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# Retardant Mixers for SEAT Bases

by

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## Background

Single engine air tanker (SEAT) usage is increasing. Typically, these aircraft hold 500 to 800 gallons of retardant and require very little runway to operate. SEAT bases can be set up on rural roads or open fields when no airport facilities are available. The retardant mixing and loading equipment for these planes is portable and can be transported to bases by a light duty truck and trailer.

Normally, wet concentrate fire retardant is used for SEAT base operations because it requires less mixing time and equipment than powdered retardant. Wet concentrate retardants only require dilution with water prior to loading so mixing and preparation time is minimal. Water-to-concentrate blending ratios are typically between 3:1 and 6:1, depending on product type and manufacturer. Until recently, blending and proportioning systems for SEAT bases were not sophisticated or foolproof. Formerly, base operators blended retardant concentrate and water while loading the aircraft. However, on at least one occasion, a potentially dangerous condition occurred when an aircraft was accidentally loaded with undiluted wet concentrate retardant.

## Discussion

Water weighs 8.33 pounds per gallon (lb/gal). Wet concentrate weighs 12.3 lb/gal and properly mixed retardant weighs between 8.93 and 9.13 lb/gal. The AT-802 air tractor, a common SEAT craft, holds 800 gallons and has a useful payload weight (with full fuel) of just over 7,500 pounds. If the aircraft is loaded with pure concentrate it could be about 2,300 pounds over maximum takeoff weight. When operating in hot weather and at high elevations, overloaded conditions become even more dangerous since available power and lift already are reduced. If the aircraft does become airborne the climb rate and obstacle clearance ability will be compromised.

Currently, SEAT base operators are required to blend the retardant and then pump it into a holding tank to reduce the risk of an over-loaded condition. The operator must verify the retardant concentration with a refractometer before pumping it into the aircraft. The extra steps of holding and checking add to the amount of equipment that is needed, the time to set up, and the total mix cycle time. Base operators mix the retardant before the plane lands so it will be ready to load, but if a mission is cancelled after a load has been mixed, the retardant must be stored or disposed of. Surplus retardant mix can be stored at fixed air tanker bases that process and store mixed wet concentrate. However, some fixed bases use dry powder that is not compatible with mixed wet concentrate, so the nearest storage facility may be impractical and the surplus retardant could be wasted.

**Purpose and Scope**

The U. S. Department of Agriculture (USDA) Forest Service, Technology and Development Program (T&D) pursued a project to evaluate and develop systems that blend retardant while loading an aircraft. The project objective was to reduce waste, process time, and overall cost of SEAT retardant mixing operations. T&D staff thought this could be accomplished by eliminating the need for a secondary holding tank prior to loading. Also, they wanted to simplify the equipment requirements and eliminate handling surplus mixed retardant. Safety was the most important consideration when evaluating the systems. Therefore, any blending system must be incapable of loading undiluted concentrate or a mostly concentrate mixture. This requirement eliminates the potential danger of overloading an aircraft. The project scope was limited to SEAT operations although the same technology possibly could be used in larger air tanker operations if the components were sized properly.

**Single Pump System**

The T&D staff designed and evaluated two systems that may meet the objectives. The simpler of the two systems uses a modified liquid eductor with a single pump. When water is pumped through the eductor it creates a negative pressure that draws retardant concentrate into the mix. If there is no water flow, the concentrate cannot be introduced into the mix. Once the system is set up for the desired ratio it will mix retardant consistently as long as the water inlet pressure remains constant. A simple ball valve is set to proportion the concentrate. The cost of this entire system, not including the pump, is about $1,400.

T&D's single pump blending system (figure 1) is easy to transport and assemble. It consists of several adapters, a gauge, two check valves, a ball valve, and an eductor. An indexed plate and a pointing needle on the ball valve are used to adjust the proportioner for the desired ratio. In use, the blender is placed at ground level close to the retardant source. The system blends about 150 gallons of retardant per minute with a 50 pounds per square inch water source. This is ideal for SEAT operations. Other pressures can be used and the system could be scaled up for higher flows and larger aircraft.

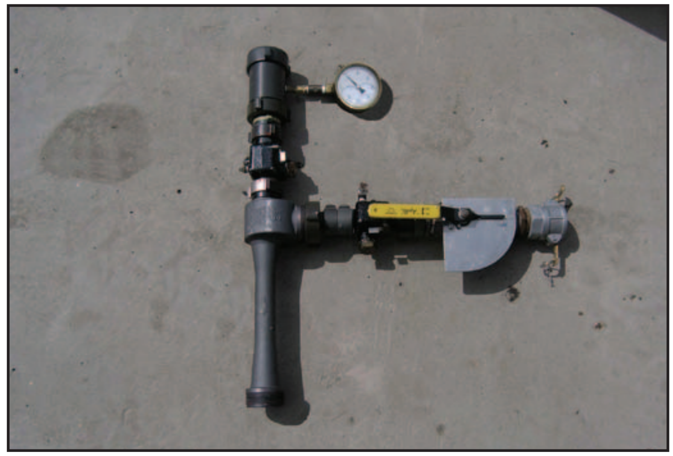

Figure 1—T&D-developed retardant mixer for SEAT bases.

In one lab test, using wet concentrate retardant, the staff found that the single pump system would blend accurately at a 6:1 ratio, which is typical of the more viscous concentrates. However, it could barely achieve a 3:1 ratio required by some of the gum-thickened concentrates. Not knowing future requirements, the staff modified the design to blend at any practical ratio. Simple hardware modifications removed some restrictions on the retardant inlet side allowing us to achieve a 3:1 ratio. With this design, a few holes in the index plate allow you to install bolts or stop pins that limit the proportioning valve's adjustment. This blending system works consistently to maintain the exact ratio once the ratio, pump, and hoses are adjusted for the product being mixed and the water supply pressure. Water pressure must be above 20 pounds per square inch.

**Two Pump System**

T&D's two-pump system used a pressure-compensated flow control valve and required pumps for both water and retardant concentrate. The idea was to have a self-compensating blender that would be insensitive to minor water pressure changes. The flow control valve senses the retardant pressure prior to the mixing point and compares it to the water pressure. If the water pressure drops, the valve will adjust and reduce the retardant pressure to match. The two-pump system worked well in laboratory conditions using plain water but it was unreliable in actual field conditions using commercial grade retardant concentrate. Clay-based retardant compounds naturally contain some fine particles and sand. The valve's sliding gate design did not lend itself to the high particle loading that is inherent in retardant concentrate. On several occasions the valve became stuck in the open position allowing pure concentrate to flow through the system without water pressure. For that reason, and the higher cost, the T&D staff decided not to pursue the two-pump system any further.

## Conclusion

The T&D blending system for SEAT bases could reduce operational costs while eliminating the risk of loading undiluted concentrate into an aircraft. Three prototype single-pump systems were sent to bases in Region 1 where they were used successfully throughout the 2005 fire season. The T&D staff will continue to monitor field results with these systems and will address any issues before continuing with additional development or implementation. Future development efforts may be turned over to private industry if no additional internal development work is required.

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