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Phos-Chek Solid Foam Stick and Scotty Foam-Fast Applicator Evaluation

Technical report no. 3 – January 2017

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Wildfire Operational Research Group

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ACKNOWLEDGEMENTS

This project was financially supported by the FPInnovations Wildfire Operations Research advisory committee and supporting members of the FPInnovations Operations Wildfire Research Program.

The author would like to extend a special thanks to staff and firefighters from Alberta Agriculture and Forestry and Northwest Territories Environment and Natural Resources, who participated in this study.

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1. INTRODUCTION

Class A foam “lowers water’s surface tension making it more effective in suppressing fire in Class A combustibles (wood, vegetation, paper and cotton products and rubber)” (ICL Performance Products LP, n.d.). Alberta Agriculture and Forestry has used class A liquid foam and liquid foam inductor kits in wildfire suppression since the 1980s. Although class A liquid foam has proven to be an effective tool, promoting the consistent use of it in Alberta has been a challenge since its introduction. Firefighter reluctance to use class A foam is often linked to reasons such as set-up time, working with the foam solution, system awkwardness, and anecdotal comparisons to straight water.

Alberta’s Provincial Warehouse and Service Centre (PWSC) was approached by ICL Performance Products LP (ICL) regarding a new class A foam system, the Phos-Chek SOLID Foam Stick and Scotty Foam-Fast Applicator. The foam stick and applicator were promoted by ICL as a simple and effective way of producing low-expansion class A foam using minimal equipment. Following an ICL presentation to Alberta’s PWSC and Fireline Equipment Working Group (FEWG), a decision was made to pursue field trials before considering a large-scale purchase.

To facilitate field trials, the PWSC purchased several applicators and a supply of foam sticks with the intent of having their firefighters assess the system. Further discussion by the group identified a lack of consistent evaluation criteria and a need for documented, fact-based test results. In follow-up, the PWSC requested assistance from Alberta’s Wildfire Management Science and Technology (WMST) program to engage a research provider, and in March of 2015, they asked FPInnovations to conduct an evaluation of the Phos-Chek SOLID Foam Stick (formulation ID #049-019F) and the Scotty Foam-Fast Applicator (model 4010-50).

FPInnovations worked with the WMST program working group, PWSC manager, and designated FEWG members to review research questions, project needs and develop the following project objectives.

Project objectives

1. To evaluate Phos-Chek SOLID Foam Stick and Scotty Foam-Fast Applicator product characteristics and field performance.
2. To determine best practices and wildfire suppression application of the Phos-Chek SOLID Foam Stick and Scotty Foam-Fast Applicator system.
3. To determine the effects of pump pressure on both the Phos-Chek SOLID Foam Stick and the Scotty Foam-Fast Applicator.
4. To identify reference material relevant to the benefits of using foam versus straight water in wildfire suppression.

2. METHODS

Project team and planning

A project team was established to aid FPInnovations with their evaluation.

The project team was composed of the FPInnovations project lead/AAF and WMST Group representative Roy Campbell, PWSC manager John Belanger, and the following FEWG representatives and technical advisors: Brad McKenzie (AAF; wildfire technologist, Blairmore), Kevin Hunt (AFF; wildfire technologist, High Level), Brett Casey (AAF; wildfire ranger, Peace River), and Brent Perih (AAF; wildfire technologist, Wabasca).

Exploratory work was conducted at the Canadian Boreal Community FireSmart Project site in Fort Providence, Northwest Territories, to aid in project plan development. FPInnovations worked with the WMST Group, PWSC manager, and FEWG members to develop an Alberta WMST project expression of interest and detailed project plan, which addressed project questions and objectives, and identified field evaluation parameters and literature review needs. Project plans were vetted by both the WMST Working Group and the FPInnovations advisory committee for input and endorsement.

Equipment requirements

A local water source was used for exploratory and fireline testing. Equipment and supplies included one MARK-3 pump and kit, 20 lengths of 1 1/2" hose, two pressure gauges, four boxes of the ICL foam stick formulation, two Scotty Foam-Fast Applicators (model 4010-50), 20 L of mixed fuel, one camera, and one video camera and tripod. For pressure testing conducted at the Hinton Training Centre, a one 200-gallon tank was used as a water source.

