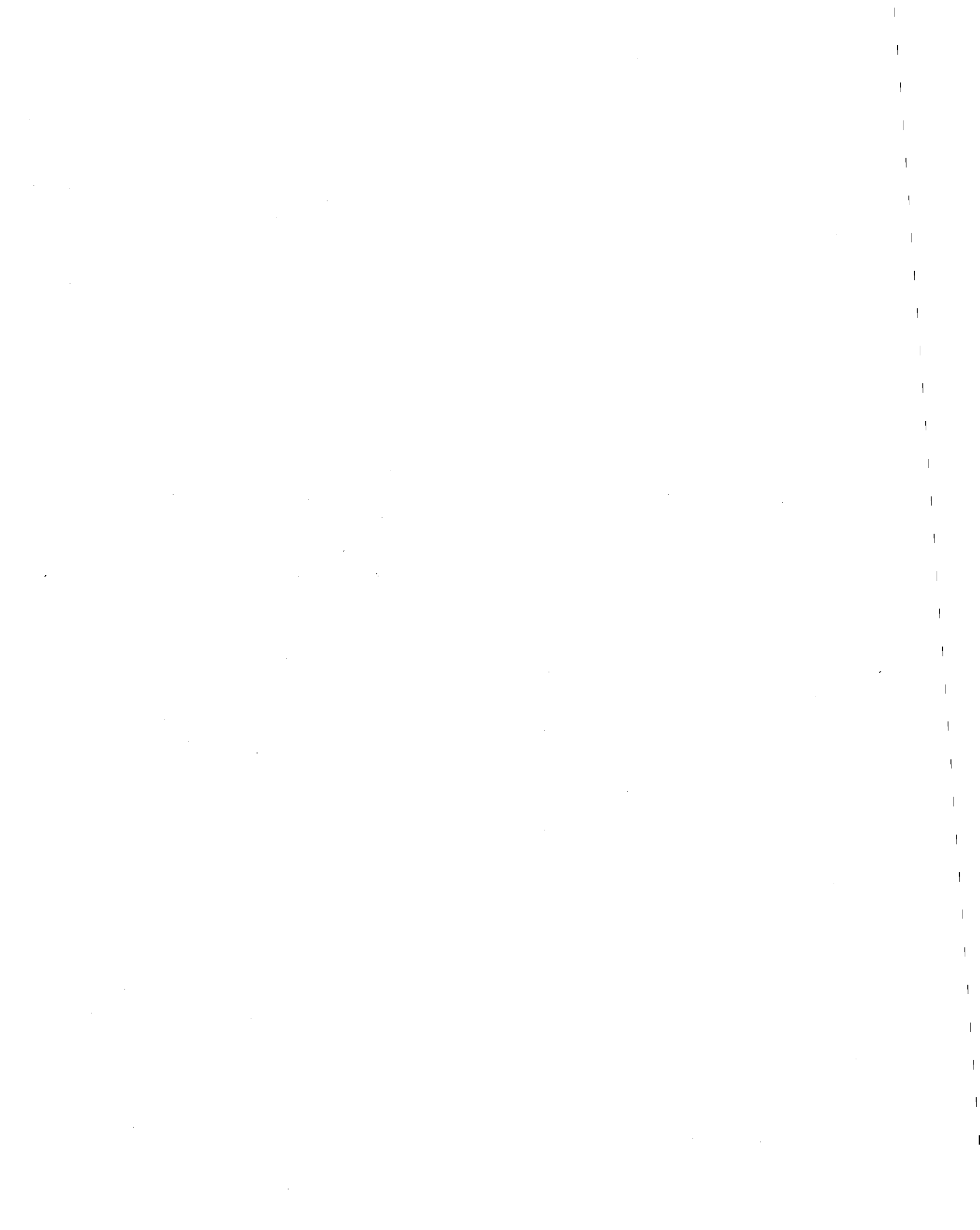




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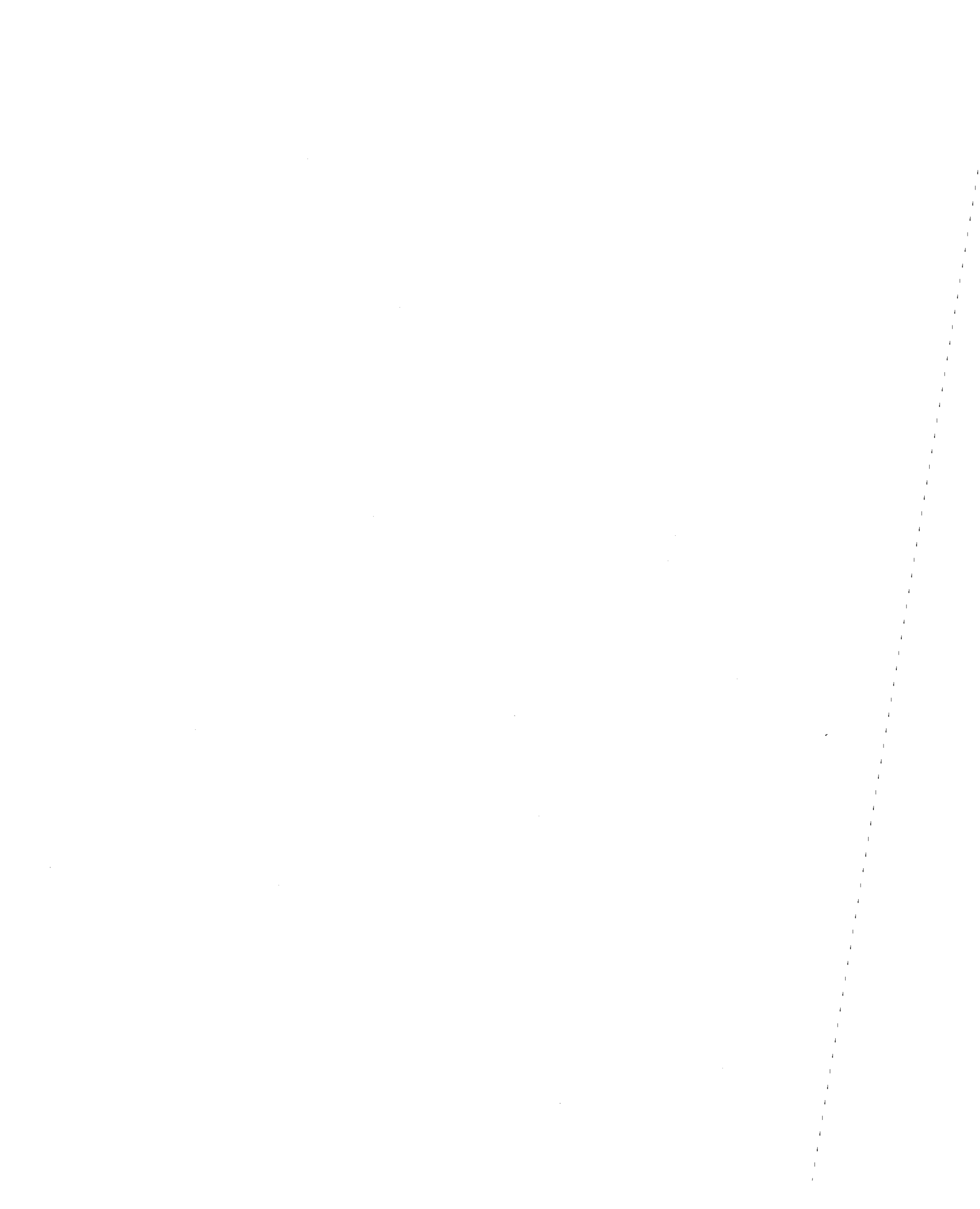
Exposure Estimation Procedure for Powder Handling Operations
Based on Dustiness Testing

November, 1989

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In order to evaluate the dust exposure potential of powders undergoing a Premanufacturing Notice (PMN) review, a dustiness test result may be an indication of a material's dustiness. Because the facilities used to produce these powders may not have been built, conventional industrial hygiene techniques can not be used to evaluate potential worker dust exposures. A correlation between dust exposures and the Midwest Research Institute (MRI) dustiness test was evaluated for use in estimating the dust exposure potential of these new powders undergoing PMN review. The MRI dustiness test is pictured in Figure 1 and the test is described by Cowherd et al.¹ The MRI dustiness test is relatively simple. The metal beaker pictured in Figure 1 is filled level with powder. The beaker is rotated to an upside down position and the powder falls out of the beaker. The resulting airborne dust is collected on a filter which is mounted in the lid of the tester. Dustiness is the milligrams of dust collected on the filter per kilogram of material tested.

