COLORADO

Center of Excellence for Advanced Technology Aerial Firefighting

Department of Public Safety

Photo Credit: BLM

Photo Credit: Saskatchewan Northern Air Operations

Aerial Firefighting Field Operational Evaluation of Water Enhancers

Results and Recommendations

CoE-20-001.10

Table of Contents

Front Page Photos.

Photo 1 (left): Thermo-Gel 200L Drop on Peekaboo Fire in Northwest Colorado in 2017

Photo 2 (right): FireIce HVO-F Drop on Spruce Fire in Saskatchewan, Canada, in 2018

Purpose

The Center of Excellence for Advanced Technology Aerial Firefighting (CoE), with support from the Colorado Division of Fire Prevention and Control (DFPC's) Aviation Unit and the Bureau of Land Management (BLM), conducted a study during the 2017–2019 wildland fire seasons to evaluate the effectiveness of water enhancers on wildfires by using single engine air tankers (SEATs) to test three products.

This report documents the results of the CoE study as well as key observations and recommendations for the effective use of water enhancers.

Introduction

The most common firefighting agents used in aerial firefighting in the United States are water and long-term retardant (LTR). Prior to this study, Colorado loaded only LTR in SEATs. LTRs are chemical concentrates mixed with water that alter fuels so that they do not support combustion.

Water enhancers are polymer products added to water to improve its fire-suppression characteristics. Plain water dropped from aircraft without the addition of water enhancers is actually a very inefficient suppressant. When it converts to steam, it has a great capacity to absorb and carry away heat. However, it also has a strong surface tension that causes it to bead up and roll off most fuels before it can absorb its full heat capacity. In essence, much of the water runs off the fuel. Typically, the terms polymer and elastomer are used to refer to firefighting gels—we use the term polymers to describe "super-absorbent polymers." The cross-linking process allows them to absorb and retain a very large amount of water and builds viscosity and thickening without altering the other properties of the water.

The term elastomers is used to describe polymers that impart what is called "viscoelasticity," or viscosity and elasticity together. This consistency is typically called rubbery; because they are lightly cross-linked they do not absorb as much water when mixed. In addition to building viscosity, they also add the elasticity so are referred to as elastomers.

When water enhancers are used, small amounts (0.1–3%) of gel concentrate are added to water to increase its viscosity (i.e., measure of the resistance of a liquid to flow) and increase adherence to fuels and structures and minimize drift and dispersion when dropped from aircraft (U.S. Forest Service 2007). Water enhancers are most effective when used for direct attack. The cost of water enhancer is significantly lower than traditional LTR and it remains effective as a suppressant much longer than water, but they are not as effective once they dry.

In this study, the CoE evaluated the use and effectiveness of the following water enhancers: GelTech Solutions FireIce 561® (uncolored), FireIce HVO-F® (orange colorant), FireIce HVB-Fx®,

[1] The use of trade names in this publication is for reader information and does not imply endorsement by the Center of Excellence for Advanced Technology Aerial Firefighting.

G5 BioSolutions BlazeTamer 380®, and Thermo Technologies Thermo-Gel 200L®.[1] All of these products are approved by the U.S. Forest Service (USFS) for use in SEATs.

The CoE developed and utilized data collection forms to gather data from firefighters, SEAT pilots, air attacks, and mixing and loading personnel. The intent was to gather information on aerial application of water enhancers on fires, what product was used, how it was used, and the outcomes. In 2019, the CoE hired two firefighters who traveled to fires to collect data in the field. Previously, the CoE had attempted to obtain this data from firefighters who were present and observed the drops, but this proved difficult. To gather useful data, it was necessary to have dedicated observers with firefighting experience who were knowledgeable on aerial suppression and were positioned daily where they could respond to incidents to collect data.

Challenges of Data Collection

Directly collecting data through observation on the fireground presented substantial challenges during the study. In spite of the small sample size of quantitative data, the CoE gathered valuable data about the safety and efficacy of water enhancers and developed a set of recommendations.

The principal objective of aerial suppression drops is to reduce the intensity or slow fire spread to a point that allows access to the fire edge by ground firefighting resources. These drops are best assessed on the ground as observers can provide detailed observations from the drop site. However, it is not always possible to do this as crews may not be on the fire at the time of the drops and conditions may not be safe for the drops to be evaluated.

There are many variables involved, such as the delivery accuracy of the drop, drop height, speed, type and settings of the delivery system, and viscosity of the product.

Environmental factors can also affect the drops. Wind, particularly cross winds, causes drops to disperse, which can reduce coverage levels and potentially cause drops to drift off target. In addition, the vegetation can cause shadowing or intercept some of the liquid and reduce its coverage levels. Lastly, fire behavior can make drops less effective, especially when fires are burning intensely with high rates of spread, and prevent firefighters from being able to safely remain in the area to observe the drops or support drop efforts.

Without direct observation at the time of the drop, it is difficult to completely assess the efficacy of the water enhancers in light of the variables present.

Key Observations

The following takeaways are discussed further in the body of the report.

1. All three products were effective when used for direct attack. However, different tactics are needed than with LTR.
2. When dropped from a SEAT, water enhancers were more effective in light fuels. Dense

canopies prevent effective penetration.

3. Prompt follow-up from ground support is essential.
4. No safety or equipment issues with aircraft were reported during the study.
5. Variability in mixing and lack of consistent quality control is an issue.
6. Water hardness and temperature may impact consistency, viscosity, and stability, but more study is needed.

Recommendations

In spite of the challenges involved in collecting quantitative data, the CoE's efforts have produced expert assessments that favor introducing a selection of water enhancers into the operational arsenal of aerial firefighters in Colorado.

The CoE recommends:

1. Increasing the use of water enhancers, especially during initial attack.
2. Providing further training on best practices for the use of water enhancers, with emphasis on direct attack.
3. Using water enhancers in situations in which ground firefighters can promptly engage the fire. Otherwise, consider using LTR.
4. Considering use of water enhancers in helicopters.
5. Developing processes and tools to ensure good quality control of the water enhancer mixture.
6. Performing further study of onboard mixing.
7. Performing further testing of the effects of water chemistry.
8. Utilizing aircraft-mounted infrared sensors/cameras to document fire interaction with suppressant drops.
9. Performing directed drop testing of water enhancers and LTR using the same aircraft in the same conditions (i.e., drops occur one after the other as quickly as possible) to evaluate whether water enhancers fall more slowly than LTR. This information would allow pilots to adjust drop release timing if needed.

Data Collection Methods

Of today's three main chemical suppression/application product groups—LTRs, foam fire suppressants, and water enhancers—the water enhancer group has recently received the greatest interest from fire managers.

The CoE developed and used web-based data collection forms to gather data from firefighters, SEAT pilots, air attacks, and mixing and loading personnel. The intent was to gather

information on the fires, what product was used, how it was used, and the outcomes. CoE personnel asked observers to focus on the objectives for the drops, placement of the drops, coverage on the fuels, holding times, and effects on fire behavior. The CoE also requested that observers record the outcomes, such as coverage of the drops, the observed holding times, whether the drops effectively reduced fire behavior or if it burned through (and, if so, why), and whether the drops met the stated objectives.

The CoE provided mixing and loading personnel with a separate form to document their observations on handling, mixing, and loading, as well as on the performance of the vendor-provided mixing equipment and any observed problems with cleaning up spills.

Throughout the 3-year duration of the CoE's water enhancer study, participants provided the CoE with useful observations on the performance of the water enhancers evaluated. The response rates were as follows: 23 responses from aerial supervision and SEAT pilots and 22 responses from ground firefighters in 2017; a total of 39 responses in 2018—6 from ground firefighters, 17 from aerial supervisors, 15 from SEAT pilots, and 1 from a mixer/loader; and 11 observations from dedicated CoE field observers in 2019.

In 2019, the CoE hired two seasonal employees who were assigned to collect field data on water enhancer drops. Due to the slow fire season in Colorado, it was necessary to work with other states with more fire activity where water enhancers were being utilized. The field team traveled to Oregon twice and to Washington once. The CoE also obtained consent from Idaho to visit their bases and to collect drop data, but activity there was limited and opportunities never presented themselves. The CoE field personnel were able to visit several fires and bases, including the Prineville and Roseburg bases in Oregon and the Dallesport and Deer Park bases in Washington. The data collection was limited, but did result in evaluations of FireIce 561 and HVB-Fx in Oregon and of BlazeTamer 380 in Washington (the latter was used by the Washington Department of Natural Resources in AT-802F Fire Bosses).

Photo 3: CoE Data Collection Crew-member on Timber Creek Fire in 2019 (Photo Credit: CoE)

During the 2019 fire season, the CoE ground data collection personnel documented numerous interviews and collected personal observations and photographs from the small number of fires they were able to visit. Despite the limited data, the field personnel made a number of excellent observations. These key observations have the potential to increase awareness of the effective use of water enhancers among fire managers, aerial supervisors, and ground firefighters.

Research Questions

The CoE's research was to determine if the water enhancers tested were effective on wildfires in Colorado. Effectiveness was determined using the following criteria:

1. Did the water enhancer stop or slow the forward advance of the fire?
2. Did the water enhancer reduce fire intensity to a sufficient level for ground crews to manage the fire?
3. Did the water enhancer persist on the surface fuels long enough to prevent hot spots from redeveloping or the fire from burning through the drop?

The CoE's intended outcomes for the project were to:

1. Raise awareness of water enhancer use among firefighters, aerial supervision, agency aviation managers, and the research community.
2. Produce information for training at all levels to improve awareness about best practices for use of water enhancers.
3. Share lessons learned from the evaluation with other states and agencies, including federal and state cooperators, and with other researchers.

Detailed Observations

Direct Attack Effectiveness

The CoE has observed that water enhancers are most effective on direct attack fires that ground resources respond to in a timely manner. On extended attack fires (which were prevalent in 2017 and 2018), and when ground support is delayed, the CoE's research indicates that using the water enhancers to slow or delay fire spread is less effective. Also, timeliness of dispatch for SEATs is most critical for direct attack with water enhancers to be effective. Figure 1 shows distribution of drop objectives.

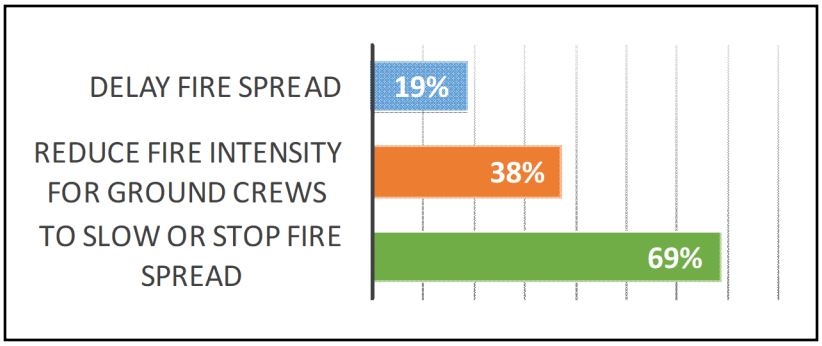


Figure 1: Drop Objectives (2017)

Direct attack is a suppression tactic in which suppression efforts are employed directly on the flame front, as opposed to indirect tactics in which unburned fuel is treated some distance from the flame front. LTR is an indirect tool, while water enhancers are intended for direct attack. Direct attack from aircraft is most effective when fires are small with lower flame heights and smaller perimeters. Direct attack on high intensity fires may only have a

dampening effect on fire spread, but may buy time for ground crews to safely support the aerial drops.

On the Spruce Fire, the assigned Air Attack personally visited the fire and observed the fireline where FireIce HVO-F drops had occurred the day before (for clarification, CoE personnel did not visit any fires in Canada). The area where the water enhancer was placed directly on the fire edge contained no portion where the fire burned through the line. There were areas that the fire had burned into the gel, but they were minimal. In addition, there were numerous areas of substantial downfall where one would have expected the fire to have burned underneath, but it did not.

Photo 4 and 5: FireIce HVO-F on 18LF-Spruce Fire in Canada in 2018
(Photo Credits: Saskatchewan Northern Air Operations)

Dense Canopies Reduce Penetration

Dense forest and brush vegetation types limit suppressant penetration and coating on surface fuels. Since the basic function of polymers is to help fuel absorb and retain water, the higher the viscosity and coverage level the longer the viability. However, the higher the viscosity, the lower the potential for penetration of the forest canopy.

On larger fires and especially during extended attack with hot, dry conditions in heavier timber fuel types, multiple loads of gel were dropped and were effective at achieving short-term reductions in fire intensity, but were ineffective at halting the overall fire spread. Higher viscosity products, such as BlazeTamer mixed at .65% were used, but were ineffective due to a lack of penetration into the surface fuels.

1. The CoE's data illustrates that heavy tree canopies played a significant role in cases where drops were not effective. The thick canopy affected ground distribution patterns of the suppressants and resulted in a lack of penetration of the water enhancer into the surface fuels, which in turn resulted in reduced residence times and burn-through. Similar observations were made on fires where there was heavy, matted grass present.
2. When water enhancers were used properly, (i.e., directly on the fire with ground resources present), the data showed that there is a noticeable difference in flame

reduction with water enhancers as opposed to straight water or LTR, especially in light fuels. In dense oak brush or areas with more canopy vegetation , firefighters and CoE personnel observed less penetration to ground fuels and less ability to reduce intensity.

3. The CoE received a number of comments from ground firefighters that suggest that enhancers are quite effective at reducing fire behavior. Specific accounts compiled from our study are included in the section “Effects on Fire Behavior—Comments from Data Collection Forms.”

Importance of Ground Resource Follow-Up and Support

Ground crews are essential to the effective use of water enhancers and retardant. With ground support, the enhancer technology can increase the ground crew’s effectiveness.

The CoE found all the products that were tested to be most effective when used in direct attack in light fuels such as grass and sagebrush, when the drop fell partially on the flame front with the rest out in front of the flame (i.e., half in/half out). It should be noted that water enhancers are not a retardant but a "suppressant”; consequently, they are not effective for pretreating and use in indirect attack applications.

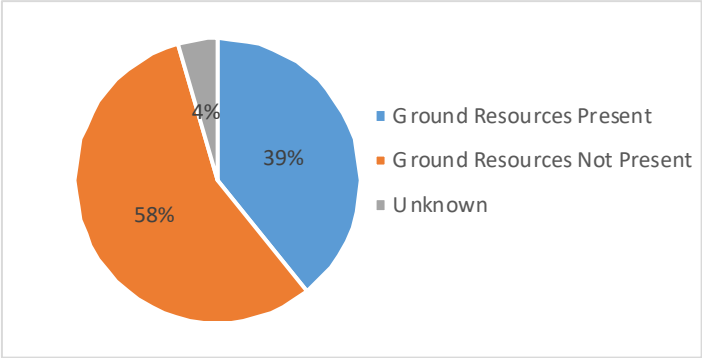


Figure 2: Was the Drop Supported by Ground Resources? (2017)

Many of the fires where the water enhancers were utilized in 2018 were initial attack fires that were exhibiting high rates of spread and intensity and were not adequately supported by ground resources. This resulted in drops being burned around or spotted over. Heavy smoke was also observed in several cases under these conditions, which limited pilot visibility and limited direct attack suppression action.

The CoE observed that water enhancers are most effective on direct attack fires that ground resources respond to in a timely manner. On extended attack fires (which were prevalent in 2017 and 2018) and when ground support was delayed, the CoE’s research indicates that using the water enhancers to slow or delay fire spread was less effective when used for indirect attack. Holding times are important to successfully delaying fire spread.

Safety and Equipment Issues

No safety or equipment issues with aircraft were reported during the study. However, there was a report from a SEAT pilot about the difficulty of washing ThermoGel 200L off of the aircraft.

The most common safety-related comments received were that Thermo-Gel and BlazeTamer are both very slippery on the surface (especially on rocks and logs) after they have been dropped. There were related comments about the products dripping out of the trees for some time after the drops and onto firefighters working in the drop areas.

In addition, asphalt may be damaged if BlazeTamer 380 concentrate is spilled on it and is not treated immediately and properly. Care must be taken to limit spills onto unintended surfaces. Set up transfer operations on natural surfaces when possible. If a spill occurs on a smooth surface, it will become slippery until treated properly. If spills occur, use absorbent materials to cover the area then dispose of them according to local regulations and agency policies.

Water enhancer products—primarily elastomers, liquid concentrates, and coarse-powdered thickeners—have shown negative effects on the ability of the SEAT's in-tank level-sensing float to properly register level due to their "gummy" or thicker scum layer. However, the water enhancers tested by the CoE have been developed and tested in multi-engine airtankers and with associated flow meters to fill at acceptable rates without excessive foaming or potential overfilling. The CoE received no comments or information indicating negative effects on internal floats or their ability to accurately register readings when water enhancer was used.

> Elastomer: a natural or synthetic polymer having elastic properties, e.g. rubber (Oxford).

However, the CoE observed issues with mixing equipment (eductors used for handling FireIce dry powdered concentrate) becoming clogged when mixing at our Fort Collins SEAT base in 2017. In contrast, comments about the FireIce products used by Oregon Department of Forestry personnel—for mixing, testing, and loading—were mostly positive. The loaders became accustomed to handling the 5-gallon tubs of powdered product by rolling them around on the ground to aerate the powder before opening them. They then used a suction wand to introduce the product into the water flowing to the storage tank. Care must be taken not to draw too much powder at a time; when this happens, the loader has to stop and clean

Photos 5 and 6: Pumps for Mixing FireIce at the Fort Collins, Colorado (left) and Roseburg, Oregon (right), SEAT Bases (Photo Credit: CoE)

the valve of the blockage before continuing to mix. Most operators mixed approximately 1,200 –1,500 gallons of FireIce at a time.

Users must ensure that anyone involved in mixing receives training from vendors on mixing processes and quality assurance practices. The desired end state is to achieve product for each load using approved Qualified Products List (QPL) mix ratios. During the course of the data collection, CoE personnel spent a considerable amount of time at SEAT bases and talked extensively with both SEAT managers and with mixmasters/loaders from the commercial SEAT aircraft companies.

Quality Control Procedures

Water enhancer products are typically polymers, but variances in the properties from different manufacturers pose unique quality control problems for mixers, airtanker pilots, and managers who are responsible for the accountability and delivery of products for use in the control of wildland fires.

