CORRELATION OF TESTS FOR MATERIAL DUSTINESS WITH WORKER EXPOSURE FROM THE BAGGING OF POWDERS

WILLIAM A. HEITBRINK • William F. Todd • Thomas J. Fischbach

National Institute for Occupational Safety and Health, Division of Physical Sciences and Engineering
Engineering Control Technology Branch, 4676 Columbia Parkway
Cincinnati, Ohio 45226, USA

INTRODUCTION

Laboratory dustiness tests have been devised[1] to provide a quick and convenient means of estimating a material's relative dustiness. These tests are empirical in that they do not measure a fundamental property or response of the material being tested. In using these dustiness tests, one assumes that the dust generation in the test simulates the dust generation in an actual powder handling operation. In order to be useful, the results of these tests must be correlated with personal dust exposures. Because this correlation has not been evaluated, NIOSH researchers conducted a study to evaluate the correlation between worker dust exposure and the results of two dustiness tests. The two dustiness test devices are the Heubach Dust Measurement Appliance and the Midwest Research Institute (MRI) tester.[1,2]

This study was conducted in the packaging room for a powdered acrylic resin production line. The plant produced a variety of resins which differ in bulk density, particle size, moisture content, and observed dustiness. The resin powders were auger fed into tuck-in valve bags. The bags were filled with 50 pounds of powder, they were sealed and dropped onto a conveyor belt which transported the bags to a palletizing operation. The operator tended a number of bag packing machines. Several workers rotated between the bagging equipment and the palletizing equipment in an adjacent storage area.

EXPERIMENTAL PROCEDURES

For six different resins, the workers' dust exposures were measured and dustiness tests were conducted on bulk samples of the material to determine if the dust exposures and the dustiness test results were correlated. For each material packaged, exposures to total dust were measured using NIOSH Method 0500.[3] Air samples were collected using personal pumps operated at 3.7 liters per minute. Separate sets of measurements were taken for different workers who rotated through the bagging machine operations. Usually, 4–6 measurements were taken for each powder.

The Heubach unit, depicted in Figure 1, consists of a horizontal rotating drum with internal baffles that produces a repeated dust fall through a regulated airstream. Airborne dust from the drum enters a settling chamber and is then collected on a preweighed glass fiber filter (50 mm, Schleicher and Schull GmbH). The test parameters (mass of material, airflow rate, and total flow) for the Heubach dustiness tester are not unique; they are set for each type of powder tested so that a desirable quantity of dust is collected on the filter. A sample of about 20 grams, a flow rate of 4 liters/minute and a sampling time of 5 minutes were selected as appropriate test conditions for this study site.

In the MRI tester shown in Figure 2, powder is poured out of a metal beaker in an enclosed space and the resulting air-

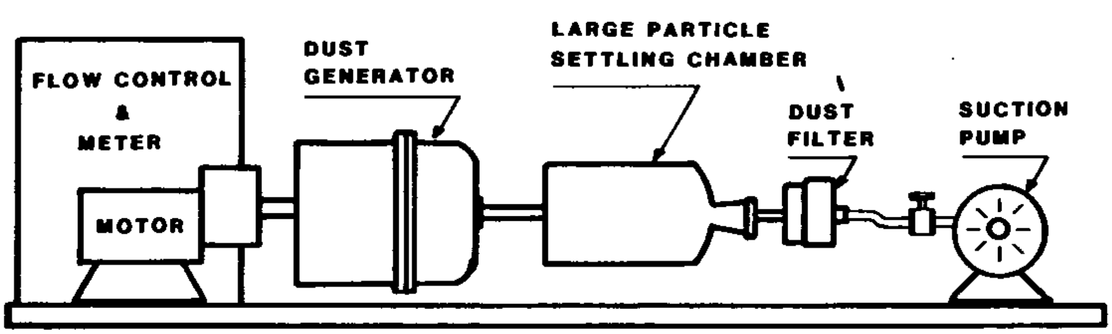

Figure 1. Heubach dustiness tester.

