval Research Laboratory's (NRL) Technology Center for Safety and Survivability. These materials will be tested at NRL, diluted with water to a 3% solution or at a level defined by the submitter, to ensure they are PFAS-free and that they perform as displayed in the submission. Viable candidates for additional research and development will be asked to submit research and development proposals for up to \$250,000.
3. Developers who have a formulation that is at a technical maturity level where additional development can yield a commercial product capable of meeting our performance and environmental requirements in less than 3 years will be asked to submit a proposal for a research and development effort not to exceed \$2,000,000 for up to 3 years of development.

Submission Instructions

Submit your entry via email to AFFFChallenge@noblis.org with the following media files included as attachments. Where necessary, a large file transfer link will be provided to you upon request.

- (1) Submission form (pages 13-15 within [AFFF Challenge Guidance.pdf](#)). Update the filename to include LASTNAME_ORGANIZATION.
- (2) Video(s) of the fire test.
- (3) Photo(s) of the setup and safety equipment.
- (4) Photo(s) of the concentrate prior to mixing with water.
- (5) Photo(s) of the solution after mixing with water (prior to generating foam).
- (6) Photo(s) of the foam product.

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Recommended Test Description(s) and Procedures

There are two options for conducting the required pan fire extinguishment test for a foam; one that uses a whipped cream dispenser to create and discharge the foam, and one that uses a blender to create the foam and then is poured onto the fire. If the proposed solution does not involve a foam, a procedure analogous to the blender method should be used.

During the whipped cream dispenser fire tests, the foam solution is mixed and discharged from a commercially available (online or at a restaurant supply store) whipped cream dispenser (such as Otis Classic 500 ml Whipped Cream Dispenser model OC 010 or equivalent). The foam is discharged directly onto the fire using a short hose/tube/nozzle connected to the dispenser. During the blender fire tests, the foam solution is mixed in a commercially available blender (such as 1200 ml Hamilton Beach Blender or equivalent) and poured onto a track fashioned from a standard sill plate metal framing stud cut to a length of 24 inch that flows down onto the fire surface. **We strongly recommend that before you initiate any fire testing, you practice mixing/aerating and pouring or spraying foam.**

Independent of the test configuration, the conduct of the test will require at least two people. Every/any participant involved in the fire portion of the test shall be suited-out in the following Personal Protective Equipment (PPE); flame retardant lab coat, protective face shield, and flame retardant gloves. Long pants and closed face shoes are also required. One of the test participants is responsible for setting up the video recorder, handling the fuel and igniting the fire (referred to as the Fire Participant). The second test participant is responsible for mixing the foam solution and discharging or pouring it on the fire (referred to as the Foam Participant). All personnel are responsible for test setup and post-test remediation and cleanup.

Detailed descriptions of both tests are provided in the following sections.

[Instructional Video Found on YouTube \(click here\)](#)



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Blender Foam Fire Test Description ([see video for further instruction](#))

Blender Configuration

In order to aspirate the foam, a straw is taped to the inside of the blender to allow air to be mixed into the solution during blending. The bottom of the straw should be located at the same level or below the mixing blades. Care shall be taken to prevent the straw from touching the blades. The top of the straw shall be about an inch below the top of the blender. A 2 inch wide piece of clear packing tape or duct tape is adequate for holding the straw in place. A photograph of this configuration is provided in the figure below.



150 ml of solution is mixed in the blender and poured on the fire during the test. The solution is prepared by pouring 4.5 ml of foam concentrate into a 100 ml graduated cylinder and then filled with 45.5 ml of water (making a total of 50 ml in the graduated cylinder). The cylinder is then poured into the dispenser. The graduated cylinder is filled with 100 ml of water and poured into the blender. The top is placed onto the blender base and the solution is then blended for 5 seconds. This blending should occur just before the solution is poured on the fire.

Fire Pan Configuration (Blender)

A 1ft², **seamless, stainless steel** cake pan shall be used as the fire pan during this challenge. These are available online or at a restaurant supply store (TeamFar or equivalent, lasagna pan, rectangular cake pan stainless steel, 12.75 by 11.25 by 3.25 inch deep). The pan must be made of steel (aluminum will melt) and shall have about 3 inch vertical depth. During the test, the pan

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is placed in a well ventilated, open area (at least 10 ft away from any combustible materials). A portable fire extinguisher shall be located in the area in case of an emergency. During the test, the pan is filled to a depth of 1 inch of water and 500 ml of ethanol free gasoline is poured/floated on the water substrate. The ethanol free gasoline can be purchased pre-packaged from your local hardware store. It is also available at most marinas (gas docks).