> Polymer: a substance that has a molecular structure consisting chiefly or entirely of a large number of similar units bonded together, e.g., many synthetic organic materials used as plastics and resins. (Dictionary.com)

To ensure the best performance, those who mix and use water enhancers should consider the following prior to deployment:

1. Perform field testing first. This includes testing the water quality at the base of operations and verifying the percent of concentrate added to water and the finished viscosity using a Marsh funnel time taken from both the storage tank and the load hose. Marsh funnel viscosities are estimates of Brookfield viscosity, good to about ± 200 centipoise (i.e., the unit of dynamic viscosity).
2. Monitor mixing, handling, and storage procedures.
3. Observing, documenting, and providing feedback on field performance is another key step to ensuring the products used are effective. It is essential to observe drop characteristics, canopy penetration, shadowing, and evenness of retention of water enhancer on fuel, as well as the interaction with fire, including resistance to ignition and flammability reduction.
4. Understanding the effects of evaporation is critical if performing batch mixing and storing mixed product. The evaporation of water from a mixture of stored water enhancer results in the product gaining viscosity. The same is true with gum or clay-based LTR. In both instances, the product needs to be checked and recirculated prior to loading. This requires experience in the field to stay within specifications. However, this procedure does not apply to end-of-line proportioned products that are direct-loaded onto the aircraft.

What is most important is that the products in their mixed form, regardless of the mixing method, meet the following USFS Specifications for Water Enhancers:

- The minimum viscosity cannot drop below 200 centipoise, which is approximately the viscosity of maple syrup or SAE 30 motor oil.

- Mixers cannot add more than 3% of the water enhancer concentrate to any amount of water. This applies to all of the products on the QPL regardless of the stated QPL Mix Ratio.[2]

Effects of Water Quality on Controlling Mixing at Tanker Bases

Because of water quality variances at airtanker bases throughout the country, the effect of water quality on the viscosity of water enhancer products must be understood and managed.

Since the highest benefit to the user is a balance of both longevity and coverage of fuels, the ability to control the viscosity within a set range, without interruption throughout an operational period and in wet storage, is of primary importance.

Although some variables are relatively controlled, such as recommended coverage levels for different fuel types, many variables remain dynamic throughout the operational and seasonal periods. It is essential to account for the dynamics of typical variables that may be encountered during operations.

Water enhancers are affected by water's pH and salinity, including retardant salts. Water enhancer products must vary their mix ratios based on water quality, so testing for these attributes before starting a mixing process is critical to quality assurance. Water hardness and temperature variability may affect the consistency, viscosity development, or stability of some water enhancers. The effects on mix ratios in hard water blending is an important factor to consider when choosing a product.[3] The effectiveness of viscosity on extinguishment was not measured in the CoE's study and warrants further research. In addition, further research into what steps to take to achieve target viscosity when mixing with hard water is needed.

Figure 3 shows data provided by USFS, in which 8 products were tested at the Wildland Fire Chemical Systems lab that had been mixed using deionized water, tap water from Missoula, Montana, and very hard water. Mid-range mix ratios for each product were used (except for BlazeTamer 380 since it has only one approved mix ratio [i.e., 0.65%]). The graph shows how water quality affects resulting viscosities. All three products were significantly impacted by water hardness. Very hard water reduced their viscosity to less than 10% versus soft water.

The flexibility of a wide range of approved mix ratios is also important, since higher concentrations, still within the QPL-approved range, may be required for harder waters. The goal should be to adjust mix ratios to deliver a product that helps achieve firefighting objectives regardless of water hardness. Field testing for water quality prior to commencing operations and adjusting mix percentages to meet the viscosity as measured by a Marsh funnel is likely needed.

---

[2] The highest concentration of the uncolored product shall be no greater than 3.0 percent weight/weight (for dry concentrates) or volume/volume (for wet concentrates) (USFS Water Enhancer Specification-5100-306b, September 2018).

[3] The effect from salinity of water is the primary water quality factor influencing the finished viscosity of water enhancers. Salinity can occur naturally in the water source, such as the source's proximity to the ocean or as a result of residual salt from LTR. Many colorants contain salts that also affect the viscosity of water enhancers.

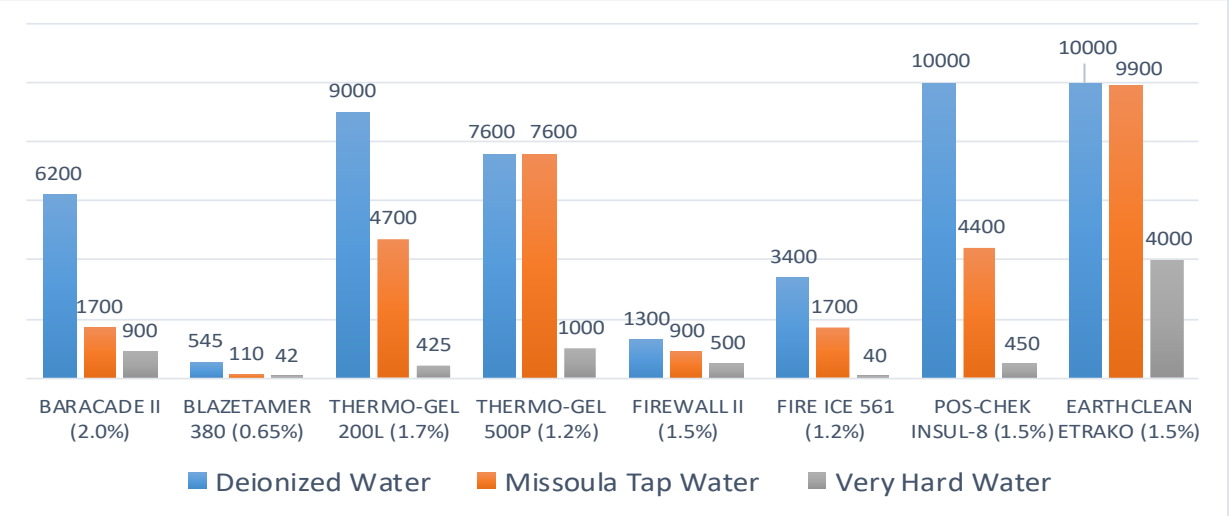


Figure 3: Water Hardness and Viscosity in Centipoise (USFS)

Water temperature has a minor effect on viscosity during initial mixing, but is generally a negligible factor as its primary effect is on the hydration rate; typically, wet storage of mixed water enhancers is required for filling of airtankers, allowing time for a product to hydrate.

Figure 4 (USFS) shows the effect of temperature on viscosity for BlazeTamer 380 at 0.65% mixed with deionized water and Thermo-Gel 200L at 1.5% mixed with deionized water at 60 degrees Fahrenheit (°F), 70°F, and 90°F respectively. Determining the most effective mix ratio of a water enhancer is a balance between the three properties of cohesion, adhesion, and viscosity.

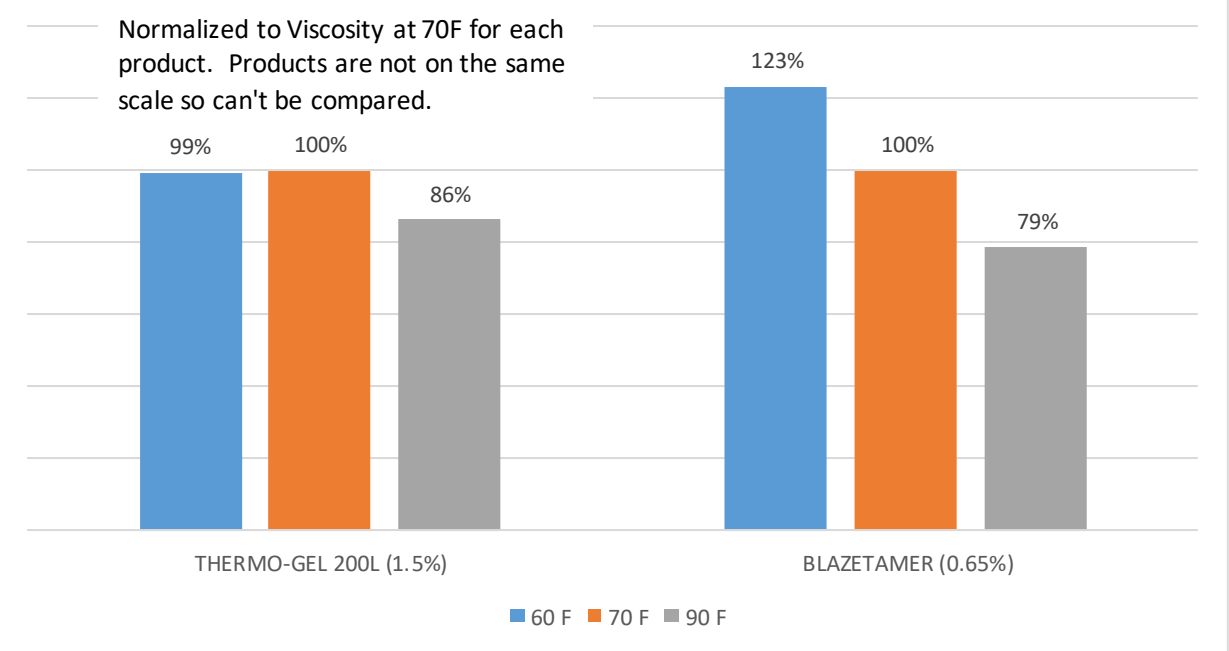


Figure 4: Relative Viscosity vs. Temperature (DI Water) (USFS)

Photos 7 and 8: Marsh Funnel Test for the Viscosity of FireIce 561 (clear) (Photo Credit: CoE)

Adhesion and cohesion are water properties that affect every water molecule on earth and also the interaction of water molecules with molecules of other substances. Essentially, cohesion and adhesion are the "stickiness" that water molecules have for each other and for other substances. The two characteristics are directly related to water enhancers and influence their effectiveness, the mixing processes, the type of equipment used, and the water quality; in addition, both characteristics are directly linked to the mixed product's viscosity.

The Marsh funnel, shown in Photos 7 and 8, is a simple device used for indicating viscosity on a routine basis.[4] After thoroughly mixing the product and water, the mixture needs to be tested using the Marsh funnel to ensure it is the correct viscosity. When used with a stopwatch and measuring cup, the funnel gives the mixing engineer a value for the consistency of both FireIce dry concentrates and Thermo-Gel 200L.[5]

It is important for the user to consider the mix ratios approved on the Wildland Fire Chemical Systems QPL for the products the CoE tested and to frame that information in the context of being able to readily modify these ratios to respond to changing penetration requirements.[6]

- The BlazeTamer 380 QPL-approved mix ratio is fixed at .65%

[4] The Marsh funnel was developed to provide a field measurement of the apparent viscosity of clay-thickened drilling mud. Provided that a conversion table has been developed, a modified Marsh funnel can be used to provide a measure of apparent viscosities for gum-thickened and polymer-thickened products used in wildland fire operations. Without a conversion table, the flow-through times can be used to determine batch-to-batch consistency of a single product and, in limited circumstances, to compare similar products.

[5] Minimum Allowable Viscosity: The viscosity of the mixed product at the lowest mix ratio, as described by the submission and disclosure information, shall be at least 200 centipoise when prepared with room temperature (70°F), American Society for Testing and Materials soft water (USFS Water Enhancer Specification-5100-306b, September 2018).

[6] USDA Forest Service Wildland Fire Chemicals, Qualified Products List, 2019

- The Thermo-Gel 200L QPL-approved ratios range from 0.5%–3.0%
- The FireIce 561 QPL-approved ratios range from 1.4%–2.1% (0.12–0.18 pound/gallon [lb/gal])
- The FireIce HVB-Fx QPL-approved ratios range from 1.7%–2.7% (0.14–0.23 lb/gal)

Holding (Residence) Time

The CoE's study collected data on holding times to determine if the products persist on the fuels long enough to delay fire spread for responding ground resources. The data also indicate a relatively large fire size at the time of the first drop (4–5 acres). This resulted in several fires in which the water enhancer drops were not as effective due to being spotted over or burned through before the arrival of ground resources. In several cases, the initial drops were effective and reduced fire intensity, but did not hold during the time that the SEATs were headed back to bases for second loads.

Holding time data was difficult to quantify because many of the drops were not observed at all or for long enough to capture data. Water enhancer longevity is affected by temperature, wind, relative humidity, exposure to sunlight, coverage, and fuel conditions.

The CoE's study showed that holding times for the products that were evaluated ranged from approximately 20 minutes to 2 hours. There were some observations of longer (up to 3-hour) holding times, but these occurred under cooler temperatures and with little wind. Because the water enhancers are only effective as long as they retain water, firefighters must realize that the use of these products should be limited to direct attack applications.

Education and awareness on the use of water enhancers has increased since the CoE began this study in 2017, but early on there were instances in which water enhancers were used for indirect drops with poor results as the drops dried out before fire interaction and were burned through. It is critical that fire managers or those directing drops know that the responding aircraft is loaded with water enhancers rather than with LTR. There must be clear communication between the air attack and SEAT pilots to attain the most effective use of these products. Some SEAT pilots may not be accustomed to the use of water enhancers and to "going direct" with a fire when using water enhancers.

Effects on Fire Behavior—Comments from Data Collection Forms:

Figure 5 shows the effect drops had on the fire behavior on a qualitative scale (data received from field observations in 2017).

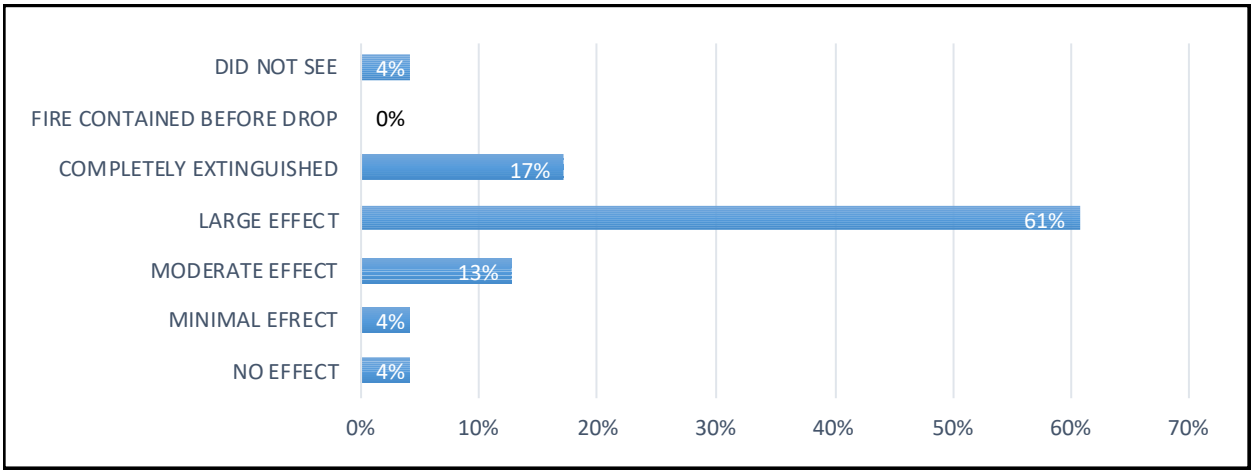


Figure 5: Effect on Fire (2017 Data)

The drops of FireIce HVB-Fx (shown in Photos 9 and 10) were 500 feet in length and 70–80 feet wide. Shadowing occurred under the juniper trees, so little if any suppressant fell under the trees. Much of this drop was well outside the fire. The portion of suppressant that hit the fire put it out or stopped the fire's progression (CoE Data Collection on Rail Fire 2019).

Photos 9 and 10: FireIce HVB-Fx Drops on Rail Fire in Oregon in 2019 (Photo Credit: CoE)

The following comments are from ground firefighters. They provide perspective on what the observers saw and their impressions of product effectiveness

> *"We used ThermoGel on multiple spots (total of 10 acres in size) on the wilderness boundary with no ground forces and it completely extinguished active fire" (Thermo-Gel 200L).*
>
> *"I called in three drops on a spot fire. There was a single tree torching and the ground fuels were also catching fire. The drop completely extinguished the fire*

Photo 11: Yampa Fire in 2017: Direct Attack with Thermo-Gel 200L; Coverage Level 3 and Complete Extinguishment (Photo Credit: Craig District BLM)

of the torching tree and ground fuels. Three drops were used. In my opinion the gel works great" (Thermo-Gel 200L).

"This product worked the best when used directly adjacent to the fire edge. It completely extinguished all open flames when applied in this manner. Indirect application was not as effective in this fuel type. Photos [Photo 11] were provided for this incident. Overall we were very satisfied with the product in the sage fuel types" (ThermoGel 200L on Yampa Fire near Craig, CO 2017).

"The Incident Commander for the Fire stated that he and his fire crew were approaching the fire when the two SEATs made their drops. SEATs (T-804 and T-827) used FireIce HVB-Fx on the fire for a total of two loads. The first SEAT dropped late on the right flank flying north to south. CoE personnel arrived on the fire approximately 20 minutes after the last drop of FireIce. In most of the fine fuels, the FireIce was dried out, but it retained some moisture on the heavier fuels. The drop was 500 feet in length and 70–80 feet wide. Shadowing occurred under the juniper trees, so little if any suppressant fell under the trees. Much of this drop was well outside the fire" (Rail Fire - 2019).

"The portion of suppressant that hit the fire put it out or stopped the fire's progression. The second drop on the left flank of the fire was late. Most of the suppressant was out ahead of the fire. Where the suppressant was dropped along the fire edge, it suppressed the fire in sage, grass, dried leaf litter, etc. Where the suppressant was heavy, it did put the fire out" (CoE Data Collection Crew-FireIce HVB-Fx on Rail Fire 2019; Photos 12 and 13).


Photos 12 and 13: FireIce HVB-Fx (Blue Colorant) Drops on Rail Fire in 2019 in Central Oregon and Effects on the Fire Edge (Photo Credit: CoE)

A consideration for pilots is that water enhancers tend to "fly" longer than retardant due to their lighter weight, so consequently the tanker pilots need to adjust by dropping earlier. Similar observations were noted by Cal Fire S-2 Tanker pilots in their 2005 evaluations of water enhancers and by SEAT pilots during the CoE's 2017 study.

> *"With water enhancers I have to release several seconds (2–4) sooner than a retardant drop in order to have a correct start. I feel this has to do with differences in weight. On the 245 Fire, gel worked great at knocking down the active flaming perimeter using coverage level 6" (SEAT Pilot on T-845 using Thermo-Gel 200L).*[7]

Onboard Injection Systems

Onboard injection systems for water enhancers have the potential to greatly improve the effectiveness of initial attack, especially when used with suppressants. However, there are questions about the ability of currently installed injection systems to achieve a consistent mix throughout the tank.

Identified specific concerns, all of which have the potential to result in a final mix that is not effective, included:

- Potential environmental issues from residual chemicals when scooping with Fire Bosses or CL-215 and or CL-415 amphibious water scooping aircraft.
- Quality control and assurance for in-tank mixed water enhancer where viscosity testing is not possible.
- The amount of shear required to thoroughly blend the products.
- Concerns about water quality and impact on viscosity.

[7] Late release was also noted by the Air Tactical Group Supervisor as a common problem on the 245 and Yampa Fires.

