AN EVALUATION OF CONTROL TECHNOLOGY FOR BAG OPENING, EMPTYING AND DISPOSAL-

"THE SELF CONTAINED FILTER/ BAG DUMP STATION"
MANUFACTURED BY

THE YOUNG INDUSTRIES INC., Muncy, Pa. 17756

REPORT WRITTEN BY:

William Heitbrink
William McKinnery
and
Ralph Rust

REPORT DATE: NOVEMBER 1983

REPORT NO.:

144-19

NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH
Division of Physical Sciences and Engineering
Engineering Control Technology Branch
4676 Columbia Parkway
Cincinnati, Ohio 45226

TEST SITE: The Young Industries, Inc.
Muncy, Pa. 17756

SURVEY DATE: August 2-3, 1983

SURVEY CONDUCTED BY: Mr. William N. McKinnery, Jr.
Dr. Jerry Smith and Mr. Ralph Rust

EMPLOYER REPRESENTATIVES CONTACTED: Mr. Harry Smith, Manager Dust Control Division,
Phone (717) 546-3165

NOTE: Mention of product name does not constitute an endorsement by the U.S. Public Health Service.

ABSTRACT

Opening, emptying, and disposing of bags containing powdered chemicals can be a serious source of worker dust exposure. A bag dump station manufactured by Young Industries appears to address dust control during bag opening, emptying and disposal. This device is marketed as "A Self Contained Filter/Bag Dump Station." Once the bag is placed inside the dump station's enclosure, a built in ventilation system controls dust generated by opening and emptying bags of chemicals. The empty bags are pushed into a trash compactor which is part of the dump stations enclosure. This arrangement minimizes dust exposure from handling empty bags. The built-in ventilation system includes a bag house which removes dust before discharging the cleaned air into the work place.

Real-Time Aerosol Monitors ™ were used to monitor respirable dust concentrations while the workers emptied bags of crushed limestone into the dump station. Respirable dust concentrations were monitored in the worker's breathing zone, at the point where cleaned air is discharged back into the work place, and away from the work place. These concentration measurements were made while the ventilation system was on and off and with two different types of bag house filters. The two types of filters were a polyester filter and a Gortex-lined, polyester filter.

With the ventilation system on, respirable dust concentration measured in the worker's breathing zone only increased by 0.01 mg/m^3 from an initial concentration 0.1 mg/m^3. When the ventilation system was off, the respirable dust concentration increased from 0.1 mg/m^3 to 0.62 mg/m^3 during bag dumping activities. This shows that the dump station does provide dust control.

The outlet of the bag house can be an emission source. When the standard 14 oz polyester filters were installed in the bag house, the respirable dust concentration increased from 0.1 to 0.14 mg/m^3 during bag dumping. No such increase was noted with the use of Gortex-lined filters.

I. INTRODUCTION

BACKGROUND FOR CONTROL TECHNOLOGY STUDIES

The National Institute for Occupational Safety and Health (NIOSH) is the primary Federal agency engaged in occupational safety and health research. Located in the Department of Health and Human Services (formerly DHEW), it was established by the Occupational Safety and Health Act of 1970. This legislation mandated NIOSH to conduct research and education programs separate from the standard setting and enforcement functions carried out by the Occupational Safety and Health Administration (OSHA) in the Department of Labor. An important area of NIOSH research deals with methods for controlling occupational exposure to potential chemical and physical hazards. The Engineering Control Technology Branch (ECTB) of the Division of Physical Sciences and Engineering has been given the lead within NIOSH to study the engineering aspects of health hazard prevention and control.

Since 1976, ECTB has conducted a number of assessments of health hazard control technology on the basis of industry, common industrial process, or specific control techniques. Examples of these completed studies include the foundry industry; various chemical manufacturing or processing operations; spray painting; and the recirculation of exhaust air. The objective of each of these studies has been to document and evaluate effective control techniques for potential health hazards in the industry or process of interest, and to create a more general awareness of the need for or availability of an effective system of hazard control measures.

These studies involve a number of phases. Initially, several walk-through surveys are conducted to select plants or processes with effective and potentially transferable control concepts or techniques. Next, in-depth surveys are conducted to determine both the control parameters and the effectiveness of these controls. The reports from these in-depth surveys are then used as a basis for preparing technical reports and journal articles on effective hazard control measures. Ultimately, the information from these research activities builds the data base of publicly available information on hazard control techniques for use by health professionals who are responsible for preventing occupational illness and injury.

Background for Bag Opening, Emptying And Dumping

Bags are a common container for the transport for industrial chemicals and minerals. Bag opening and associated operations are labor intensive and offer significant potential for occupational exposure to a wide variety of dusts. Although successful methods of dust control may exist, there is presently no publicly available, centralized information base which allows the effectiveness of various control techniques to be compared. In fact, there is no, publicly available, centralized information base at all on hazard control techniques.

Several studies have revealed that the handling of dry material is an important source of airborne dust generation in the workplace.[1,2,3,4] The problem of dust dispersion during material handling spans many industries and can be a major source of chemical exposure. Although the number of people involved in these operations cannot be precisely determined, it is estimated that the number is in the millions.

Some companies are already employing effective measures to reduce worker exposures. The challenge is to find these applications and evaluate their operation. In some cases, less expensive and/or more effective methods may be available. In still other situations, no engineering controls may be used and, in some instances, none may be needed. The results of this study should provide guidelines which will allow dust control considerations to be based upon experimentally determined facts and upon the pooled experience of others. These guidelines will present useful alternatives rather than specifying a single way to control a specific operation.