Evaluation process

A series of field evaluations was conducted during actual firefighting activity to answer project questions and meet project objectives, including the aforementioned exploratory work in Fort Providence, Northwest Territories; suppression activities on Peace River fire PMF-001; and pressure testing conducted at the Hinton Training Centre.

Evaluation procedure

1. Establish water source.
2. Set up pump (Wajax MARK-3 and 1 1/2" hose lay).
3. Install pressure gauges at pump and nozzle (pressure testing only).
4. Attach Scotty Foam-Fast nozzle.
5. Insert Phos-Chek SOLID Foam Stick.
6. Start pump and adjust pressure to desired range(s) using pump throttle.
7. Observe and photograph foam output.
8. Observe and measure foam stick consumption.
9. Document test results.

Evaluation parameters and rationale

Objective #1. To evaluate Phos-Chek SOLID Foam Stick and Scotty Foam-Fast Applicator product characteristics and field performance.

The Phos-Chek SOLID Foam Stick characteristics assessed during field trials included field handling, packaging, weight, foam production, product longevity, and wastage**.**

The Scotty Foam-Fast Applicator characteristics assessed during field trials included design, weight, assembly, field handling, and durability.

Objective #2. To determine best practices and wildfire suppression application of the Phos-Chek SOLID Foam Stick and Scotty Foam-Fast Applicator system.

The Phos-Chek SOLID Foam Stick and Scotty Foam-Fast Applicator system was observed for determination of basic best practices and tactical value.

Objective #3. To determine the effects of pump pressure on both the Phos-Chek SOLID Foam Stick and the Scotty Foam-Fast Applicator.

Phos-Chek SOLID foam output was monitored during testing and firefighter feedback was gathered to determine an effective pressure range for wildfire firefighting. Testing was also monitored for “flaking” of the Phos-Chek SOLID Foam Stick, which previous insight had suggested might occur with pressures greater than 100 psi. Pressure was measured at both the pump and the applicator during testing to capture pressure fluctuation.

Scotty Foam-Fast Applicator pressure testing was also conducted to determine applicator durability in wildfire applications.

Objective #4. To identify reference material relevant to the benefits of using foam versus straight water in wildfire suppression.

A Web search was conducted to address the request for reference material specific to the benefits of using foam as opposed to straight water in wildfire suppression.

3. EVALUATION RESULTS

Northwest Territories exploratory testing, June 2015

Exploratory testing provided an opportunity to work with firefighters, equipment, and product, which proved beneficial in project planning and in the development of project methods. Results captured during exploratory testing yielded the following results and firefighter feedback:

1. The system worked well during research plot containment (see Figure 1).
2. The system worked well during research plot mop-up operations (see Figure 2).
3. Testing was run at varying pressures up to 100 psi (at the pump), which proved to be more than ample pressure for suppression action in the fuels encountered (see Figure 3).

4. Foam consistency was positive (i.e., wet and runny) in the applications tested (see Figure 4).
5. The ability to adjust foam thickness was limited, in that the amount of foam being introduced into the system cannot be regulated and foam thickness could only be adjusted slightly by reducing stream flow over the foam stick using the applicator shut-off valve (see Figure 5).
6. Foam content in the stream decreases proportionally with foam stick use and surface area reduction (see Figure 6).
7. Acceptable foam output lasted approximately 12 minutes at 100 psi, at which time a second foam stick could be added to the applicator chamber.
8. Wastage of partial foam sticks was minimal using the foam stick replacement method referred to above under result #7.
9. Field handling of foam stick boxes and individual foam stick cylinders proved awkward: boxes needed to be carried while working with the applicator, and foam stick cylinder casing ends separated easily, allowing the foam stick to slip from the casing.
10. Management of foam stick boxes, casings, and casing ends was required to alleviate garbage issues.
11. The applicator was assembled in less than 1 minute once practitioners were familiar with applicator parts and assembly instructions.
12. Applicator joints tended to twist easily, and maintaining handle alignment required ongoing adjustment (i.e., set screws in swivel joints did not hold joints securely and care had to be taken not to twist handles during operations). Using the handles to twist open the foam stick chamber also resulted in handle misalignment.
13. The applicator was uncomfortable to hold for an extended period of time using the two-handle method; most users preferred the over-the-shoulder position (see Figure 7).

