$ECO_2FUME^{®}$ Fumigant Gas

Rail Car Fumigation Trial

June 10, 2003

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1. PURPOSE AND OBJECTIVES FOR RAILCAR FUMIGATION TRIAL

Purpose:

- To provide the industry with an alternative to aluminum phosphides for the fumigation of railcars that is safe, environmentally friendly, cost effective, efficacious and easy to use.

Objectives:

- Demonstrate the use of $ECO_2FUME^®$ (cylinderized phosphine) in this application
- To conduct the railcar trials in accordance with EPA and State requirements..
- Determine what, if any, hurdles are to be cleared when fumigating railcars with $ECO_2FUME^®$ fumigant gas.
  - most effective and efficient manner of fumigant gas introduction into railcars
  - ensure the penetration of gas throughout the flour within the railcar
  - examine gas loss, if any, over the course of transportation to its final destination
- Determine the concentration of phosphine within the headspace of the railcar after transit to final destination.
- Determine optimal dosage rate of $ECO_2FUME^®$ based upon phosphine concentration readings in the headspace of railcar after transit to final destination

2. OVERVIEW RAILCAR FUMIGATION TRIAL

Trial Date: April 15-17, 2003
Trial Location: Kansas
Transfer Location (Final Destination): Texas
Participants: Industrial Fumigant Company (IFC), Cytec Industries.

A total of 7 railcars containing flour wee provided for fumigation trials with $ECO_2FUME^®$ fumigant gas. These cars were treated over the course of 3 days using different dosages. See Section 5-Results, Table 1 for a summary of the fumigation data. Only one cylinder of $ECO_2FUME^®$ (68lbs. Product) was required to conduct the tests on all 7 railcars.

Each railcar was held on-site for a minimum of 24 hours before release for shipment to their customer in Alliance, Texas. The first two cars fumigated were held on-site for 48 hours before release for transport to the customer. This allowed for the monitoring of the headspace after 24 hours to assess the time required for the phosphine to penetrate the flour mass. During the fumigation, readings were taken using an ATI Portasens phosphine detector (0-1000ppm range) and a Drager Pac III phosphine detector (0-20 ppm range). Results are listed in Section 4 - Results, Table 1 and show that some phosphine had reached the headspace within 24 hours.

The first 5 fumigated railcars were released for transport to Texas on April 17, 2003 at approximately 9:00 am. The remaining 2 cars were released for transport on April 18, 2003 in the morning. IFC personnel performed the analysis of phosphine concentrations in the headspace for each of the 7

treated railcars upon receipt in Texas. Phosphine concentrations were obtained using Drager tubes. These railcars were then aerated in the usual manner until the concentration of phosphine was 0.3ppm or less. A summary of these results is listed in Section 4-Results, Table 2.

3. EXPERIMENTAL

Each of the seven railcars provided for these trials were of the same type, referred to as "PD" cars or pressure differential cars. These railcars are commonly used in the transportation of flour. They have the ability to withstand 15 psig pressure and are equipped for pneumatic offloading. It was decided upon inspection of this type of railcar that the addition of $ECO_2FUME^®$ to the bottom would be most desirable. If successful, the addition of the $ECO_2FUME^®$ could be made quickly and easily, without the need for workers to climb on top of the railcars to add fumigant, as is currently practiced with aluminum phosphide fumigant.

The "PD" cars have an easily accessible pneumatic manifold system used for supplying air to the bottom of each of the railcar hoppers to vibrate and loosen the flour during the offloading process. An illustration of this manifold system and various components including valves and location of $ECO_2FUME^®$ addition follows.