Several recent ECTB projects have studied bag opening and dumping stations. In the tire manufacturing industry, three of these stations were studied.[1] The worker opened the bag and emptied it in an enclosure. The empty bag was either set in a dumpster or placed in a bag disposal system. Although local exhaust ventilation could control the dust generated by emptying bags, the dust generated by bag disposal was not controlled and was a significant source of worker exposure.

During a study of the pesticides industry, an automatic bag opening machine was studied.[2] The dust concentrations around this machine were of the same magnitude as those found at the manual dumping stations studied by NIOSH in the tire industry, about 3 mg/m^3. Whether this was due to background contamination, production rates, the performance of the controls used in that particular bag opener, or other factors is unclear.

First and Love studied a manual bag opening station that greatly reduced worker exposure to asbestos.[3] At this station, the workers stood outside of a booth and opened a bag inside the booth. After emptying the bag, the worker placed it in a disposal bag. The booth's face velocity was 200 feet per minute and the asbestos exposures were below 0.1 fibers/cc.

These studies led to the review of bag opening, dumping, and disposal on a wider basis. Our review revealed that bag opening, emptying, and disposal is a common problem in many industries. Much of the equipment used in these operations has been developed in the last five years and there has been no review of its effectiveness in terms of dust control. Based on NIOSH experience, there is a need to evaluate and document the existing methods for controlling dust generated by bag opening, emptying, and disposal.

Some literature exists describing how solid material flow properties affect equipment selection. Johanson[5] has reviewed the basic flow properties of solids. These flow properties vary with different materials. They also appear to change significantly for the same material with changes in moisture content and consolidating pressure. Thus the flow properties may be a function of the past history of a given bag of material as well as the intrinsic physical properties of the material. These properties have a direct impact on the performance of both manual and automatic bag opening, emptying, and disposal equipment.

The equipment manufacturers' literature and the preliminary surveys show that there are two types of equipment commercially available for bag opening, emptying, and disposal.[6]

1. Automatic equipment - This equipment opens, empties, and disposes of bags in such a way that the workers are intended to be completely isolated from any dust that might be generated. In most cases the worker loads the bags on a conveyor which feeds directly into the mouth of the bag opener. The bag is opened inside the machine by a rotating knife and the bag is tumbled to release the material which falls into a chute. The bag is then pushed into an enclosure of some type.

2. Manual dump stations - A manual dump station may be as simple as an open bin with a ledge or it may be as complex as an enclosed, ventilated bin with provisions for air cleaning and bag disposal. Most dump stations only provide dust control during bag dumping. A few units provide dust control during bag opening, emptying, and disposal. In using these units, the worker places the bag in or on the unit and slits it with a knife, dumps the bag into a chute, and shakes the bag to remove any residual material. Following the removal of the material the worker may place the bag into a disposal unit inside the manual dump station, place it in a disposal unit outside the dump station, or just throw it on the floor to be picked up by the cleaning staff.

There are approximately ten (10) major manufacturers of bag opening equipment. Most of them claim that their products can be used for a wide variety of products. Such claims appear to be based upon bag opening tests conducted in the manufacturer's facilities by companies who want to purchase the equipment. The results of these tests are not usually given to the manufacturer. The manufacturer can only judge the results of the test based on whether or not they sell the equipment.

Principles of Air Containment Control In the Workplace

Occupational exposures can be controlled by the application of a number of well-known principles, including engineering measures, work practices, personal protection, administrative measures, and monitoring. These principles may be applied at or near the hazard source, to the general workplace environment, or at the point of occupational exposure to individuals. Controls applied at the source of the hazard, including engineering measures (process/equipment modification, isolation or automation, local ventilation) and work practices, are generally the preferred and most effective means of control both in terms of occupational and environmental concerns. Controls which may be applied to hazards that have escaped into the workplace environment include dilution ventilation, dust suppression, and housekeeping. Control measures may also be applied near individual workers, including the use of remote control rooms, isolation booths, supplied-air cabs, work practices, and personal protective equipment.

In general, a system comprised of all of the above control measures is required to provide worker protection under normal operating conditions as well as under conditions of process upset, failure and/or maintenance. Process and workplace monitoring devices, personal exposure monitoring, and medical monitoring are important mechanisms for providing feedback concerning effectiveness of the controls in use. Ongoing (scheduled) monitoring and maintenance of controls to insure proper use and operating conditions, and the education and commitment of both workers and management to occupational health are also important ingredients of a complete, effective, and control system.

These principles of control apply to all situations, but their optimum application varies from case-to-case. The application of these principles for The Young Industries, Inc. bag opener is discussed below.

The Young Industries' Dustless Bag Dump Station As a Control For Dust

The Young Industries' Dustless Bag Dump Station was selected for study because it addresses all of the emission sources mentioned above. As shown in Figures 1-4, the bags are opened and emptied in a ventilated enclosure which contains the dust. The empty bags are fed through a chute in the side of the enclosure into a ventilated trash compactor. At the opening of the dump station, a face velocity of 136 fpm is intended to keep dust from entering the workroom air. The design of the bag disposal chute and the ventilation of the trash compactor should keep dust generated by bag disposal from escaping the enclosure. This bag dump station has its own ventilation system. The system consists of a fan, a bag house, and a silencing plenum. The fan draws 1200cfm of air through the enclosure and passes the contaminated air through a bag house mounted on the back of the unit. The air is discharged toward the ceiling. The bag house is normally supplied with 8, fourteen ounce polyester felt fiber filters. These filters are mounted on a wire retainer which is clamped in position.