Figure 1. Containment.

Figure 2. Mop-up.

Figure 3. Stream flow at 100 psi.

Figure 4. Foam consistency.

Figure 5. Maximum foam thickness.

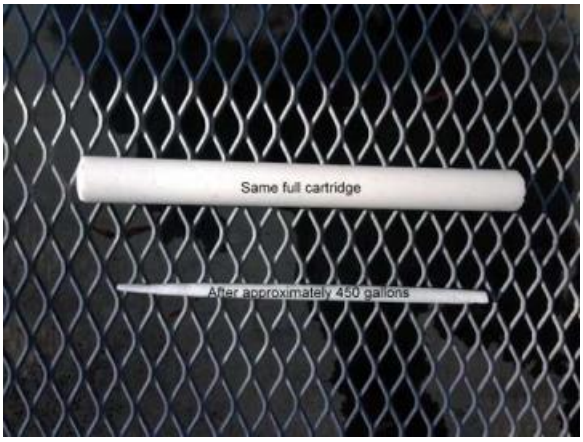

Figure 6. Foam stick surface area reduction.

Figure 7. Preferred holding position.

Wildfire PMF-001 testing, April 20 and 21, 2016

Wildfire PMF-001 provided an opportunity to evaluate the use of the Phos-Chek SOLID Foam Stick and the Scotty Foam-Fast Applicator by firefighters during actual wildfire operations under two suppression scenarios.

Scenario 1

A unit crew was assigned to the north-northeastern section of the fire with the objective of securing a dozer guard. This was a pump (Wajax MARK-3) and hose (1 1/2") operation, with crew members initially working a 10 m line depth, then working back over the same ground to a depth of 50 m. The dozer guard had been cut along the edge of the fire between a C2 black spruce and an M1 aspen/black spruce fuel type. The duff depth ranged between 2" and 6", and numerous squirrel caches were present. The fire behaviour had diminished to localized flare-ups and ground fire as a result of decreased temperature and wind speed. Temperatures had dropped below freezing overnight, and ice had to be purged from hose lines before operations. Daytime temperatures during testing did not exceed 10°C, and winds remained light. Testing of the foam stick and applicator was integrated into operations over the entire day. The following crew feedback was documented during operations:

Phos-Chek SOLID Foam Stick

1. Easy to use (i.e., stick can be inserted quickly into applicator chamber) (see Figure 8).
2. Less likely to make contact with skin and clothing than liquid foam solution.
3. Less odour than liquid foam solution.
4. More effective on ground fire than water (e.g., squirrel caches).
5. Foam stick boxes and foam sticks were a little awkward to carry and handle on the fireline.
6. Extra work required in managing empty foam stick boxes, containers, and container caps.
7. Stick packaging end caps fall out, causing the foam stick to drop out of the casing.
8. A slow but noticeable reduction in foam content after approximately 5 minutes of use.

Scotty Foam-Fast Applicator

1. Acceptable applicator weight.
2. Applicator D handle was easy to use and adjust stream flow.
3. Hose seemed less stiff (pressure) and easier to manoeuvre.
4. Less water blow-back occurred with this style of applicator.
5. Easy to switch between foam and water.
6. Good stream range was achieved, which minimized hose repositioning and provided for greater coverage (see Figure 9).
7. Applicator handle alignment required adjustments (i.e., joint set screws did not hold handles firmly in place).
8. Some joint leakage was encountered after prolonged use.
9. Some crew members felt the applicator handles were too far apart (see Figure 10).

Figure 8. Foam stick loading.

Figure 9. Range and coverage.

Figure 10. Applicator handle spacing.

Scenario 2

Firetack crew and a Caterpillar 315C excavator were assigned to extinguish ground fire in the southwestern corner of the fire (see Figure 11). This was primarily a digging/spreading/mixing-to-extinguish operation using the excavator and a MARK-3 pump and a 1 1/2" hose lay. Ground fire was significant (up to 1 meter in places). The windrow was approximately 75 m long and 25 m wide. The fuel was debris from previous land clearing, and it had been half buried. Temperatures had dropped below freezing overnight, and ice had to be purged from the hose lines. During the day, temperatures did not exceed 10°C, and winds were light. Testing of the applicator and foam stick was integrated into actual operations over the entire day.

