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Henry Kyle
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Dear Mr. Kyle:

I have enclosed a copy of ASAE Paper number 87-6550 which is entitled Dust Suppression Results With Mineral Oil Applications for Corn and Milo. This paper presents the results of research performed on the application of mineral oil to corn and milo. I hope that this paper will answer some of your questions pertaining to the application of mineral oil.

If you have any questions concerning the content of the paper or would like any further information, please feel free to contact me.

Sincerely,

Calvin B. Parnell, Jr. P.E.
Professor

CBP/bjl
Enclosures
cc:Bruce J. Lesikar

PAPER NO. 87-6550

DUST SUPPRESSION RESULTS WITH MINERAL OIL APPLICATIONS FOR CORN AND MILO

by

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SUMMARY: Mineral oil was added to milo and corn at five different application rates and it's dust suppression effectiveness was determined for four dust concentration levels. The dust suppression effectiveness was determined by comparing percentages of dust captured for the different mineral oil application rates. Overall, the optimum mineral oil application rates for milo and corn were determined to be 100 and 200 ppm, respectively.

KEYWORDS:

Corn, Grain Sorghum, Milo, and Mineral oil

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area and fuel a secondary explosion. The significance of this phenomenon is the implication that a seemingly clean elevator (except for the confined space of the initial explosion) can have a disastrous series of explosions with fuel provided by the legs, bins, or enclosed conveyors.

Since fuel for a grain dust explosion is dust in suspension at concentrations at or above the MEC, a logical approach to reducing the probability of a dust explosion is to minimize the occurrences of an MEC. This can only be accomplished by the application of engineering methods such as ventilation system design and/or dust suppression.

The Food and Drug Administration (FDA, 1982) has given the approval for the use of a white food-grade mineral oil as a dust control agent for commodity seed (21 CFR 172.378) stored in grain elevators. In 1982, the FDA issued a ruling that allowed white food-grade mineral oil application to wheat. This ruling was later modified to include all commidity seeds. The concentration limits for the mineral oil were set at 0.02% (200 ppm) by weight for grain subject to human consumption and 0.06% by weight for grain destined for animal consumption.

White food-grade mineral oil was defined in 21 CFR 172.878 as "a mixture of liquid hydrocarbons essentially paraffinic and napthenic in nature obtained from petroleum". The food-grade mineral oil must go through several stages of cleaning and must meet specific test requirements and specifications before it is said to be "grain safe" (McIlveen, 1984).

The use of a control agent, like mineral oil is a promising alternative to large expensive dust collection systems. Lai and Martin (1982), did a large scale study at the U. S. Grain Marketing Research Laboratory in Manhatten, Kansas, for treated and untreated corn, wheat, and soybeans using the suppression additives of water, deodorized soybean oil and mineral oil. The oil was applied at the first transfer point on both the bottom and top of the grain by an automatic spray unit. The results showed an oil additive level between 0.02% and 0.05% by weight was optimal and grain dust entrained in the air could be reduced 71% when an oil additive was used (Lai and Martin, 1982). Dust on the gallery floor was reduced by more than 90% at an application rate of 0.03% by weight of soybean or mineral oil. A hydrocarbon based textile oil added to wheat reduced the dust level up to 59% at an application rate of 700 ppm. But, the application of higher concentrations of oil did not further reduce dust levels. Significant reductions have also been noted with corn and soybean dust (Cocke et al., 1978). No adverse effects were detected after twelve months of storage (Pomeranz, 1981). The functional (milling and breadmaking) properties of wheat were unchanged and no evidence of oxidative or hydrolytic rancidity were found with mineral oil applications to grain (Lai et al., 1981).