According to the commercial literature, this clamping system provides a positive seal by compressing the cloth flange on the filter bag between the wall of the plenum and the wire supports. This is illustrated in Figure 5. Periodic pulses of air clean the material off the bags.

The use and operation of this bag dump station is straightforward:

1. The bag is set in the enclosure.

2. The bag is slit and emptied.

3 The empty bag is placed through a chute into a ventilated trash compactor.

4. The powdered material flows into a conveying system.

5. The airborne dust is controlled by drawing air through the partial enclosure shown in Figure 1. This air is either recirculated through the bag house into the work place or removed from the occupational environment entirely by a local exhaust ventilation system vented to the outdoors.

According to Mr. Smith, this device is a custom engineered product. The dump station with the ventilation system and bag house can be obtained for as little as $4500. The built in compactor costs $5200. These prices include modifications to suit customer needs.

II. MEASUREMENT OF CONTROL PARAMETERS

At the Young Industries facility one Filter/Bag Dump Station was studied. The effectiveness of the control methods for airborne respirable dust were evaluated quantitatively by monitoring respirable dust concentrations and taking ventilation measurements.

Atmospheric Dust Measurements - Instruments which monitor respirable dust concentrations were used to experimentally evaluate the extent to which this Dustless Bag Dumpstation controls a worker's dust exposure during bag opening, emptying, and disposal. The experimental techniques and study hypothesis are described latter.

Ventilation Measurements - Ventilation measurements were taken in the exhaust duct to determine airflow. Air velocity measurements using a hot wire anemometer were taken at the hood opening where emissions of respirable dust into the ambient air were likely. The in-duct measurements were compared, where possible, between the designed values and the actual performance. Personal, source, and area sampling for respirable dust were performed along with the ventilation measurements to determine, if the dust was being controlled.

The equipment used to make these measurements is listed in Table 1. The results of ventilation measurements are presented in Table 2. these measurements show that the unit's ventilation is operating at design values.

Table 1
Equipment Used in the Study.

Item	Model	Used for
Air-Sampling:		
Real Time	GCA Model 1	Evaluation of respirable dust
Aerosol	GCA Model 1	levels in real time.
Monitors	GCA Model S	
Data Recording		
Strip Chart Recorders	Hewlett Packard Model: H01-680	Recording real time data from RAMS.
Air Velocity Measurements:		
Air Vel. Meter	TSI Model 1650	Ventilation measurements
Air Vel. Meter	Kurz Model 441	Ventilation measurements

Table 2.
Ventilation Measurements

Measurement or Computation	Value
1. Face velocity into 43 3/4 x 29" inlet	100-120 feet per minute(fpm)
2. Computed volumetric flow rate into 43 3/4 x 29" inlet 1100 cubic feet per minute(cfm)	
3. Average velocity along center line of air plenum outlet	1950 fpm
4. Computed air flow out of air plenum outlet	1300 cfm
5. Average air velocity into opening for the trash hopper. The 43 3/4 x 29" opening is closed.	240 cfm
6. Computed flow rate through trash compactor	760 cfm

Test material. Crushed limestone was used to evaluate the bag dump station's ability to control dust generated by opening, emptying and disposing of bags of powdered material. This limestone is marketed as Camel White by Genstar Stone Products Company of Hunt Valley, Maryland. The physical properties of this material reported by Genstar are in the appendix.