Illustration of "PD" Car Manifold System

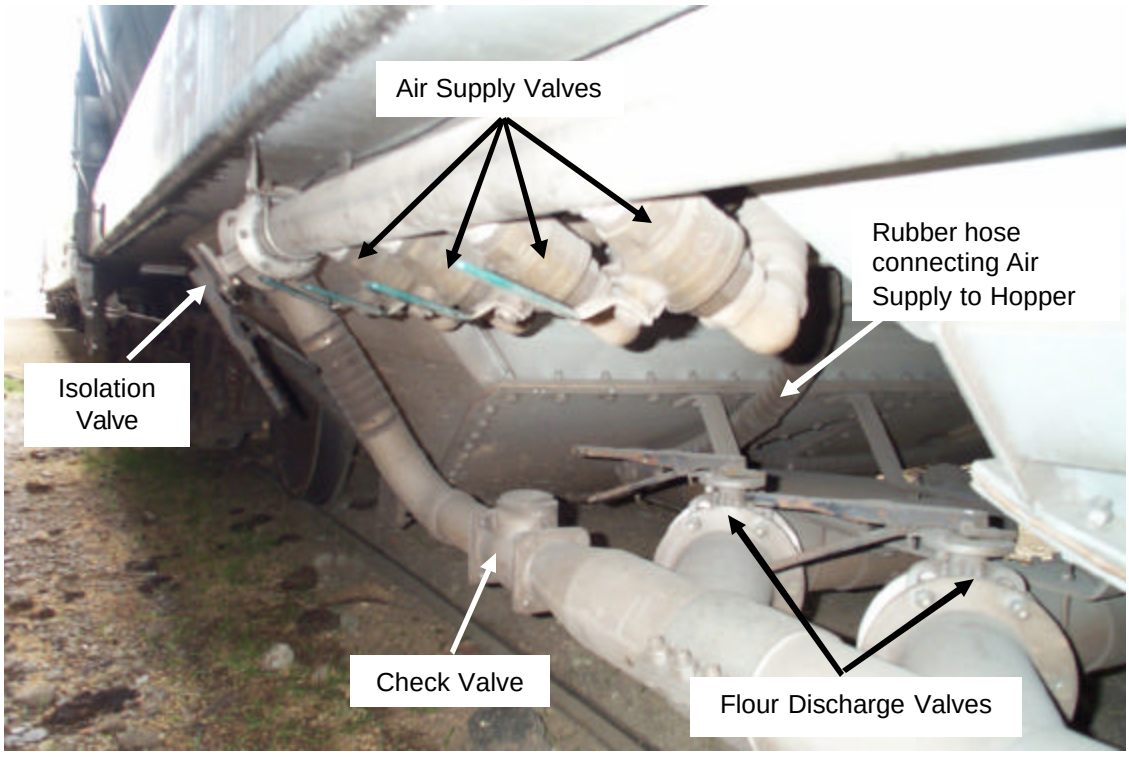
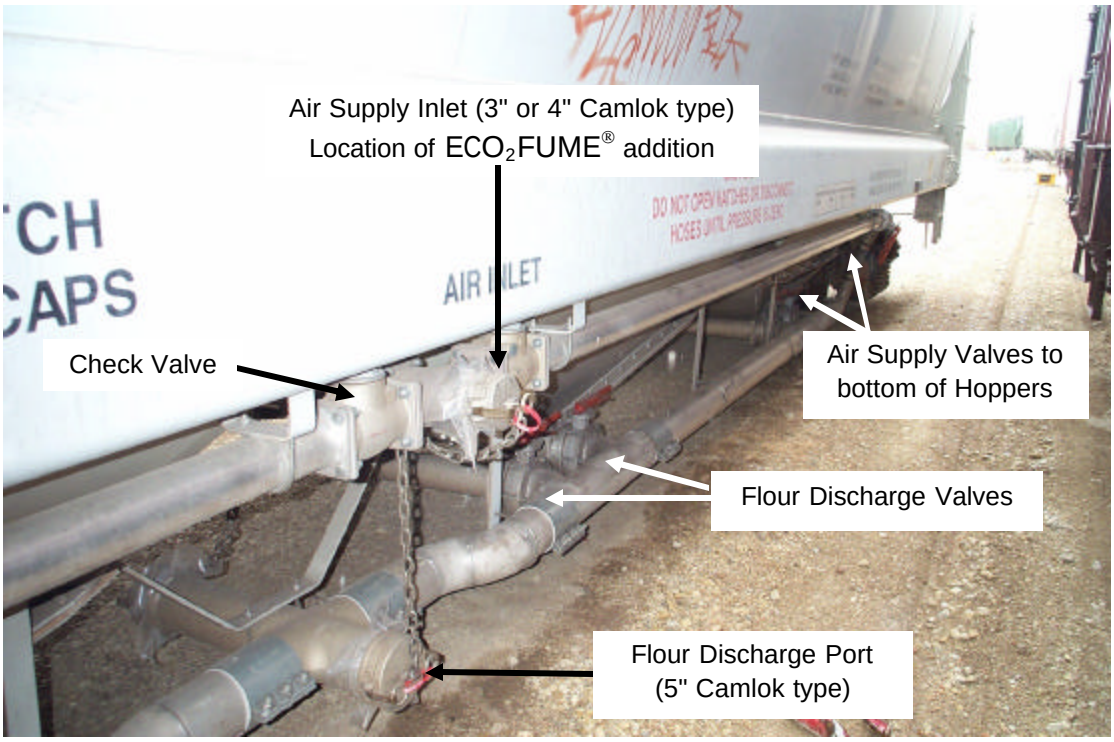