The following results were noted during use:

Phos-Chek SOLID Foam Stick

1. Easy to use.
2. Would add to initial attack capability (liquid foam application is generally not an option during initial attack because of the logistics of carrying and hooking up a liquid foam system and the urgency of gaining control of a wildfire).
3. Running the applicator at a reduced pressure seemed to extend foam stick life.
4. Foam stick was more effective than straight water on the type of ground fire that was encountered (i.e., buried debris).
5. Foam stick packaging (i.e., the end caps) came off too easily, allowing the actual foam stick to drop out of the casing during handling.
6. Managing empty boxes and containers could pose a garbage issue.

Scotty Foam-Fast Applicator

1. Liked the applicator concept.
2. Liked the applicator weight.
3. Liked the ability to adjust flow using the D handle.
4. Good stream range and coverage.
5. Joint leakage after prolonged use.
6. Maintaining applicator handle alignment proved challenging (i.e., the set screws on the applicator swivel joints did not hold handles firmly in place).

Figure 11. Excavator mixing foam stream.

Hinton Training Centre pressure testing, August 3, 2016

A series of pressure tests were conducted at the Hinton Training Centre to establish a pressure range best suited for average wildfire operations (see Figure 12), and to establish the effects of pump pressure on both the Phos-Chek SOLID Foam Stick and the Scotty Foam-Fast Applicator.

Figure 12. Pressure-testing equipment and set-up.

Study findings indicated that a nozzle pressure of 40 psi to 90 psi would support most wildfire scenarios. Lower pressures allowed slight foam buildup and increased foam stick longevity, while higher pressures provided increased digging power to penetrate deeper ground fire (e.g., squirrel caches). Pressures exceeding 90 psi (at nozzle) provided additional range, but they increased stream blow-back and seemed excessive for the applications encountered. No applicator durability issues were encountered during testing. A summary of test results is provided in Table 1, and individual pressure test results follow.

Table 1. Pressure testing summary

Pressure (pump)	**45 psi**	**80 psi**	**100 psi**	**135 psi**
Pressure (nozzle)	**40 psi**	**70 psi**	**90 psi**	**105 psi**
Foam stream	Soaking	Digging	Strong digging	Extreme digging
Foam consistency	Wet, runny	Wet, runny	Wet, runny	Wet, runny
Foam accumulation	Moderate	Light	Light, dispersed	Very light, dispersed
Foam stick longevity	18 minutes	13 minutes	N/A	N/A
Applicator durability	No issues	No issues	No issues	No issues

Test 1: Pump at 45 psi, nozzle at 40 psi

- 13:25 - Start water and foam stream
- 13:35 - Stop water and foam stream
- 13:55 - Start water and foam stream
- 14:00 - Stop water and foam stream
- 14:01 - Start water and foam stream
- 14:04 - Stop water and foam stream

Test 1 findings

1. Pressure loss from pump to nozzle was 5 psi.
2. Wet, runny foam was produced.
3. Foam stream was adequate for soaking down, but lacked significant digging pressure (see Figure 13).
4. Foam stick diameter and surface area narrowed with use (see Figure 14).
5. Foam content reduction noticeable at test mid-point.
6. Foam content at 18-minute mark was considerably less, but still visible in the stream (see Figure 15).
7. Test terminated at 18-minute mark; original foam stick diameter had reduced to the point at which a new foam stick could be inserted into the applicator chamber without discarding the remainder of the original foam stick.

Figure 13. Pump at 45 psi, nozzle at 40 psi.

Figure 14. Foam stick size at 10 minutes (nozzle at 40 psi).

Figure 15. Foam stick size at 15 minutes (nozzle at 40 psi).

