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CURRENT EVALUATION OF LONG TERM FIRE RETARDANT MIXING AND
STORAGE TESTS IN ALBERTA.

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CURRENT EVALUATION OF LONG TERM FIRE RETARDANT
MIXING AND STORAGE TESTS IN ALBERTA

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by R. J. Lieskovsky and R. Kruger

INTRODUCTION

This report is the first of a three phase investigation into the (a) laboratory mixing, (b) settling-out and cold storage effects on fire retardants and (c) field mixing observations.

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3 Fire retardants being tested are Fire-Trol 100 Fire-Trol 931 and Phos-Chek 202XA.

This first phase of the report deals with the laboratory mixing aspects of all three retardants, a brief description of the mixing equipment and preliminary observations regarding mixing and settling-out characteristics.

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- 4 Fire-Trol 100, and Fire-Trol 931 marketed in Canada by Chemonics Industries Ltd., Kamloops British Columbia
- Phos-Chek 202XA marketed by Monsanto Canada Ltd, Edmonton, Alberta

MIXING EQUIPMENT

Two commercial mixers, A Waring Blender and an electric variable speed stirrer were tested for mixing Phos-Chek 202XA and Fire-Trol 100 to establish mixing capabilities.

The Waring Blender, (Figure 1), capacity one U.S. quart mixed both retardants adequately. However, due to the small volume which could be mixed at one time, it was not adequate for the one gallon samples required.

The electric stirrer (Figure 2), one Imperial gallon capacity, did not have any shearing capability due to its top motor mounted drive and improper impeller design. Aeration of the retardant was also a problem with this mixer.

Because of the problems encountered with the two commercial mixers a 1 1/2 Imperial gallon mixer was designed and manufactured similar to the Lely designed mixer and impeller.

Fire-Trol 931, a liquid concentrate commercial fertilizer was mixed by simply stirring (with a piece of wooden doweling) the recommended mixture of water and retardant (4:1 Ratio) in a 2 gallon container for 1 minute.



FIGURE 1 WARING BLENDER (1 U.S. QUART CAPACITY).



FIGURE 2 ELECTRIC STIRRER (1 IMPERIAL GALLON CAPACITY).

MIXER

The manufactured mixer, impeller and tanks, (Figure 3), are a scaled down model of the Lely designed mixer and driven by a 1 1/2 H.P. electric motor. This horsepower is required to obtain a peripheral impeller velocity of 5,000 feet per minute. (Table 1)

The impeller blade is made of stainless steel, 5 inches in diameter having 16 fins each at a 12 degree angle. (Figure 3a).

Two, 1 1/2 Imperial gallon mixing tanks, one round 6 3/4 inches in diameter, and one of a four leaf clover design (7 inches outside diameter, and 5 3/4 inches in diameter at the inner most point) were manufactured.

With the 5 inch diameter impeller a peripheral speed of 4458 feet per minute, is obtained. Both tanks were experimented with for the mixing of Fire-Trol 100 and Phos-Chek 202XA and found adequate.

Although field mixing tanks are round, the cloverleaf design 1 1/2 Imperial gallon tank was used for these laboratory tests (Figure 3b), to provide reduced mixing time and because the major features of field mixers could not be duplicated in the laboratory.