Dust suppression using mineral oil offers other advantages to grain storage and processing operators. Using mineral oil at the levels cited earlier can likely reduce the incidence of dust explosions and provide a cleaner working environment. Workers involved in grain elevators reported obvious differences when moving oiled and unoiled grain and were enthusiastic about the use of mineral oil on grain (Goforth et al., 1985). An average worker will inhale about 4 to 10 m^3 of air during an 8 hour work shift (Peterson, 1977). If the amount of respirable dust (dust less than 10 microns) can be reduced, the working environment of grain handling facilities will be improved and it will be less likely that employees will develop respirable diseases.

How does the mineral oil sprayed on grain suppress entrainment of grain dust at transfer points? The following mechanism is hypothesized to explain grain dust suppression:

Sample Preparation

Milo and corn were obtained from local feed distributors. Approximately 68.1 kilograms (kg) (150 lbs) of each type was cleaned using a Sweco Vibro-Separator with a 2449 μm screen. The mass concentration (MC) of each of the grains were determined to find the amount of residual dust in the grain. The milo and corn contained 0.11% and 0.20% (2.25 lb/ton and 4.0 lb/ton) residual dust, respectively. Each grain type was divided into five 9.08 kg (20 lb) samples representing five treatments.

Each of the samples were prepared using a mixing box constructed of wood and powered by a 1/8 hp motor with a speed reducer to produce 54 in/lb of torque. The mixing box was painted with a latex paint to prevent absorption of mineral oil into the walls of the box. The mixing box had a volume of .03893 m^3 (1.375 ft^3). Due to the small amount of surface area associated with the mixing box, compared to the total grain surface area, the mineral oil losses on the walls were considered negligable.

Mineral Oil Preparation and Addition

The exact amounts of mineral oil referred to above were added to the 20 lb grain samples using the following procedure. The mineral oil was measured with a pipet and placed into a flask. It was subsequently diluted with 25 milliliters (mL) of hexane before it was added to the grain. The addition of hexane had a two-fold purpose. First, the hexane facilitated the removal of the small amounts of oil normally left on the flask used to measure mineral oil. Secondly, the hexane aided in uniform mixing of the mineral oil with grain. Hexane was used as the diluting agent because it readily dissolved the mineral oil and quickly evaporated after mixing. The mineral oil and hexane mixture was added in four equal parts. After the addition of each part, the mixing box was turned for five minutes at a rate of 40 revolutions per minute (rpm). The total mixing time was 20 minutes. At the completion of the mixing process, the lid was opened to allow the hexane to completely evaporate.

Grain Dust Preparation and Addition

Milo and corn screenings were obtained from terminal elevators in Texas. The grain dust was sieved through a 100 micron (μm) screen using a Tyler Portable Sieve Shaker and the particle size distribution (PSD) of the dust was determined.

The grain samples which were mixed with mineral oil were separated into 20 - 454 gram (g) samples and placed in separate plastic containers. Grain dust less than 100 μm in aerodynamic diameter, was added to five 454 g grain samples to obtain approximate dust concentrations of 0.0%, 0.1%, 0.25% and 0.5% by weight of grain. Each 454 g oiled grain sample and its corresponding dust level was subsequently tumbled for 15 minutes at a rate of 40 rpm.

Tumbler Box Air Wash Procedure

Following the 15 minute mixing period, each container was subjected to the tumbler box air wash. The air wash tumbler box was constructed of plexiglas and had a volume of 4.48 Liters (L) (273 in^3) with the sides having 20% open area. Each of the 454 g grain samples which had been mixed with corresponding amounts of dust, were placed in the air wash tumbler box and tumbled for three minutes at 40 rpm. Free dust, dust not adhering to the grain, was removed from the sample by transferring air through the sample at a rate of 18.9 L per second (Lps) (40 cfm). The free dust removed by the air wash was captured on a 20.32 centimeter (cm) by 25.4 cm (8 in by 10 in) preweighed filter. The mass of free dust obtained from a sample was divided by the mass of the sample to

In comparing the capture percentages of mineral oil levels on milo and corn, the observation can be made that oiled grain retains more dust when the grain is corn rather than milo. For example, the maximum dust retained on the milo surface was 3 mg/g at the 200 ppm application rate with a dust concentration of of 6.125 mg/g. The maximum quantity of dust retained on the corn surface was 5.5 mg/g at the 400 ppm oil application rate with a dust concentration of 7.0 mg/g. This shows that the mineral oil captured 2.5 mg/g more dust on the corn than on the milo at the highest dust concentration in the grain.