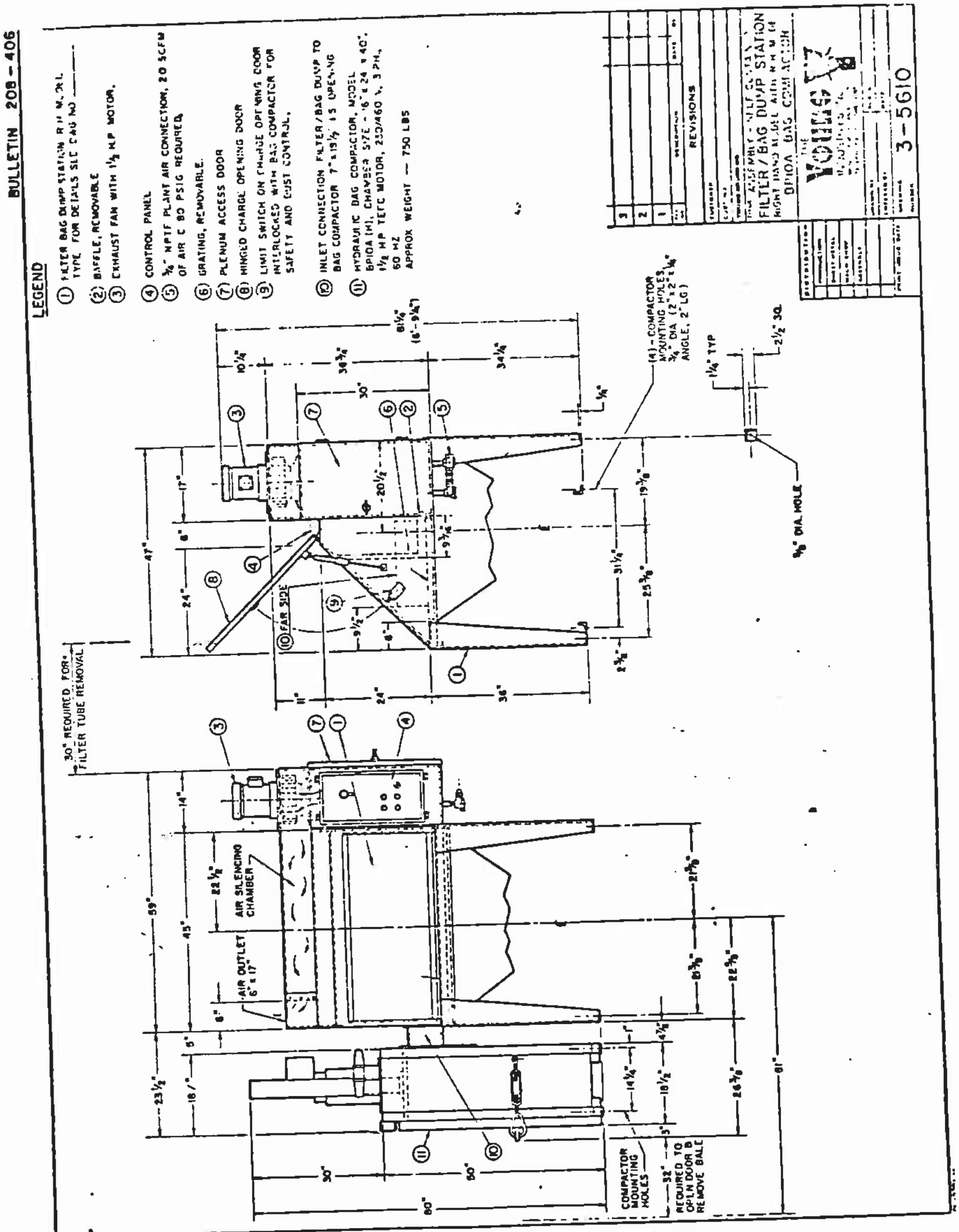


FIGURE 1

Engineering Drawing of Filter/Bag Dump Station[7]
(Courtesy of The Young Industries, Inc.)

