DRAFT

IN-DEPTH SURVEY REPORT

CONTROL OF DUST IN A TEXTILE DYEING OPERATION

Multicolor Industries, Inc

Brooklyn, New York

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U S DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
Centers for Disease Control and Prevention
National Institute for Occupational Safety and Health

PLANT SURVEYED | Multicolor Industries
791 Kent Ave
Brooklyn, NY 11205

SIC CODE
NAICS

SURVEY DATES | February, 1999
September, 1999

PLANT OWNER / OPERATOR | Mr Ben Hursch

SUMMARY

Researchers from NIOSH conducted an evaluation to determine the efficiency of three techniques for controlling exposure to powdered dyes These techniques were 1) a down draft hood to move dust away from the employees' breathing zone, 2) the addition of a "de-dusting agent," typically a light oil, to the dye to reduce the dye's tendency to become and stay airborne, and 3) the size of the large containers used to ship and store the dyes

Two series of measurements were made under varying control conditions to quantify the inhalation exposure of a weigh-out operator to airborne dye dust A Crompton and Knowls Azoanthrene Jet Black K Crude was used for the first series of measurements and a Dystar Remazon Red RB for the second This "weigh-out" process where the powders are scooped from open containers and dumped into smaller containers for weighing, is the time of greatest potential exposure to employees

In the first (February, 1999) series of tests, the use of ventilation was shown to significantly reduce the airborne dust exposure to the worker, producing an 88% decrease Barrel size seemed marginally effective in reducing dust exposure The use of small barrels produced an estimated reduction of 80% when high dustiness dye was used The use of de-dusted dye produced an estimated reduction of about 60% when large barrels were used (The corresponding estimate for small barrels indicated no reduction due to de-dusted dye)

The second (September, 1999) tests confirmed the effectiveness of ventilation in reducing airborne dust levels, and also indicated that the de-dusted dye, used when the ventilation is off, significantly reduced airborne dye concentration by approximately 80% This effect would have been greater but for the one sample (identified as R3 in the September results) which appears to be inconsistent with the others However, no other justification can be developed for regarding this sample as an outlier

The small number of total tests and particularly the limited replication are considered to be the primary factor responsible for statistical significance It is recommended that additional tests be conducted to investigate the effects of the dye dustiness or drum size Because the availability of a downdraft ventilation system such as was evaluated during this study is limited, this additional testing would be most appropriately conducted with no such ventilation system

INTRODUCTION

Researchers from the National Institute for Occupational Safety and Health (NIOSH) conducted an evaluation of control techniques for reducing occupational exposure to dye dust in a textile dying facility The purpose of this evaluation was to determine the efficiency of various techniques for controlling exposure of weigh-out operators where dry powder dyes were removed from large drums and weighed into smaller containers Because the toxicity of these powder dyes is not well defined, it is prudent to control employees' exposure as far as practical It was the goal of this study to determine the effectiveness of three available techniques to control this exposure

Dry powdered dyes of many chemical types are used extensively in the coloring of textiles These dyes are typically provided in bulk containers holding up to several hundred pounds and are removed as needed in measured amounts to be used alone or combined with measured quantities of other dyes to produce a desired color This "weigh-out" process where the powders are scooped from open containers and dumped into smaller containers for weighing, is the time of greatest potential exposure to employees

To reduce workers' exposure in the weigh-out operations, the Ecological and Toxicological Association of Dye Manufacturers (ETAD), in collaboration with NIOSH, investigated three control solutions These were 1) a down draft hood to move dust away from the employees' breathing zone, 2) the addition of a "de-dusting agent," typically a light oil, to the dye to reduce the dye's tendency to become and stay airborne, and 3) the size of the large containers used to ship and store the dyes

The down draft hood which was evaluated was a commercially available unit purchased by ETAD and installed at Multicolor Industries, Brooklyn, NY, specifically for use in the weigh-out operation at that dye house This local exhaust ventilation system had been partially evaluated in a prior NIOSH study that indicated it did reduce the concentration of total dust in the work environment, but did not specifically measure dye dust

The addition of a de-dusting agent to reduce dye dustiness is a common procedure for materials manufactured and shipped in the US, and is thought by some in the industry to significantly reduce airborne (i e , breathable) dye dust concentrations Varying amounts of oil are mixed with the dye by the manufacturer, with a concentration of about 1% w/w as a nominal maximum