The best method for determining the optimum oil application rate is to plot the mass concentration particle size distribution (MCPSD) for each combination of oil application rate, dust concentration and grain (Figures 3-8). The actual (ACT) dust level illustrates the dust concentrations in each of the 15 particle size ranges prior to the air wash and MCPSD procedures. The ideal capture curve would be an MCPSD that exactly overlays the ACT curve. The area between the right hand side of the MCPSD's associated with oil application rate and the ACT MCPSD defines the amount and particle size of the free dust. Figure 3 illustrates very little difference in the amount of dust captured by a 100 or 200 ppm application rate for the 2 mg/g dust concentration level in milo. Figure 4 provides similiar results for the 3.625 mg/g dust concentration level. Figure 5 suggests that a slight increase can be gained by applying 200 ppm when the dust concentration is 6.125 mg/g. These results suggest that a 100 ppm application rate would likely achieve the maximum dust suppression benefits for milo.

The capture curves for corn and corn dust at different mineral oil application rates illustrate the effectiveness of the different application rates at capturing the dust in the grain. The 400 ppm and 200 ppm mineral oil application rates at a dust concentration of 3.0 mg/g showed similiar capture curves with the 400 ppm oil application rate having a slightly greater capture volume (Figure 6). The MCPSD plot of the 4.5 mg/g dust concentration showed the 200 ppm oil application capture curve above the 400 ppm oil application capture curve (Figure 7). The MCPSD plot of the 7.0 mg/g dust concentration showed the 400 ppm mineral oil application rate capturing the greatest percentage of the actual dust in the grain (Figure 8). In general the amount of free dust is considerably less for the corn when compared to the milo. The 200 and 400 ppm application rates result in the maximum dust capture for the corn until the grain dust concentration reaches 7.0 mg/g. At this high dust concentration, the 400 ppm oil application rate results in a significant increase in the amount of dust captured. These results suggest that the 200 ppm oil application rate would likely achieve the maximum dust suppression benefits for corn.

CONCLUSIONS

Research into the dust retention capabilities of corn and milo treated with mineral oil has provided new information about the dust retained on corn and milo. The dust retained on the grain and the free dust remaining in the corn and milo was determined so that a comparison between the effectiveness of the mineral oil application rate could be made. The PSD of the free dust retained on the grain and left as free dust could be evaluated. Capture curves were developed from the test results to determine the benefits of adding different application rates of mineral oil.

The significant findings of this research are summarized as follows:

1) Results of the test performed on corn illustrated that an application rate of 200 ppm of mineral oil provided the maximum dust retention and least