A cinder block is placed 16 inch from the side of the pan. A 24 inch piece of metal framing stud is positioned from on top of the cinder block to side of the fire pan as shown below. A small notch (1" wide, 5/8" deep, bent downward at 90 degrees) is cut in the bottom and center of the stud to keep it from sliding into the fire pan.



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Post Test Action Items

If the fire is not extinguished within one minute of formulation discharge, there are three options:

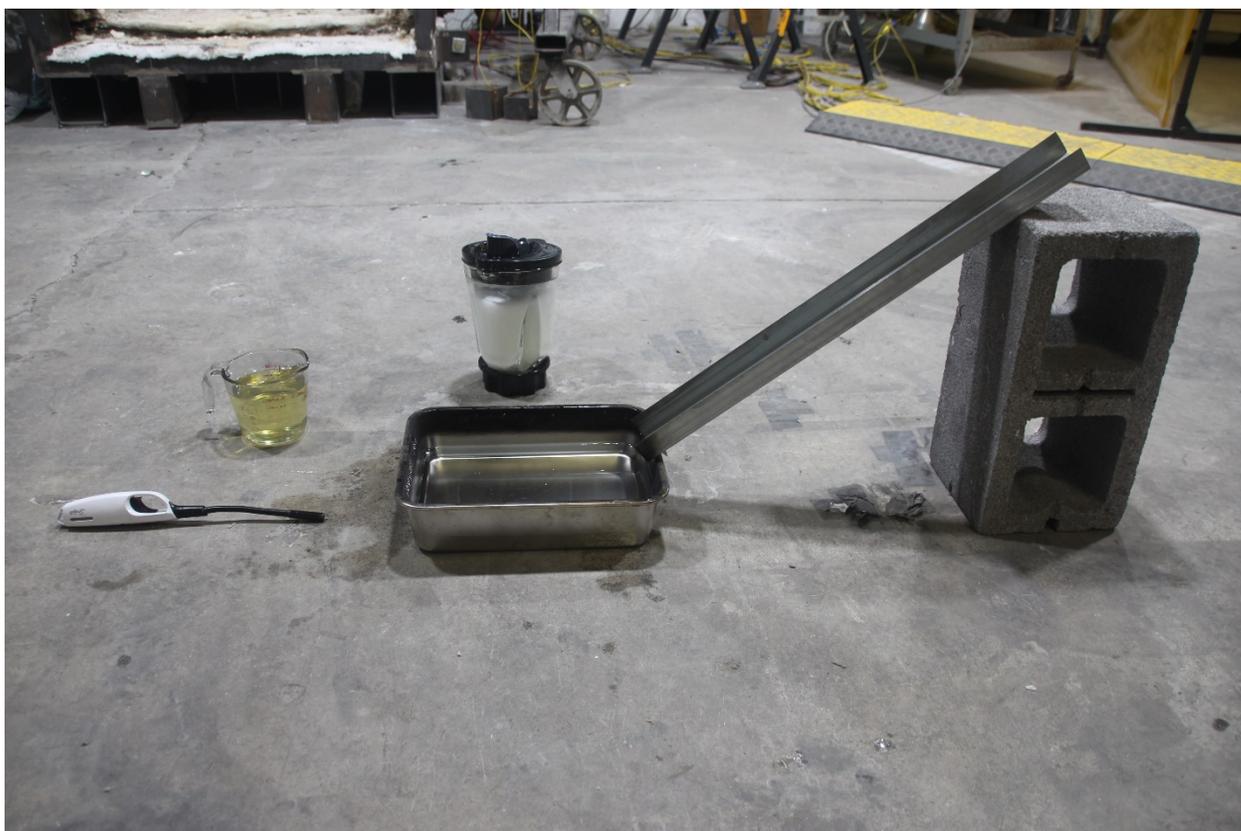
1. allow the fire to burn out (if selected, the fire status shall be monitored for the entire burn out period),
2. extinguish the fire by placing a piece of 5/8 inch drywall (at least 3 ft wide by 3 ft long) on top of the pan to smother the fire, or
3. extinguish the fire using the portable extinguisher. Caution shall be taken when discharging the extinguisher on the fire since direct application of the agent on the fire can cause the fuel to splash out of the pan.

In any case, the foam ramp shall be removed from the side of the pan to allow unobstructed access to pan.

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Test Procedures

- **We strongly recommend that before you initiate any fire testing, you practice mixing/aerating and pouring foam.**
- The test area is set up with the extinguisher in position and the fire pan filled with water to a depth of 1 inch and the cylinder block and foam ramp installed.
- Test personnel don PPE (face-shield, flame resistant gloves, and flame resistant lab coat).
- The gasoline (500 ml) is measured-out and placed in a beaker adjacent to the pan.
- An igniter for a gas grill (i.e., propane lighter or BBQ lighter with at least a 6 inch extension) is placed next to the beaker of gasoline.
- The foam solution is prepared and brought to the test area.