Current onboard mixing equipment is designed for mixing Class A foam and is commonly an Original Equipment Manufacturer designed and installed product that injects foam at a ratio between 0.1%–1.0% concentration. This percentage applies to all of the Class A foam products on the USFS QPL. The products are generally self-dispersing and require minimal agitation to mix. The addition of any concentrate not meeting the specification for Class A foam and listed on the USFS QPL is not allowed.

In addition, foam injection pumps are calibrated to inject foam concentrate with viscosity less than 40 centipoise (about the viscosity of SAE 10 motor oil). Water enhancers are thicker fluids and pump slower, resulting in a lower concentration of water enhancers being injected. The pumps inject fluid for a programmed time to achieve the right quantity of concentrate for the amount of water onboard. Running the pump for a longer duration to compensate for the higher viscosity of water enhancers can damage the pump and inject an unknown quantity of concentrate. This applies to pump proportioners installed in all aircraft and factory bucket systems. Another potential consequence of using a water enhancer in a system designed for foam is possible corruption of the foam concentrate tank with water, causing gellation in the concentrate storage tank and resulting in damage or exhaustive clean-out.

The ability to blend water enhancers onboard aircraft while in flight increases the amount of suppressant that can be delivered and results in more efficient use of aircraft and potentially more rapid containment of wildland fires. The CoE recommends further testing of onboard systems, both those that have been developed in controlled tests and those that have been used operationally, to address the environmental protections and achieve the capabilities for blending and delivery of a quality product.

Existing Knowledge About Water Enhancers

Studies into suppressant and retardant effectiveness have been conducted throughout much of the 20th century. The majority of the work that has been done has focused on LTR effectiveness and was performed in laboratory settings.

The effectiveness of retardants and suppressants has received a considerable amount of research in laboratory experiments (Àgueda, Pastor and Planas 2008) and (Giménez et al. 2004); however, their aerial application for wildfire suppression has rarely been evaluated. This is probably because it is difficult to access and observe drop effects on wildfires (George and Johnson, 1990).

Studies of water enhancer use that considered aerial application in direct attack roles have mainly been conducted in Australia (e.g., Plucinski et al. 2011; Ault et al. 2012). A lab-based method for comparing the effectiveness of different suppressants (including water enhancers) has found some gel suppressants to be much more effective than water (Plucinski et al. 2014; Plucinski et al. 2015; Plucinski et al. 2017). Other state agencies—including California Department of Forestry in 2005, Oregon Department of Forestry beginning in 2016, and Minnesota Department of Natural Resources in 2015—have conducted their own operational

evaluations of FireIce and BlazeTamer 380. Each one prepared unpublished reports that the CoE has examined.

Additional research has focused on evaporation rates and holding times and practitioners have observed that gel-treated fuels dry more slowly than those treated with water and foam when exposed to the same conditions (Taylor et al. 2005; de Bruijn and Mooney 2010; Plucinski et al. 2014). Holding time, or the duration of suppressed fuels resisting reignition, has also been found to be longer in gel-treated litter fuels than water-treated fuels exposed to repeated point ignitions in the laboratory (Plucinski et al. 2014). Additional research (Biggs 2012) summarized data collected and observations in relation to the application of aerial suppressants on public land within Victoria during field evaluation trials and fire suppression operations. It was produced to provide both ground and airborne firefighters with a general understanding of the characteristics of aerial suppressants inclusive of water, Class A foam, LTR, and water-enhancing polymers.

Products Evaluated

In this study, the CoE evaluated the use and effectiveness of the following water enhancers: GelTech Solutions FireIce 561® (uncolored), FireIce HVO-F® (orange colorant), FireIce HVB-Fx®, G5 BioSolutions BlazeTamer 380®, and Thermo Technologies ThermoGel 200L®. All of these products are approved by USFS for use in SEATs. See the USFS Qualified Products List.

Photo 14: Test Drop of FireIce 561 Sunset Orange (Photo Credit: CoE)

FireIce 561 is a highly refined, cross-linked polyacrylate copolymer gel. It is a dry powder that weighs approximately 8.45 lbs/gal when mixed with water. The mixing ratio is between 0.12 and 0.18 lbs of powder per gallon of water. FireIce 561 is available uncolored and can be colored for greater visibility. Recently, USFS approved FireIce HVB-Fx, which is the first aerially approved gel with a one-part, fugitive blue colorant package that meets USFS specifications found in 5100-306b and is on the QPL.[8] FireIce 561 was utilized at the State-managed Fort Collins SEAT base during 2017 and 2018.

Photo 15: Test Drop of FireIce HVB-FX Blue (Photo Credit: GelTech Solutions)

BlazeTamer 380 is a polymeric-elastomer-based water enhancer designed for deployment by aircraft to suppress wildfires. It contains a mix of polymers, surfactants, water, and other ingredients. It is a liquid concentrate that weighs approximately the same as water. The mixing ratio is .65% concentrate for each gallon mixed. This product was used at the Rifle SEAT base during 2017–2018.

Thermo-Gel 200L is a hydrophilic polymer based in mineral oil and contains a blue dye colorant. It is packaged in a liquid concentrate form that, when added to water, transforms into a heat-absorbing gel. The water-filled gel particles adhere directly to the burning material and, in doing so, aid in the quick extinguishment of fire. It has a mixing rate between .5% and 3% of each gallon mixed. A U.S. Department of Agriculture blue food colorant was added for enhanced visibility to pilots at 2,500 feet. It is an effective colorant that is fugitive (i.e., fades completely in a few days). This product was used at the Craig SEAT base during 2017–2018.

Photo 16: Test Drop of BlazeTamer 380 (Photo Credit: CoE)

[8] Our evaluations of FireIce HVB-Fx were done in cooperation with the Oregon Department of Forestry in 2019

Gallons of Water Enhancer Used and Costs Compared to Long-Term Retardant

In 2017, Thermo-Gel 200L accounted for the most use as a greater number of fires occurred in the Craig area than near the Fort Collins and Rifle SEAT bases. In 2017, use of Blaze Tamer 380 was very limited due to issues with the State of Colorado procurement process that delayed start-up, as well as due to some issues with the mixing equipment at the Rifle base.

In 2018, the use of water enhancers increased considerably. There was no use of water enhancers in Colorado during 2019 due to the quiet fire season. Figure 7 shows usage in 2017 and 2018.

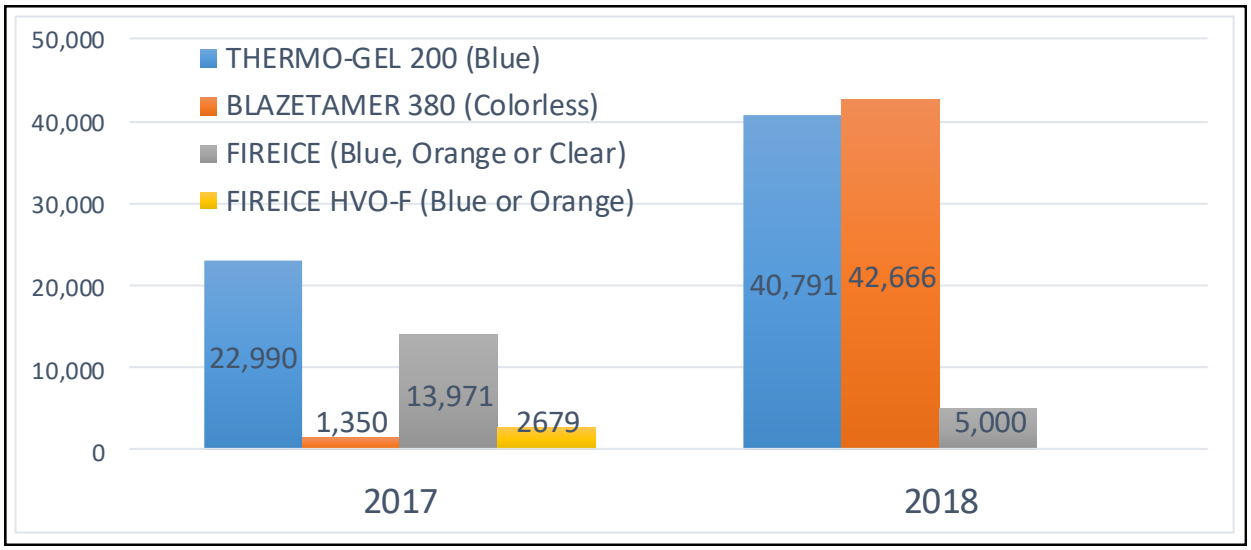


Figure 7: Usage of Water Enhancers in 2017 and 2018 in Colorado

Mixed costs per gallon for the products ranged from approximately $0.90 per gallon for BlazeTamer 380, $0.67 and $0.79 per gallon respectively for FireIce 561 and HVO-F, and $0.89 per gallon for Thermo-Gel 200L.

A 5-gallon container of BlazeTamer 380 at $645.00 per pail will produce 1,550 mixed gallons at 0.325% at a cost of $0.42 per gallon. If mixed at 0.65% it will produce approximately 780 gallons, at a cost of $0.83 per mixed gallon. In either case, this is noticeably less expensive than Phos-Chek LC95A (for buckets) and 259-F (for fixed tank) LTR, which costs from $2.30–$2.50 or more per mixed gallon.[9] Bulk pricing from 2017 is shown in Table 1.

LTR costs vary from base to base and with gallons used. For example, costs for LC-95A LTR from the Grand Junction (National Full Service Retardant Contract) Tanker Base are shown in Table 2.

[9] Costs are from USFS Long-Term Retardant pricing for MRB-H, 4/28/16-4/27/17.

Table 1: Water Enhancer Bulk Pricing

FireIce HVO-F	Dry Concentrate	40.5-lb pails	$357.92 each
FireIce 561	Dry Concentrate	25-lb pails	$307.66 each
FireIce HVB-Fx	Dry Concentrate	42-lb pails	$446.00 each
BlazeTamer 380	Liquid Concentrate	5 gallons	$645.00 or $129.00/gallon
BlazeTamer 380	Liquid Concentrate	264-gallon tote	$34,056 or $129.00/gallon
Thermo-Gel 200L	Liquid Concentrate	5gallon pails	$431.50 or $86.30/gallon

Table 2: Costs for LTR in 2017 at the Grand Junction Base

2017 CALENDAR YEAR

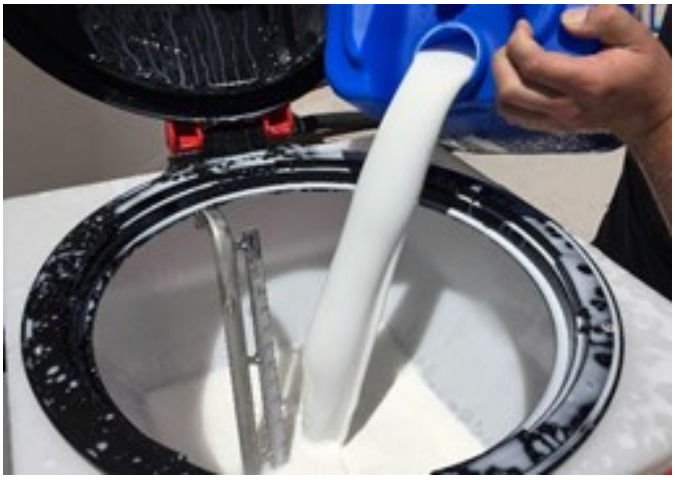
CLIN	AIRTANKER BASE	AGENCY	PRODUCT REQUIREMENT	REQUIRED DELIVERY PERIOD	
03	**GRAND JUNCTION, CO**	BLM	APPROVED QPL PRODUCTS	MAY 12 THROUGH OCTOBER 1	
QUALIFIED PRODUCT REQUIRED NAME: **Phos-Chek LC95A-R**				QUALIFICATION LOT NO 1051695-C	
PRICING CATEGORY		ESTIMATED QUANTITY	UNIT	UNIT PRICE	AMOUNT
A. Zero to 100,000 gallons		100,000	Gallons	**$5.70**	$570,000
B. 100,001 to 300,000 gallons		200,000	Gallons	**$1.85**	$370,000
C. 300,001 to 500,000 gallons r		200,000	Gallons	**$1.49**	$298,000
D. 500,001 gallons and over		200,000	Gallons	**$2.32**	$464,000
TOTALS FOR BASIS OF AWARD		700,000			$1,702,000

Mixing Equipment

Mixing equipment and the processes used to mix or "shear" the products vary by product type, agency, location, and aircraft types. When using water enhancers for the first time, training on their use and proper procedures for mixing to ensure a safe and effective mixed load is essential. Water sampling should also be done ahead of time if possible. During the CoE's study, personnel evaluated three different mixing systems at three locations and learned that there are pros and cons to each.

BlazeTamer FastFiller

The BlazeTamer FastFiller 7 was used at the Rifle SEAT base. It is small, lightweight, and can be set up quickly and operated with minimal training. In 2017, State personnel used the 5-gallon pails, which are easy to store and move around, but found that filling the hopper on the FastFiller was challenging, especially during windy conditions. The larger 264-gallon totes were found to be more efficient for storage and handling. When mixing, the product is drawn up into the fast-filler directly from the tote and, due to the closed circuit nature of the system,



Photos 17 and 18: BlazeTamer 380 Being Poured into the FastFiller Hopper at the Rifle SEAT Base in 2017 (Photo Credit: CoE)

Photos 19, 20, and 21: BlazeTamer 265-Gallon Tote (left), FastFiller 7 (middle), and 5-Gallon Pails (right) (Photo Credit: CoE)

there is less work involved when compared to handling 5-gallon pails, as well as less chance of spills or contamination since the product is not exposed to the elements. The system is able to load 750 gallons into the aircraft in approximately 3–4 minutes. Another noticeable advantage of BlazeTamer 380 is the small footprint required to set up the system.

FireIce Mobile Air Base

The FireIce Mobile Automated Base (F-MAB) system is an integrated, direct mixing and loading system designed exclusively for FireIce fire chemicals. The State's Fort Collins SEAT base personnel used this system for mixing FireIce dry concentrate powders, including FireIce 561 and FireIce HVO-F. It is the fastest, cleanest, and most precise system we used for mixing these products during this study. The F-MAB was designed specifically for loading heavy airtankers and is intended to be portable. It has a somewhat larger footprint and, for best results, should have dedicated and trained staff to oversee its operation.

Photos 21 and 22: FireIce Mobile Automated Base (F-MAB) at the Fort Collins SEAT Base in 2017 (Photo Credit: CoE)

The F-MAB the CoE tested was a prototype unit designed and built by Gel Systems Canada. State personnel were able to test this prototype at the Fort Collins SEAT base in 2017–2018. It is the largest and most sophisticated mixing equipment used during the COE study and should be considered for use where multiple loading pits might be used and or when loading large airtankers since this device is specifically designed to accommodate those operations. Water supply is critical in any case. If using this system with large air tankers, having the capability for premixed product (wet storage) should be considered to keep up with demand and in the event that the mixing equipment should break down. In the CoE's experience with dry powder products, such as FireIce 561, the F-MAB provides added efficiency in that it allows the user to preload large quantities of dry powder in sealed vessels prior to use and thus reduces the

effects of wind on open pails. However, the system requires training and, in at least one case, did not provide the proper mix due to operators not following the correct loading procedures.

The capacity and specifications of the current version of the Gel Systems Canada F-MAB are as follows:

- Accuracy: <.001% of dry powder weight per total load
- Powder mix yield to mixed gallon: Approximately 8–11 gallons/lbs of powder depending on water quality
- Loading pump capacity: Variable range from 150–330 gallons per minute
- Dry powder storage per loaded F-MAB vessel: 1300 lbs of FireIce
- Mixed gallon equivalent: 10,400–14,300 gallons depending on water quality
- Recharge capabilities: 1,000-lb increments
- Recharge time: 4–6 minutes
- Has the ability to perform a field water test (takes approximately 20 minutes; should be done prior to arrival to speed up setup)
- Easy adjustment to account for water quality variability
- Data tracking and digital record keeping specific to each aircraft tail number

Thermo-Gel FireDos® Mixing Equipment

Photo 23: Thermo-Gel FireDos Pumps and Support Trailers at the Craig SEAT Base in 2017 (Photo Credit: CoE)

During the CoE's study, Thermo-Gel® 200L was directly proportioned by the FireDos®, a water-driven proportioner that is capable of pumping approximately 250 gallons per minute. This afforded firefighting personnel with a reliable delivery system at the Craig SEAT base. This precise mixing and metering system can produce the wide variety of mixed percentages and viscosities needed for Colorado's fuel types, terrain, and wind conditions. Firefighting personnel regularly mixed at 1.5–1.6% and found this ratio to work well. The system consistently provided 700–750 gallon loads in approximately 3 minutes. Marsh funnel flow time of 23–25 seconds was used to test for viscosity. It has a relatively small footprint, as shown in Photo 23.

Recommendations

This section provides a summary of the most important recommendations from the CoE's study. Aircraft are routinely used for wildfire suppression, but their effectiveness has rarely been evaluated. The recommendations are the result of the CoE's research and are intended to assist users in their consideration of implementing the use of water enhancers.

Increase the Use of Water Enhancers (Especially During Initial Attack)

Aircraft are used in a variety of wildfire management roles in many parts of the world. They can be used to deliver suppressants to sections of the fire edge that are difficult to access on the ground and can reduce the intensity and spread rates to allow ground crews to work along the fire edge. This is critical during the initial attack of wildfires in remote locations.

When used properly, specifically in direct attack on the fire with ground resources present, the CoE's data showed that there is a favorable reduction in flame heights with the use of water enhancers as opposed to LTR, especially in light fuels. Observers shared a number of comments that suggest that they are quite effective at reducing fire behavior.

- Water enhancers are much more effective when used in direct attack than water or foam and much less expensive than retardant.
- The choice of tactics may also depend on the availability of suitable aircraft, payload, and airbase facilities for each option.
- Water and foam all dry at a faster rate than do water enhancers; however, ground follow-up is critical to the success of a water enhancer line "holding." This is even more important on hot and windy days when spread rates and the probability of ignition are both high, as holding times under these conditions will be 30 minutes or less.
- Holding time was difficult to quantify because many of the drops were not observed at all or did not last long enough to capture data.
- The CoE's study showed that holding times for the products that were evaluated range from 20 minutes to 2 hours. Because the water enhancers are only effective as long as they retain water, fire managers must realize that the use of these products should be limited to direct attack applications.

