Whatever Happened to Water Enhancers?


Fire Chemicals are just tools in the toolbox when it comes to Aerial Firefighting, but this toolbox seems to be the one that sits in the garage with hardened cans of Bondo and Harbor Freight Tools leftovers in it. Fire Chemicals used in Wildland Fire Aviation provide a specific capability, for a multitude of reasons, but we continually seem to default to “Slurry for Indirect Attack, water for Direct Attack,” lather, rinse, and repeat. Especially as the lines continue to blur between the Wildland Urban Interface (WUI) and we seek to be more aggressive in Initial Attack, why not “stack all the tactical cards in our favor?” This paper seeks to inform, reorient, and spur discussion at all levels around Wildland Suppression activities and using more than just Retardants and water.

Fire Chemicals for Wildland are broken into two major categories: Long Term Retardants (LTR) and Suppressants. Retardants, or “the red stuff” are intended for Indirect Attacks, and they actually modify fuels they touch chemically, reducing the fire’s ability to generate heat. LTRs, as the name implies, are intended to continue to retard the fire growth after the water mixed in the LTR has evaporated.

Suppressants are different and meant for a different tactic. Suppressant materials are added to water to change the properties of the water itself, or “enhance” it for a specific use. The key difference is that Suppressants are dependent on the water they use and unlike all Retardants, when the water is evaporated, so is the Suppressant. Suppressants are intended for specific missions such as Direct Attack operations or structure protection and are capable of fuel penetration (foams) or coating (gels or air induced foams) depending on the need.

Suppressants are categorized on the Forest Service’s Qualified Products List (QPL) by their intent: Class A Foams and Water Enhancers. Foams are intended to reduce the surface tension of water and allow water to penetrate fuels. Foams are hard to deliver by air because of its properties, so most of the effectiveness of the water modified by the foam is lost in the drop.

Water Enhancers keep the surface tension of the water molecules intact, and have polymers or other “thickeners” in them that, from an Aerial Firefighting perspective, help “hold” the water together through heat and wind and hopefully deliver it in a more effective payload directly on fire. Water Enhancers work to modify behavior or extinguish the fire by absorbing the energy being released (heat). It does this by thickening the water into a film (of various viscosity) and "sticks" to fuels in a form that is slower than water to evaporate. Although not a retardant, which chemically alters the fuel when heat is applied, water enhancers can hold fire like a retardant, though for a much shorter period of time; usually around 30-45 minutes. The water evaporates as heat energy is absorbed and the and the enhancer loses effectiveness, which is why it shouldn't be compared or used as LTR.

A Single Engine Air Tanker (SEAT) drops Long Term Retardant (LTR) in an Indirect Attack. It's placed in the fire's path in an effort to slow the fire and help "Boots-on-the-Ground" protect the structure. Photo courtesy of the Center of Excellence.

Water Enhancers Explained

Water Enhancers have been around since the 1960s! Since then, they have re-emerged at least three times in Aerial Firefighting, and each time they have faded due to varied reasons; perceived lack of effectiveness, lack of substantiating data, operational issues, incompatibility with existing delivery technologies, or a lack of Firefighter education. When not embraced, water enhancers are simply not added to "off season" thoughts and programming, so they fall victim of politics and contracting challenges, then quickly become "too hard to do right now." The Center of Excellence for Advanced Technology Aerial Firefighting, part of the Colorado's Department of Fire Prevention and Control, a division within the Colorado Department of Public Safety conducted a multiyear study on Water Enhancers (2017-2019). One can argue that we as an Aerial Firefighting community, have let Water Enhancers fade again since, requiring a fourth "act."

Water Enhancers, though encompassed in one USFS QPL, can be further divided into two subcategories based on their properties: Gels or Elastomers. Both contain polymers (elastomers are a subset of polymers) and polymers are "thickeners," but they interact with the water they are "enhancing" differently.

Gels contain water super absorbing polymers (SAPs) that "absorb" the water molecules. They absorb and retain a large amount of water and coat the fuel it is delivered onto, SAPs are completely dependent on the water they capture for work, so lose all effectiveness when the water evaporates. Some form a “chain of globules” that bond together and form a soft, jelly type material in varying forms of thickness/viscosity, depending on how rich the mixture. Others just from independent globules that when dropped, again depending on how rich it is mixed, form a thick blanket. The key factor is not the richness of the mixture as much as in the rigidity of the globule itself, which is determined at the molecular level by the polymer properties.