- The video camera is started, and the two test personnel assume their positions.
- The fuel is then poured into the water-filled pan and ignited by the Fire Participant.
- The Foam Participant counts to 10 (to allow a 10 second preburn) and then pours the foam solution on the ramp.

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- The Fire Participant will time the extinguishment with a stopwatch, starting as soon as the foam touches the fuel and ends when extinguished – no flickering or edge effect burning.
- It should take between 5-10 seconds to pour the foam on the ramp.
- The solution is given 1 minute to extinguish the fire (for this configuration, AFFF extinguished the fire in less than 10 seconds).
- If the fire has not been extinguished by the foam, the fire can be allowed to burn out or can be extinguished using the methods previously mentioned.
- If the fire is extinguished, the time for extinguishment measured from the start of the foam reaching the fuel surface is recorded on the data sheet to be submitted.
- If the fire was almost extinguished, the test can be repeated with higher foam quantities (i.e., 200 ml, 250 ml, ...).
- On completion of the test, the pan shall be allowed to cool for at least 5 minutes after the fire has been extinguished prior to approaching the pan.
- Once cool, the remaining material from the test shall be poured into an approved Department of Transportation (DOT) fuel container (i.e., 5-gallon gasoline can from your local hardware store) to be disposed of per all applicable local, state and federal regulations. In some communities, this can be taken to the local recycle center as hazardous waste.

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Whipped Cream Dispenser Foam Fire Test Description ([see video for further instruction](#))
Whipped Cream Dispenser Configuration

The whipped cream dispenser uses 8 gram (g) nitrous oxide chargers to aerate and dispense the foam. CO₂ chargers have shown to produce poor foam quality and are not recommended for this application. The dispenser has a discharge lever and comes with three discharge nozzles that screw onto the top of the dispenser. The dispenser shall be modified to provide an extension between the dispenser and the fire. The modifications include sliding a 4 inch long, 3/8 inch (internal diameter) flexible rubber hose over the discharge tip, adding a 1 ft section of 0.5 inch metal extension tube on the end of the hose and taping (with aluminum tape) a bernzomatic fan pattern tip on the end of the tube. All of these items can be purchased at your local hardware store.



500 ml of solution is mixed in the dispenser but only about 150-200 ml is discharged during the test. The solution is prepared by pouring 15 ml of foam concentrate into a 100 ml graduated cylinder and then topping it off with 85 ml of water. The cylinder is then poured into the dispenser. The graduated cylinder is then filled with 100 ml of water 4 more times and poured into the dispenser. The top is then tightened onto the dispenser and the solution is shaken for about one minute to ensure good mixing. After mixing, the nitrous oxide charger is placed in

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the holder and tightened onto the dispenser (which pressurizes the dispenser). More details can be found in the whipped cream dispenser manual.

At this point, the dispenser is charged and ready for discharge and should be placed in the fire area. It should be noted that the dispenser needs to be upside down when discharging the foam on the fire.

Fire Pan Configuration (Whipped Cream Dispenser)

A 1ft², **seamless, stainless steel** cake pan shall be used as the fire pan during this challenge. These are available online or at a restaurant supply store (TeamFar, lasagna pan, rectangular cake pan stainless steel, 12.75 by 11.25 by 3.25 inch deep). The pan must be made of steel (i.e., aluminum will melt) and shall have a 3 inch nominal vertical depth. During the test, the pan is placed in a well ventilated, open area (at least 10 ft away from any combustible materials). A portable fire extinguisher shall be located in the area in case of an emergency. During the test, the pan is filled to a depth of 1 inch of water and 500 ml of ethanol free gasoline is poured/floated on the water substrate. The ethanol free gasoline can be purchased pre-packaged from your local hardware store. It is also available at most marinas (gas docks).

Post Test Action Items (see video for further instruction)

If the fire is not extinguished within one minute of formulation discharge, there are three options:

1. allow the fire to burn out (if selected, the fire status shall be monitored for the entire burn out period),
2. extinguish the fire by placing a piece of 5/8 inch drywall (at least 3 ft wide by 3 ft long) on top of the pan to smother the fire, or
3. extinguish the fire using the portable extinguisher. Caution shall be taken when discharging the extinguisher on the fire since direct application of the agent on the fire can cause the fuel to splash out of the pan.