The exposure estimation procedure is based upon dustiness test results because it is too difficult to estimate from physical parameters. During one of the field studies, a regression model developed by Midwest Research Institute was used to predict the MRI index from the physical properties supplied by the company.^{1,2} There was no relation between the predicted and observed MRI Index.

The data for this correlation were obtained at one bag filling operation at a plastic resin plant and at a bag filling and bag packing operation at a lead chromate plant. The data are available in individual survey reports^{2,3}.

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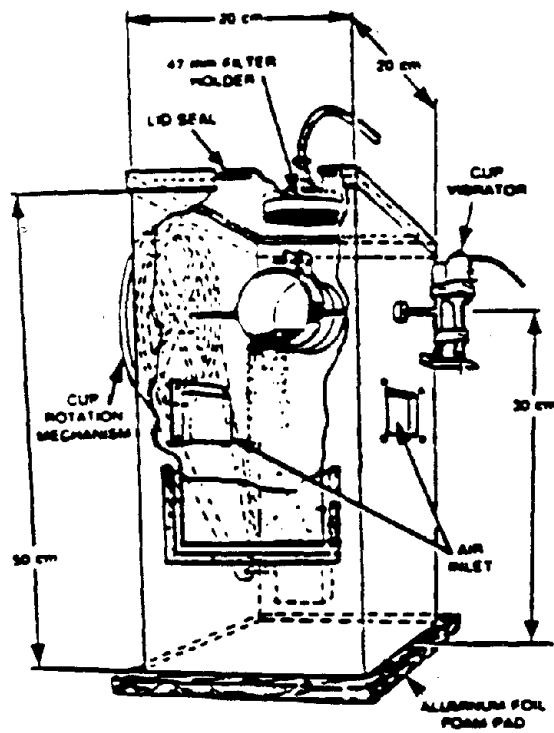


Figure 1. Schematic of MRI dustiness tester.

The findings of the individual field surveys and the laboratory evaluation of the dustiness testers are summarized in two articles, which are in press at the American Industrial Hygiene Association Journal.^{4,5} During these field studies, NIOSH researchers evaluated the correlation between worker dust exposure and dustiness as measured by the MRI and Heubach dustiness tests. Because the test parameters of the Heubach dustiness test varied among the study sites, the correlation between all the Heubach dustiness test results and all of the personal dust exposure measurements was not evaluated. The conditions of the MRI test were not altered during the NIOSH field studies.

Regression analysis was used to develop a model relating the MRI dustiness index to worker dust exposure. The MRI dustiness test data and the worker exposure data were combined into a single data set which contains 75 data points. (One data point was excluded from the analysis because the worker's exposure was less than area air sampling results). Regression analysis was used to fit the data to a model of the following form:

$$\ln(C) = a + b (M) \quad (1)$$

Where:

- a, b - regression coefficients,
- M - MRI dustiness Index (mg/Kg), and
- C - Worker dust exposure (mg/m³).

The resulting regression model, expressed directly in terms of worker dust exposure, C, and MRI dustiness test result, M, is presented below:

$$C = 0.82e^{0.0086M} \quad (2)$$

This model has an R^2 of 0.5 and is significant at a level of confidence greater than 0.0001. The value of R^2 is the fraction of the variability explained by a regression model. The level of confidence is the probability of a regression model fitting the data by chance when in fact there is no relationship. Figure 2 illustrates the relationship between worker dust exposure and MRI dustiness test results for all of the data. When the MRI dustiness index increases above 30, worker dust exposure increases noticeably. This occurs because the exposure data for a MRI index of less than 20 were obtained at the lead chromate production plant. At this plant, there was no relationship between worker exposure to lead chromate and dustiness test results. As discussed elsewhere, the reason for this is unclear. Possibly, dust exposure may be affected by other more important factors such as work practices and variations due to the operation of equipment. An additional possibility is that dust generation in the dustiness testers does not adequately simulate dust generation in the processes under study.