Elastomers are slightly different; they are a subset of SAPs that create long flexible chains and are not considered gels. In addition to absorbing water, they bind the water molecules together that can stretch greatly under stress and then return to their original shape. This creates a typically less viscous, more flexible, and less noticeable change in the water qualities that are not recognized until energy is applied to them.

Testing has been done on Water Enhancers; hence they’re reflected on the QPL, but can those tests be referenced for reasons why Water Enhancers are not used? Is the data compared to an incompatible subset making them look ineffective? Is there a lack of training, knowledge, or a general lack of access to Water Enhancers or their required equipment that is causing us to live in this Sisyphean Paradigm? Is technology moving faster than the government’s ability to understand, appropriately test, and validate water enhancers? The short answer to all these questions is “yes.”

Water Enhancers do have their own stand-alone QPL, but there’s a huge caveat included that hamstring their use across the whole Aerial Firefighting community; “Note 3: Forest Service policy does not allow application of water enhancers from large air tankers. These products meet the requirements for application from multi-engine aircraft for those agencies whose policy permits this use.” There’s a much more liberal approach to Single Engine Air Tankers (SEATs) and they are allowed to carry just about every product on this QPL. But for LATs and VLATs, which have been employed more frequently in a Direct Attack role recently (at least in Western Colorado), it’s still a no-go. Chances are, the capability doesn’t even exist at your local fixed Retardant Reloading Base, and in turn, it is unavailable for all aircraft at that location.

It's hard to get a straight or complete answer as to why water enhancers are okay for SEATs, but not okay for LATs and VLATs. Presumably it’s a mixed bag of reasons depending on your source; corrosive (especially if mixed with residual LTR in the tank) or damaging to Aerial Firefighting equipment, or not effective or unproven in LAT/VLAT quantities. There may be some validity to the rationale as LATs are expensive, and residual LTR salts affect the salinity and pH of the water to be used, and some gels require adjusting mix ratios based on water quality. Regardless of the technical “why,” the restriction exists and is the first barrier to entry into using LATs with enhancers onboard for Initial/Direct Attack. Until whatever action is required at the Federal level to remove this restriction, “Note 3” remains as an unconscious warning to Incident Commanders nationwide that may be quickly turning them off from requesting enhancers in the first place.

A Single Engine Air Tanker (SEAT) drops water with polymer mixed in during testing. Photo courtesy of the Center of Excellence.

It is difficult to get a straight or complete answer as to why water enhancers are okay for SEATs, but not okay for LATs and VLATs. Presumably, it's a combination of reasons depending on one's source; limited number of air tankers, corrosive (especially if mixed with residual LTR in the tank) or damaging to Aerial Firefighting equipment, not effective or unproven in LAT/VLAT quantities. There may be some validity to the rationale as LATs are expensive, and residual LTR salts affect the salinity and pH of the water to be used, and some gels and elastomers require adjusting mix ratios based on water quality. Regardless of the technical "why," the restriction exists and is the first barrier to entry into using LATs with enhancers onboard for Initial/Direct Attack. It is important to recognize that both Australia and the state of Alaska have been very successful using elastomer based water enhancers out of their LATS.Until whatever action is required at the Federal level to remove this policy restriction, "Note 3" remains as an unconscious warning to Incident Commanders nationwide that may be quickly turning them off from requesting enhancers in the first place.

There are some common notes across water enhancer studies, included that gels were hard to mix correctly, react to different water chemistries, are messy to use (most come in a dry powder additive), time consuming to mix, and the equipment for mixing/injecting was unreliable and or clogged often. Training can overcome some of these issues, but working with industry for improvements to the equipment is required too. Industry can only advance technology so far from testing alone; they need use and input from the field to refine their product and support. Use gives them iterations or repetitions, and if we don't use the products, they don't get the valuable "reps" needed to make improvements.

Some of these issues are solved by moving to an elastomer-based enhancer or a liquid mix; liquids make it easier to "mix on the fly" using pre-loaded containers that inject the right amount of elastomer for the tank size. These systems and polymers have been employed in the agriculture industry and have proven effective on Scoopers, tanked helicopters, in addition to SEATs. On-board injection with SEATs speeds reloading, and is essential for fixed-tank helicopters reloading at a dip site (if you want to use

Fixed tank helicopters are becoming more prevalent and, if available, are almost always dispatched as part of Initial Attack. In addition to exploiting the ability to dip virtually anywhere, making the platform a good choice for Initial and Direct Attacks, these helicopters typically only use water. If we want to improve efficiency and effectiveness, these platforms are ripe for onboard injection, where an external tank that meter's liquid water enhancer in each load can be accomplished.