Test Procedures

- **We strongly recommend that before you initiate any fire testing, you practice mixing/aerating and spraying foam.**
- The test area is set up with the extinguisher in position and the fire pan filled with water to a depth of 1 inch.
- Test personnel don PPE (face-shield, flame resistant gloves, and flame resistant lab coat).
- The gasoline is measured-out and placed in a beaker adjacent to the pan.

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- An igniter for a gas grill (i.e., propane lighter or BBQ lighter with at least a 6 inch extension) is placed next to the beaker of gasoline.
- The foam solution is prepared and brought to the test area.
- The video camera is started, and the two test personnel assume their positions.
- The fuel is then poured into the water-filled pan and ignited by the Fire Participant.
- The Foam Participant counts to 10 (to allow a 10 second preburn) and then discharges the foam solution onto fire.
- The Fire Participant will time the extinguishment with a stopwatch, starting as soon as the foam touches the fuel and ends when extinguished – no flickering or edge effect burning.
- The solution is discharged for 4 seconds (i.e., Foam Participant counts to 4) and then the foam discharged is stopped.
- The foam is gently discharged on the fire with the fan pattern parallel to the fuel surface.
- The solution is given 1 minute to extinguish the fire (for this configuration AFFF extinguished the fire in less than 10 seconds).
- If the fire has not been extinguished by the foam, the fire can be allowed to burn out or can be extinguished using the methods mentioned previously.
- If the fire is extinguished, the time for extinguishment measured from the start of discharge is recorded on the data sheet to be submitted.
- If the fire was almost extinguished, the test can be repeated with longer discharges (i.e., up to 8 seconds).
- **WARNING**: The whipped cream dispenser typically will run out of solution between 10-12 seconds after the start of discharge. When the solution is expended, the remaining nitrous oxide in the canister can cause the fire to flare up if this occurs while discharging on the fire.
- On completion of the test, the pan shall be allowed to cool for at least 5 minutes after the fire has been extinguished prior to approaching the pan.
- Once cool, the remaining material from the test shall be poured into an approved DOT fuel container (i.e., 5-gallon gasoline can from your local hardware store) to be disposed of per all applicable local, state and federal regulations. In some communities, this can be taken to the local recycle center as hazardous waste.

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Criteria and Submittal Form

1. **Submitter Name:** _____
2. **Submitter Email Address:** _____
3. **Submitter Phone Number:** _____
4. **Affiliation (If Applicable):** _____
5. **List the filename(s) of all video and photo files that will be submitted with this form:**

6. **Date of Submission:** _____
7. **Product Description:**
 - a. Provide a high-level description of the type of product and chemical composition:

8. **Physical Properties:**
 - a. Describe a qualitative viscosity of your concentrate (water, oil, syrup, etc.):

 - b. What is the percent concentrate in solution that will be used for the fire test (i.e., 3% concentrate / 97% water)?

 - c. Provide the pH of your concentrate (measured using litmus paper):

 - d. Provide the pH of your solution (measured using litmus paper):

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9. Foam Description

a. Check the box that best describes your foam:

Milky Substance _____ Lathered Shampoo _____ Shaving Cream _____

Other (describe) _____

10. 1 Square Foot Pan Fire Extinguishment Test (see video file and test procedures above for further instructions):

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The 1 square foot pan fire extinguishment test can be done with your PFAS-free solution using one of two methods below, or by a user defined method* if the product is not a foam. Choose one method and use the corresponding procedure outlined above in addition to the instruction video to complete this test. Select which test method was performed:

- Whipped Cream Dispenser Foam Fire Test _____

OR

- Blender Foam Fire Test _____

OR

- Other (explain/define)*

*The user defined test method must demonstrate the ability of the product to extinguish the 1 ft² gasoline pan fire. The device used to discharge the product onto the fire must be described in detail and include the discharge rate and total mass of the product discharged.

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Reporting on 1 Square Foot Pan Fire Extinguishment Test (ONLY FILL OUT ONE TABLE)

Based on the conducted 1 Square Foot Pan Fire Extinguishment Test, use the specific test parameters you completed below to fill in the results section of the table:

Whipped Cream Dispenser Foam Fire Parameters	Results
Pre-Burn Time (s)	
Dispenser Foam Quantity (ml)	
Dispenser Discharge Time (s)	
Fire Extinguishment Time (s)	

Blender Foam Fire Test Parameters	Results
Pre-Burn Time (s)	
Blender Foam Quantity (ml)	
Blender Pour Time (s)	
Fire Extinguishment Time (s)	

If other, provide a complete description and parameters of your extinguishment test. Furthermore, provide supporting documents within your submittal:

Other Fire Test Parameters	Results
Pre-Burn Time (s)	
Formulation Quantity (ml)	
Application Time (s)	
Fire Extinguishment Time (s)	

Application Time – time spent applying formulation to fire.

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