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Helicopter On-Board System for Mixing Water-Enhancing Gel: Field Assessment

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Background

To ensure that the gel mixtures used in aerial firefighting are fully effective, it is important to ensure the gel concentrate is properly mixed with the water. The proper mixing of the liquid water-enhancing gel concentrate with water requires a precision mixing process, and turbulence is required for the gel to fully disperse and mix with the water. This process is referred to as “shearing” the concentrate. The first step in evaluating a gel-mixing and delivery system is to determine the system’s ability to shear the gel and achieve a complete mixing of the product with water.

In May 2017 FPInnovations conducted an initial field assessment of a helicopter on-board system for mixing water-enhancing gel concentrate at Fort Vermillion. For this study, Alberta Agriculture and Forestry contracted a Bell 214B helicopter with on-board gel mixing capability. The helicopter company chose Firewall II gel and an Isolair external tank to meet the contract requirements.

This Info Note presents FPInnovations’ observations of the ability of the on-board mixing system to effectively mix Firewall II gel with water.

Gel-Mixing System

Components

FPInnovations assessed an Isolair (model 4600-214) Eliminator II tank with an on-board chemical-mixing system for aerial firefighting (Figure 1). The system consists of:

- Tank assembly – External belly-mounted fibreglass and aluminium tank mounted to external hardpoints.
- Refill pump – Electrically driven pump-and-hose assembly.
- Dump doors – Electrically actuated and hydraulically operated. It is a fail-safe system; doors will open with the loss of electrical power.
- Cyclic control – Allows the pilot to control loading, dump volume, and drop length.
- Chemical concentrate tank – A 121-L polyethylene tank located inside the helicopter. The system includes plumbing and valves to deliver the chemical to the injector.

- Injector – Located within the refill hose, just before the water enters the tank. It provides the needed shearing (turbulence) to mix the gel and water.
- Controller – The gel-mixing system has a unique, proprietary control system that records the number of liters of mixed product loaded into the Isolair tank and delivered to the fire line at each of the specified mix ratios selected by the pilot**.**
- Firewall II – Water-enhancing gel, approved for helicopter fixed-tank use under the U.S. Forest Service Wildland Fire Chemical Systems program's Qualified Products List.[1]

Figure 1. Isolair tank attached to a Bell 214B helicopter.

Operation

While the helicopter is on the ground, the concentrate tank is manually filled with gel liquid concentrate. The plumbing is inspected for leaks and then the system is ready for operation. Once the helicopter is airborne, the pilot finds a suitable water source of adequate depth and clean water. Depending on the anticipated forest cover at the fire site, the pilot selects the appropriate mix ratio on the controller. As the helicopter hovers over the water body, the probe is lowered into the water, and the hydraulic pump pushes water up the hose into the Isolair belly-mounted external tank. At the point where the water leaves the hose and enters the tank, a pipe protrudes into the middle of the water stream and injects a predetermined amount of gel into the flow. The amount of gel is precisely measured by the controller. The water–gel solution remains in the tank and is transported to the fire, where the pilot releases the tank's contents on the target using the cyclic control switch.

Study Methods

Fundamental to the assessment was the known relationship between the percent of gel concentrate used and the ultimate viscosity of the gel mixture. We know that the higher the percentage of FireWall II gel concentrate added to the mixture, the more viscous the gel is. For example, a mixture made with 2% FireWall gel is more viscous than one made with 1% gel.

[1] See https://www.fs.fed.us/rm/fire/documents/qpl_we.pdf.

This known relationship also allows researchers and field staff to determine whether a gel concentrate is fully mixed with the water. A water–gel solution that is not adequately mixed has a different viscosity than one that is properly mixed.[2]

Baseline determination

To determine a baseline viscosity we made up a small amount of gel mixture.

We took a sample of gel concentrate from a storage container and then used a Cuisinart high-speed blender to blend it with distilled water at a 0.25% concentration. The gel mixture was left to sit for 5 min and was then poured into a modified Marsh funnel. The time to empty the Marsh funnel of gel was 12.26 sec, and this number became the baseline for further data comparison.

Drop samples

We then collected samples from three helicopter tank drops and compared these samples to the baseline so that we could determine whether the on-board mixing system had mixed the gel and water sufficiently.

Three drops were made at noon on May 16, 2017. A clear sky with light winds provided perfect conditions. The temperature was 12°C and relative humidity was 47%. The on-board mixing system was set to provide a gel concentrate at 0.25%. A full tank of water (2498 L) was drawn using an attached snorkel pump. Tarps measuring 1.8x2.5 m were used to capture samples of the dropped gel mixture. The pilot was instructed to drop the gel mixture onto the tarps from 30 m above ground level at a helicopter speed of between 8 and 12 knots. Once the gel was dropped from the helicopter tank, a ground crew collected the gel mixture from the tarps into glass jars. The gel was then poured into a modified Marsh funnel and the time to empty the funnel was recorded.

Because some allowance had to be made for the induced variability associated with field data collection, if the viscosity of a drop sample was within 10% of the viscosity of the baseline sample, we would conclude that the on-board mixing system could provide a fully mixed gel product.

Visual inspection

As a way of quickly determining the mixing adequacy, we also visually assessed the dropped gel product. White globules or long strings of gel concentrate on the ground indicate incomplete mixing.

Results

A visual inspection of the gel mixture on the tarps indicated that the gel product was completely mixed (Figure 2).

In terms of drainage through the Marsh funnel, the comparisons of the drop samples to the baseline showed that the consistencies of the gel mixture were relatively close and within the 10% target set at the beginning of the project (Table 1).

[2] Although this relationship occurs with Firewall II gel concentrate, it is not true of all gel-like products.

Figure 2. Gel mixture dropped onto a tarp.

Table 1. Drainage assessment

Drop number	Gel concentration (%)	Drainage time (sec)	Relative to baseline (%)
1	0.25	11.75	4.15
2	0.25	12.60	2.77
3	0.25	12.46	1.63
Average		12.27	
Baseline	0.25	12.26	

Discussion

We made visual assessments of the Firewall II gel product by looking at the gel on the tarp (Figure 2) after it was collected in sample bottles. While the visual inspections confirmed a complete mix and the absence of gel globules, it was not possible to visually compare concentrate levels; none of the people involved in the study was able to accurately assess the concentrate level visually. This suggests that assessment of gel concentration must be done using the March funnel in order to validate product quality.

Conclusion

FPInnovations found the Isolair on-board mixing system effectively mixes Firewall II water enhancing gel with water.