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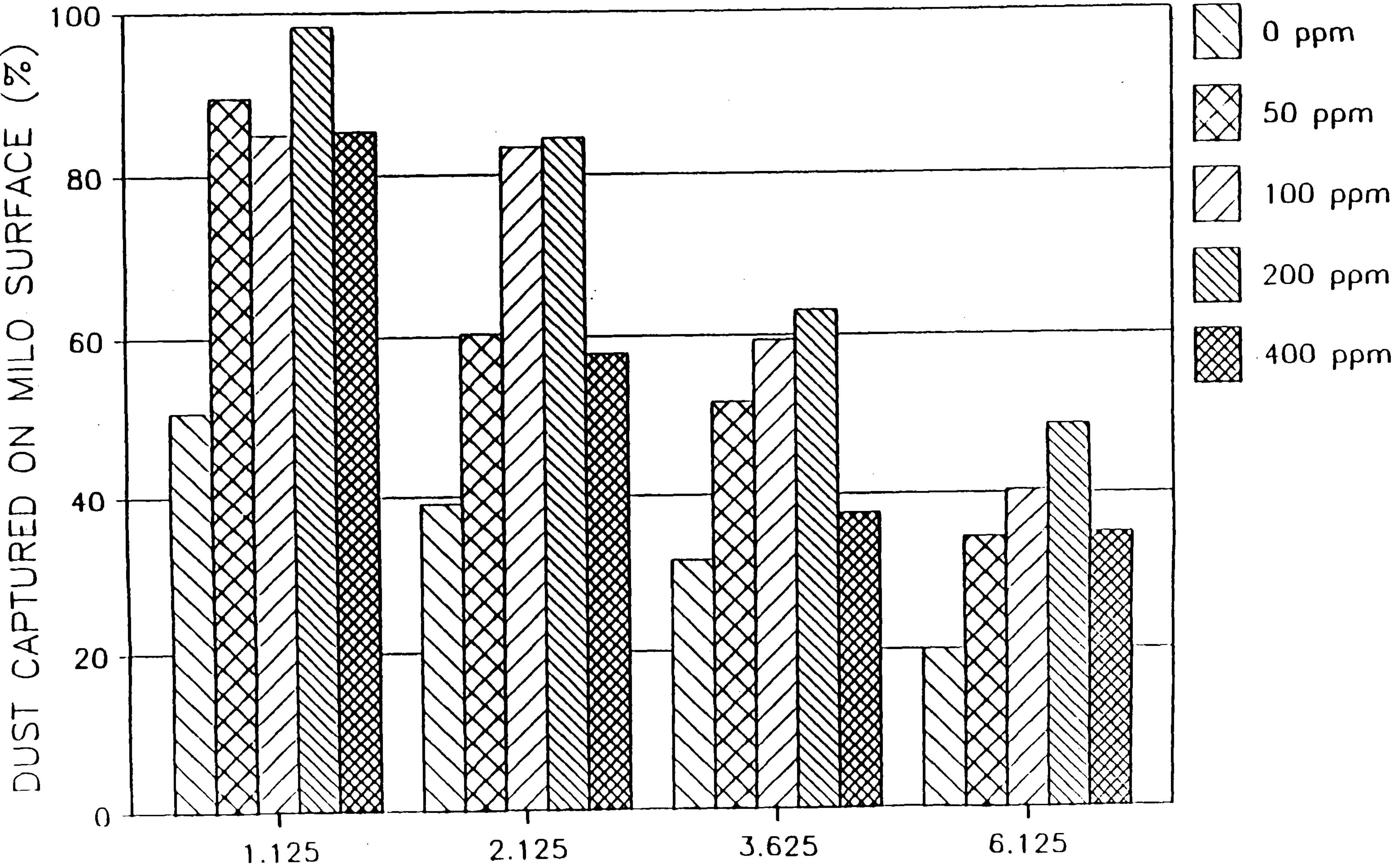
FIGURE 1: PERCENTAGE OF DUST CAPTURED
ON MILO SURFACE