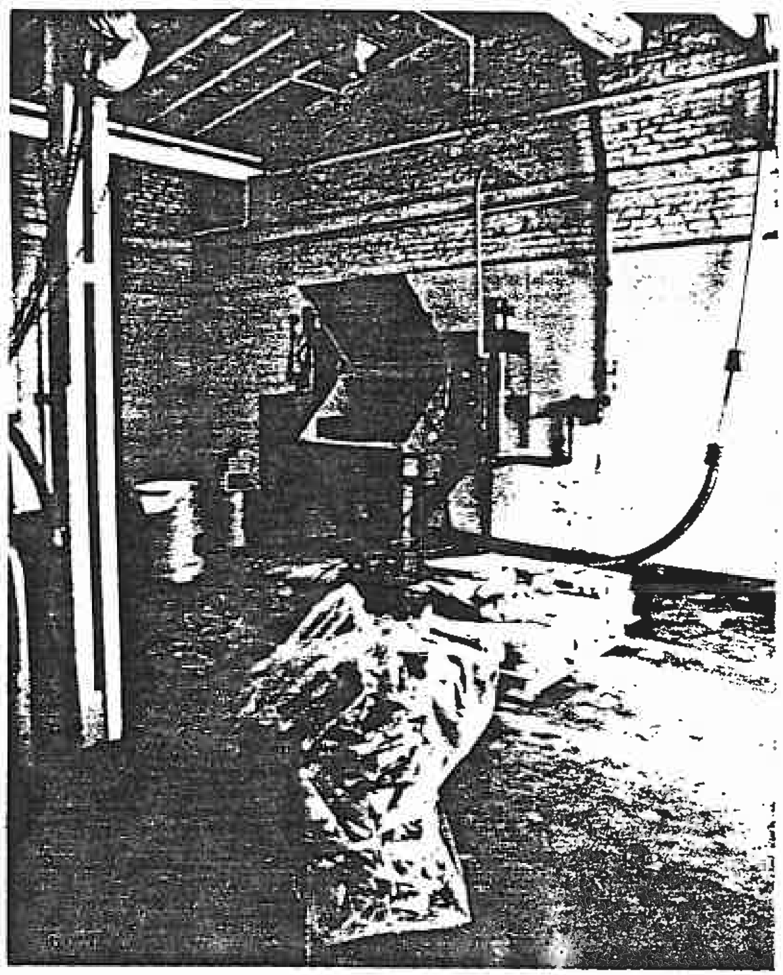


Figure 2

Photograph of Filter/Bag Dump Station Used for Test

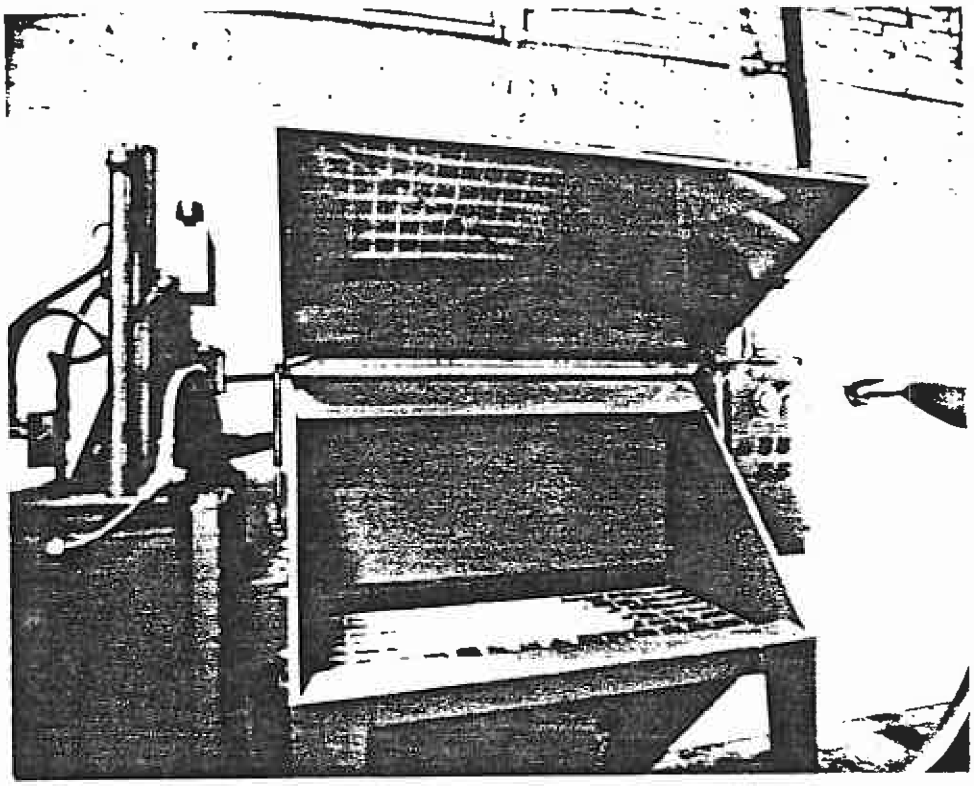


Figure 3

Photograph of Filter/Bag Dump Station Enclosure

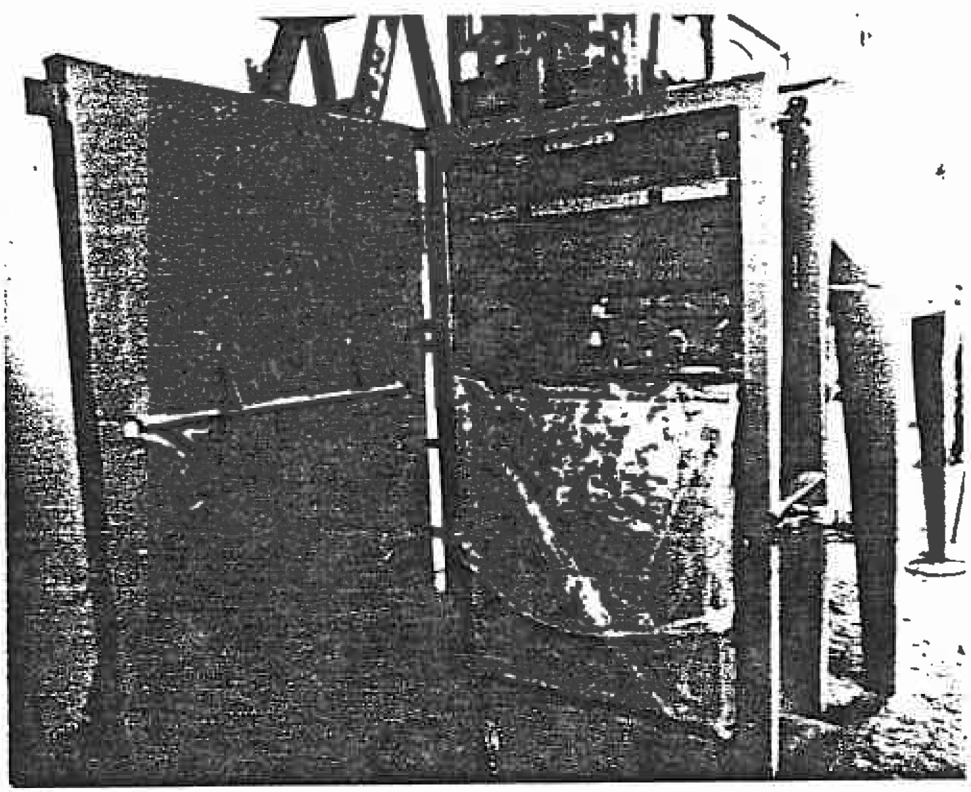


Figure 4

Photograph of Filter/Bag Dump Trash Compactor

III. EXPERIMENTAL PROCEDURES

At the Young Industries' plant in Muncy, Pennsylvania, a laboratory type study was conducted to evaluate this bag dump station. The ability of this device to control the dust from bag opening, emptying and disposal was studied. To conduct the study, a worker emptied a number of bags of crushed limestone in the Young Industries' dump station, and the respirable dust concentration was measured near the worker (C_w), at the baghouse outlet (C_o), and away from the dump station (C_{bag}) which will also be called background concentration.

If the dumpstation is to be considered an effective control, the worker's exposure and the dust concentration measured at the bag house outlet will not be elevated. The respirable dust concentration measurements are used to test a null hypothesis against an alternative hypothesis:

H_o C_w and C_o are not higher than C_{bag} which should reflect ambient air concentrations.

H_a: $C_{bag} < C_o$ or $C_{bag} < C_w$.

Furthermore, C_{bag}, C_w, and C_o should not increase when bags are being opened, emptied, and discarded.

Such hypotheses can be used to quantitatively evaluate deviations from "ideality". Statistic can be used to evaluate the significance of these deviations, however, judgmentt is needed to evaluate the importance of such deviations.