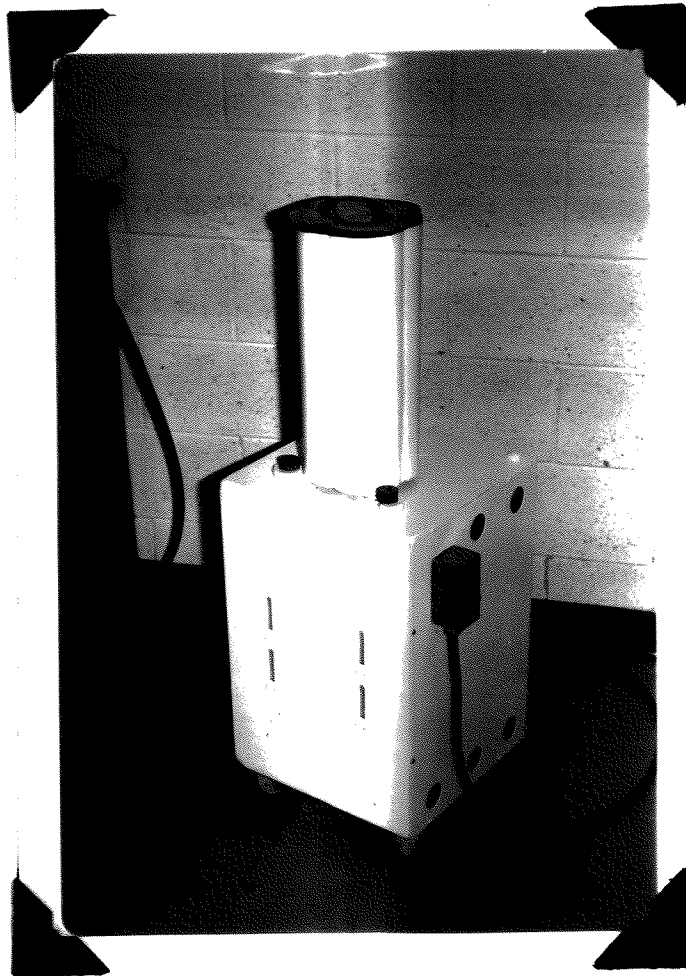


FIGURE 3 ALBERTA FOREST SERVICE MANUFACTURED MIXER, IMPELLER, AND TANK.



FIGURE 3a IMPELLER BLADE



FIGURE 3b 1 1/2 IMPERIAL GALLON CLOVERLEAF DESIGN TANK

TABLE 1 - REQUIRED PERIPHERAL SPEED OF THE ALBERTA FOREST SERVICE
500 GALLON AND 1 1/2 GALLON LABORATORY MIXERS

A.F.S. MIXER 500 GALLON

Impeller Diameter	Engine R.P.M.	F.P.M. Peripheral Speed
Lely 12 inch	1600	5034
12 inch	1650	5192
12 inch	1700	5349
12 inch	1750	5506
12 inch	1800	5664
12 inch	1850	5821
12 inch	1900	5978
12 inch	1950	6136
12 inch	2000	6293
12 inch	2100	6608
12 inch	2200	6922
12 inch	2300	7237
12 inch	2400	7552

A.F.S. MIXER 1 1/2 GALLON ELECTRIC

5 inch	3400	4458
5 3/4 inch	3400	5126
5 3/4 inch	3350	5051

QUALITY CONTROL TEST PROCEDURE

A number of preliminary tests were conducted to determine the effect of mixing time on each of Phos-Chek 202XA, Fire-Trol 100 (1 bag product) and Fire-Trol 931. Also the relationship between various salt and clay contents in Fire-Trol 100 (3 bag product) was determined using various mixing time intervals.

In order to establish a uniform and consistent mix for fire retardants, tests were conducted to determine:

1. Maximum viscosity obtainable in accordance with manufacturers recommended quantities of basic ingredients.
2. Optimum specific gravity as per U.S.D.A.-F.S. specifications.
3. Effect of temperature increase on specific gravity and viscosity during and after mixing basic retardant ingredients.
4. Maximum mixing time required to obtain maximum viscosity for various retardant concentrations.
5. Mixing effect on settling-out and separation of retardant and water.
6. Temperature and storage effects on retardants during long term storage under a variety of conditions.

QUALITY CONTROL RESULTS

The following results (in tabular form) and observations are noted on each retardant after 1 month storage.

Fire-Trol 100 (1 Bag Product)

The 1 bag product consists of 63.5% ammonium sulphate, 35% attapulgite clay (thickener), 1% iron oxide (color agent), and 0.5% corrosion inhibitor. Mixing ratio is 3.34 lbs. of retardant per Imperial gallon of water to obtain a desired viscosity between 1800-2000 centipoises along with a salt content of 15.6%.

Water temperature for the laboratory tests was 53°F. A one Imperial gallon sample was mixed for 1 minute intervals up to 3 minutes. After each minute viscosity, specific gravity (salt content) and mixed retardant temperature was measured. (Table 2). Viscosity ranged from 3295 centipoises, after 1 minute mixing, to 5300 centipoises, after 3 minutes mixing. Salt content readings for all 3 samples was 15.6%. One sample was mixed for 45 seconds to achieve a viscosity of 2600 centipoises, and after one month no separation or settling-out was noted.