Develop User Training

The CoE recommends the development of training and best practices for the use of water enhancers, specifically focused on direct attack as well as on mixing operations and quality control. Those using water enhancers should assess and compile current knowledge on the use of these products and develop guidelines for use in training and best practices to address the following:

- Tactical uses/when to use water enhancers versus LTR

- Use in direct attack, coverage levels, release points, and residence times
- Products in use and differences between dry powders and liquid concentrates and colorants
- Procurement of products, mixing equipment, and equipment rental agreements for both fixed-wing and helicopter operations
- Mixing considerations—water testing, water quality, and temperature effects on viscosity
- Equipment rental agreements and ordering processes for portable bases and equipment to support SEATs and helicopters with buckets
- Training for mixing personnel that includes best practices for quality assurance/quality control protocols

Experienced operators are essential to trouble-free loading. Although the mixing systems the CoE used are relatively easy to operate, it is essential to provide training, practice procedures, and maintain consistency in application. This equipment can be overwhelming at first, so a full -time "mix master" may be most effective.

"Trial by fire" is not the best way to educate people. Historically, agencies only loaded aircraft when there is a dispatch, which was not a good time to train new operators. Proficiency and test flights are a great way to exercise the equipment and educate loading staff and pilots in a low-stress situation. The CoE cannot overemphasize how important off-season training is to successful operations.

Use Water Enhancers with Prompt Ground Resource Follow-Up

When enhancers are used properly for direct attack and the number of aircraft is sufficient, they may be capable of fully extinguishing the fire with little to no ground support. The CoE recommends water enhancer use for situations where follow-up from the ground can be provided promptly (typically within 1 hour).

For an extended attack incident, particularly when the ground support is several hours away and the need is to hold or slow the spread until they can catch up, retardant is likely the best tool. There were numerous observations made during this study in which the enhancers were very effective when supported by ground resources. Ground crews play an essential role during fire suppression, with water enhancer technology offering a method to increase their suppression capacity. Aerial suppression provides a temporary holding role, rather than extinguishing fires. Follow-up by ground crews before the water enhancers dry out or fire burns through the drop zone is essential.

In 2018, the CoE received observations from several initial attack fires with high rates of spread and intensity where ground resources were delayed in supporting the drops in a timely manner, resulting in drops being burned around or spotted over.

Consider Use of Water Enhancers in Helicopters

Use of water enhancers in helicopters should also be considered on large fires to directly support crews in controlling hot spots and reducing the amount of time required to control critical sections of fireline.

Some additional benefits of water enhancer use in helicopters may include:

- Fireline production per drop when using water enhancers is increased significantly due to the creation of a dense, narrow drop pattern versus the pattern created when dropping untreated water.
- Retardant is expensive and inefficient when used for direct attack.
- Retardant increases the weight of water from 8.3 lb per gallon to about 9.1 lb per gallon.
- Only 85% of retardant (i.e., the water content) is effective when used for direct attack; 15% is the chemicals and coloring agent used for indirect attack.
- Retardant is more expensive. For example, BlazeTamer 380 costs $0.83 per gallon as compared to $2.50 per gallon for Phos Chek 259-F LTR.
- Ease of set-up and breakdown of water enhancer mixing systems as compared to mobile retardant bases allows for fast movement around a fire rather than having to stay in one location. No heavy equipment is needed.

Develop Processes and Tools to Ensure Good Quality Control of the Water Enhancer Mixture

Water enhancer products are typically polymers, but variances in the properties from different manufacturers pose unique problems in quality control for mixers, airtanker pilots, and managers, all of whom are responsible for the accountability and delivery of products for use in the control of wildland fires.

- Processes to ensure properly mixed loads of water enhancers have been developed by manufacturers. These methods need to be reviewed and training put in place to ensure proper mix ratios.
- This includes procedures to follow for mixing, sampling, testing the samples, and documenting the results. Sampling results, as well as any abnormalities, should be shared as widely as possible with the field personnel from an approved website.

Perform Further Study of Onboard Mixing

The CoE recommends that work continue in 2020 to test the systems under development and those that have been used operationally.

Onboard aircraft injection systems currently in use have the potential to greatly improve the effectiveness of initial attack, especially when used with suppressants. This could result in more efficient use of aircraft and potentially more rapid containment of wildland fires.

However, concerns have been raised over currently available systems and their ability to achieve a consistent mix throughout the tank.

Specifically:

- Lack of quality control and assurance methods for onboard injection systems.
- The amount of shear required to thoroughly blend the products. In some cases, there is insufficient shear resulting in lower-than-expected viscosity.
- How water quality impacts standardized mixing and the ability to calculate how much concentrate must be added to produce the desired final viscosity, since viscosity cannot be measured in the aircraft tank.

These all have the potential to result in a final mix that is too thin or too thick to be useful, and could result in safety and effectiveness concerns.

Performing Further Testing of the Effects of Water Chemistry.

Data from the USFS Wildland Fire Chemical Systems lab (Figure 3) illustrates how water quality, particularly hardness, impacts achieved viscosity of product after mixing. Further study on the impact of water hardness and how to compensate for it is needed.

- Some manufacturers provide guidance on how to vary mix ratios to compensate for water hardness, but precise water hardness measurements are not typically available at fill bases.
- It is possible that compensating for hardness by measuring final viscosity using a Marsh funnel is more effective than trying to measure water hardness and pre-compensate.
- In any case, Marsh funnel testing to verify viscosity should be standard practice.

Utilize Infrared-Equipped Aircraft to Evaluate Drops

The extent of a drop coverage footprint cannot be easily determined from the ground unless drops contain a colorant. The effective drop footprint could easily be determined from the perimeter of burned and unburned fuels within the drop footprint by utilizing an aircraft with an electro-optical/infrared sensor.

Photo 24: DFPC Pilatus PC-12 Multi-Mission Aircraft (Photo Credit: DFPC)

Observations from one of the DFPC Multi-Mission Aircraft (MMA) could provide a reliable means of recording the immediate effects of drops on fire behavior.

Two examples are shown in Photos 26 and 27 below taken by the MMA during drop testing in May 2017.

Photo 25: MX-15 Electro-Optical/Infrared Turret (Photo Credit: CoE)

Wet areas from drops can be detected for some time after the suppressant has been dropped, allowing the location to be geo-referenced and defined. Aircraft-mounted infrared allows real-time monitoring of the drop zone and the fire behavior around it. This fire activity and the effects on the suppressant would not normally be seen due to smoke.

Photo 26: Electro-Optical Color Image of FireIce HVO-F Orange Drop Taken by the MMA in 2017 (Photo Credit: DFPC)

The monitoring platform should be located at a height that allows the fire perimeter section of interest to be captured in the field of view, while still providing adequate spatial resolution during the critical periods before and after drops.

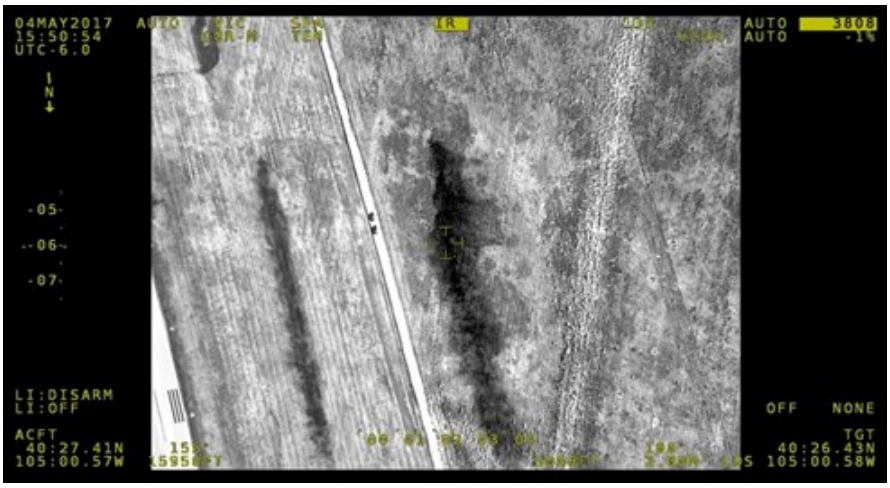


Photo 27: Infrared Imagery of Two FireIce 561 Drops Side by Side Taken by the MMA in 2017 (Photo Credit: DFPC)

Infrared imagery captured from independent observation aircraft can provide the best known means for monitoring and recording the interactions between fire and aerial suppression drops. The sensor can be used to measure drop dimensions, proximity to fire perimeter, and their effect on fire spread. These evaluations could then be used to compare tactics, suppressants, and delivery systems and to inform cost-benefit analyses of aerial suppression. Infrared imagery for determining the

spatial and temporal extent of drops and the effects that they have on fire behavior could greatly benefit the CoE's efforts to evaluate aerial fire suppression.

Perform Drop Testing from SEATs to Help Inform Pilots of Drop Timing

There is some evidence that water enhancers drop more slowly than LTR, resulting in pilots dropping "late." The CoE recommends performing some limited testing to evaluate this, as well as drop tests at the beginning of each fire season and during proficiency drops if possible.

- Perform a test drop with LTR and water enhancers using the same aircraft in the same configuration in quick succession (to minimize environmental impacts).
- Video the drop and measure the drop start/stop points to quantify whether a significant drop difference exists.
- Provide feedback to pilots so they can adjust drop timing when dropping water enhancer.

Conclusions

While the data collection in the water enhancer study proved to be challenging, the CoE believes enough information has been obtained to make the recommendations presented in this report. The CoE will evaluate further study opportunities and may conduct further general or directed research during 2020 and beyond.

Works Cited

Àgueda, Alba, et al. “Different Scales for Studying the Effectiveness of Long-Term Forest Fire Retardants.” *Progress in Energy and Combustion Science*, vol. 34, no. 6, 2008, pp. 782–96.

Ault, R., et al. “Determining the effectiveness of water-enhancing gel as a fire-control agent using helicopter drops on wildfire.” *A Case Study Near Manning*, *Alberta*, FP Innovations Wildfire Operations Research, Hinton, Alberta, Canada, 2012.

California Department of Forestry and Fire Protection. “Field Operational Evaluation Plan for Evaluation of Water Enhancing Gels Delivered from CDF Airtankers with Results and Conclusions.” Unpublished Report, 2005.

de Bruijn, P., and Mooney, C. “Exploring a Method to Evaluate the Longevity of Fire-Control Agents (Gel, Class A Foam, Water) Under Field Conditions.” FP Innovations Wildfire Operations Research, Hinton, Canada, 2010.

George, C.W. “An Update on the Operational Retardant Effectiveness (ORE) Program.” *The Art and Science of Fire Management. Proceedings of the First Interior West Fire Council Annual Meeting and Workshop*, Edited by M.E. Alexander and G.F. Bisgrove, 1990, pp. 24–27.

George C.W., Johnson G.M. (1990) “Developing Air Tanker Performance Guidelines.” USDA Forest Service, Intermountain Forest and Range Experiment Station, General Technical Report INT-268, 2020.

Giménez, Anna, et al. “Long-Term Forest Fire Retardants: A Review of Quality, Effectiveness, Application and Environmental Considerations.” *International Journal of Wildland Fire*, vol. 13, no. 1, 2004, pp.1–15.

Loane, I.T. and Gould, J.S. “Aerial Suppression of Bushfires: Cost-Benefit Study for Victoria.” National Bushfire Research Unit, CSIRO Division of Forest Research Canberra, 1986.

Plucinski, M.P., et al. “A Methodology for Comparing the Relative Effectiveness of Suppressant Enhancers Designed for the Direct Attack of Wildfires.” *Fire Safety Journal*, vol. 87, 2017, pp. 71–79.

Plucinski, M.P., and Elsa Pastor. “Criteria and Methodology for Evaluating Aerial Wildfire Suppression.” *International Journal of Wildland Fire*, vol. 22, no. 8, 2013, pp. 1144–1154.

Plucinski, M.P., et al. “Laboratory testing of water enhancer (gel) fire suppression efficacy.” *CSIRO Client report for the Victorian State Aircraft Unit No. EP145430*, Canberra ACT, 2014.

Plucinski, M.P., et al. “Project FuSE Aerial Suppression experiments.” *Bushfire Cooperative Research Centre Technical Report*, 2011.

Plucinski, M.P., et al. “The effectiveness and efficiency of aerial firefighting in Australia.” Bushfire Cooperative Research Centre, 2007.

Taylor, D., et al. “A Preliminary Trial of Phos-Chek AquaGel-K for Aerial and Ground Application by DPI Forestry in Exotic Pine Plantation Fire Management.” Queensland Government, Department of Primary Industries and Fisheries, 2005.

U.S. Forest Service. “Specification for Water Enhancers (Gels) for Wildland Firefighting.” Specification 5100-306a. Wildland Fire Chemical Systems, Missoula, Montana, 2007.

Appendix A

The following tables show the raw data from web-based forms. It should be noted that, while this data informs this report, further input in terms of direct interviews, observations, and conversations were an important part of this work. By necessity, that information is not presented in tabular form. Data is provided for the 2017, 2018, and 2019 observations. The precise data collected on the web-based forms was modified each year as a result of feedback form participants.

Timestamp	DATE	FIRE NAME & NUMBER	FIRE SITUATION	LOCATION (Lat./Long.)	TACTICS	DROP OBJECTIVES	WERE THE DROP OBJECTIVES MET:	DROP TIME	SEAT TAIL NUMBER	DROP LOCATION
4/4/2017 14:35:51	4/4/2017	Red rock fire	INITIAL ATTACK	(-26.352498, -66.093750)	INDIRECT		YES	1430	1172CH	
5/10/2017 14:05:37	5/4/2017	TEST DROPS at FNL	INITIAL ATTACK	40 26.44N 105 00.51W	DIRECT		YES	1522	831	
5/10/2017 14:10:54	5/4/2017	TEST DROPS at FNL	INITIAL ATTACK	40-27.109633N / 105-00.680133W	DIRECT		YES	1533	831	
5/18/2017 15:33:30	5/18/2017	test jon	EXTENDED ATTACK	none	INDIRECT		YES	4:15:00 PM	56456	RIGHT SHOULDER, HEAD
7/11/2017 11:34:16	7/4/2017	Nicholas E1419	LARGE FIRE	Peekaboo Fire	INDIRECT	TO SLOW OR STOP FIRE SPREAD	UNKNOWN	11:00:00 AM	Unkown	RIGHT FLANK
7/18/2017 9:20:29	7/4/2017	Peekaboo	EXTENDED ATTACK	Peekaboo ridge	DIRECT	TO SLOW OR STOP FIRE SPREAD	YES	2:00:00 PM	888	RIGHT FLANK
7/18/2017 10:57:18	7/18/2017	Mill Creek K3N5	LARGE FIRE	unknown	DIRECT	TO SLOW OR STOP FIRE SPREAD	YES	3:15:00 PM		RIGHT SHOULDER
7/20/2017 15:03:45	7/6/2017	Mill Creek CO-RTX-000161	LARGE FIRE	4040.200 1078.484	DIRECT	REDUCE FIRE INTENSITY FOR GROUND CREWS	YES	1:30:00 PM	N58HJ	SPOT
7/21/2017 14:26:34	7/21/2017	Mill Creek Fire	LARGE FIRE	Unk	INDIRECT	REDUCE FIRE INTENSITY FOR GROUND CREWS	UNKNOWN	1:30:00 PM		SPOT
7/22/2017 11:32:42	7/8/2017	Mill Creek Fire	EXTENDED ATTACK	N/A	DIRECT	REDUCE FIRE INTENSITY FOR GROUND CREWS	YES	3:00:00 PM	Helicopter 58HJ	SPOT
7/22/2017 11:39:47	7/22/2017	Mill Creek CO-RTX-161	LARGE FIRE	N/A	DIRECT	REDUCE FIRE INTENSITY FOR GROUND CREWS	YES	3:00:00 PM	Helicopter 58HJ	Interior hot spot
7/22/2017 11:54:36	7/8/2017	Mill Creek CO-RTX-000161	EXTENDED ATTACK	Division Alpha	DIRECT	REDUCE FIRE INTENSITY FOR GROUND CREWS	YES	1:00:00 PM	N-58HJ	HEEL, LEFT FLANK
7/24/2017 17:12:42	7/22/2017	Spring Glade CO-LRX-	INITIAL ATTACK	104	DIRECT	TO SLOW OR STOP FIRE SPREAD, DELAY FIRE SPREAD	NO	3:00:00 PM	381	RIGHT FLANK
7/25/2017 12:50:42	7/24/2017	Yampa Fire. IA. MFX 289	INITIAL ATTACK	40 25 28.7. -108 19 32.2	DIRECT, STRUCTURE PROTECTION	TO SLOW OR STOP FIRE SPREAD	YES	5:30:00 PM	T845, T815	HEAD
7/26/2017 8:41:03	7/22/2017	Spring Glade LRX-548	INITIAL ATTACK	40.4712, -105.1401	DIRECT	TO SLOW OR STOP FIRE SPREAD	YES	4:00:00 PM		HEEL
7/28/2017 11:47:23	7/24/2017	Bitter Creek K7XP	INITIAL ATTACK	N 41 31.188 X W 109 15.516	INDIRECT	TO SLOW OR STOP FIRE SPREAD	NO	3:30:00 PM	871 & 861	RIGHT FLANK
9/27/2017 15:02:55	7/24/2017	Yampa, MFX-289-K7YF	INITIAL ATTACK	40 6.702, -108 7.194	DIRECT, STRUCTURE PROTECTION	TO SLOW OR STOP FIRE SPREAD	YES	5:15:00 PM		LEFT FLANK, HEAD
9/27/2017 15:15:06	6/27/2017	Peekaboo, LSD-152-K3BJ	INITIAL ATTACK, EXTENDED ATTACK, LARGE FIRE	40 47.610, -108 50.070	DIRECT, INDIRECT	TO SLOW OR STOP FIRE SPREAD, DELAY FIRE SPREAD	YES	3:00:00 PM		RIGHT FLANK, LEFT FLANK, HEAD
10/3/2017 13:02:52	8/18/2017	Meyers	LARGE FIRE	DIV Q	DIRECT	TO SLOW OR STOP FIRE SPREAD	YES	9:00:00 AM	H-2NH	SPOT
10/19/2017 14:45:13	7/22/2017	Spring Glade LRX-548	INITIAL ATTACK	40.478, -105.136	DIRECT	TO SLOW OR STOP FIRE SPREAD, REDUCE FIRE INTENSITY FOR GROUND CREWS, DELAY FIRE SPREAD	NO	2:00:00 PM	Multiple	RIGHT FLANK, LEFT FLANK, HEAD