The concentration measurements were made by using two GCA RAM-1's and a GCA RAM-S.[8,9] These devices use light scattering techniques to measure respirable dust concentrations. The output of these devices was measured using strip chart recorders. The strip chart recorders were started shortly before the bags were opened and stopped after the dust concentration returned to background levels. Less than 3 minutes were required for each bag that was emptied.

Dust monitors which use forward-scattered light can precisely monitor respirable dust concentrations. The instrument's manufacturer claims that the instruments precision is better than 0.1 % full-scale. Calibration curves generally have correlation coefficients better than 99%[10]. However, the instruments calibration does depend upon the aerosol. Rubow and Marple[10] noted that for two coal dust test aerosols, there was a 20% difference in the slope of a calibration curve. This study bases conclusions upon measuring concentration difference to determine what increases concentration. So long as the bag opening operation does not change the optical properties of the dust, the slope of the calibration curve will not change and the study's ability to detect concentration differences will be unaffected.

The experimental design used to take the concentration measurements followed a 3 X 3 X 2 factorial experiment (ie., 2 factors with 3 levels and 1 factor with two levels) with six replications. The effects of three factors were studied. This first factor with three levels was the different sampling LOCATIONS. The second factor with three levels was the INSTRUMENT used. The factor with two levels was the TYPE OF SAMPLE, initial measurement before dumping or measurement during dumping.

Instrument effects were included in the experimental design to prevent a slight difference in the response of each instrument from, affecting the study's conclusion. Therefore, this experimental design involved rotating the instruments through the different locations. For each bag that was opened, the concentrations before and during bag opening were measured. A total of eighteen bags were emptied. After every third bag, the instruments wererotated to a new location. Figure 6 illustrates the layout of the room where the testing was done and also shows the locations where samples were collected.

Additional Experiments

After conducting this first experiment, a number of additional experiments were conducted. The first experiment suggested that the baghouse outlet was a significant source of air contamination and that the instrument did not greatly affect the concentration measurements. As a result a second test was conducted. Before this test was conducted, the standard 14 oz polyester bags were replaced with 12 oz polyester bags with a Gortex™ membrane liner. Concentrations were measured at the same locations used during the first test. The instruments were not rotated through the different sampling locations. The Concentrations were measured during three trials. During the first two trials, one bag was emptied per trial. During the third trial, five bags were emptied.

After the first two experiments were conducted, a third experiment was conducted. For the sake of comparison, the ventilation system was turned off and eight bags were emptied. This experiment was performed to determine the dust concentrations when the ventilation was off and there is no attempt to control the dust generated.

Data Collections Methods

From the strip chart recordings, the initial concentration and an average concentration during bag opening, emptying and disposal was obtained. The initial concentration was obtained from the distance between the electrical zero and the instrument response on the strip chart paper. The initial concentration was computed as follows:

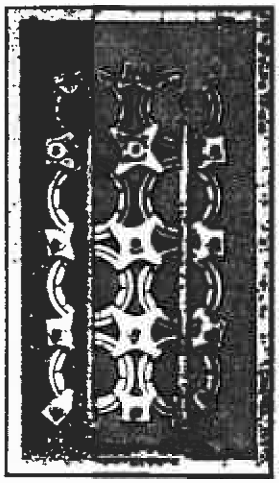
initial concentration = (length)(voltage for full scale deflection/length of full scale deflection)($2mg/m^3$/volt).

The average concentration during bag opening, emptying, and disposal was obtained by summing the initial concentration and the average concentration increase. The average concentration increase was obtained as follows:

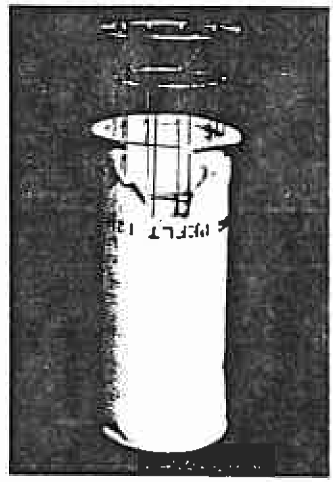
average concentration increase = (peak area/peak length)(voltage for full scale deflection/length of full scale deflection)(2mg/m^3/volt).

The peak area was measured using a planimeter. With the planimeter, we measured the area bounded by the instrument response and the initial concentration. The peak length was the distance between the initial increase in concentration and the point were concentration returned to background conditions.

Standard on all bag dumps



View inside plenum: Continuous cleaning "Uni-Cage" filter. Filter bag replacement is fast and easy: loosen tube sheet clamps, slide out tube assembly, slip off and replace old bag, reinstall tube assembly, tighten clamps. Removal of tube assemblies not required for inspection.



Unitized Filter Tube construction: Filter bag has cloth flange with a metal retaining ring sewn into its outer edge. When secured by the cage clamps, the ring of the filter cage compresses the flange and a positive seal is formed.

Figure 5

Filter/Bag Dump Baghouse Details
(Courtesy of The Young Industries, Inc.)