Test 2: Pump at 80 psi, nozzle at 70 psi

- 14:30 - Start water and foam stream
- 14:40 - Stop water and foam stream
- 15:00 - Start water and foam stream
- 15:03 - Stop water and foam stream

Test 2 findings

1. Pressure loss from pump to nozzle was 10 psi.
2. Wet, runny foam was produced.
3. Foam bubble size decreased in size with use.
4. No significant foam accumulation (i.e., thickening of a foam blanket).
5. Foam stream had adequate digging pressure and less ability to pool foam (see Figure 16).
6. Foam stick diameter and surface area narrowed with use (see Figure 17).
7. Foam content reduction was visible at test mid-point.
8. Test was terminated at 13-minute mark; original foam stick diameter had reduced to the point at which a new foam stick could be inserted into the applicator chamber without discarding the remainder of the original foam stick (see Figure 18).

Figure 16. Pump at 80 psi, nozzle at 70 psi.

Figure 17. Foam stick size at 10 minutes (nozzle at 70 psi).

Figure 18. Foam stick size at 13 minutes (nozzle at 70 psi).

Two additional tests were run at higher pressures to further determine pressure effects; specifically, the presence of foam stick "flaking" and applicator durability. Foam stick longevity was not tested in tests 3 or 4 as pressures over 100 psi appeared excessive for general wildfire foam applications.

Test 3: Pump at 100 psi, nozzle at 90 psi

Test 3 findings

1. Pressure loss from pump to nozzle was 10 psi.
2. Wet, runny foam was produced.
3. No significant foam accumulation.
4. Foam stream had strong digging pressure (see Figure 19).
5. No foam stick flaking was observed.
6. Applicator showed no signs of failure.

Figure 19. Pump at 100 psi, nozzle at 90 psi.

Test 4: Pump at 135 psi, nozzle at 105 psi

Test 4 findings

1. Pressure loss from pump to nozzle was 25 psi.
2. Wet, runny foam was produced.
3. No significant foam accumulation.
4. Foam stream had very strong digging pressure.
5. Foam stick deformity noted (i.e., uneven spiral grooves evident on foam stick) (see Figure 21).
6. Applicator showed no signs of failure.

Figure 20. Pump at 135 psi, nozzle at 105 psi.

Figure 21. Foam stick deformity.

Literature review

The United States' National Wildfire Coordinating Group (NWCG, n.d.) defines class A foam as "foam intended for use on Class A or woody fuels; made from hydrocarbon-based surfactant, therefore lacking the strong filming properties of Class B foam, but possessing excellent wetting properties." An Internet search was conducted to identify reference material relevant to class A foam use in wildfire suppression. This information is considered key to Alberta wildfire firefighter education and training and was researched to meet project objective #4.

The material reviewed indicates that foam studies date back as early as the 1930s, when a number of additives were identified to improve knock-down characteristics of water and decrease the tendency of fires to rekindle. At this time, and into the 1960s, foam had been studied numerous times, but developments were hampered by poor performance, specialized equipment needs, and low levels of interest.

More recent developments in foam technology, specifically the development and use of compressed air foam systems and the introduction of new synthetic hydrocarbon surfactant foaming agents, developed and introduced in Canada in 1985, gave rise to a new round of interest in the use of class A foam. Essentially, class A foam is a mechanically generated aggregation of bubbles that has a lower density than water. The foam is made by introducing air into a mixture of water and foam concentrate, and the bubbles adhere to class A fuels, gradually releasing the moisture that they contain. The water–bubble mixture absorbs heat more efficiently than straight water, and bubble mass provides a barrier to oxygen, which is necessary to sustain combustion. The reduced rate of water release results in more efficient conversion of water to steam, providing enhanced cooling effects and, along with the surfactants contained in the solution, allows water to penetrate fuels and reach deep-seated fire. The bubble mass also provides a protective barrier for unburned, exposed fuels. Although class A foam contains wetting agents that reduce the surface tension of the contained water, it should not be confused with wetting agents, which are used exclusively for improving the penetration of water into deep-seated fire in class A fuels (NWCG, 1993).