Timestamp	ASPECT	SLOPE ON FIRE	WEATHER ONSITE	POSITION ON SLOPE	FIRE SPREAD DIRECTION	FLAME LENGTH	FUEL TYPE	FUEL LOADING	ESTIMATED CANOPY HEIGHT	IS THERE ADEQUATE PENETRATION THROUGH THE CANOPY AND COATING ON SURFACE FUELS
4/4/2017 14:35:51	SOUTH	25-50%	AVERAGE	MID SLOPE	UP HILL	8-12 ft	TIMBER	MODERATE		
5/10/2017 14:05:37	SE	0-25%	AVERAGE	FLAT	LEVEL GROUND	<4 FT	GRASS	MODERATE		
5/10/2017 14:10:54	SE	0-25%	AVERAGE	FLAT	LEVEL GROUND	<4 FT	GRASS	MODERATE		
5/18/2017 15:33:30	EAST	25-49%	Scattered Clouds, Intermittent Showers	BOTTOM 1/3	ACROSS SLOPE	8-12 ft	GRASS, BRUSH, TIMBER	MODERATE		
7/11/2017 11:34:16	EAST	50-74%	Clear	RIDGE TOP	ACROSS SLOPE, UPHILL, DOWNHILL	>12 ft	PINON JUNIPER	HEAVY	8.5 - 20 ft	YES
7/18/2017 9:20:29	SE	0-24%	Building Cumulus	RIDGE TOP	ACROSS SLOPE	<4 ft	GRASS	MODERATE	< 2 ft	YES
7/18/2017 10:57:18	SW	0-24%	Scattered Clouds	RIDGE TOP	UPHILL	8-12 ft	SPRUCE/FIR	MODERATE	> 20 ft	YES
7/20/2017 15:03:45	SOUTH	0-24%	Overcast	MID-SLOPE	ACROSS SLOPE	<4 ft	GRASS	MODERATE	> 20 ft	PARTIAL
7/21/2017 14:26:34	WEST	0-24%	Clear, Overcast	FLAT	LEVEL GROUND	4-8 ft	GRASS, BRUSH, TIMBER	MODERATE	> 20 ft	YES
7/22/2017 11:32:42	EAST	0-24%	Scattered Clouds	MID-SLOPE	ACROSS SLOPE	<4 ft	SPRUCE/FIR	LIGHT	8.5 - 20 ft	YES
7/22/2017 11:39:47	FLAT	0-24%	Scattered Clouds	FLAT	LEVEL GROUND	<4 ft	GRASS, SLASH	MODERATE	> 20 ft	YES
7/22/2017 11:54:36	WEST	0-24%	Scattered Clouds	BOTTOM 1/3	LEVEL GROUND	<4 ft	TIMBER	MODERATE	8.5 - 20 ft	YES
7/24/2017 17:12:42	EAST	25-49%	Scattered Clouds	MID-SLOPE	ACROSS SLOPE	4-8 ft	GRASS, BRUSH	MODERATE	< 2 ft	NO
7/25/2017 12:50:42	EAST	0-24%	Scattered Clouds	FLAT	LEVEL GROUND	4-8 ft	GRASS, SAGE	MODERATE	2.5 - 8 ft	YES
7/26/2017 8:41:03	EAST	25-49%	Clear	BOTTOM 1/3	DOWNHILL	<4 ft	GRASS, BRUSH	MODERATE	< 2 ft	YES
7/28/2017 11:47:23	FLAT	0-24%	Clear	BOTTOM 1/3	UPHILL	4-8 ft	GRASS, BRUSH, PINON JUNIPER	MODERATE	2.5 - 8 ft	YES
9/27/2017 15:02:55	FLAT	0-24%	Scattered Clouds	FLAT	LEVEL GROUND	4-8 ft	GRASS, BRUSH, SAGE	MODERATE	2.5 - 8 ft	YES
9/27/2017 15:15:06	SOUTH	0-24%	Scattered Clouds, Thunderstorms in Area	RIDGE TOP	LEVEL GROUND	>12 ft	GRASS, BRUSH, PINON JUNIPER, SAGE	MODERATE	2.5 - 8 ft	PARTIAL
10/3/2017 13:02:52	SOUTH	0-24%	Clear	MID-SLOPE	DOWNHILL	<4 ft	SPRUCE/FIR	HEAVY	> 20 ft	YES
10/19/2017 14:45:13	EAST	25-49%	Clear	MID-SLOPE	ACROSS SLOPE	<4 ft	GRASS, BRUSH	MODERATE	2.5 - 8 ft	YES

Timestamp	ADHESION TO FUELS	FIRE SIZE AT TIME OF APPLICATION IF KNOWN (in acres)	FIRE BEHAVIOR	NAME OF PRODUCT	GROUND COVERAGE	EFFECTS ON FIRE BEHAVIOR	HOW LONG DID THE GEL HOLD THE FIRE?
4/4/2017 14:35:51			TOURCHING		OCCASIONAL GAPS	MODERATE EFFECT	16-30 MIN
5/10/2017 14:05:37			CREEPING		VERY FEW GAPS	COMPLETELY EXTINGUISHED	30-60 MIN
5/10/2017 14:10:54			CREEPING		VERY FEW GAPS	COMPLETELY EXTINGUISHED	1-2 HRS
5/18/2017 15:33:30			RUNNING, CROWN FIRE	FIREICE HVO-F (BLUE OR ORANGE) (FORT COLLINS BASE)	OCCASIONAL GAPS	LARGE EFFECT	>2 hrs
7/11/2017 11:34:16	YES	1,000	RUNNING, CROWN FIRE, SPOTTING	THERMO-GEL 200L (BLUE) (CRAIG BASE)	CONTINUOUS COVERAGE	All the PJ on that slope burned except what was coated in blue gel.	30-60 min
7/18/2017 9:20:29	YES	1500	CREEPING	THERMO-GEL 200L (BLUE) (CRAIG BASE)	OCCASIONAL GAPS	MODERATE EFFECT	<=15 min
7/18/2017 10:57:18	PARTIAL	482	TORCHING, CROWN FIRE	THERMO-GEL 200L (BLUE) (CRAIG BASE)	OCCASIONAL GAPS	MODERATE EFFECT	UNKNOWN
7/20/2017 15:03:45	NO	500	SMOLDERING, CREEPING	BLAZETAMER 380 (WHITE/COLORLESS) (RIFLE BASE)	CONTINUOUS COVERAGE	MODERATE EFFECT	16-30 min
7/21/2017 14:26:34	PARTIAL	400	SMOLDERING, CREEPING, TORCHING	THERMO-GEL 200L (BLUE) (CRAIG BASE)	OCCASIONAL GAPS	MINIMAL EFFECT	UNKNOWN
7/22/2017 11:32:42	YES	N/A	TORCHING	UNKNOWN	CONTINUOUS COVERAGE	COMPLETELY EXTINGUISHED	>2 hrs
7/22/2017 11:39:47	PARTIAL	484	SMOLDERING	THERMO-GEL 200L (BLUE) (CRAIG BASE)	OTHER	FIRE CONTAINED PRIOR TO DROP	UNKNOWN
7/22/2017 11:54:36	YES	470	SMOLDERING, TORCHING	BLAZETAMER 380 (WHITE/COLORLESS) (RIFLE BASE)	VERY FEW GAPS	MODERATE EFFECT, FIRE CONTAINED PRIOR TO DROP	UNKNOWN
7/24/2017 17:12:42	PARTIAL	300	CREEPING, RUNNING	FIREICE (BLUE, ORANGE, OR CLEAR) (FORT COLLINS BASE)	FREQUENT GAPS	MODERATE EFFECT	<=15 min
7/25/2017 12:50:42	YES	95	CREEPING, RUNNING	THERMO-GEL 200L (BLUE) (CRAIG BASE)	OCCASIONAL GAPS	LARGE EFFECT	UNKNOWN
7/26/2017 8:41:03	PARTIAL	300	CREEPING, RUNNING, TORCHING	FIREICE (BLUE, ORANGE, OR CLEAR) (FORT COLLINS BASE)	VERY FEW GAPS	MODERATE EFFECT	0 OR NOT AT ALL
7/28/2017 11:47:23	YES	15	RUNNING	THERMO-GEL 200L (BLUE) (CRAIG BASE)	CONTINUOUS COVERAGE	MINIMAL EFFECT	<=15 min
9/27/2017 15:02:55	YES	20+	RUNNING	THERMO-GEL 200L (BLUE) (CRAIG BASE)	CONTINUOUS COVERAGE	LARGE EFFECT, COMPLETELY EXTINGUISHED	>2 hrs
9/27/2017 15:15:06	YES	rapidly growing	RUNNING, TORCHING, SPOTTING	THERMO-GEL 200L (BLUE) (CRAIG BASE)	OCCASIONAL GAPS	MODERATE EFFECT	30-60 min
10/3/2017 13:02:52	YES	10 Ac	CREEPING	THERMO-GEL 200L (BLUE) (CRAIG BASE)	OTHER	COMPLETELY EXTINGUISHED	>2 hrs
10/19/2017 14:45:13	PARTIAL	~250	RUNNING	FIREICE (BLUE, ORANGE, OR CLEAR) (FORT COLLINS BASE)	VERY FEW GAPS	NO EFFECT, MINIMAL EFFECT	0 OR NOT AT ALL

Timestamp	VISIBILITY OF DROPPED PRODUCT	ICS POSITION	OBSERVER'S NAME	COMMENTS
4/4/2017 14:35:51	ACCEPTABLE	IC 5	Joe	Great work
5/10/2017 14:05:37	ACCEPTABLE	ICT4	Dave Toelle	Test Drops with FireIce HVO-F at FNL SEAT Base.
5/10/2017 14:10:54	ACCEPTABLE	ICT4	Dave Toelle	Drop test with FireIce HVO-F (Blue colorant) at FNL SEAT Base. Coverage level 3
5/18/2017 15:33:30	VISIBLE WITH DIFFICULTY	4th	Jon WIlliams	None
7/11/2017 11:34:16	VISIBLE	Crew member	Nick Wood	The Fire spotted and made a crown run through PJ. It burned all of the PJ on that side of the mountain except for a strip that was coated in Blue gel. Flames were at least 20 ft. high moving alongside the gel.
7/18/2017 9:20:29	VISIBLE	operations	Tim Hasselmann	Fire backed through gel with minaml effort in about 20 minutes. Drop was at a good height and speed level 3, it just didn't have a affect on the matted cheat grass.
7/18/2017 10:57:18	NOT VISIBLE	TFLD	CW Portell	We used it to help minimize some group tree torching. The feed back I got from the people on the ground was that there really wasn't much difference than regular water. They had concerns about the slippery nature of it, in fact they fell a couple times retrieving their panel. It wasn't colored so hard to see exactly where it was. They also mentioned that they were getting it on themselves for just moving around down there directing helicopter drops. Similar to walking thru retardent drops had completed. Would have to think a little more on the best situation to use the therma-gel, i.e grass or unmanned areas of the fire.
7/20/2017 15:03:45	VISIBLE WITH DIFFICULTY	HECM	Cameron Meganck	I believe this product could be effectively used on a wildfire but did not make a huge difference during mopup operations. It did have a distinct smell to it and a small texture difference as well. I believe the gel we received was more diluted than the beginning of gel operations. Canon Helitack enjoyed getting to work with thermogel and would like to be able to experiment with it on future fires.
7/21/2017 14:26:34	VISIBLE WITH DIFFICULTY	FFT2	Colin Brown	
7/22/2017 11:32:42	VISIBLE	HECM (Canon Helitack)	Mitchell Andrews	I called three drops on a spot fire. There was a single tree torching and the ground fuels were also catching fire. The drop completely extinguished the fire of the torching tree and ground fuels. 3 drops were used. In my opinion the gel works great.
7/22/2017 11:39:47	VISIBLE WITH DIFFICULTY	FFT1 Cañon Helitack	Steven Lawson	Thermo-gel was heavily diluted with water during the time of the drops I witnessed.
7/22/2017 11:54:36	VISIBLE	Canon Helitack	Carter Miller	Gel was diluted. Used to eliminate further torching potential within fire perimeter.
7/24/2017 17:12:42	VISIBLE WITH DIFFICULTY	DIVS	Wilson Branch	Grass had a thick thatch layer and fire burned right under the gel. Bitter brush and mahogany was leafed out and gel stuck to top. Fire underburned and then reburned across top once gel dried. Overall the gel was mildly effective. Total of 19 loads of gel. skycrane dropping concentrated water was also not as effective as hoped.
7/25/2017 12:50:42	VISIBLE	Operations	Todd Wheeler	Coverage level of 2 worked well in sage and grass. Level 3 seemed a little to heavy.
7/26/2017 8:41:03	VISIBLE WITH DIFFICULTY	ENGB	Michael Haynie	The coverage level on this fire seemed too light. When the SEAT was dropping the product, we observed fire continually backing into the retardant line and burning through recently treated areas. It appeared as though the mix was too light to provide adequate viscosity to fully provide a solid line. Given the fuel type (grass) I felt as though the retardant would provide adequate coverage had the viscosity/coverage level been increased. Overall it appeared lighter than expected compared to traditional retardant in similar fuels.
7/28/2017 11:47:23	VISIBLE	East Divison	Frank Haines	The slope on the flank they dropped on was relatively flat where it burnt through. I also have picture to show, fuels and where it burnt through the gel line.
9/27/2017 15:02:55	VISIBLE	Zone FMO- FFt=T1	Toni Toelle	This product worked the best when used directly adjacent to the fire edge. It completely extinguished all open flame where applied in this manner. Indirect application was not as effective in this fuel type. Photos were provided for this incident. Overall we were very satisfied with the product in the sage fuel types.
9/27/2017 15:15:06	VISIBLE WITH DIFFICULTY	Zone FMO, not assigned to incident	Toni Toelle	The product seemed to loose effectiveness after sitting for 30 or more minutes. The weather was very hot dry and windy. Also of note, the vendor mixing the product was changing the thickness of the gel and the pilots were trying to adjust the coverage levels to meet the needs of the firefighters on the ground. Not sure the correct combination was used during this operation. It would be good to understand more about the effectiveness of this product when used at different coverage levels and which coverage levels work best on which fuel types. Also the effects of temperature and winds on this product.
10/3/2017 13:02:52	VISIBLE	OSC 2	Clark Hammond	Used Thermo Gel on multiple spots on the wilderness boundary with no ground forces
10/19/2017 14:45:13	VISIBLE WITH DIFFICULTY	Division	Justin Whitesell	Product was ineffective, we requested retardant after ineffectiveness of the enhancer. Retardant was ordered the rest of the year due to ineffectiveness of the enhancer.

Timestamp	FIRE NAME & NUMBER	DATE	TACTICS	FIRE POSITION ON SLOPE	FIRE BEHAVIOR	FUEL TYPE	WEATHER ON FIRE	WIND SPEED	ACCURACY
6/19/2017 20:29:43	North Millsap	6/16/2017	INDIRECT	MID-SLOPE	CREEPING	GRASS, BRUSH, PINON JUNIPER	CLEAR	0-5	OFF TARGET
7/7/2017 11:09:47	Peekaboo. K3BJ	7/5/2017	DIRECT	MID-SLOPE	TORCHING	PINON JUNIPER	CLEAR	5-15	PARTIALLY ON
7/7/2017 16:32:29	Peekaboo. K3BJ	7/5/2017	DIRECT	MID-SLOPE	TORCHING	PINON JUNIPER	CLEAR	5-15	PARTIALLY ON
7/7/2017 16:47:47	Peekaboo	7/5/2017	DIRECT	RIDGE TOP	RUNNING, TORCHING	PINON JUNIPER, SAGE	SCATTERED CLOUDS	0-5	ON TARGET
7/9/2017 18:17:51	Peekaboo/K3BJ	7/8/2017	DIRECT	RIDGE TOP	RUNNING	GRASS, PINON JUNIPER	CLEAR	0-5	ON TARGET
7/13/2017 14:39:26	Peekaboo	7/3/2017	DIRECT	MID-SLOPE	CREEPING	GRASS, BRUSH, PINON JUNIPER	CLEAR	5-15	ON TARGET
7/14/2017 15:25:18	Peekaboo	7/14/2017	LINE BUIDING	RIDGE TOP	CREEPING, RUNNING, TORCHING	GRASS, BRUSH, PINON JUNIPER	CLEAR	0-5	ON TARGET
7/14/2017 15:32:49	Peekaboo	7/14/2017	LINE BUIDING	BOTTOM	RUNNING, TORCHING	GRASS, PINON JUNIPER, SAGE	CLEAR	5-15	ON TARGET
7/19/2017 10:21:54	Picabo	7/5/2017	DIRECT		SMOLDERING	GRASS, BRUSH	CLEAR	0-5	ON TARGET
7/19/2017 10:25:25	Picabo	7/5/2017	LINE BUIDING	RIDGE TOP	SMOLDERING	GRASS, BRUSH	CLEAR	0-5	ON TARGET
7/19/2017 10:29:52	Picabo	7/5/2017	DIRECT		TORCHING	GRASS, BRUSH	BUILDING CUMULUS	0-5	ON TARGET
7/25/2017 12:37:36	Boxer Fire / CO-ARF-000528	7/16/2017	DIRECT	RIDGE TOP	CREEPING	GRASS, TIMBER	SCATTERED CLOUDS	0-5	ON TARGET
7/25/2017 13:20:16	Yampa / CO-MFX-000289	7/24/2017	DIRECT	BOTTOM	RUNNING	GRASS, BRUSH	SCATTERED CLOUDS	0-5	PARTIALLY ON