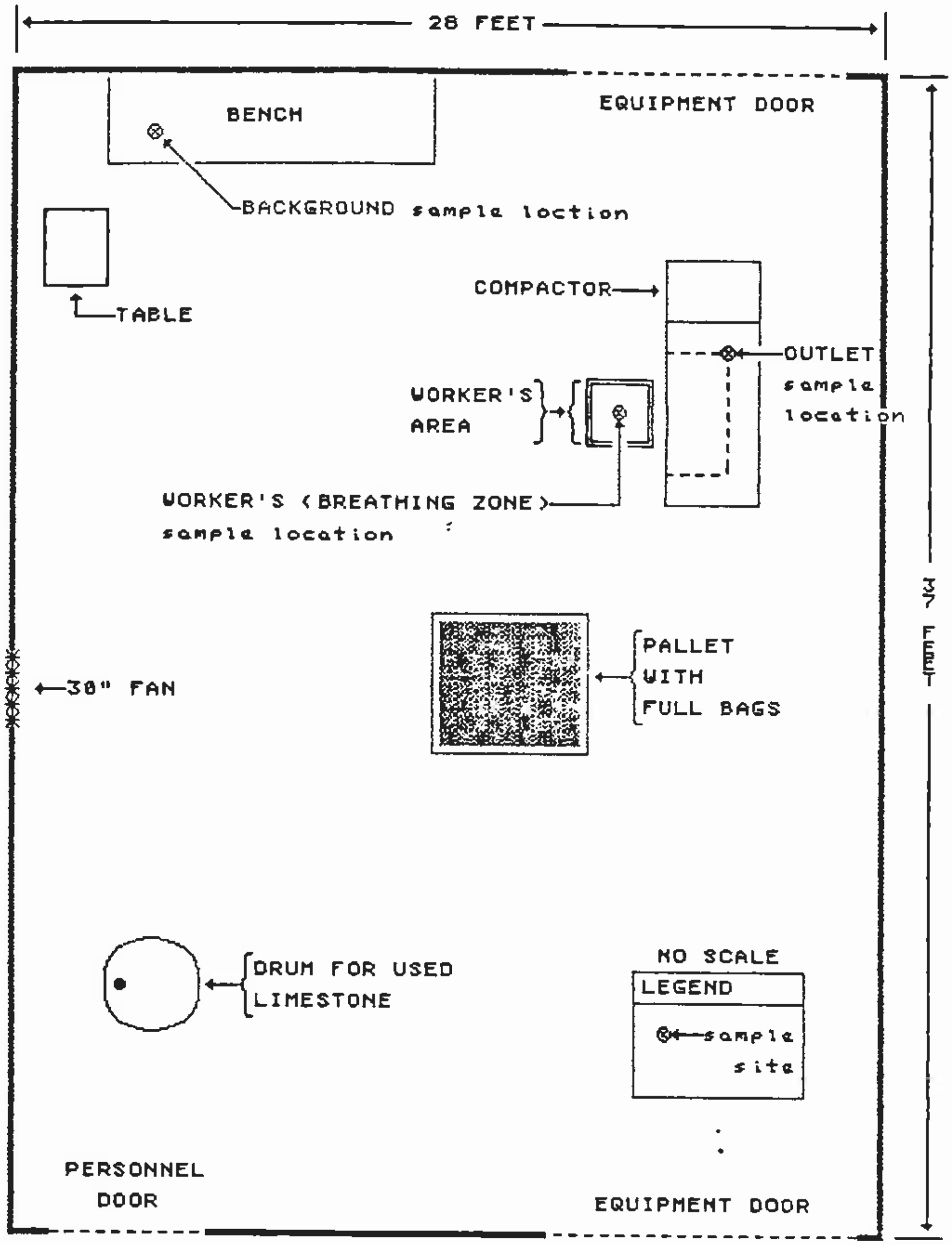


Figure 6

Schematic of Room Where Tests Were Conducted

VI. RESULTS AND STATISTICAL ANALYSIS

Qualitative results from the first experiment were obtained by examining the strip chart recordings for the three sampling locations (Figures 7 through 9). After bag opening, the instruments located at the baghouse outlet detected a sharp increase in the dust concentration, followed by a return to baseline conditions. However, the background and the worker's breathing zone dust concentrations did not rise as sharply. This suggested that the dust was escaping from the baghouse.

For quantitative evaluation of the data, the initial dust concentrations before bag dumping and the average dust concentrations during bag dumping were calculated from the strip chart recordings and are presented in the Appendix. A statistical analysis using the General Linear Models procedure of SAS82[10] was used to examine the data for factors which significantly affected the dust concentration. In this procedure, Analysis of Variance is used to test whether a factor, such as sampling location, explains a significant part of the variability of the data. These factors and the results of this analysis are summarized in Table 3.

This analysis shows that the first experiment generated considerable data which were relatively precise. The standard deviation computed from the mean square error was 0.016 mg/m^3 and the correlation coefficient from the underlying linear model was 0.97. This suggests that some of the effects of using different instruments can be viewed as statistically significant but of minor importance.

Table 3 shows that LOCATION and STATUS significantly affected the dust concentrations measured. The results of a Waller-Duncun multiple range test showed that C_o was significantly greater than C_{bag} and C_w. This statistical test assigns letter values to the average dust concentrations as shown in Table 4 under the column labelled "Groupings." Averages which have the same letter value are not significantly different.

The results depend upon whether the bags are being emptied. Table 5 shows the average dust concentrations measured before bag dumping and during bag dumping. The difference in the means is significant only at the bag house outlet. Furthermore, the initial concentrations are all in close agreement. Tables 4 and 5 show that only the baghouse outlet dust concentration is significantly elevated by bag opening, emptying, and disposal.

Table 3 and the results of the Multiple Range Test presented in Table 6 show that instrument has a statistically significant affect upon dust concentration measurements. However, Table 6 shows that the minimum significant difference was only 0.008 mg/m^3; this is too small to have any affect upon the results presented above. This indicates that there is a statistically significant, but judgementally small, difference between instruments. Because one combination of location and instrument in the factorial experimental design had only 5 replications instead of six, instrument is a biasing factor in this experiment. Fortunately, the significant differences presented in Tables 4 and 7 are larger by a factor of 3 and 5 than the instrument effect.