TABLE 2 - MIXING TEST RESULTS OF FIRE - TROL 100 BY 1 BAG AND 3 BAGS

Quantity		Water Temp.	Mixing Time	Mixed Retardant Temp.	Viscosity (Centipoises)	Specific Gravity And Salt Content (% wt)	Remarks
1 - Imp. Gal.	3.34 lbs.	53°F	1 - min. 2 - min. 3 - min.	60°F 67°F 74°F	3295 4495 5300	1.103 15.6 (NH ₄) ₂ SO ₄	One bag product
1 - Imp. Gal.	3.34 lbs.	53°F	15 - sec. 20 - sec. 25 - sec. 2 - min. 3 - min.	54°F 65°F 74°F	1200 1500 2200 6500 7000	1.103 15.6 (NH ₄) ₂ SO ₄	Three bag product Salt-clay Dye and inhibitor

Fire-Trol 100 (3 Bag Product)

The same components make up the 3 bag product as did the 1 bag; the difference being that each ingredient (salt, clay, dye and inhibitor) is packaged separately.

From the high viscosities achieved using the 1 bag product reductions in mixing time was experimented with at the recommended 3.34 lbs. of retardant per Imperial gallon of water. Mixing times of 15 seconds, 20 seconds, 25 seconds, 2 minutes, and 3 minute intervals resulted in viscosities of 1200, 1500, 2200, 6500 and 7000 centipoises. (Figure 1). Salt content was 15.6% for all samples.

A reduction in clay content by 19%, 38%, 42%, and 47% was experimented with and results are shown in Table 3.

Salt reduction was experimented with, resulting in a corresponding decrease in salt content. Therefore, the salt quantity specifications as per Fire-Trol 100 3 bag product was used in the remaining experiments.

By reducing the clay content by 19%, 38%, and 47% and mixing for 1 minute, viscosities of 2200, 1600, and 1000 centipoises were obtained. Note that with a reduction of 19% in clay content a similar viscosity resulted. Also by mixing the 38% less clay sample for 30 seconds longer a viscosity of 2050 centipoises was obtained.

Furthermore, the samples containing 38% and 42% less clay were mixed; the former for 8 minutes and the latter for 10 minutes with viscosities of 2300 and 2000 centipoises being achieved respectively. These samples were allowed to stand for 1 and 3 days respectively with viscosity increases of 100 and 400 centipoises evident in the 8 minute mix, and 30 and 400 centipose in the 10 minute mix.

TABLE 3 - MIXING TEST RESULTS OF FIRE - TROL 100 BY 3 BAGS

Quantity		Water	Mixing	Mixed	Viscosity	Spec. Gra. And	Viscosity (Centipoises)		Percentage Clay
Water	Retardant	Temp.	Time	Temp.	(Centipoises)	Salt Cont.	1-day	3-day	Reduction
1 - Imp. Gal.	3.15 lbs.	53°F	1 - min. 2 - min. 3 - min.	58°F 64°F 70°F	2200 3150 3650	1.115 17.7%			19%
1 - Imp. Gal.	3 lbs.	53°F	0.5 - min. 1 - min. 1.5 - min. 2 - min. 8 - min.	64°F 58°F 62°F 65°F 96°F	860 1660 2050 2525 2300	1.115 17.7%			38%
							2400	2700	
1 - Imp. Gal.	2.85 lbs	53°F	8 - min. 10 - min. 12 - min.	94°F 103°F 111°F	1860 2000 2050	1.103 15.6%	2000 2030 2060	2400 2400 2350	42%
1 - Imp. Gal.	2.78 lbs.	53°F	0.5 - min. 1 - min. 0.5 - min. 2 - min.	54°F 58°F 61°F 67°F	460 1000 1260 1675	1.098 14.8%			47%

A cooling down test of the mixed retardant was also conducted. By letting the samples cool to 59°F from as high as 104°F and increase in viscosity of 50-100 centipose was measured.