Timestamp	GROUND COVERAGE	EFFECT ON FIRE	VISIBILITY OF DROP	PILOT/ATGS NAME	COMMENTS	FIRE SITUATION
6/19/2017 20:29:43	NO COVERAGE	NO EFFECT	NOT VISIBLE	James Daniell	made drop on green side of ridge, ATGS called line good but drop went over ridge into the black	INITIAL ATTACK
7/7/2017 11:09:47	CONTINUOUS COVERAGE	LARGE EFFECT	VISIBLE	Dennis, Nelson/Shane McCormick (t)	The drop didn't encompass the entire flare up with torching. It was effective where it hit the flames. Had it hit the entire area where the flames were I think it would have been successful extinguishing the fire. It would have been way more effective with boots on the ground to back it up just like retardant.	EXTENDED ATTACK
7/7/2017 16:32:29	CONTINUOUS COVERAGE	LARGE EFFECT	VISIBLE	Dennis, Nelson/Shane McCormick (t)	The drop didn't encompass the entire flare up with torching. It was effective where it hit the flames. Had it hit the entire area where the flames were I think it would have been successful extinguishing the fire. It would have been way more effective with boots on the ground to back it up just like retardant.	EXTENDED ATTACK
7/7/2017 16:47:47	CONTINUOUS COVERAGE	COMPLETELY EXTINGUISHED	VISIBLE	Dennis, Nelson Shane McCormick (t)	I think the gel worked quite well after seeing the effectiveness of retardant from the ground for years. Would like to get an opportunity to use the gel in combination with a crew and see what their opinion of it is. I think it's as effective as retardant. I have seen fire burn though retardant just as easy as burning through the gel.	EXTENDED ATTACK
7/9/2017 18:17:51	VERY FEW GAPS	LARGE EFFECT	VISIBLE WITH DIFFICULTY	Curtis Carpenter/Jennifer Martynuik	Good response.	INITIAL ATTACK
7/13/2017 14:39:26	CONTINUOUS COVERAGE	MODERATE EFFECT	VISIBLE	Nathan Higginbottom	FIRE SEEMED BURN THROUGH THE LINE BY THE TIME I RETURNED WITH THE NEXT LOAD	INITIAL ATTACK
7/14/2017 15:25:18	CONTINUOUS COVERAGE	LARGE EFFECT	VISIBLE WITH DIFFICULTY	Curtis Carpenter	Hard to remove off exterior of aircraft once it has dried and it stains the paint in places and the inside of the hopper.	EXTENDED ATTACK
7/14/2017 15:32:49	CONTINUOUS COVERAGE	LARGE EFFECT, COMPLETELY EXTINGUISHED	VISIBLE WITH DIFFICULTY	Curtis Carpenter	In building continuous line it put the fire out but is very hard to see where it has been placed.	INITIAL ATTACK
7/19/2017 10:21:54	CONTINUOUS COVERAGE	Did not see effect	VISIBLE	Jeff Erger	Busy fire so I did have anytime to check effect of product.	LARGE FIRE
7/19/2017 10:25:25	CONTINUOUS COVERAGE	MINIMAL EFFECT	VISIBLE	Jeff Erger	Busy fire so I didn't really get to see the effect	LARGE FIRE
7/19/2017 10:29:52	CONTINUOUS COVERAGE	MODERATE EFFECT	VISIBLE WITH DIFFICULTY	Jeff Erger	Direct on 5 foot flame length, was told by Lead that it was effective but busy fire so I didn't nougat a chance to see results.	LARGE FIRE
7/25/2017 12:37:36	CONTINUOUS COVERAGE	LARGE EFFECT	VISIBLE	MIKE MILLER	Fire spread was stopped using this product.	INITIAL ATTACK
7/25/2017 13:20:16	CONTINUOUS COVERAGE	LARGE EFFECT	VISIBLE	Dennis Fogel	The product worked well in short sage and grass, mostly extinguished the flame front when applied half in/half out. Split the load to stop forward progress but due to a late start on the drop sequence we had to adjust tactics on the second half of the load. Once applied in the correct spot it worked amazingly well. Unknown if the late start was due to the pilots or the gel exiting the aircraft differently than retardant but it should be noted that over all three of the drop sequences each one had a late start.	INITIAL ATTACK

Timestamp	LOCATION (Lat./Long.)	ASPECT	SLOPE ON FIRE	NAME OF PRODUCT	SEAT TAIL NUMBER	DID THE DROP REQUIRE RELEASE CHANGE FROM NORMAL THICKENED RETARDANT?	IF A RELEASE CHANGE WAS REQUIRED, PLEASE ELABORATE.	WAS THE DROP SUPPORTED BY GROUND RESOURCES?
6/19/2017 20:29:43	38 00.7N 105 15.0W	WEST	0-24%		T871	NO CHANGE		YES
7/7/2017 11:09:47	40 40.6/108 50.1	SW	0-24%	THERMO-GEL 200L (BLUE) (CRAIG BASE)	815	NO CHANGE		NO
7/7/2017 16:32:29	40 40.6/108 50.1	SW	0-24%	THERMO-GEL 200L (BLUE) (CRAIG BASE)	815	NO CHANGE		NO
7/7/2017 16:47:47	40 47.6 108 50.1	WEST	0-24%	THERMO-GEL 200L (BLUE) (CRAIG BASE)	888	NO CHANGE		NO
7/9/2017 18:17:51	40 47 6/-108 50 1	SOUTH	0-24%	THERMO-GEL 200L (BLUE) (CRAIG BASE)	T815	NO CHANGE		NO
7/13/2017 14:39:26	40 47'37/108 50'4	SOUTH	0-24%	THERMO-GEL 200L (BLUE) (CRAIG BASE)	T888	NO CHANGE		YES
7/14/2017 15:25:18	40 47 6/108 50 1	SOUTH	0-24%	THERMO-GEL 200L (BLUE) (CRAIG BASE)	N3033H/T815	NO CHANGE		NO
7/14/2017 15:32:49	40 47 6/108 50 1	WEST	0-24%	THERMO-GEL 200L (BLUE) (CRAIG BASE)	N3033H/T815	NO CHANGE		NO
7/19/2017 10:21:54	40 47.6N/108 50.1W	NORTH	75-100%	THERMO-GEL 200L (BLUE) (CRAIG BASE)	N207LA	NO CHANGE		NO
7/19/2017 10:25:25	40 47.6N/108 50.1W	NORTH	75-100%	THERMO-GEL 200L (BLUE) (CRAIG BASE)	N207LA	NO CHANGE		NO
7/19/2017 10:29:52	40 47.6N/108 50.1W	WEST	50-74%	THERMO-GEL 200L (BLUE) (CRAIG BASE)	N207LA	NO CHANGE		NO
7/25/2017 12:37:36	40.51.3 / 105.22.1	NW	0-24%	FIREICE HVO-F (Orange) (FORT COLLINS BASE)	N166LA / T831	NO CHANGE		UNKNOWN
7/25/2017 13:20:16	40 25.476 x 108 19.536	FLAT	0-24%	THERMO-GEL 200L (BLUE) (CRAIG BASE)	845 and 815	EARLIER RELEASE	All three drops that we put on the fire had a late start.	YES

Timestamp	FIRE NAME & NUMBER	DATE	TACTICS	FIRE POSITION ON SLOPE	FIRE BEHAVIOR	FUEL TYPE	WEATHER ON FIRE	WIND SPEED	ACCURACY
7/28/2017 9:58:44	Yampa/zo-mfsx-000289	7/24/2017	DIRECT	BOTTOM	RUNNING	GRASS, BRUSH, SAGE	CLEAR	5-15	ON TARGET
8/20/2017 12:44:09	Pole fire. CO-LSD-000400	8/19/2017	DIRECT	BOTTOM	CREEPING	GRASS, BRUSH	CLEAR	5-15	ON TARGET
8/20/2017 12:56:57	Pole	8/19/2017	DIRECT	BOTTOM	RUNNING	GRASS, BRUSH, SAGE	CLEAR	15+	ON TARGET
8/20/2017 18:16:28	Horse Valley/CO MFX 405	8/20/2017	DIRECT	BOTTOM	RUNNING	GRASS	BUILDING CUMULUS, THUNDERSTORMS IN AREA	5-15	ON TARGET
8/26/2017 10:51:42	245 fire	8/25/2017	DIRECT	BOTTOM THIRD	SMOLDERING, CREEPING	GRASS, BRUSH	CLEAR	5-15	ON TARGET
9/2/2017 11:08:01	245 Fire / CO-GWD-000434	8/25/2017	DIRECT	MID-SLOPE	SMOLDERING, CREEPING	BRUSH	SCATTERED CLOUDS	0-5	PARTIALLY ON
10/3/2017 11:01:33	Peekaboo	7/4/2017	DIRECT	RIDGE TOP	CREEPING, RUNNING	GRASS, BRUSH	SCATTERED CLOUDS	0-5	ON TARGET
10/3/2017 11:03:49	PEEKABOO	7/4/2017	DIRECT	RIDGE TOP	CREEPING, RUNNING	GRASS, BRUSH	SCATTERED CLOUDS	0-5	ON TARGET
10/3/2017 11:05:54	PEEKABOO	7/4/2017	DIRECT	RIDGE TOP	CREEPING, RUNNING	GRASS, BRUSH	SCATTERED CLOUDS	0-5	ON TARGET
10/3/2017 11:08:06	PEEKABOO	7/4/2017	DIRECT	RIDGE TOP	CREEPING, RUNNING	GRASS, BRUSH	SCATTERED CLOUDS	0-5	ON TARGET

Timestamp	GROUND COVERAGE	EFFECT ON FIRE	VISIBILITY OF DROP	PILOT/ATGS NAME	COMMENTS	FIRE SITUATION
7/28/2017 9:58:44	CONTINUOUS COVERAGE	COMPLETELY EXTINGUISHED	VISIBLE	Curtis Carpenter	Works very well on sage and brush.	INITIAL ATTACK
8/20/2017 12:44:09	CONTINUOUS COVERAGE	MODERATE EFFECT	VISIBLE WITH DIFFICULTY	Paul Yedinak	Due to heavy smoke from burning sagebrush we switched to retardant in order to flank the fire and have better visibility during the drops.	INITIAL ATTACK
8/20/2017 12:56:57	VERY FEW GAPS	LARGE EFFECT	VISIBLE WITH DIFFICULTY	Curtis Carpenter	Works good in grass and sage and in wind below 20 mph.	INITIAL ATTACK
8/20/2017 18:16:28	CONTINUOUS COVERAGE	COMPLETELY EXTINGUISHED	VISIBLE	Nathan Higginbottom	the thermol gel was very effective	INITIAL ATTACK
8/26/2017 10:51:42	CONTINUOUS COVERAGE	LARGE EFFECT	VISIBLE	Paul Yedinak	The gel worked great for knocking down the active flames. We then used retardant to line the fire to buy the ground crews some time.	INITIAL ATTACK
9/2/2017 11:08:01	VERY FEW GAPS	LARGE EFFECT	VISIBLE	Dennis Fogel	NONE	INITIAL ATTACK
10/3/2017 11:01:33	CONTINUOUS COVERAGE	LARGE EFFECT	VISIBLE	C.Hammond	None	EXTENDED ATTACK
10/3/2017 11:03:49	CONTINUOUS COVERAGE	LARGE EFFECT	VISIBLE	C.HAMMOND	n/a	EXTENDED ATTACK
10/3/2017 11:05:54	CONTINUOUS COVERAGE	LARGE EFFECT	VISIBLE	C.HAMMOND	N/A	EXTENDED ATTACK
10/3/2017 11:08:06	CONTINUOUS COVERAGE	LARGE EFFECT	VISIBLE	C.HAMMOND	N/A	EXTENDED ATTACK

Timestamp	LOCATION (Lat./Long.)	ASPECT	SLOPE ON FIRE	NAME OF PRODUCT	SEAT TAIL NUMBER	DID THE DROP REQUIRE RELEASE CHANGE FROM NORMAL THICKENED RETARDANT?	IF A RELEASE CHANGE WAS REQUIRED, PLEASE ELABORATE.	WAS THE DROP SUPPORTED BY GROUND RESOURCES?
7/28/2017 9:58:44	40 25 47/108 19 53	FLAT	0-24%	THERMO-GEL 200L (BLUE) (CRAIG BASE)	T815/N3033H	NO CHANGE		YES
8/20/2017 12:44:09	4058.4n/10739.3w	FLAT	0-24%	THERMO-GEL 200L (BLUE) (CRAIG BASE)	T-845	LATER RELEASE	Flying into strong winds requires a later release with water and gells	YES
8/20/2017 12:56:57	40 58 4/107 39 3	FLAT	0-24%	THERMO-GEL 200L (BLUE) (CRAIG BASE)	N3033H	EARLIER RELEASE	Slower on release.	YES
8/20/2017 18:16:28	4029.967 / 10740.074	SE	0-24%	THERMO-GEL 200L (BLUE) (CRAIG BASE)	T888	NO CHANGE		YES
8/26/2017 10:51:42	39 39.49N/107 36.13W	NE	0-24%	THERMO-GEL 200L (BLUE) (CRAIG BASE)	T-845. N1531S		With water enhancers I have to drop several seconds (2-4) sooner than a retardant drop, in order to have a correct start. I feel this has to do with the differences in weight.	YES
9/2/2017 11:08:01	39 40 x 107 38	NE	50-74%	THERMO-GEL 200L (BLUE) (CRAIG BASE)	845, 815, 888	EARLIER RELEASE	Late start Seems to be common problem	YES
10/3/2017 11:01:33	North side of fire	FLAT	0-24%	THERMO-GEL 200L (BLUE) (CRAIG BASE)	888	NO CHANGE		NO
10/3/2017 11:03:49	NORTH END OF FIRE	FLAT	0-24%	THERMO-GEL 200L (BLUE) (CRAIG BASE)	871	NO CHANGE		NO
10/3/2017 11:05:54	NORTH END OF FIRE	FLAT	0-24%	THERMO-GEL 200L (BLUE) (CRAIG BASE)	815	NO CHANGE		NO
10/3/2017 11:08:06	NORTH END OF THE FIRE	FLAT	0-24%	THERMO-GEL 200L (BLUE) (CRAIG BASE)	824	NO CHANGE		NO

Timestamp	FIRE NAME & NUMBER	AGENCY	DATE	NAME OF PRODUCT	SEAT BASE	MIX RATIO USED (ENHANCER TO WATER RATIO)	MIXED BY	CONSISTENCY OF MIXED PRODUCT
5/9/2017 14:19:13	Allyn Herrington	STATE	5/4/2017	FIREICE	FORT COLLINS	Automatic through GSC mix plant	AGENCY	THIN
6/17/2017 12:10:51	Confluence Fire	STATE	6/16/2017	BLAZETAMER 380 (Clear) (Rifle Base)	RIFLE	16.8 Qt to 650 gal water	AGENCY	Don't know. No way to know it is mixed in the hose and plane
6/20/2017 12:22:09	No Fire making Pre-mix	STATE	6/20/2017	FIREICE (Clear with Cool Blue Added) (Fort Collins)	FORT COLLINS	1.5 to 2 to 800 gal to 3-5 buckets to 800 gallons	AGENCY	THIN
7/3/2017 17:21:53	Testing	STATE	7/2/2017	FIREICE HVO-F (Orange) (Fort Collins)	FORT COLLINS	ptr-ptogramed based on water quality	AGENCY	between thick and thin
7/3/2017 17:31:59	re circulating	STATE	7/3/2017	FIREICE (Clear with Cool Blue Added) (Fort Collins)	FORT COLLINS	Marsh funnel 63-67	COMPANY	inbetween thick and thin
7/3/2017 19:09:14	Peekaboo	BLM	7/3/2017	THERMO-GEL 200L (Blue) (Craig Base)	CRAIG	1%	COMPANY	THIN
7/3/2017 19:12:07	Peekaboo	BLM	7/3/2017	THERMO-GEL 200L (Blue) (Craig Base)	CRAIG	1%	COMPANY	THIN, THICK
7/3/2017 19:57:12	Hog Back	STATE, COUNTY, CO-GRX	7/3/2017	FIREICE HVO-F (Orange) (Fort Collins)	FORT COLLINS	automactically mixed	AGENCY	between thick and thin
7/14/2017 14:18:14	Mill creek	Private	7/8/2017	THERMO-GEL 200L (Blue) (Craig Base)	OTHER	1%	COMPANY	THICK
7/15/2017 10:09:20	Peekaboo	BLM	7/7/2017	THERMO-GEL 200L (Blue) (Craig Base)	CRAIG	1.15 %	COMPANY	THICK
7/20/2017 12:48:07	Boxer CO-ARF-000528	USFS	7/17/2017	FIREICE HVO-F (Orange) (Fort Collins)	FORT COLLINS	Product is mixed based on water quality curently set at 78	AGENCY	in between thick and thin

Timestamp	WERE CHANGES REQUIRED TO NORMAL MIXING PROCEDURES?	RAMP SURFACE	FREQUENCY OF RAMP CLEANUP	RAMP CLEANUP	AIRTANKER CLEANUP	EQUIPMENT CLEANUP	NAME	HOME UNIT	ICS POSITION	IF CHANGES WERE REQUIRED, WHY?
5/9/2017 14:19:13	NO	paved	EACH LOAD	VERY EASY	EASY	EASY	Allyn Herrington	FNL	SEMG	
6/17/2017 12:10:51	NO	CONCRETE	EACH LOAD	EASY	EASY	EASY	Clinton Bellingar	DFPC Rifle SEAT Base	SEMG	
6/20/2017 12:22:09	YES	ASPHALT, OTHER	Other	EASY	EASY	MODERATELY EASY	Allyn Herrington	CO-CDPS-FNL	SEMG	had to add more product to get to marsh funnel limits
7/3/2017 17:21:53	NO	ASPHALT	Other	EASY	EASY	EASY	allyn herrington	CO-CDPS	SEMG	
7/3/2017 17:31:59	YES	ASPHALT	Other	EASY	EASY	DIFFICULT	Allyn Herrington	CO-CDPS	SEMG	pump would not move product to recirculate, product appreared to be contaminated from air borne products due to Firelce fix of leaving the top open.
7/3/2017 19:09:14	NO	ASPHALT	ONCE A DAY	VERY EASY	EASY	VERY EASY	Derrick Charpentier	NWCFAMU	SEMG	
7/3/2017 19:12:07	NO	ASPHALT	ONCE A DAY	VERY EASY	EASY	VERY EASY	Derrick Charpentier	NWCFAMU	SEMG	
7/3/2017 19:57:12	NO	ASPHALT	Other	VERY EASY	EASY	VERY EASY	allyn herrington	CO-CDPS	SEMG	
7/14/2017 14:18:14	NO	OTHER		VERY EASY	EASY	VERY EASY	Jess Pitt	Craig	VENDOR	
7/15/2017 10:09:20	NO	ASPHALT	ONCE A DAY	VERY EASY	EASY	EASY	Bill reid	Craig	VENDOR	
7/20/2017 12:48:07	NO	ASPHALT	Other	VERY EASY	EASY	VERY EASY	Allyn	CO-CDPS	SEMG	

Timestamp	ADDITIONAL COMMENTS	SEAT TAIL NUMBER	If other, please explain	Any issues with storage, mixing, loading?	EFFICIENCY OF VENDOR PROVIDED MIXING EQUIPMENT
5/9/2017 14:19:13					
6/17/2017 12:10:51		T-888		The battery was very low charge. Forgot to select out instead of in on the selector	Satisfactory
6/20/2017 12:22:09	Ramp and Air tanker clean up are NOT correct answers as thier is no choice for not loading or spilling. I was only pre mixing not involved with aircraft or ramp.	N/A	only clean as needed	Mixing was very time consuming and difficult, eductor clogged 1st bucket and then every 1/2 bucket until 2 hoses were clogged, had to stop mixing and clean and wait for them to dry before starting again 30-40 min delay in mixing 1 load. Powder goes everywhere as soon as you open the container and very hard to get product to the 100-110 marsh funnel specs. May try to cut hole in top of bucket to reduce powder mess.	Unsatisfactory
7/3/2017 17:21:53		Testing	as needed		Satisfactory
7/3/2017 17:31:59	Product stains hands when mixing, eductor system has not worked correctly gets moisture in system and cloggs eductor	N/A	As needed	product looked contaminated with dirt and airborne debrie from FireIce leaving top open, vendor notified system O/S until items fixed	Unsatisfactory
7/3/2017 19:09:14		821		Needs clean water so tanks must be completely clean of LTR	Satisfactory
7/3/2017 19:12:07		888		Needs clean water for mix. Can not have any LTR in tank due to salt content.	Satisfactory
7/3/2017 19:57:12		T-831	as needed	no mixing plant works very good	Satisfactory
7/14/2017 14:18:14		Helicopter type 2		No	Satisfactory
7/15/2017 10:09:20		815		No	Satisfactory
7/20/2017 12:48:07	Product is self contain in the mix plant very little clean up is needed before or after mixing. we are testing a advance technology computer mixing plant which has many great additions in mixing, loading and printing information for the SEMG	T-831	as needed		Satisfactory