Because many of the dyes of interest are shipped and used from standard 55 gallon metal drums, it was considered that the occupational exposure of employees during the weigh-out would increase as that employee was required to reach lower into the barrel as the dye was used Therefore, the concept of using short or "half" barrels, similar in diameter but smaller in height than a standard barrel, was developed with the hope of eliminating the need for the weigh-out operator to reach so far into the barrel that his head (i e , breathing zone) was pulled into this area of high dust concentration

A study was designed to test each of these three variables (ventilation, dustiness and drum size) and their interactions in both the presumed "safe" or "unsafe" mode Tests were conducted with the down draft hood on and with it off, with dye to which a maximum amount of de-dusting oil had been added and to which no oil was added, and weighing the samples from both the short and the standard sized drums A fourth variable, the dye itself, was tested by conducting an initial set of tests for the first three variables during one week, and returning later to repeat these tests using a second dye

METHODS

Since the primary emphasis of this work was to evaluate three procedures for the control of inhalation exposure to dye dust, the essential measurements were those of dye dust concentration in employees' breathing zone during the weigh-out operation using the control procedure of interest To reliably collect these concentration data, a simulated weigh-out operation was established in which an experienced employee opened and scooped dye with specified dustiness level from full or half barrels, as specified, into brown paper bags, weighing increments on a balance in the hood The hood ventilation was turned on or off as specified by the test parameters for the run in progress The bags were folded and set aside until the drum was empty The test was then stopped (sampling devices were removed) and the dye was returned from the bags back into the drum The drum was then replaced by the size and dustiness level required for the next run, and the process was repeated

Specific tasks that were conducted to complete this work included

- development of a sampling and analytical technique for monitoring airborne dye concentrations at anticipated levels in durations which would allow multiple tests in a day
- development of an experimental protocol which would provide statistical power to determine the effect of each of the three control techniques as well as their interactions
- the use of a real time monitoring technique to measure dust concentrations during and between tests to assure independence of each test from the previous
- additionally, a series of laboratory tests were conducted to measure the tendency of the dyes used in this work to produce dust in both the "dedusted" and the "non-dedusted" forms

Each of these four tasks is described below

<u>Sampling and analytical procedures</u>

A sampling and analytical technique to measure airborne dye dust was developed using a midget impinger to collect the sample and visible spectrophotometry for quantification Initial attempts to collect samples on various types of filters resulted in highly variable extraction due to the dyes' tendency to bind with those filters, and this technique for sample collection was considered unreliable A sampling procedure was selected which takes advantage of the dyes' high water solubility, eliminating the extraction and sample preparation steps for analysis

Air samples were collected by drawing air at 3 liters per minute through a midget impinger containing 15 ml of distilled water and clipped on the worker's lapel

Preliminary testing at the Multicolor facility in September, 1998, indicated that a quantifiable sample could be collected in less than an hour using this technique Due to the high molar absorbtivity of these materials, a statistical limit of detection of approximately 2 µg per sample and a limit of quantitation of approximately 6 µg per sample was achievable using a Hewlett Packard Model 8452A Diode Array Spectrophotometer and a 1 cm quartz cell at wavelengths optimized for each dye Calibration for each dye was done by serial dilution of weighed aliquots of dried dye (without additives) and plotting absorbance vs dye concentration in liquid solution

Statistical protocol

An experimental protocol was developed that was designed to look at each of the 3 variables (ventilation, dustiness, and drum size) in both the controlled and uncontrolled mode Tests were arranged to measure workers' exposure with the ventilation on and off, using the dedusted and un-dedusted dye, and weighing from the short and full drum All combinations of variables were thereby testable in a total of 8 test runs using a 2 X 2 X 2 factorial design

It was anticipated that multiple sets of 8 test runs would be conducted during each of two separate visits to Multicolor in 1999 This would produce replicate measurements for the sampling conditions, giving the statistical power required to make a conclusion regarding the effectiveness of the control techniques The second visit was designed to repeat the first, but using a chemically different dye The first study, conducted in February, 1999, used a Dystar Remazon Red RB material The second study, conducted in September, 1999, used a Crompton and Knowles Azoanthrene Jet Black K Crude material Comparison of results from the two studies was designed to both confirm the effect of each variable, and also to provide information on the tendencies of the different materials to produce airborne dust