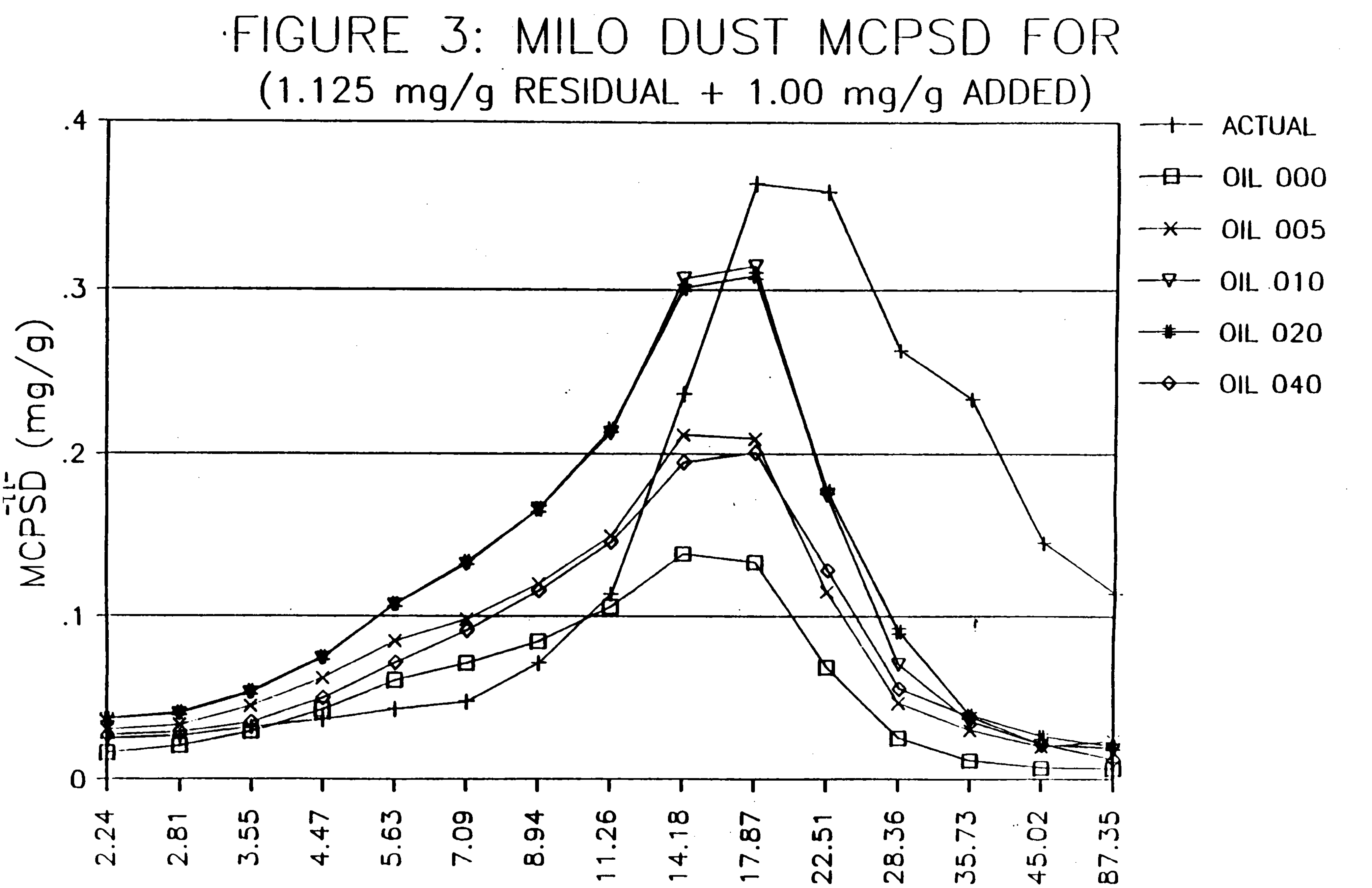


FIGURE 3: MILO DUST MCPSD FOR
(1.125 mg/g RESIDUAL + 1.00 mg/g ADDED)
MCPSD (mg/g)
.4
.3
.2
.1
0
2.24
2.81
3.55
4.47
5.63
7.09
8.94
11.26
14.18
17.87
22.51
28.36
35.73
45.02
87.35
ACTUAL
OIL 000
OIL 005
OIL 010
OIL 020
OIL 040
-11-

FIGURE 5: MILO DUST MCPSD FOR (1.125 mg/g RESIDUAL + 5.00 mg/g ADDED)