Observation of the warm storage 1 gallon samples, (Table 4) mixed at 42% less clay content, over the 1 month period indicated that a separation in the form of water patches and cracks was taking place. (Figure 4). No further observations can be made at this early stage. An evaluation of the cold storage samples cannot be made at this time owing to their frozen state. (Figure 5).

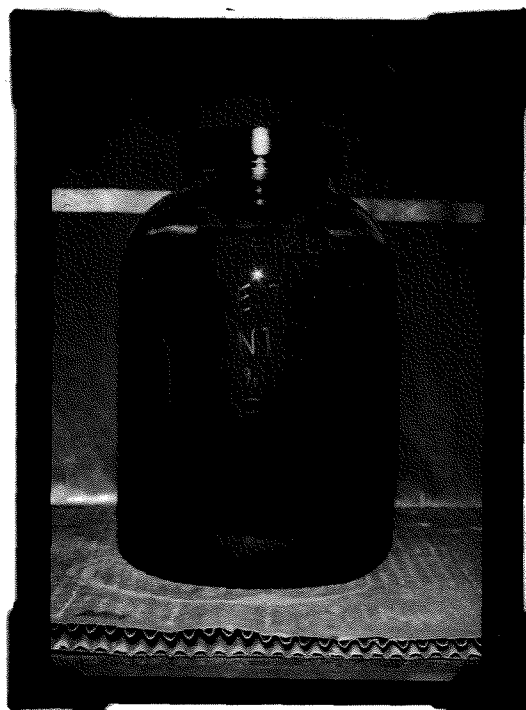


FIGURE 4 FIRE-TROL 100 WITH 42% LESS CLAY; (NOTE SEPARATION IN CONTAINER).

TABLE 4 - MIXING AND STORAGE PROGRAM FOR FIRE - TROL 100 (3 BAG PRODUCT)

Quantity		Water Temp.	Mixing Time	Mixed Retardant Temp.	Viscosity (Centipoises)	Specific Gravity	Remarks
Water	*Retardant						
1 - Imp. Gal.	2.85 lbs.	52°F	10 - min.	103°F	2150	1.102	Warm Storage
1 - Imp. Gal.	2.85 lbs.	52°F	10 - min.	103°F	2000	1.102	Warm Storage
1 - Imp. Gal.	2.85 lbs.	52°F	10 - min.	99°F	2000	1.102	Warm Storage
1 - Imp. Gal.	2.85 lbs.	52°F	10 - min.	100°F	2000	1.102	Warm Storage
1 - Imp. Gal.	2.85 lbs.	52°F	10 - min.	105°F	2030	1.102	Cold Storage
1 - Imp. Gal.	2.85 lbs.	52°F	10 - min.	103°F	2000	1.102	Cold Storage
1 - Imp. Gal.	2.85 lbs.	52°F	10 - min.	102°F	2000	1.102	Warm Storage
1 - Imp. Gal.	2.85 lbs.	52°F	10 - min.	104°F	2000	1.102	Warm Storage
1 - Imp. Gal.	2.85 lbs.	52°F	10 - min.	99°F	1900	1.102	Warm Storage
1 - Imp. Gal.	2.85 lbs.	52°F	10 - min.	104°F	1950	1.102	Warm Storage
1 - Imp. Gal.	2.85 lbs.	52°F	10 - min.	102°F	1900	1.102	Cold Storage
1 - Imp. Gal.	2.85 lbs.	52°F	10 - min.	98°F	2000	1.102	Cold Storage
1 - Imp. Gal.	2.85 lbs.	52°F	10 - min.	102°F	2000	1.102	Cold Storage Mild Steel Container

* Fire-Trol 100 mixing specifications (3.34 lbs. per imperial gallon of water).
 Note the 2.85 lbs. of retardant is 42% less clay added per imperial gallon of water.