Due to scheduling problems at the Multicolor facility and extreme weather conditions, only 12 runs were completed during the April visit and another 12 runs were completed in September

Real time monitoring

Real time monitoring for total airborne particulate was conducted using a Grimm Model 1106 Dust Monitor (Pioneer Emissions Detection and Control, Inc , Wilmington, DE 19803), during the April, 1999, testing The primary purpose of this monitor was to assure that there was no residual dust remaining from one test run that would affect subsequent runs This monitor was not a personal breathing zone sampler, but rather was placed in the general area where the weigh-out operation was taking place It measured total airborne particulate in selected size ranges, so it provided minimal information regarding the worker's inhalation exposure to dye dust

Dustiness testing

In addition to the testing conducted on-site at the Multicolor facility, the Crompton and Knowls Azoanthrene Jet Black K Crude and the Dystar Remazon Red RB were both evaluated using three dustiness testers These measures were termed the Roaches test, the Huebach test and the Leith test after the name of the instrument used to conduct the measurement Both dyes were evaluated in the "dusty" state (i e , without any agent added to reduce dustiness of the powder), and also in the "fully dedusted" state These four dye samples were taken from the drums used in the Brooklyn dye house while the environmental monitoring was being conducted The dustiness testing was conducted in the NIOSH Cincinnati laboratory (Huebach and Leith tests) and in the Crompton and Knowles Quality Assurance Laboratory in Nutley, NJ (Roaches test)

The Roaches tester drops a measured amount of powder (12 5 g used for these tests) through a closed cylinder into a receiver, and the dust created by this fall is removed through a filter at a constant flow rate (15 lpm) for a set time period The filter is then removed from this closed system and visually evaluated Dustiness of the powder is rated on a numeric scale from 1 (heavily stained) to 5 (negligible or no staining) A rating of 4 (slightly stained) or 5 would be considered acceptable for dye shipment

The Heubach tester places a measured amount of powder (50 g in this test) in a rotating drum set to turn for a fixed time (4 minutes, 10 seconds) Air was pulled from the drum at a fixed rate (11 3 lpm) through a filter The filter and backup pad were both pre-weighed By re-weighing the filter and pad subsequent to the test the mass of dust produced by the rotation of the drum was determined

The Leith tester, operating similarly to the Roaches tester, drops a measured amount of powder (50 g in this test) through a closed chamber into a receiver, and the dust created by this fall is removed through a filter at a constant flow rate (11 3 lpm) for a set time period In this test, the filter and backup pad were weighted pre- and post-testing to measure the mass of powder produced by the drop

Using any of these testers it is possible to compare relative dustiness of various powders by making measurements under conditions of constant powder mass, fall distance (or rotation time), air flow rate and sample time on that tester Measurements are not comparable between one tester to the others

RESULTS

Multicolor Industries was selected as the site for this dust control testing due to the availability at that facility of a down draft hood for the weigh-out operation Multicolor is located in urban Brooklyn, NY, in a two story brick building At street level is the production facility and the upper level serves as office and storage space The weigh-out operation occurs in one room designated for that function only, containing the down drft hood at one end and providing storage for many 55 gallon drums and smaller containers of powdered dyes in the remainder of the space Other than the hood, there is minimal general exhaust ventilation in this room, provided primarily by an exhaust fan in the wall behind the hood The only person generally working in this room is the weigh-out operator

Personal breathing zone data

The airborne concentration of black or red dye, expressed in μg of dye per cubic meter of air, measured in the weigh-out operators breathing zone during the February and

September tests, are shown in Table I Also listed in this table is the status of each of the three control techniques being evaluated, either on or off for the ventilation system, low or high dustiness for the dye to indicate dedusting agent added or deleted, and short or full to indicate the size of the barrel from which the dye was being scooped

Table I

Breathing zone dye dust concentrations

February Samples

SAMPLE NUMBER	VENTILATION	DYE DUSTINESS	BARRELL SIZE	AIRBORNE DYE CONC.
B 1	On	High	Short	28 µg / M^3
B 2	On	Low	Short	7
B 3	Off	High	Full	2080
B 4	Off	Low	Full	1400
B 5	Off	High	Short	220
B 6	On	High	Full	280
B 7	On	Low	Short	95
B 8	Off	Low	Full	660
B 9	Off	High	Full	1450
B 10	Off	Low	Short	1190
B 11	On	Low	Full	60
B 12	On	High	Short	170