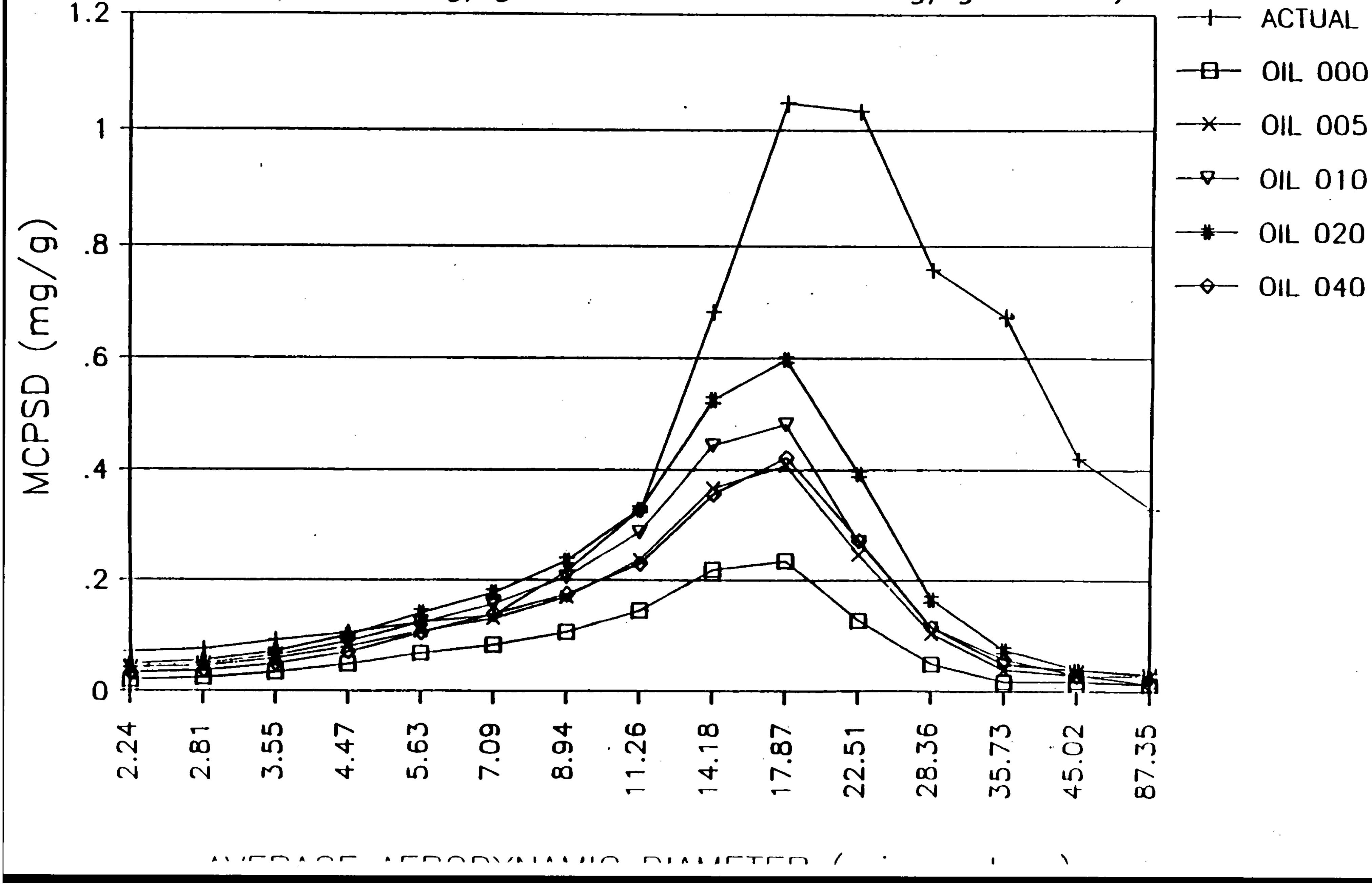


FIGURE 7: CORN DUST MCPSD FOR (2.00 mg/g RESIDUAL + 2.5 mg/g ADDED)