Timestamp	If unsatisfactory, what were the issue(s)?	Can you premix the product?	GALLONS LOADED & LOAD TIME?	ARE THERE LIMITATIONS ON MIXING EQUIPMENT TO MEET DEMAND?
5/9/2017 14:19:13				
6/17/2017 12:10:51		No	9 minutes	Yes, there are. It's made per load so depending on the base set up could hold things up a bit.
6/20/2017 12:22:09	have had several problems, the company has been responsive to fix each issue timely in most cases.	Yes	to mix 1 load 30-40 min for it to meet marsh funnel specs.	seems process is slow for each load if your trying to get it to meet marsh funnel specs.
7/3/2017 17:21:53		Yes	52 gal 30sec	no system is made for high volume mixing
7/3/2017 17:31:59	Pump system has not worked correctly for the BLUE FireIce product with several failures in mixing and pumping.	Yes	N/A	yes only can mix 1 load at a time and slow to marsh funnel, could not meet demand if had 2-3 seats in pit. I have not actually had to load multiple aircraft with it
7/3/2017 19:09:14		Yes	2 drops w/1470gal total	no
7/3/2017 19:12:07		Yes	3 loads 2250gal total	They Need fresh water
7/3/2017 19:57:12		Yes	649gal/4min	system is designed for high volume incidents
7/14/2017 14:18:14		Yes	11000 gal dip tank 21000 mixed	No
7/15/2017 10:09:20		Yes	750 gal 3min	No
7/20/2017 12:48:07		Yes	2029 gallons average load time 5.20 min	No this mix plant is design for high volume mixing/use

Timestamp	FIRE NAME & NUMBER	AGENCY	DATE	NAME OF PRODUCT	SEAT BASE	MIX RATIO USED (ENHANCER TO WATER RATIO)	MIXED BY	CONSISTENCY OF MIXED PRODUCT
7/25/2017 11:47:43	Spring Glade CO-LRX-000548	STATE, PRIVATE	7/22/2017	FIREICE HVO-F (Orange) (Fort Collins)	FORT COLLINS	Determine based on water quality	AGENCY	THIN, VERY THICK
7/25/2017 12:47:18	Spring Glade CO-LRX-0455	STATE	7/22/2017	FIREICE (Clear with no Color Added) (Fort Collins)	FORT COLLINS	1.5 to 2 buckets to 800 gallon water	AGENCY	in between thick and thin
9/15/2017 13:27:36	CO-ARF-Starwood	USFS	9/10/2017	FIREICE (Clear with Cool Blue Added) (Fort Collins)	FORT COLLINS	pre mixed 2 buckets'800 gal +-	AGENCY	WATER-LIKE
9/27/2017 14:15:14	Horse Valley K9ZH	Mnt. Air Spray	8/20/2017	THERMO-GEL 200L (Blue) (Craig Base)	CRAIG	100/1	COMPANY	THIN

Timestamp	WERE CHANGES REQUIRED TO NORMAL MIXING PROCEDURES?	RAMP SURFACE	FREQUENCY OF RAMP CLEANUP	RAMP CLEANUP	AIRTANKER CLEANUP	EQUIPMENT CLEANUP	NAME	HOME UNIT	ICS POSITION	IF CHANGES WERE REQUIRED, WHY?
7/25/2017 11:47:43	YES, NO	CONCRETE, ASPHALT	Other	VERY EASY	EASY	VERY EASY	allyn	FNL	SEMG	
7/25/2017 12:47:18	NO	ASPHALT	Other	VERY EASY	EASY	VERY EASY	Allyn	FNL	SEMG	
9/15/2017 13:27:36	NO	ASPHALT, OTHER	Other	VERY EASY	MODERATELY EASY	EASY	Allyn Herrington	CO-CDPS	SEMG	
9/27/2017 14:15:14	NO	CONCRETE	ONCE A DAY	EASY	EASY	EASY	Adam Tucker	Contractor at Craig	MXMS	

Timestamp	ADDITIONAL COMMENTS	SEAT TAIL NUMBER	If other, please explain	Any issues with storage, mixing, loading?	EFFICIENCY OF VENDOR PROVIDED MIXING EQUIPMENT
7/25/2017 11:47:43		T-831	as needed	Identified after use that the mixing was light due to water intrusion in to the [owder storage tank on mixer which caused light loads being sent out, some techmical issues did deveolpe with mix plant which caused slow loading at times or had to stop loading and use clear product to finish load.	Satisfactory
7/25/2017 12:47:18	using buckets does make it messy and requires a larger garbage site then we have available so buckets stack up all over the place. Too small of a mixing hose and storage capacity. Hearing preconcieved opinions that product does not work from a large portion of contacts without them knowing the actual performance of new products.	T-831	as needed	Currently with the company recomendation and DFPCs set up it is impossible to keep up with any incident having more then 1 SEAT assigned to it with less then a 30-40 min turn around time. We have a 2500 hundred storage tank and need as a minimum a 3000 but a 5000 gallon tank would be better. Also with the 2 colors of Firelce along with our P100F this base has become too complex for 1 SEMG to work/manage. If DFPC wanted to keep this configuration they should look at additional staffing due to the complex nature of the 3 separte mixing system and no staff.	Unsatisfactory
9/15/2017 13:27:36	Air tanker clean up should not be here as I do not clean the airtanker and answer is incorrect but system requires a answer???????	871	as needed	FNL set up is poor and needed to be re done to make it more efficient, too small of storage tanks were used and pump seems too small along with poor placement but the base prevents the relocation as it already was a small base and the addition of 2 additional systems made it only smaller.	Unsatisfactory
9/27/2017 14:15:14				none	Satisfactory

Timestamp	If unsatisfactory, what were the issue(s)?	Can you premix the product?	GALLONS LOADED & LOAD TIME?	ARE THERE LIMITATIONS ON MIXING EQUIPMENT TO MEET DEMAND?
7/25/2017 11:47:43	If machine goes down it does require a little time to clear, but when running is a great way to load and is very effiecient	Yes	650-750 5-6min	Is made for high volume loading, but it has sensiative equipment that requires specific methodes to be followed when loading and if not followed will cause error and possible shut down of mix plant and take 1-3 hours to clear. anyone using this mix plant has to have very specific training and understanding of directions to be used for loading before they can load.
7/25/2017 12:47:18	to slow to keep up with more then 1 SEAT with less than a 30 min turn around	Yes	700-750 gallons 5-8 min	Storage capacity and pump size makes it impossible to keep up with more then 1 SEAT if less then a 30 min turn around. It also is a labor intensive operation
9/15/2017 13:27:36	set up is poor and pump seems to small have changed it out 1 or twice.	Yes	750/ 6min +-	Very poor setup at FNL for mixing and loading product with long loading hoses pump seems to be to small for system, can only load out of pit 2 if only SEMG is staffing base, if in pit 1 will need a minimum of 2 staffed at the base or a safety issue with not being able to see the SEAT from the pump.
9/27/2017 14:15:14		Yes	700 / 3 mins	none

Date	Fire Type	Fire Resource	Drop Time	Tanker ID	Fuels at Drop	Fire Behavior at drop location	Strategy	Drop Location	Drop Objectives	Objectives Met	Drop Accuracy	Temp (F)	RH%	Wind Speed (mph)	Product Used	Line Continutity
5/1/2018	Initial Attack	SEAT	1500	844	Timber	Running	Direct Attack	Left Flank	Delay Spread	Yes	On Target	66	15	8	Firelce HVO-F	Continuous
5/1/2018	Initial Attack	SEAT	1500	844	Timber	Running	Direct Attack	Head	Support Crews	Yes	On Target	65	24	12	Firelce HVO-F	Occaisional Gaps
5/1/2018	Initial Attack	SEAT	1506	848	Timber	Running	Direct Attack	Head	Support Crews	Yes	On Target	65	22	12	Firelce HVO-F	Occaisional Gaps
5/7/2018	Initial Attack	SEAT	1400	896	Grass Shrub	Running	Direct Attack	Left Flank	Halt Fire Spread	Yes	On Target	80	20	20	Firelce HVO-F	Continuous
5/22/2018	Initial Attack	LAT	1537	474	Timber	Creeping	Direct Attack	Heel	Halt Fire Spread	Yes	On Target	86	23	20	Firelce HVO-F	Few Gaps
5/22/2018	Initial Attack	LAT	1541	471	Timber	Running	Parallel Attack	Left Flank	Halt Fire Spread	Yes	On Target	85	23	20	Firelce HVO-F	Continuous
5/22/2018	Initial Attack	LAT	1615	474	Slash	Running/Spotting	Parallel Attack	Left Flank	Halt Fire Spread	Yes	On Target	85	22	21	Firelce HVO-F	Continuous
5/22/2018	Initial Attack	LAT	1620	475	Slash	Running/Spotting	Parallel Attack	Left Flank	Halt Fire Spread	Yes	On Target	85	23	20	Firelce HVO-F	Continuous
5/22/2018	Initial Attack	LAT	1700	474	Slash	Torching	Parallel Attack	Left Flank	Reduce Fire Intensity	Yes	On Target	83	25	20	Firelce HVO-F	Continuous
5/22/2018	Initial Attack	LAT	1707	475	Timber	Crowning w/spotting	Parallel Attack	Left Flank	Line Completed	Yes	On Target	82	25	20	Firelce HVO-F	Continuous
5/22/2018	Initial Attack	LAT	1900	474	Timber	Running	Parallel Attack	Left Flank	Halt Fire Spread	Yes	On Target	80	25	20	Firelce HVO-F	Continuous
5/22/2018	Initial Attack	LAT	1908	475	Timber	Torching	Parallel Attack	Left Flank	Reduce Fire Intensity	Yes	On Target	80	35	15	Firelce HVO-F	Continuous
6/4/2018	Initial Attack	SEAT	1603	850	Pin-Juniper	Running/Spotting	Indirect	Head	Delay Spread	No	Early	85	18	10	ThermoGel 200L	Frequent Gaps
6/5/2018	Initial Attack	SEAT	1855	862	Pin-Juniper	Running w/Spotting	Indirect	Head	Delay Spread	Yes	On Target	81	14	10	BlazeTamer 380	Continuous
6/9/2018	Initial Attack	SEAT	1630	862	Pin-Juniper	Creeping	Direct Attack	Left Flank	Delay Spread	No	Late	80	15	22	BlazeTamer 380	Frequent Gaps
6/9/2018	Initial Attack	SEAT	1630	864	Pin-Juniper	Torching	Direct Attack	Left Flank	Reduce Fire Intensity	Yes	On Target	80	15	14	BlazeTamer 380	Frequent Gaps
6/5/2018	Initial Attack	SEAT	1830	862/864	Pin-Juniper	Running	Direct Attack	Head	Delay Spread	Yes	On Target	75	15	20	BlazeTamer 380	Continuous
6/22/2018	Initial Attack	SEAT	1900	864	Shrub	Creeping	Direct Attack	Right Flank	Halt Fire Spread	Yes	On Target	79	15	18	BlazeTamer 380	Continuous
6/22/2018	Initial Attack	SEAT	2040	864/862	Shrub	Creeping	Direct Attack	Right Flank	Delay Spread	No	On Target			15	BlazeTamer 380	
6/22/2018	Loading	SEAT	1830	864/862	Shrub	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	BlazeTamer 380	N/A
7/2/2018	Initial Attack	SEAT	1545	862	Timber	Creeping	Direct Attack	Right Flank	Delay Spread	Yes	Unknown	N/A	N/A	8	BlazeTamer 380	Few Gaps
7/9/2018	Loading	SEAT	Unknown	unknown	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	ThermoGel 200L	N/A
7/4/2018	Loading	SEAT	Unknown	Unknown	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	ThermoGel 200L	N/A
7/6/2018	Loading	SEAT	Unknown	Unknown	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	ThermoGel 200L	N/A

Date	Drop Visibility	Effect on Rate of Spread	Effect on Flame Length	Duration Line Held	If Line Crossed- Why	Drop Supported by Ground Resources	Overall Effectiveness	Gallons Loaded	Comments
5/1/2018	Visible	Stopped	Extinguished	197 minutes		yes	Effective		
5/1/2018	Visible	Slowed	Reduced Intensity	50 minutes	Outflanked	yes	Completely Effective		SEAT drops were in Mixed Hardwood & Pine Fuels with Leaf off Conditions.
5/1/2018	Visible	Slowed	Reduced Intensity	50 minutes	Outflanked	yes	Completely Effective		
5/7/2018	Visible	Slowed	Extinguished	360 minutes		yes	Completely Effective		The product worked well. There were two SEAT drops on this fire, approximately 1400 gallons of FireIce. The two SEAT drops were targeted toward the head of the fire. The product did a nice job slowing down the fire and allowed our tractor plows to keep the fire to a smaller acreage. The total acreage on this fire was 34.4 acres.
5/22/2018	Visible	Stopped	Reduced Intensity	180 minutes		yes	Effective		FIREICE Works excellent when used direct. Apply product half in half out.
5/22/2018	Visible	Stopped	Reduced Intensity	180 minutes		yes	Effective		
5/22/2018	Visible	Stopped	Reduced Intensity	180 minutes		yes	Effective		
5/22/2018	Visible	Stopped	Reduced Intensity	180 minutes		yes	Effective		
5/22/2018	Visible	Stopped	Reduced Intensity	180 minutes		yes	Effective		
5/22/2018	Visible	Stopped	Reduced Intensity	180 minutes		yes	Effective		
5/22/2018	Visible	Stopped	Reduced Intensity	180 minutes		yes	Effective		
5/22/2018	Visible	Stopped	Reduced Intensity	180 minutes		yes	Effective		
6/4/2018	Visible	No effect	No effect	40 minutes	Spotted Over	unknown	ineffective		
6/5/2018	Not Visible	Slowed	Reduced Intensity	30 minutes		yes	Effective		
6/9/2018	Visible w/Diffculty	Minimal	Minimal	15 minutes	Gap in Line	Unknown	Minimally Effective		
6/9/2018	Visible w/Diffculty	Moderate	Moderate	20 minutes	Gap in Line	No	Slows fire spread		Blaze Tamer dropped on active flames as directed by Air Attack. Tanker directed to exit out bottom of canyon. Pilot never saw result of the drop. Pilot queried Air Attack on effectiveness of gel. AIr Attack did not provide feedback of the drop as he was busy. Air Attack directed T-864 to load and return with retardant. AIr Attack for Bocco fire will be your best feedback for this gel drop. When T864 returned to fire for next drop, smoke was laid over area of previous gel drop. Pilot had no way to validate gels effectiveness for this drop
6/5/2018	Not Visible	Moderate	Moderate	120 minutes	Burned through	No	Slows fire spread		Late evening dispatch, SEATs only, 2 from RIL initially with Gel, 2 from GJT with retardant, utilized retardant across the heel to establish an anchor, there was a request to avoid retardant use in a small drainage in front of the head so we utilized the Gel product as the fire was beginning to encroach down the side of the drainage instead of retardant. All aircraft then reloaded GJT with retardant as we worked the right (south) flank from the heel toward the head until dark. The Gel product was somewhat more effective than water, but probably only about 30 - 50 % as effective as retardant would have been.
6/22/2018	Visible	Moderate	Moderate	20 minutes		Yes	Slows fire spread		T-864/T-862 arrived at fire as a two ship formation both loaded with Blaze Tamer. Air Attack directed we drop direct on right flank next to several houses. Fire was in tall oak brush. Flames could not be seen from above the oak brush only smoke filtering up through it was observed. T-864 started drop at beginning of smoke and carried drop up right flank. Drop appeared to slow smoke. Requested debrief from Lead after last drop of the day. Lead stated that Ground crew reported Gel Drop as "OK" but wanted retardant. T-864 was directed to reload with retardant rest of the day after the initial drop. Upon return with retardant, Lead had us start again with retardant on same area we had spread gel.
6/22/2018	Not Visible	Minimal	Minimal			No	Minimally Effective		Two SEAT drops from the heel starting up the right flank. Not visible at all, fuel model was oak brush. Ground personnel said it worked OK, we made the decision to load with retardant and continue to build line
6/22/2018	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1467	
7/2/2018	Not Visible	Unknown	Unknown	Unknown			Unknown		
7/9/2018	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1255	
7/4/2018	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1395	
7/6/2018	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1276	