September Samples

SAMPLE NUMBER	VENTILATION	DYE DUSTINESS	BARRELL SIZE	AIRBORNE DYE CONC.
R 1	Off	Low	Full	140 µg / M^3
R 2	Off	High	Short	1770
R 3	Off	Low	Short	3970
R 4	Off	High	Full	3210
R 5	On	High	Full	70
R 6	On	High	Short	190
R 7	On	Low	Full	200
R 8	On	Low	Short	120
R 9	Off	Low	Short	160
R 10	Off	High	Full	2070
R 11	Off	High	Short	1780
R 12	Off	Low	Full	290

Because the three control techniques had just two configurations each, there were only 2^3 or 8 possible combinations of tests, so on both site visits all eight permutations were tested and half were duplicated The duplicate runs were

B1 and B12	R1 and R12
B2 and B7	R2 and R11
B3 and B9	R3 and R9
B4 and B8	R4 and R10

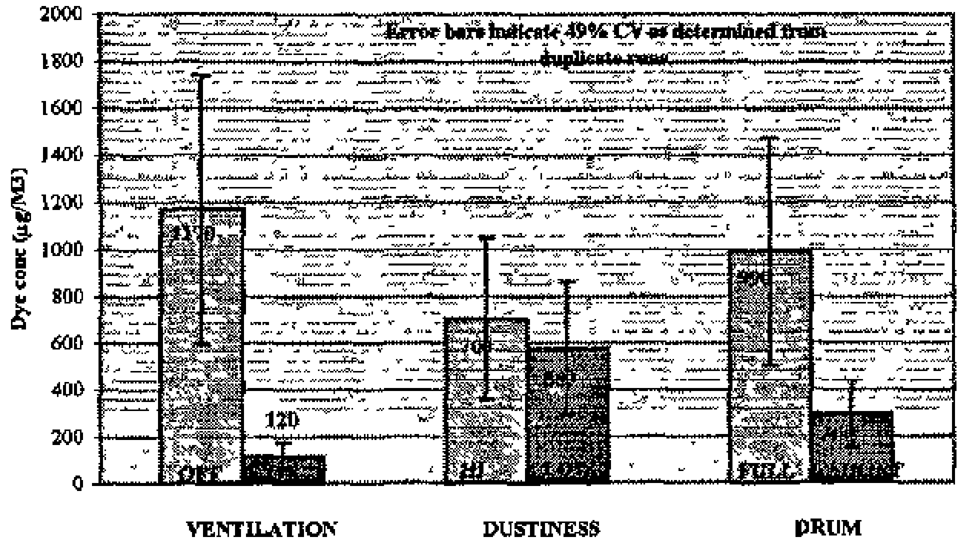
From these replicates it was possible to obtain a measure of sample variability under the same conditions of controls Coefficients of variation (CVs) were calculated for each set of duplicate runs, and mean CVs for the February and September runs were 49% and 53%, respectively

Plots were drawn showing the means of all runs with the ventilation off vs with the ventilation on, all runs with no dedusting agent vs with full dedust, and all runs using the full vs using the short drum The CV for each set of data was then incorporated as error bars to indicate overlap in results, and these are presented in Figure IA and B, for the two data sets