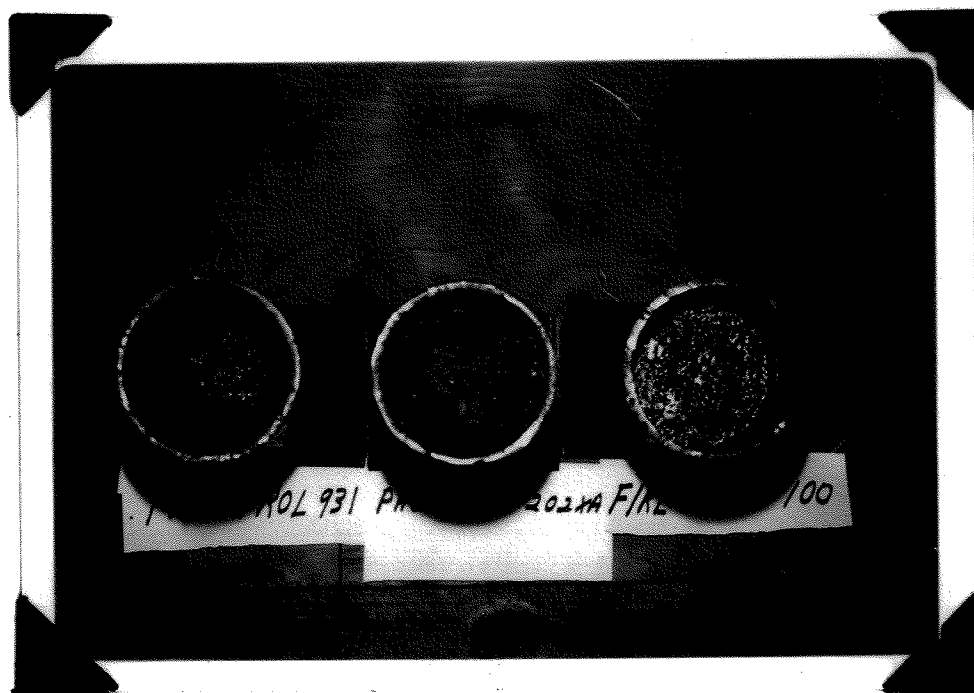


FIGURE 5 COLD STORAGE SAMPLES IN MILD STEEL CONTAINERS.
(FIRE-TROL 931, PHOS-CHEK 202XA, AND FIRE-TROL 100)

Phos-Chek 202XA

This is a 1 bag fire retardant product consisting of 89% diammonium (ortho) phosphate, 8% guar gum (thickener), 1% iron oxide (color agent) and 2% corrosion and spoilage inhibitors. It is mixed at a ratio of 1.37 lbs. per Imperial gallon of water to obtain a viscosity of between 1500-2000 centipoises at a 10.6% salt content. (D.A.P. Equivalent).

For the laboratory mixing tests water temperature was 54°F. The retardant was mixed for 3 minutes and viscosity readings, mixed retardant temperature and salt contents measured. (Table 5).

It was noticed that upon leaving the retardant sit for 1 day an average viscosity increase of 100 centipose occurred. After 1 month a noticeable separation of thickener and salt has taken place, and there is a drop in viscosity of 400 centipoises. No definite conclusion can be drawn at this early stage. (Figure 6).



FIGURE 6 PHOS-CHEK 202XA 1 GALLON SAMPLE (NOTE SEPARATION)

TABLE 5 - MIXING AND STORAGE PROGRAM FOR PHOS-CHEK 202XA (1 BAG PRODUCT)

Quantity		Water	Mixing	Mixed Retardant	Viscosity		
Water	Retardant	Temp.	Time	Temp.	(Centipoises)	Specific Gravity	Remarks
1 - Imp. Gal.	1.37 lbs.	54°F	3 - min.	73°F	1400	1.072	Warm Storage
1 - Imp. Gal.	1.37 lbs.	54°F	3 - min.	81°F	1600	1.072	Warm Storage
1 - Imp. Gal.	1.37 lbs.	54°F	3 - min.	75°F	1680	1.072	Warm Storage
1 - Imp. Gal.	1.37 lbs.	54°F	3 - min.	73°F	1500	1.075	Warm Storage
1 - Imp. Gal.	1.37 lbs.	54°F	3 - min.	71°F	1575	1.075	Cold Storage
1 - Imp. Gal.	1.37 lbs.	54°F	3 - min.	74°F	1460	1.072	Cold Storage
1 - Imp. Gal.	1.37 lbs.	54°F	3 - min.	72°F	1440	1.072	Warm Storage
1 - Imp. Gal.	1.37 lbs.	54°F	3 - min.	72°F	1500	1.072	Warm Storage
1 - Imp. Gal.	1.37 lbs.	54°F	3 - min.	80°F	1530	1.072	Warm Storage
1 - Imp. Gal.	1.37 lbs.	54°F	3 - min.	72°F	1535	1.072	Warm Storage
1 - Imp. Gal.	1.37 lbs.	54°F	3 - min.	72°F	1660	1.072	Cold Storage
1 - Imp. Gal.	1.37 lbs.	54°F	3 - min.	79°F	1550	1.072	Cold Storage
1 - Imp. Gal.	1.37 lbs.	54°F	3 - min.	74°F	1575	1.072	Cold Storage Mild Steel Container