Illustration of "PD" Car Manifold System



$ECO_2FUME^®$ was added to each of the 7 railcars via the "air supply inlet" line. The railcar inlet fittings were "CamLok" type, either 3" or 4". A "CamLok" cap was modified to provide a ¼" quick-connect fitting for gas introduction and a series of pressure gauges to monitor pressure buildup within the manifold system during or after the addition of $ECO_2FUME^®$. Labeled photographs of this modified dispensing cap are illustrated below. It is important to note that this elaborate dispensing cap fitted with pressure gauges was used for experimental data collection only and would not be required in practise.

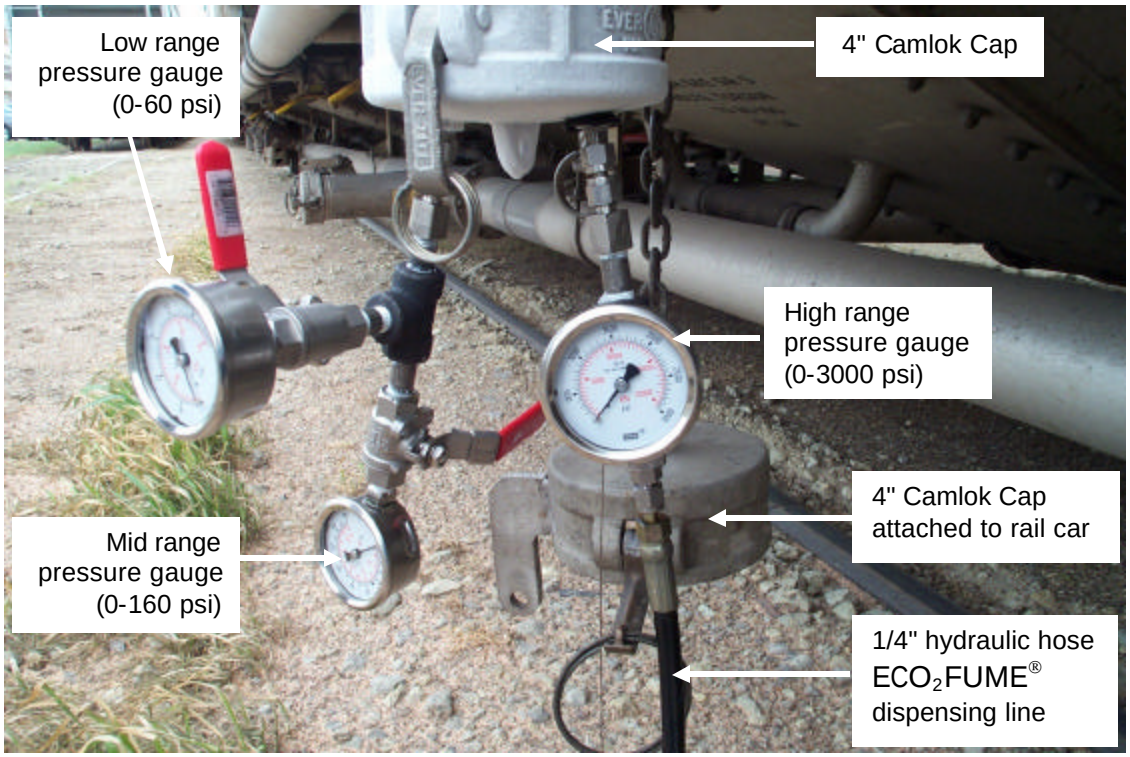
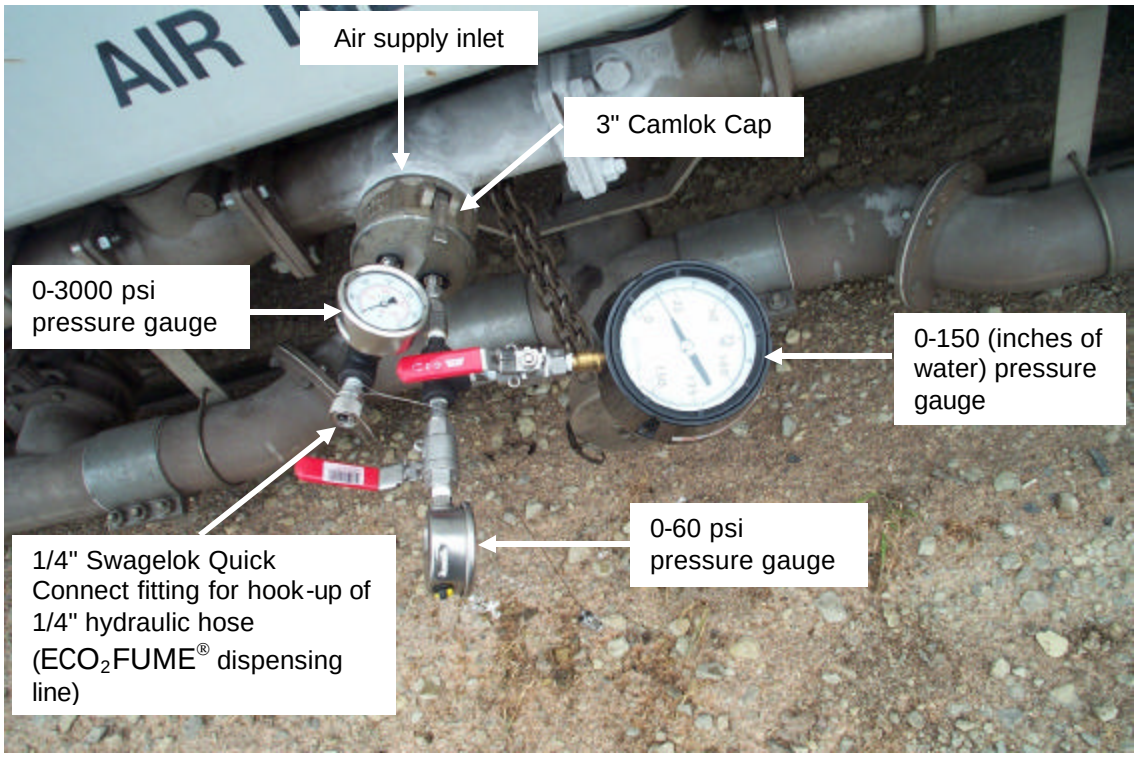
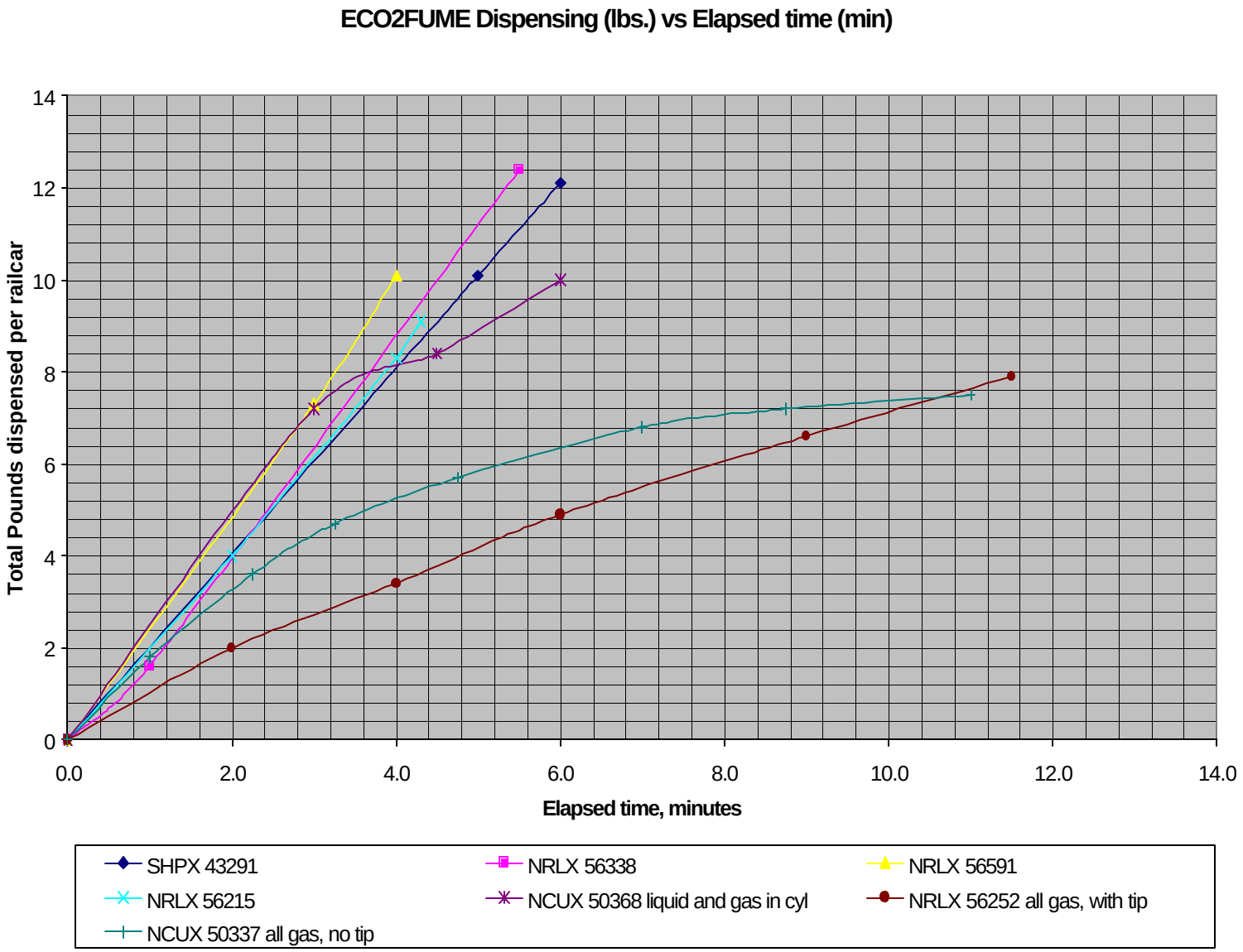