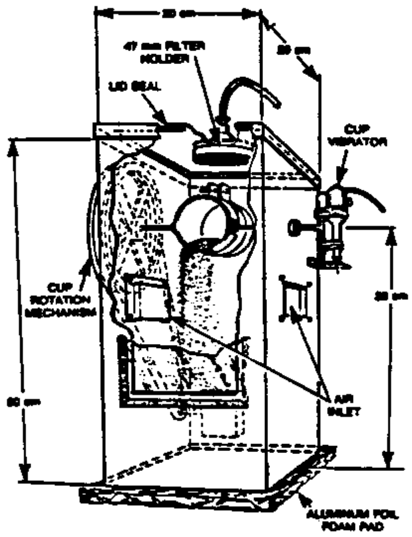

Figure 2. MRI dustiness tester.

borne dust is collected on a preweighed filter (47 mm glass fiber Gelman type AE) at a rate of 10.8 liters per minute. The cup was rotated at a constant speed to dump the powder. A vibrator mounted to the cup shaft helps to dislodge the dust. The sample pump was run for 10 minutes after the rotation of the cup was initiated. The MRI dustiness index was computed from the following formula: Dustiness Index = Dust collected (mg)/((Sample Weight [Kg])(Flow rate [1 pm])).

RESULTS

The personal dust exposure data and the dustiness test indices were fit to a regression model of the following form: in (X) = a + b (Y). In this model, the terms "a" and "b" are the regression coefficients, the term "X" is the individual dust exposure, and the term "Y" is the average dustiness index for a material. For both the MRI and Heubach dustiness test indices, a significant correlation was found between MRI and Heubach dustiness test results and worker dust exposures. Statistical results for the analyses are listed in Table I. In Figures 3 and 4, the exposure data, the predicted worker dust exposure, and the 95% prediction intervals for individual dust exposures are plotted as a function of dustiness test results. The prediction intervals include 95% of the exposures which would be predicted from the regression model.[4] The prediction interval width is proportional to the standard error of estimate (S_e), which is essentially the standard deviation about the regression line. It is the result of two sources of error: (1) the lack of fit of the model to the data; and (2) the sampling error in measuring the dust exposure. The significance of the lst source of error was evaluated using the method described by Mendenhall.[4] This method tests whether the error caused by the lack of fit is larger than the sampling error. The significance of this difference is stated as "the-significance level for lack of fit" in Table I. This indicates that the correlation between the MRI dustiness test and the worker dust exposure involves a significant lack of fit. Apparently, this source of error causes the wider prediction intervals for the MRI dustiness tester. For the Heubach dustiness test, the lack of fit was not significant. This means that the width of the prediction interval is caused by the variability in the workers' exposure data. Thus, the prediction intervals in Figure 3 cannot become much smaller.

DISCUSSION AND CONCLUSION

The preceding regression analysis shows that dustiness test results were correlated with worker dust exposure and can be used to predict worker dust exposure to within an order of magnitude. The width of the prediction interval about the regression lines was largely caused by the variability in the worker dust exposures and the width of this prediction cannot become mucb smaller. The correlations between worker dust exposure and dustiness test results are totally empirical and the results of the regression analysis must be used care-

Table I
Evaluation of Exposure Models

Statistical terms	Heubach	MRI
intercept (a)	-0.5	-0.1
slope (b)	10	0.09
Probability of a larger F	<0.0001	<0.0001
R^2	0.59	0.45
s_e	0.75	0.86
significance level for lack of fit test (Probability of a larger F)	0.28	0.013

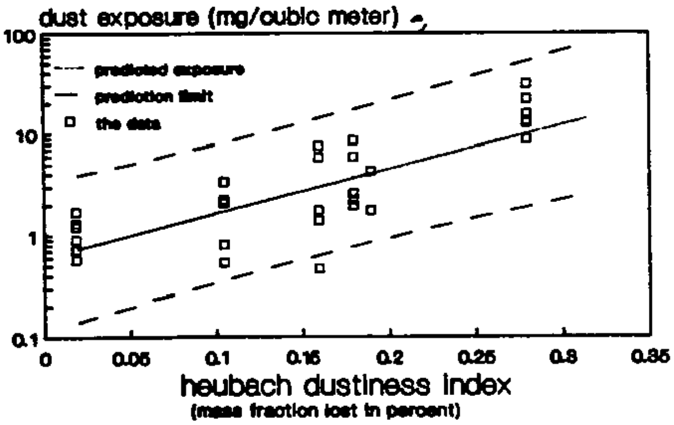

Figure 3. Predicted dust exposure, and prediction intervals plotted as a function of weight % lost, Heubach test.