Fire-Trol 931 (Liquid Concentrate)

Fire-Trol 931 consists of 93% diammonium polyphosphate (10-34-0), 4% attapulgite clay (color carrier and thickener), 2% iron oxide (color agent), and 1% corrosion inhibitor. It is mixed at a ratio of 4 parts water to 1 part liquid concentrate. This produces a retardant slurry of 50-150 centipoises with a 15.4% diammonium phosphate salt content. (Table 6).

All laboratory warm and cold storage samples were mixed for 1 minute by stirring the recommended water-retardant ratio. It was noted that after leaving the samples sit for a short time (4 days) approximately 75% of the solution had settled out. This illustrates that Fire-Trol 931 should not be mixed until required for loading on board the air tanker.



FIGURE 7 FIRE-TROL 931 1 GALLON SAMPLE (NOTE SEPARATION).

TABLE 6 - MIXING AND STORAGE PROGRAM FOR FIRE-TROL 931 LIQUID CONCENTRATE

Quantity		Water	Mixing	Mixed Retardant	Viscosity	Specific Gravity	Remarks
Water	Retardant	Temp.	Time	Temp.	(Centipoises)		
1 - Imp. Gal.	1 - Imp. Qt.	54°F	1 - min.	54°F	75	1.100	Warm Storage
1 - Imp. Gal.	1 - Imp. Qt.	54°F	1 - min.	54°F	75	1.100	Warm Storage
1 - Imp. Gal.	1 - Imp. Qt.	54°F	1 - min.	54°F	75	1.100	Cold Storage
1 - Imp. Gal.	1 - Imp. Qt.	54°F	1 - min.	54°F	75	1.100	Cold Storage
1 - Imp. Gal.	1 - Imp. Qt.	54°F	1 - min.	54°F	75	1.100	Cold Storage Steel Container

OBSERVATIONS

Several one gallon samples of Fire-Trol 931 were mixed in the high shear mixer and the resultant viscosity increase was considerable.

Fire-Trol 931 contains 3.9% attapulgite clay which may not be sheared properly when the concentrate is made. This assumption appears to be substantiated by the foregoing tests on various reductions of clay content in the 3 bag Fire-Trol 100, which indicated that reduced volumes of clay could increase viscosity of Fire-Trol 100 slurry through improved shearing time and peripheral impeller velocity.

Although separation occurs rapidly, it does not occur immediately and therefore is of no concern. Generally the retardant is used immediately or a short time after mixing.

Phos-Chek 202XA can be mixed with the high shear mixer and results in consistent mixes.

A high shear mixer is not required for mixing Phos-Chek, as it can be adequately mixed through an orifice with 80 to 100 pounds water pressure.

Fire-Trol 100 can only be mixed properly with high shear mixing equipment. The thickening agent is attapulgite clay in granular form, which requires high shear effect to break down the granular particles and hydrate the clay.

It was possible to shear the clay in Fire-Trol at 4458 feet per minute peripheral velocity. Although it is quite possible to cut down the mixing time by increasing the peripheral speed of the impeller, tests based on this assumption will not be complete until May or June of 1973. Furthermore, tests concerning impeller orientation relative to direction of shaft rotation, tank design, and impeller/tank size relationship are being conducted in an effort to observe the effects of these criteria on product separation or settling.