Illustration of Dispensing Cap





The flow rate of the gas was controlled by the use of a restricting nozzle at the end of the dispensing line. A 1/16" stainless steel tube with and inner diameter of 0.04" was used inside the ¼" quick-connect fitting assembly of the dispensing cap. A 25-foot length of ¼" hydraulic hose was used to provide the connection between the dispensing cap and the $ECO_2FUME^{®}$ cylinder. The cylinder was placed on a scale to ensure accurate dosage of each railcar. The 0.04"ID restricting nozzle provided an average flow rate of 2lbs $ECO_2FUME^{®}$ per minute. The nozzle was removed for the fumigation of the last railcar to speed the dispensing process, as the cylinder was almost empty and as a result was lower in pressure. The following chart is a plot of total $ECO_2FUME^{®}$ dispensed versus time for each railcar.

Before $ECO_2FUME^{®}$ was introduced, all 8 “air supply valves” that supply air to the bottom of each hopper were placed in the “open” position. All “flour discharge valves” were checked to ensure they were in the “closed” position and the 2 “manifold isolation valves” which separate the bottom discharge line from the top air supply line were placed in the “closed” position.

The flour is discharged via a “5” outlet port” located at the bottom the manifold system. $ECO_2FUME^{®}$ was not added at this point because the bottom discharge line was filled with flour. Adding $ECO_2FUME^{®}$ to the “air supply inlet” just above provided an injection point that was free of flour and afforded the gas some void space for vaporization. This vaporization resulted in the frosting of the inlet area, a condition normally experienced when dispensing $ECO_2FUME^{®}$ into a limited void space. In all 7 railcars “frosting” of the piping extended for as much as 2 feet on either side of the dispensing cap.

Pressure increases experienced during the addition of fumigant did not exceed 1 psig. The only time pressure built up within the manifold in any appreciable amount (less than 5 psig) was during the “thawing” process of the manifold system when the "air spring valves" were closed to "keep the gas in" the hopper. This occurred after the addition of the gas was complete. This "thawing" process took anywhere from 2-15 minutes. Opening one or all of the 8 “air supply valves” that direct air to the bottom of the hoppers allowed this pressure build-up to dissipate. We learned to leave the air supply valves open for a short period after the introduction the gas was complete, until the "thawing" process was finished. This eliminated any pressure build–up and prevented exposure to gas blow back during the removal of the dispensing cap.