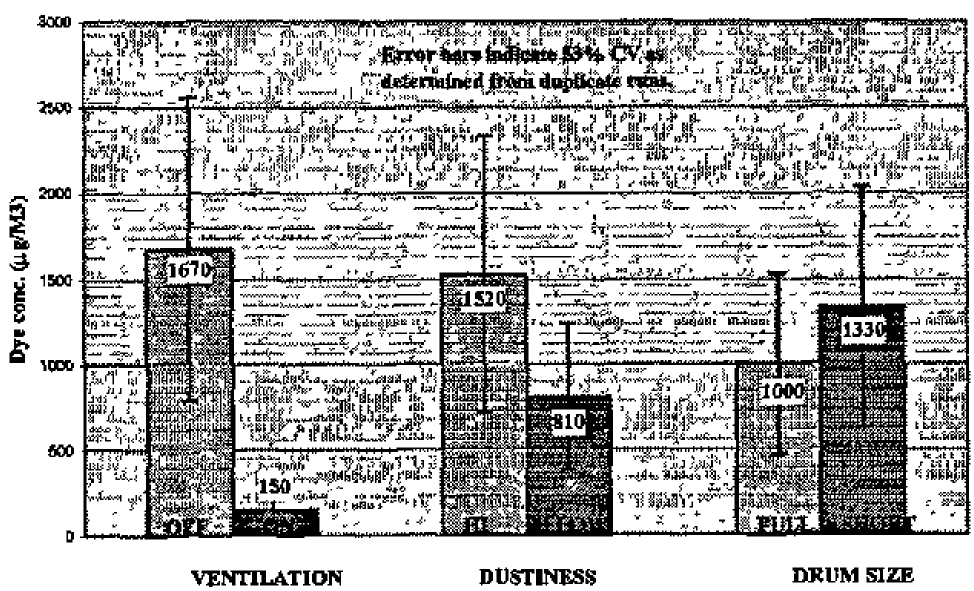
Figure I

DYE CONCENTRATIONS FOR INDICATED VARIABLES

IA - DATA FROM FEBRUARY TESTS



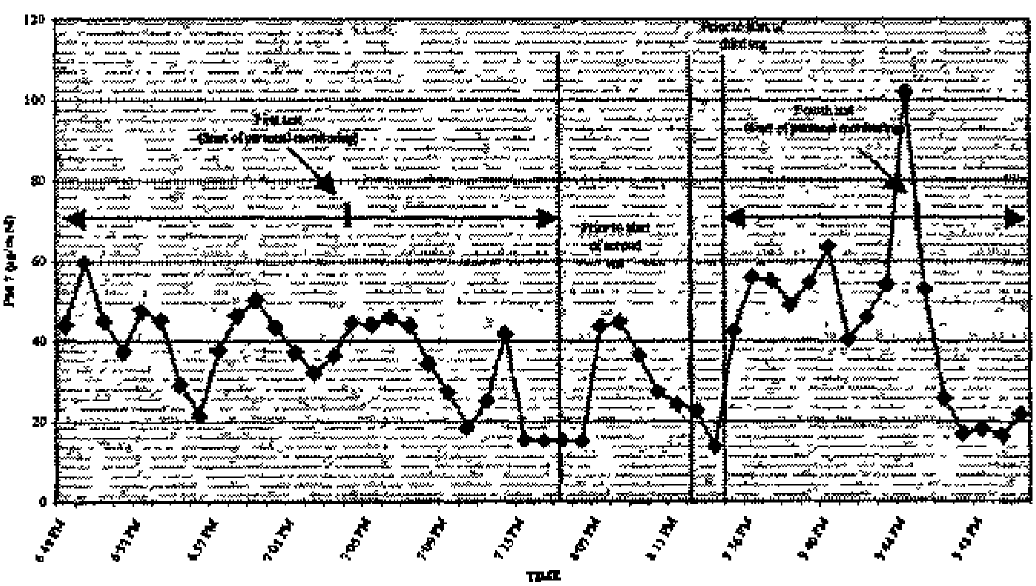
IB - DATA FROM SEPTEMBER TESTS



Real time dust monitoring data

The Grimm dust monitor provided a continuous display, updated every few seconds, of both total airborne particulate and the airborne particulate matter <7 µm mean aerodynamic diameter (PM 7) These measurements were taken in the area near the face of the hood where the weigh-out operation was conducted They do not represent either the operators breathing zone exposure or a measure of airborne dye These data quantify the airborne dust (dye plus other particulate) before the test runs began, between runs, and in some cases during part of a run and during the time when the dye was being returned from the bags to the drums This last procedure was not part of the experimental testing since it is not a normal weigh-out procedure, and no breathing zone samples were being collected At the end of each test run the exhaust hood was turned on, or left on if the protocol called for it to be on during the test, in an attempt to reduce the dust level in the work area and thereby eliminate potential interference in subsequent tests Figure II presents a plot of PM 7 prior to the four tests conducted on February 23, 1999, and also indicates that PM 7 concentration during the first few minutes of the first and fourth run of that day These data are typical of the real time measurements made during this study

Figure II
PM 7 concentration prior to the 4 test runs on February 23, 1999, and during the first few minutes of the first and fourth run