Figure 2 contains prediction limits about the predicted exposure. Based upon statistical theory, 95 percent of the predicted exposures should be within these limits. These prediction limits illustrate that, when the MRI index exceeds 100, a significant number of workers will be exposed to concentrations

dust exposure vrs mri index
combined data

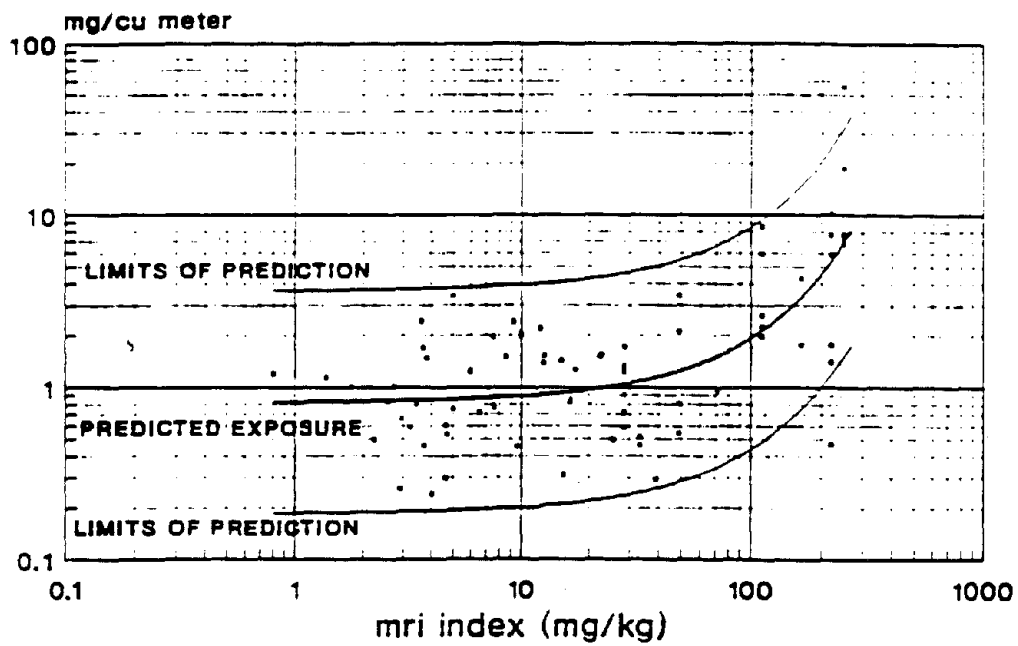


Figure 2. Exposure as a function of MRI Index. Included in this plot are the predicted exposure and the 95% prediction limits about this exposure.

in excess of 10 mg/m^3 , which is the current OSHA standard for total dust⁶. A personal dust exposure of 10 mg/m^3 is excessive. Also, the available information suggests that reducing the dustiness below about 30, as measured by the MRI dustiness index, does not result in a further reduction in worker dust exposure. Based on this correlation, the following exposure prediction logic is proposed:

Table 1.
Exposure Estimation Logic

MRI INDEX (mg/kg)	HEUBACH TEST RESULT ^a (% COLLECTED ON FILTER)	MAXIMUM PREDICTED EXPOSURE ^b (mg/m ³)
<20	<0.05	< 5
20-100	0.05 - 0.15	5-10
>100	>0.15	>10

Note: a. The Heubach test was conducted as described in reference 2. This test was conducted at a flow rate of 4 lpm and mass of 20 grams.

b. The maximum predicted exposure is based upon the upper limit of prediction. In order to be in compliance with OSHA standards, a worker's dust exposure must always be below the level specified by the standard. Based upon regression statistics, the probability of an exposure measurement being less than the stated value is 0.975. This can be stated in common, everyday language: "Generally, the workers dust exposure will be less than the value stated in the table."

In using this correlation, there is a need to understand the limitations of models developed from regression analysis. Unlike deterministic equations such as Newton's law, Bier's law or the ideal gas law; regression models do not have an a priori form. The form of the model is chosen because it appears to fit the data. The coefficients for the correlation (regression equation) are chosen to minimize the standard deviation about the regression line. If data had been obtained under different circumstances, a different correlation could occur.

In spite of these concerns, the PMN reviewer needs to estimate worker dust exposure based upon dustiness test results. For plants with reasonable engineering controls and process equipment, the logic presented in Table 1 will probably lead to overestimates of worker dust exposures.

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