Once the “thawing” process was complete, the dispensing cap was removed. A small sheet of "poly" was placed over the air supply inlet and the railcar cap replaced. The 8 “air inlet valves” were placed in the “closed” position and all “CamLok” caps on the railcar were secured with a coded security wire supplied by the customer. This measure is taken to prevent tampering with the railcar during transit.

4. RESULTS

Table 1 Summary of Railcar Fumigation Activity

Railcar #	Car Size ft^3	Date Fumigated	Target PH3 Conc. (PPM)	$ECO_2FUME^{Ò}$ Dosage (lbs.)	Dosage Equivalent in g/1000 ft^3 (approx.)	Time to Introduce Gas (min)	Conc. of PH3 in Headspace after 24 hrs (ppm)
SHPX 43291	5310	April 15, 2003	500	12.1	21	6	5-15
NRLX 56338	5650	April 15, 2003	500	12.4	20	5	5
NRLX 56591	5650	April 16 2003	400	10.1	16	6	NA
NRLX 56215	5650	April 16 2003	400	9.1	15	4.5	NA
NCUX 50368	5650	April 16,,2003	375	10	16	6	NA
NRLX 56252	5650	April 17, 2003	350	7.9	13	11.5	NA
NCUX 50337	5650	April 17, 2003	350	7.5	12	11	NA

Table 2 Summary of Railcar Fumigation Results

Railcar #	Date of Receipt for Testing & Aeration	# Days under Fumigation	PH_3 Concentration in Headspace of Railcar (ppm)	$ECO_2FUME^{Ò}$ Dosage (lbs.)	Dosage Equivalent in g/1000 ft^3 (approx.)
SHPX 43291	April, 27, 2003	12	250	12.1	21
NRLX 56338	April, 23, 2003	8	200	12.4	20
NRLX 56591	April, 25, 2003	9	225	10.1	16
NRLX 56215	April, 23 2003	7	225	9.1	15
NCUX 50368	April, 23, 2003	7	150	10	16
NRLX 56252	April, 27, 2003	10	100	7.9	13
NCUX 50337	April, 25, 2003	8	125	7.5	12

5. CONCLUSIONS

- Introduction of $ECO_2FUME^®$ into the bottom of the railcars proved to be very efficient and effective.
- Over pressurization of the "PD" railcar with $ECO_2FUME^®$ was not an issue.
- The use of $ECO_2FUME^®$ prevents the need for fumigators to work on top of the railcars.
- The required dosage was added quickly and easily, thus allowing the fumigation of a large number of railcars in a short period of time.
- Results of this trial suggest that the dispensing rate of $ECO_2FUME^®$ not exceed 2lbs. /min.
- Results suggest that the $ECO_2FUME^®$ fumigant had made its way up through the flour mass to the headspace after 24 hours.
- Results indicate that lethal concentrations of phosphine are maintained within the railcar over the course of several days in -transit.
- The results of this trial suggest that a dosage of no less than 15-18g/1000 ft^3. or 9-11 lbs. of $ECO_2FUME^®$ is required. This translates into a dosage range of 375-400 ppm phosphine.
- $ECO_2FUME^®$ eliminates the hazards associated with the handling of aluminum phosphides during their introduction and removal from a railcar.
- $ECO_2FUME^®$ fumigant gas also eliminates the deactivation of the partially spent aluminum phosphide material and disposal of this waste at the receiving end.
- The risk of dropping and/or losing aluminum phosphide material into the flour is eliminated with the use of $ECO_2FUME^®$.
- $ECO_2FUME^®$ addressed the growing concerns of both State and Federal Agencies regarding the exposure of workers whose job it is to receive, handle and aerate railcars under fumigation.
- The procedures and associated training required for receiving fumigated railcars would be simplified and made safer with the use of $ECO_2FUME^®$ fumigant gas.
- This trial has proven that $ECO_2FUME^®$ fumigant gas is a practical, safe and effective alternative to aluminum phosphide pre-pacs for the fumigation of railcars.