Numerous manufacturers' class A foam videos and testimonials are available on the Internet. Given the number of articles, videos, and pictures available, only those considered most relevant to this project have been included for reference:

1. *Foam Vs Fire*, a series of publications that arguably provide the most comprehensive background on wildfire class A foam use:
    a) http://www.fs.fed.us/t-d/pubs/pdf/hi_res/93511208hi.pdf
    b) http://www.fs.fed.us/eng/pubs/pdf/92511209.pdf
2. Wildland Fire Chemical Systems is a part of Missoula Technology and Development Center. Located at the Missoula Technology and Development Center in Missoula, Montana, Wildland Fire Chemical Systems provides national resource agencies with detailed information that promotes safe and effective fire suppression chemicals and aerial delivery systems. The link to class A foam information can be found here: http://www.fs.fed.us/rm/fire/wfcs/foam-fir.htm
3. The NFPA 1145 is a guide for the use of class A foam in firefighting: http://www.nfpa.org/codes-and-standards/all-codes-and-standards/list-of-codes-and-standards?mode=code&code=1145
4. The following YouTube video illustrates and compares the use of foam versus straight water in the suppression of class A fuels: https://www.youtube.com/watch?v=yV6PBoeU3Lk

4. DISCUSSION

Study findings indicated an overall positive response from firefighters to the Phos-Chek SOLID Foam Stick and Scotty Foam-Fast Applicator system. Firefighters found the system easy to use and the foam concentrations acceptable for the wildfire scenarios encountered. Firefighter feedback also indicated that the system was less intrusive to work with than the traditional liquid foam inductor system: it is less likely that users would get concentrate on themselves, and the foam solution did not have as strong a smell. Overall system weight was acceptable, and there were positive comments regarding the applicator D handle valve, lesser stream blow-back at higher pressures, and stream range.

Study findings also revealed areas for potential system improvements, and firefighters offered feedback and some design recommendations. Firefighters found carrying the applicator and boxes of foam sticks cumbersome, and that individual foam stick casing end caps fell out too easily, resulting in the foam stick slipping out onto the ground during handling. Managing empty foam stick boxes and casings also proved challenging. Firefighters suggested that the development of a kit bag would alleviate many of these concerns (i.e., foam stick and applicator transportation and field management). In follow-up, FPInnovations has made preliminary inquiries with the Industrial Design facility at the University of Alberta, and it seems possible to have a carrying bag designed and prototype built for a trial, should there be interest. Firefighters also suggested applicator design modifications, including improved joint set screws to hold swivel joints in place and improve handle alignment; adjustable handle spacing; and improved joint seals to reduce leakage. An improved back-handle design would allow for over-the-shoulder applicator placement, and an applicator sling was also suggested.

Testing during firefighting operations provided opportunities to observe, discuss, and make suggestions regarding best practices, including:

1. The Phos-Chek SOLID Foam Stick and Scotty Foam-Fast Applicator system could be used in wildfire suppression scenarios where pump and hose lays are deployed.
2. The Phos-Chek SOLID Foam Stick and Scotty Foam-Fast Applicator system could improve the use of class A foam in initial attack scenarios where class A foam is not presently being used and a pump and hose lay is applicable.
3. The Phos-Chek SOLID Foam Stick and Scotty Foam-Fast Applicator system should not be considered a replacement to the liquid foam inductor system, but rather an option dependent on the wildfire suppression scenario being encountered (i.e., an option for quick mobile application as opposed to longer-term and stationary operations, where the versatility of a liquid foam inductor system could prove more beneficial).
4. Foam stick wastage can be reduced by allowing the foam stick diameter to decrease to a point at which a new stick can be inserted into the applicator chamber.
5. Applicator leakage can be reduced through the use of a sealant tape on the applicator's threaded joints.
6. Nozzle pressures for most wildfire applications range between 40 psi and 90 psi; nozzle pressure above 90 psi increases blow-back and seems excessive.

Alberta firefighters receive class A foam training and have a basic understanding of the benefits of the use of foam over straight water. However, during this study crew members seemed to lack class A foam knowledge and, to some extent, experience. Some firefighters also expressed concern about working around foam, and the potential negative effects it might have on personal health and on the environment. Taking the time to work directly with crews helped with overall understanding and acceptance of class A foam during this study, and the availability of educational information captured in the literature research suggests education, training, and field supervision should be reviewed.

The testing completed during this study answered the questions that were asked and met the objectives of the study. Further testing based on more specific questions may be warranted, such as testing with a specific pump or a different applicator.

5. REFERENCES

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