Date	Fire Type	Fire Resource	Drop Time	Tanker ID	Fuels at Drop	Fire Behavior at drop location	Strategy	Drop Location	Drop Objectives	Objectives Met	Drop Accuracy	Temp (F)	RH%	Wind Speed (mph)	Product Used	Line Continutity
7/7/2018	Loading	SEAT	Unknown	Unknown	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	ThermoGel 200L	N/A
7/10/2018	Extended Attack	Helicopter	1245	Unknown	Timber	Creeping	Indirect	N/A	Halt Fire Spread	Yes	On Target	75	21	10	BlazeTamer 380	Few Gaps
7/11/2018	Extended Attack	Helicopter	1130	K-MAX	Timber	Creeping	Direct Attack	N/A	Halt Fire Spread	Yes	On Target	73	19	7	BlazeTamer 380	Few Gaps
7/13/2018	Extended Attack	Helicopter	1030	Unknown	Timber	Creeping	Direct Attack	Left Flank	Halt Fire Spread	Yes	On Target	75	17	8	BlazeTamer 380	Few Gaps
7/9/2018	Extended Attack	SEAT	1000	877/873	Grass Shrub	Torching	Direct Attack	Head	Halt Fire Spread	No	On Target	89	10	8	ThermoGel 200L	Few Gaps
7/3/2018	Loading	SEAT	Unknown	839/877	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Firelce HVO-F	N/A
7/2/2018	Loading	SEAT	Unknown		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Firelce HVO-F	N/A
7/3/2018	Loading	SEAT	Unknown	Unknown	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Firelce HVO-F	N/A
7/18/2018	Initial Attack	SEAT	1533	864	Pin-Juniper	Torching	Direct Attack	Right Flank	Halt Fire Spread	Yes	On Target	86	12	28	ThermoGel 200L	Continuous
7/20/2018	Initial Attack	SEAT	1100	886	Timber	Torching	Direct Attack	Left Flank	Delay Spread	Yes	On Target	90	10	11	BlazeTamer 380	Frequent Gaps
7/19/2018	Initial Attack	SEAT	1545	862	Pin-Juniper	Creeping	Direct Attack	Head	Delay Spread	Yes	On Target	93	11	11	ThermoGel 200L	Occaisional Gaps
7/20/2018	Loading	SEAT	1500	850	Timber	Running/Spotting	Direct Attack	Parallel Attack	Reduce Fire Intensity	Yes	On Target	N/A	N/A	N/A	BlazeTamer 380	Frequent Gaps
7/19/2018	Large Fire Support	SEAT	1640	861	Timber	Running/Spotting	Direct Attack	Left Flank	Delay Spread	No	On Target	98	14	10	Firelce HVO-F	Few Gaps
7/19/2018	Large Fire Support	SEAT	1500	897	Pin-Juniper	Torching	Direct Attack	Left Flank	Halt Fire Spread	No	On Target	85	15	10	BlazeTamer 380	Few Gaps
7/19/2018	Loading	SEAT	Unknown	Unknown	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	BlazeTamer 380	N/A
7/25/2018	Extended Attack	SEAT	1100	839	Grass Shrub	Running/Spotting	Direct Attack	Left Flank	Delay Spread	No	On Target	93	10	16	ThermoGel 200L	Few Gaps
7/24/2018	Extended Attack	ATGS	1500	873	Shrub	Torching	Direct Attack	Right Flank	Halt Fire Spread	Yes	On Target	90	10	16	ThermoGel 200L	Continuous
7/24/2018	Extended Attack	ATGS	1500	874	Shrub	Creeping	Direct Attack	Right Flank	Halt Fire Spread	Yes	On Target	90	10	0	ThermoGel 200L	Continuous
7/24/2018	Extended Attack	ATGS	1500	839	Shrub	Smoldering	Direct Attack	Right Flank	Halt Fire Spread	Yes	On Target	90	12	2	ThermoGel 200L	Continuous
7/29/2018	Initial Attack	SEAT	1130	862	Timber	Running/Spotting	Parallel Attack	Heel	Delay Spread	Yes	On Target	77	21	7	BlazeTamer 380	Continuous
8/3/2018	Initial Attack	LAT	1443	475	Timber	Torching	Direct Attack	Head	Halt Fire Spread	Yes	Late	88	30	14	Firelce HVO-F	Continuous
7/29/2018	Initial Attack	SEAT	1700	808	Timber	Torching	Extended Attack	Right Flank	Halt Fire Spread	No	On Target	93	15	9	BlazeTamer 380	No Coverage
7/29/2018	Initial Attack	SEAT	1100	864	Timber	Torching	Direct Attack	Left Flank	Delay Spread	No	On Target	90	18	13	BlazeTamer 380	Few Gaps

Date	Drop Visibility	Effect on Rate of Spread	Effect on Flame Length	Duration Line Held	If Line Crossed-Why	Drop Supported by Ground Resources	Overall Effectiveness	Gallons Loaded	Comments
7/7/2018	N/A	N/A	N/A	N/A	N/A	N/A	N/A	3840	
7/10/2018	Visible w/Diffculty	Slowed	Moderate	169 minutes	Did Not Cross	yes	Effective		1. Pilots feel it effects operation of bucket, to the extent buckets not shutting completely so much they noticeably leak. Solutions include rinse out during each fuel cycle and to use a “Hotsie” pressure washer.
7/11/2018	Visible w/Diffculty	Slowed	Moderate	120 minutes	Did Not Cross	yes	Effective		3 KMAX Pilots flew gel on 7/9/18. Holds together well. Was windy and not as much drift as water. Didn't have enough perspective to judge ground effectiveness to judge. Affected seals on bucket. Despite use of dip tank with water to clean out, after a couple more water cycles, seals' integrity back .
7/13/2018	Visible w/Diffculty	Slowed	Moderate	120 minutes	Did Not Cross	yes	Effective		Recommend hotsie wash out after every gel cycle. Pilots have no preference of retardant over gel but no leakage with retardant. Leakage bothered a lot about leakage, made them think they had a bucket problem.
7/9/2018	Visible w/Diffculty	Minimal	No effect	40 minutes	Burned Through	No	Slows fire spread		I received two drops from two different SEATS. Water Enhancer was requested. The fuel Type was Brush, a combination of mature gambles oak and serviceberry. The first drop was coverage level 2 and the second drop was a little lower and coverage level 4. Of the 2 the second was more effective. The fuels were torching at the time and displaying extreme fire behavior.
7/3/2018	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1410	
7/2/2018	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1700	
7/3/2018	N/A	N/A	N/A	N/A	N/A	N/A	N/A	675	(jetisoned)
7/18/2018	Visible	Moderate	Moderate	44 minutes	Did Not Cross	yes	Effective		6 Seats dispatched out of Craig. First load retardant, then told to load and return with water due to proximity to Dinosaur Natl Mon. After second load of water, we were told to load with Therma Gel. Therma Gel applied direct on flames. Air Attack reported " gel way more effective than the water drops". He was also happy with the color so he could keep track of drops.
7/20/2018	Visible	Slowed	Minimal	25 minutes	N/A	yes	Unknown		
7/19/2018	Visible w/Diffculty	Moderate	Moderate	30 minutes	Did Not Cross	yes	Effective		
7/20/2018	Visible w/Diffculty	N/A	N/A	N/A	N/A	N/A	N/A	20,000	
7/19/2018	Visible	Minimal	Minimal	89 minutes	Unknown	No	ineffective		
7/19/2018	Visible w/Diffculty	Minimal	Minimal	78 minutes	Did Not Cross	No	Ineffective		
7/19/2018	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1600	
7/25/2018	Visible	Minimal	Minimal	Unknown	Burned Through	No	Ineffective		
7/24/2018	Visible	Slowed	Reduced Intensity	184 minutes	Did Not Cross	yes	Completely Effective		
7/24/2018	Visible	Slowed	Reduced Intensity	182	Did Not Cross	yes	Effective		Extended attack. Fire smoldering, creeping. Gel used to slow/halt fire creeping through existing retardant line. Limited ground crews available.
7/24/2018	Visible	Stopped	Reduced Intensity	177 minutes	Did Not Cross	yes	Effective		Fire smoldering, creeping. Few ground crews. Trying to keep fire from creeping through existing retardant line, which it seemed to do.
7/29/2018	Visible	Slowed	Reduced Intensity	unknown	Did Not Cross	yes	Effective		I placed 4 drops at head, right flank and heel; also viewed drop made by other SEATs. Heavy fuel but product seemed to be very effective where it landed on flames. Recommend ATGS commentary on effectiveness if available.
8/3/2018	Visible	Moderate	Moderate	57 minutes	Did Not Cross	yes	Completely Effective		
7/29/2018	Visible	No effect	No effect	unknown	Burned Through	No	Minimally Effective		
7/29/2018	Visible	No effect	No effect	Unknown	Burned Through	Unknown	Minimally Effective		Air Attack ordered SEATS loaded with water. Upon arrival, someone mentioned that there was Gel at Rifle. Air Attack ordered all SEATS to load and return with Gel. Fire was in heavy timber. 6 x SEATS made approximately 24 loads on the fire with Gel. Gel did not seem to affect the fire in heavy timber. It just kept getting bigger. Air Attack then directed SEATS to load and return with Retardant. Retardant didnt seem to have much effect on the heavy timber fire either.

Date	Fire Name	Incident Number	Your name	Land Ownership	Fire Type	Fire Remarks	Tanker Base	Other Base Name	Observation Type	Drop Time	Tanker ID Call Sign	Drop Aircraft Type	Fuels at Drop Location
7/22/2019	ODF NVG Trial	96 Ranch	Chris Doyle	Private		Night drops on a simulation in timber. Trialed with a more concentrated mix to see if a higher drop could be effective but once out flying with the NVG's it became apparent that no increase in drop height is required.	Other	John Day	Personally Observed	23:00	T-860	SEAT	Timber
7/23/2019	Toppenish	WA-YAA-000072	Darin Suter	BIA	Initial Attack	Fire caused due to lightning strike previous date. Estimated at 1+ Acres with 3 personnel on the ground. Objective was to cool off right flank and head of fire with good results utilizing blaze tamer from lead aircraft followed by second aircraft using Eco Foam. Blazetamer was effective in coating fuels to slow fire spread while Eco Foam provided additional cooling affect for ground personnel to continue line production.	Other	Dallesport, WA (WADNR)	Personally Observed	17:30	205	FireBoss	Timber
7/23/2019	Toppenish	WA-YAA-000072	Darin Suter	BIA	Initial Attack	Fire caused due to lightning strike previous date. Estimated at 1+ Acres with 3 personnel on the ground. Objective was to cool off right flank and head of fire with good results utilizing blaze tamer from lead aircraft followed by second aircraft using Eco Foam. Blazetamer was effective in coating fuels to slow fire spread while Eco Foam provided additional cooling affect for ground personnel to continue line production.	Other	Dallesport, WA (WADNR)	Personally Observed	17:30	237	FireBoss	Timber
7/23/2019	Toppenish	WA-YAA-000072	Darin Suter	BIA	Initial Attack	Fire caused due to lightning strike previous date. Estimated at 1+ Acres with 3 personnel on the ground. Objective was to cool off right flank and head of fire with good results utilizing blaze tamer from lead aircraft followed by second aircraft using Eco Foam. Blazetamer was effective in coating fuels to slow fire spread while Eco Foam provided additional cooling affect for ground personnel to continue line production.	Other	Dallesport, WA (WADNR)	Personally Observed	17:30	205	FireBoss	Timber
7/23/2019	Toppenish	WA-YAA-000072	Darin Suter	BIA	Initial Attack	Fire caused due to lightning strike previous date. Estimated at 1+ Acres with 3 personnel on the ground. Objective was to cool off right flank and head of fire with good results utilizing blaze tamer from lead aircraft followed by second aircraft using Eco Foam. Blazetamer was effective in coating fuels to slow fire spread while Eco Foam provided additional cooling affect for ground personnel to continue line production.	Other	Dallesport, WA (WADNR)	Personally Observed	17:30	246	FireBoss	Timber
7/25/2019	Timber Creek	1805s	Keaton Mitchell	Private	Initial Attack	Wildland fire reported on private land 9 miles northeast of Deer Park SEAT base. Two Fire Boss aircraft, one loaded with BlazeTamer 380 and the other with straight water. One with BlazeTamer dropped 7 loads and the other dropped 6 loads of water. Hanson and I hiked on the fire and witnessed the last two drops of from the 2 Fire Boss aircraft. We took pictures and notes from the fireline of the drops. A/A 4TS (Ben Renfro) 541-589-0452	Other	Deer Park, WA	Personally Observed	16:15	207 and 210	FireBoss	Timber

Date	Fire Behavior at Drop	Strategy	Tactics	Drop Objective	Objectives Met	Drop Location on Fire	Drop Accuracy	Temp	Relative Humidity	Wind Speed (mph)	Product used	Line Continuity	Drop Visiblity	Effect on Rate of Spread	Effect on Flame Length	Duration the Line Held (min)	If Line Crossed, Why
7/22/2019	Unknown	Indirect		Support Crews	Yes	Left Flank	On Target	18 C	50	3	FireIce 561 Orange	Continuous	Not Visible				
7/23/2019	Creeping	Direct	Parallel (1/2 in - 1/2 out)	Reduce Fire Intensity	Yes	Right Flank	On Target	?	?	5	BlazeTamer 380 Uncolored	Continuous	Visible with Difficulty	6	2		
7/23/2019	Creeping	Direct	Parallel (1/2 in - 1/2 out)	Support Crews	Yes	Right Flank	On Target	?	?	5		Continuous	Visible with Difficulty	6	2		
7/23/2019	Creeping	Direct	Parallel (1/2 in - 1/2 out)	Support Crews	Yes	Head	On Target	?	?	5	BlazeTamer 380 Uncolored	Continuous	Visible with Difficulty	6	2		
7/23/2019	Creeping	Direct	Parallel (1/2 in - 1/2 out)	Support Crews	Yes	Head	On Target	?	?	5				6	2		
7/25/2019	Creeping	Direct	Parallel (1/2 in - 1/2 out)	Support Crews	Yes	Head	On Target	90	35	6	BlazeTamer 380 Uncolored	Continuous	Visible with Difficulty	6	4	50	

Date	Drop Supported by Ground Resources	Overall Effectivness	Consistency	Quality Control Method	Marsh Funnel Time	Efficiency of Equipment.	Gallons Loaded	Load Time Minutes	Comments
7/22/2019					0	5	780	0	
7/23/2019	Yes	7			0	5	0	0	
7/23/2019	Yes	7			0	5	0	0	
7/23/2019	Yes	7			0	5	0	0	
7/23/2019	Yes	7			0	5	0	0	
7/25/2019	Yes	5			0	5	0	0	The Fire Boss scoops approx. 600 gallons of water and injects approx. 2 gallons of Blazetamer 380 into internal tank of water. From A/A the Blazetamer drops held together better and were on target vs. the water drops were more spread out and the spray drifted in the wind causing a "rainbow" effect.

Date	Fire Name	Incident Number	Your name	Land Ownership	Fire Type	Fire Remarks	Tanker Base	Other Base Name	Observation Type	Drop Time	Tanker ID Call Sign	Drop Aircraft Type	Fuels at Drop Location
7/27/2019	Round Butte	OR-BUD-009057	Carrie Straub	BLM	Large Fire Suppor t	Fire was burning in grass and sage brush with active fire 2 to 3 foot flame lengths. A/A requested two SEATs to drop their FireIce - Clear in an area of active fire. The A/A made one show pass where he wanted the drop. Both SEATs dropped in the designated area but due to smoke from the fire the pilots were not able to get a good post-drop read on effectiveness of the drops. The went to Burns and returned to the fire with LC retardant and continued to build a line around the fire as directed with one each of retardant before returning to Prineville. Followup calls were made to the A/A 2GA but didn't get a response back from messages left.	Other	Prineville, OR	Told by Fire Personnel	18:45	T-827 and T-804	SEAT	Grass-Shrub
8/1/2019	539	OR-PRD-000539	Carrie Straub	BLM	Initial Attack	The call for 2 SEATs to manage a spot fire believed to be from the main Glass Butte incident. The fire was burning grass with no resources on the fire. A/A 37H	Other	Prineville, OR	Told by Fire Personnel	18:24	T-827 and T-804	SEAT	Grass
8/2/2019	Milepost 97	732069-20	Steve Winslow	Private	Initial Attack	Fire made a push on an east-facing slope of Douglas fir mixed with ground vegetation with crown and ground fire. To help prevent slop-over and spotting five SEAT aircraft were used dropping FireIce (HVBlue) on the active head of the fire. Between the use of FireIce and a backing fire from a dozer line the fire was slowed and didn't spot over the fireline	Other	Roseburg, OR	Post Fire Examination	16:38	T-838	SEAT	Timber
8/7/2019	Bear Creek	PRD610	Donald Tschida	Private	Initial Attack	Fire started on a ridge top and moved cross slope and downhill pushed by the wind. The SEATs were used dropping 2 loads each of HVB-Fx FireIce and LC retardant to pinch off the fire spread on the right flank. The fire grew later that night after the drops, burning to the east away from where the suppressant and retardant were dropped. On 8/9/19 Hanson and Winslow observed the burn from a vantage point about a mile from the fire where we met with the IC and other fire crew members and discussed the tactics. A few pictures were taken of the whole fire on a north-facing mountain.	Other	Prineville, OR	Told by Fire Personnel	20:10	T-827 and T-804	SEAT	Grass-Shrub
8/8/2019	Rail Fire	OR-951S-29-019-627	Stephen Winslow	Private	Initial Attack	Two SEATs dropped on an IA fire both loaded with HVB-Fx FireIce. The two drops were followed with hand lines and required some work to contain the fire. The first drop was on the right flank slightly inside the active ground fire. The second SEAT dropped on the left flank. Both drops were a bit late and the coverage was well downhill of of the main fire. Hanson and Winslow hiked to this fire arriving approx. 30 minutes after the drops. All the HVB FireIce was had dried out on the vegetation except for where it had pooled on leaves or other ground litter. The trees shadowed the ground vegetation below and did not pass through the foliage.	Other	Prineville, OR	Post Fire Examination	16:20	T-827 and T-804	SEAT	Grass-Shrub

Date	Fire Behavior at Drop	Strategy	Tactics	Drop Objective	Objectives Met	Drop Location on Fire	Drop Accuracy	Temp	Relative Humidity	Wind Speed (mph)	Product used	Line Continuity	Drop Visiblity	Effect on Rate of Spread	Effect on Flame Length	Duration the Line Held (min)	If Line Crossed, Why
7/27/2019	Running/Spotting	Direct	Parallel (1/2 in - 1/2 out)	Halt Fire Spread	No	Head	Unknown	Unknown	Unknown		FireIce 561 Uncolored	Frequent Gaps	Not Visible				
8/1/2019	Running	Direct	Full Coverage Drop	Extinguish Fire	Yes	Spot Fire	On Target	Unknown	Unknown	9	FireIce 561 Uncolored		Visible with Difficulty	9	8	0	
8/2/2019	Crowning	Direct	Parallel (1/2 in - 1/2 out)	Delay Spread	Yes	Head	On Target	High 80s	Unknown	14	FireIce HVB-Fx Blue	Few Gaps	Visible	3	2	76	Unknown
8/7/2019	Running	Direct	Delayed Attack Fire	Delay Spread	Yes	Right Flank	On Target	Unknown	Unknown	10	FireIce HVB-Fx Blue	Continuous	Visible	7	6		
8/8/2019	Smoldering	Direct	Parallel (1/2 in - 1/2 out)	Halt Fire Spread	Yes	Right Flank	Late	77	33	6	FireIce HVB-Fx Blue	Few Gaps	Visible	4	3	30	

Date	Drop Supported by Ground Resources	Overall Effectivness	Consistency	Quality Control Method	Marsh Funnel Time	Efficiency of Equipment.	Gallons Loaded	Load Time Minutes	Comments
7/27/2019	Yes		Within Usable Range	Marsh Funnel	65	5	0	8	Prineville SEAT Base, (ODF) AirSpray, Inc. loader tested the FireIce in the morning and again in the later afternoon. Both tests were within normal limits.
8/1/2019	No	8			0	5	0	0	
8/2/2019	Yes	4	Within Usable Range	Marsh Funnel	70	5	0	5	The SEAT manager said that working with the Blue FireIce was different than the red colored product. The blue seemed to need more water and when left in the tank mixed and ready for a fire it needed to be checked daily and additional water was needed to pass the Marsh Funnel test.
8/7/2019	Yes	5			0	5	0	0	
8/8/2019	Yes	4			0	5	0	0	