Colorado Division of Fire Prevention and Control FireHawk with fixed 1,000 gallon tank. The "black box" on the side of the tank is the retractable snorkel tube that sucks water into the tank from remote locations. Photo courtesy of DFPC.

Powder based polymers can work, however they must be mixed and held prior to loading, so onboard injection doesn't work there. Use of Longterm Retardant (LTR) in tanked helicopters isn't a solution for Initial Attack, at least in Colorado; LTR weighs an additional pound per gallon where weight and turn-around time detracts from the value of the asset to begin with. What can be used to make drops more effective? Interestingly, the QPL only lists five products approved for use in tanked helicopters: Thermo-Gel 500P, Firewall II (formerly Wildfire AFG Firewall II), BioCentral Blazetamer 380, Phos-Chek Insul-8, and Phos-Chek 259 LTR.

I was unable to open-source Thermo-Gel 500L, but the 200L version (not approved for tanked helicopters) is marketed as a home defense surface adhesion gel. Firewall II may not be manufactured anymore as it yielded no applicable returns except the QPL mention itself. BlazeTamer 380 is an elastomer, comes as a liquid, requires a .65%/gallon mix ratio, and has external tanks and equipment available for "in-flight injection." Phos-Chek Insul-8 is a Super Absorbent Polymer (SAP) that advertises a "very low viscosity" additive liquid (mix at .37%). I could not find an on-board injection system, but that my be related to the type of water enhancer Insul-8 is.

Just comparing the previous two products, since that's all the QPL approved solutions we have to apply our new-found knowledge towards, we are comparing an Elastomer (BlazeTamer 380) and a SAP “gel” (Phos-Chek Insul-8). If true, we should be able to prove that point looking at viscosity. At QPL approved mix ratios, BlazeTamer has a viscosity of 3-30cP, and Insul-8 is advertised at 800-1000 cP. Centipoise (cP) is a unit of dynamic viscosity, which is a measure of a fluid's internal friction or its resistance to flow. Based on this information, and what we know about Elastomers and Polymers, we can presume Insul-8 will be more of a gel material mixed at .37% as it’s probably closer to 800cP vice the broad-range but still very low viscosity of 3-30cP BlazeTamer shows.

NOTE: Why the “broad range” of Centipoise for BlazeTamer? You know the answer already; it’s made up of Elastomers, the most elastic form of Polymer!

A common thread with studies of water enhancers, and it’s critical to remember; you only get 30-45 minutes max of water (the key ingredient) therefore you must have “boots on the ground” (Wildland Firefighters) to put the fire out or exploit the advantages gained from using water enhancers in Initial or Direct Attacks. This places Water Enhancers back into the category of being another tool in the toolbox.

Based on our newfound information, and applying some lessons learned from the various studies, why wouldn’t Incident Commanders seek this capability? They strive to eliminate fire before it becomes out of control, as evidenced by how aggressive they’ve become in Initial Attack. As part of the IA, we owe this capability to our “boots on the ground” to be as effective as possible from the air with every load, in the interest of helping them help Mr. and Mrs. Smith (their local citizenry).

Practical Application

A practical application of this information requires some decisions at both the strategic and tactical level. Take for example the I-70 Corridor through Colorado. This is the only East-West running Interstate through Colorado, and with the mountains, is sometimes the only route through Colorado. When Wildland Fires occur along the Interstate, which occurs multiple times per year, especially on the Western Slope (from dragging chains, cigarettes, and vehicle fires among other causes) the Interstate is shut down while the fires are being fought. When this occurs, millions of dollars in revenue are lost nationwide.

For organizations that are fortunate enough to have access to Firehawk Helicopters, or helicopters with on-board tanks, a strategic level decision would be to invest in injection tank systems and have them installed. This provides the capability that an Incident Commander can now make tactical level decisions using another tool in the toolbox (or not). The IC now has the ability to gain tactical advantages or target suppression efforts in an attempt to exploit advantages gained by air.

In Colorado, we have this advantage now, and should be using it, if for nothing else than to better support the “boots on the ground.”

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