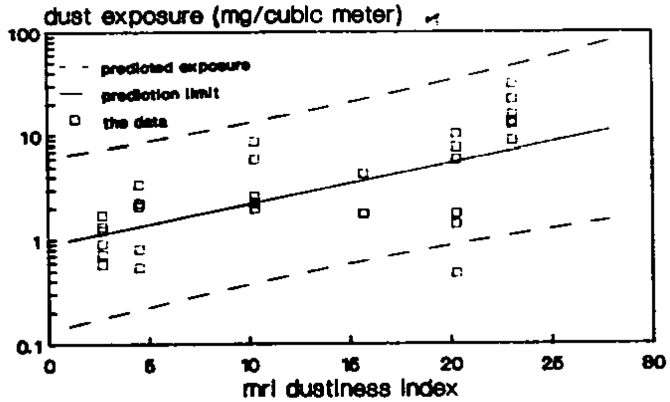

Figure 4. Predicted dust exposure, and prediction intervals as a function of MRI Dustiness Index.

fully. The regression equations present in this paper are useful only to the extent that conditions at this plant at the time of this study are duplicated. If conditions at the plant change, the correlation will change.

The fact that a significant correlation between dust exposures and dustiness test results was observed in an actual plant shows that addressing material dustiness is important in predicting and controlling worker dust exposure. It also suggests that significant correlations may be present at other plants and other processes. As a result of this, dustiness testers can presently be used to do predictive industrial hygiene (the estimation of exposures before they occur). For example, suppose a new product is being considered for production in a process or an operation where two or more different materials are being used. For this process or operation, one can develop a correlation between dustiness tester results and dust exposure. The correlation and dustiness test results from a small sample of this new material could be used to predict the dust exposures to within an order of magnitude. This could allow one to make dust control recommendations before the new product is produced or used on an industrial scale.

Presently, dustiness testers are empirical tests which are used to simulate the formation of airborne dust during powder handling operations. Unfortunately, the mechanism of aerosol generation during operations such as bag dumping is not well understood in terms of the identity and magnitude of the forces which affect dust generation. An improved fundamental understanding of airborne dust generation by powder handling operations would allow one to select and devise dustiness tests which closely simulate the actual process which generates the airborne dust.

REFERENCES

1. Midwest Research Institute. 1986. *Exposure to Particulate When Handling Small Volumes*. EPA Prime Contract No 68-02-4252. U.S. Environmental Protection Agency, Office of Pesticides and Toxic Substances. Washington, D.C.
2. Heubach Inc. *Heubach Dust Measuring Appliance*. Heubach Avenue, Newark, New Jersey.
3. National Institute for Occupational Safety and Health. 1985. Nuisance Dust, Total Method 0500. In: *NIOSH Manual of Analytical Methods*, 3 ed. NIOSH Publication 84-100. Cincinnati, Ohio.
4. Mendenhall W. 1968. *Introduction to Linear Models and the Design and Analysis of Experiments*. Dusbury Press. Belmont California.

Note: A more complete version of this paper has been submitted to *Applied Industrial Hygiene*.

Proceedings of the VIIth International Pneumoconioses Conference — Part I
Transactions de la VIIe Conférence Internationale sur les Pneumoconioses — Tome I
Transaciones de la VIIa Conferencia Internacional sobre las Neumoconiosis — Parte I

NIOSH - ILO

Pittsburgh 1988

BOM - MSHA - OSHA

Pittsburgh, Pennsylvania, USA—August 23-26, 1988
Pittsburgh, Pennsylvanie, Etats-Unis—23-26 aout 1988
Pittsburgh, Pennsylvania EE. UU—23-26 de agosto de 1988

DEPARTMENT OF HEALTH & HUMAN SERVICES-USA

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

CDC
CENTERS FOR DISEASE CONTROL

Sponsors

International Labour Office (ILO)
National Institute for Occupational Safety and Health (NIOSH)
Mine Safety and Health Administration (MSHA)
Occupational Safety and Health Administration (OSHA)
Bureau of Mines (BOM)

September 1990

DISCLAIMER

Sponsorship of this conference and these proceedings by the sponsoring organizations does not constitute endorsement of the views expressed or recommendation for the use of any commercial product, commodity, or service mentioned.

The opinions and conclusions expressed herein are those of the authors and not the sponsoring organizations.

DHHS (NIOSH) Publication No. 90-108 Part I