Dustiness testing

The tendency of the two dyes to produce airborne dust as measured by the Roaches test, the Huebach test and the Leith test makes it possible to compare relative dustiness of these powders although measurements are not comparable between one test to the others Samples of the Crompton and Knowls Azoanthrene Jet Black K Crude and the Dystar Remazon Red RB were both evaluated using all three tests Both dyes were evaluated in the "dusty" state (i e , without any agent added to reduce dustiness of the powder), and also in the "fully dedusted" state These four dye samples were taken from the drums used in the Brooklyn dye house while the environmental monitoring was being conducted Results from these tests are shown in Table II below

Table II
Results of laboratory dustiness testing

	C&K Black		Dystar Red	
	HEUBACH TEST		HEUBACH TEST	
	DUSTY	DE-DUSTED	DUSTY	DE-DUSTED
Mean dust (mg)	12 05	6 29	47 34	0 2765
Std Dev	1 72	0 66	15 12	0 17
%RSD	14 27	10 53	31 95	62 06
Number of replicates	4	4	4	4
% Reduction in dustiness	48%		17,122%	
	LEITH TEST		LEITH TEST	
	DUSTY	DE-DUSTED	DUSTY	DE-DUSTED
Mean dust (mg)	0 26	0 27	0 26	0 0145
Std Dev	0 23	0 16	0 01	0 01
%RSD	86 11	57 43	4 02	64 08
Number of replicates	4	4	4	4
% Reduction in dustiness	-4%		1,803%	
	ROACHES TEST		ROACHES TEST	
	DUSTY	DE-DUSTED	DUSTY	DE-DUSTED
Estimated dustiness level	1	4 - 5	2	4

SUMMARY AND CONCLUSIONS

Two series of measurements of airborne dye dust have been made During each series, three variables have been evaluated the ventilation system, the barrel size and the dustiness of the dye To evaluate the ventilation system, the hood was turned on or off Either full or half size barrels were selected for use to test this parameter, and the dye for each series was provided both with and without a de-dusting agent added to investigate the third variable A fourth variable, the dye itself, was tested by using a Crompton and Knowls Azoanthrene Jet Black K Crude for the first series of measurements and using a Dystar Remazon Red RB for the second series

An experienced employee opened and scooped dye with specified dustiness level from full or half barrels, as specified, into brown paper bags, weighing increments on a balance in the hood The hood ventilation was turned on or off as specified by the test parameters for the run in progress The bags were folded and set aside until the drum was empty The test was then stopped (sampling devices were removed) and the dye was returned from the bags back into the drum The drum was replaced by the size and dustiness level required for the next run, and the process was repeated

In the first (February, 1999) series of tests, the use of ventilation was shown to significantly reduce the airborne dust exposure to the worker, producing an 88% decrease Barrel size seemed marginally effective in reducing dust exposure The use of small barrels produced an estimated reduction of 80% when high dustiness dye was used The use of de-dusted dye produced an estimated reduction of about 60% when large barrels were used (The corresponding estimate for small barrels indicated no reduction due to de-dusted dye)

The second (September, 1999) tests confirmed the effectiveness of ventilation in reducing airborne dust levels, and also indicated that the de-dusted dye, used when the ventilation is off, significantly reduced airborne dye concentration by approximately 80% This effect would have been greater but for the one sample (identified as R3 in the September results) which appears to be inconsistent with the others However, no other justification can be developed for regarding this sample as an outlier

The variance in these tests, calculated as the coefficient of variation from duplicate runs using the same control conditions, was 49% and 53% for the February and September tests, respectively When this variance is included in the evaluation of results, it indicates no significant effect from dye dustiness or drum size

There was a difference in the dustiness of the bulk materials as measured by the Heubach tester, the Leith tester, and the Roaches tester The red Dystar material showed a reduction to less than 1% and to about 6% of its original level on being de-dusted when the Heubach and UNC testers were used to evaluate it, and a change in Roaches rating from 2 to 4 The black C&K material showed a reduction to about 17% of its untreated level with the Heubach, the UNC tester showed a significant decrease (from 0 38 to -0 92 mg per test), and the Roaches rating went from a 1 to a 4 - 5 on addition of dust suppression agent These data appear consistent with the airborne measurements but there does not seem to be any way to correlate the two measurements

The small number of total tests and particularly the limited replication are considered to be the primary factor responsible for statistical significance It is recommended that additional tests be conducted to investigate the effects of the dye dustiness or drum size Because the availability of a downdraft ventilation system such as was evaluated during this study is limited, this additional testing would be most appropriately conducted with no such ventilation system