Table 3 shows that the source of variation "run" had a significant effect upon concentration. The variable "run" refers to the concentration data collected while a specific bag was being opened. The statistical significance of this factor is not surprising since the amount of dust from each bag is not controlled and there are other manufacturing operations in the building. The variable "run" was included to reduce the mean square error and thus improve the precision in the experiment.

Before the second experiment, the standard 14-ounce polyester bags in the baghouse were replaced with 12-ounce, Gortex™ lined polyester bags. Concentration measurements were obtained during three trials. For this data, a one-way analysis of variance showed that location significantly affected concentration at a level of confidence between 95% and 99%. As shown in Table 7, C_{bag} was significantly higher than C_o and C_w. However, the differences are only 0.015 mg/m^3 and could be an artifact of the instrument effect shown in Table 4. However, the instrument which gave the highest reading in Table 4 gave the lowest reading in Table 7. This suggests that the difference between locations in Table 7 is not an artifact, although this difference is small, but statistically significant.

To evaluate whether the above two tests created significant amounts of dust, eight bags were opened, emptied, and disposed of while the ventilation was turned off. The average respirable dust exposure for the worker was 0.62 mg/m^3 with a standard deviation of 0.45 mg/m^3. A peak concentration of 5 mg/m^3 was observed. Similar results were reported elsewhere during a study of bag opening, emptying and disposal in the tire industry.[6]

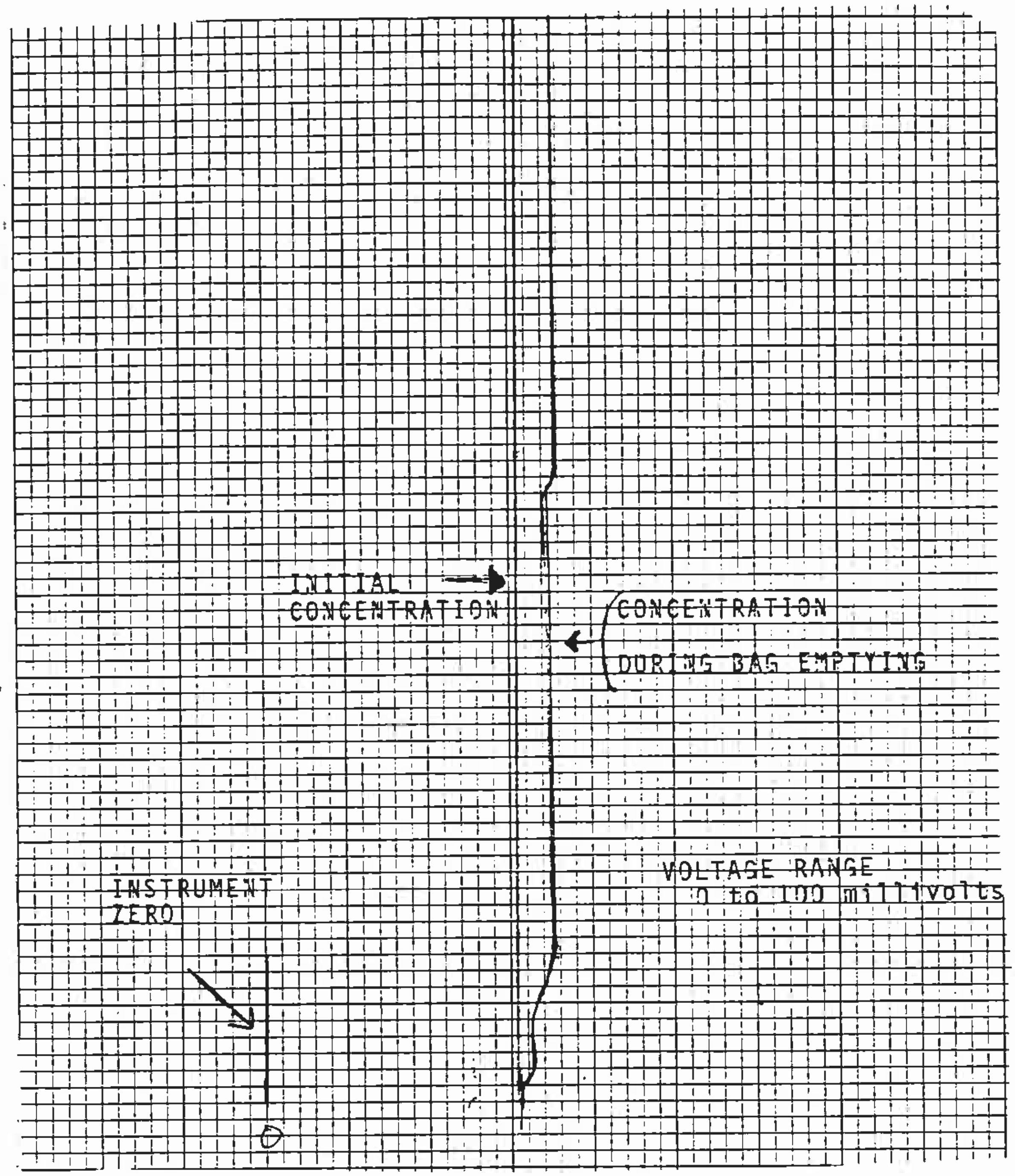


Figure 7.

Tracing of Strip Recording of Ram Which is Located Away from Bag Dump Station

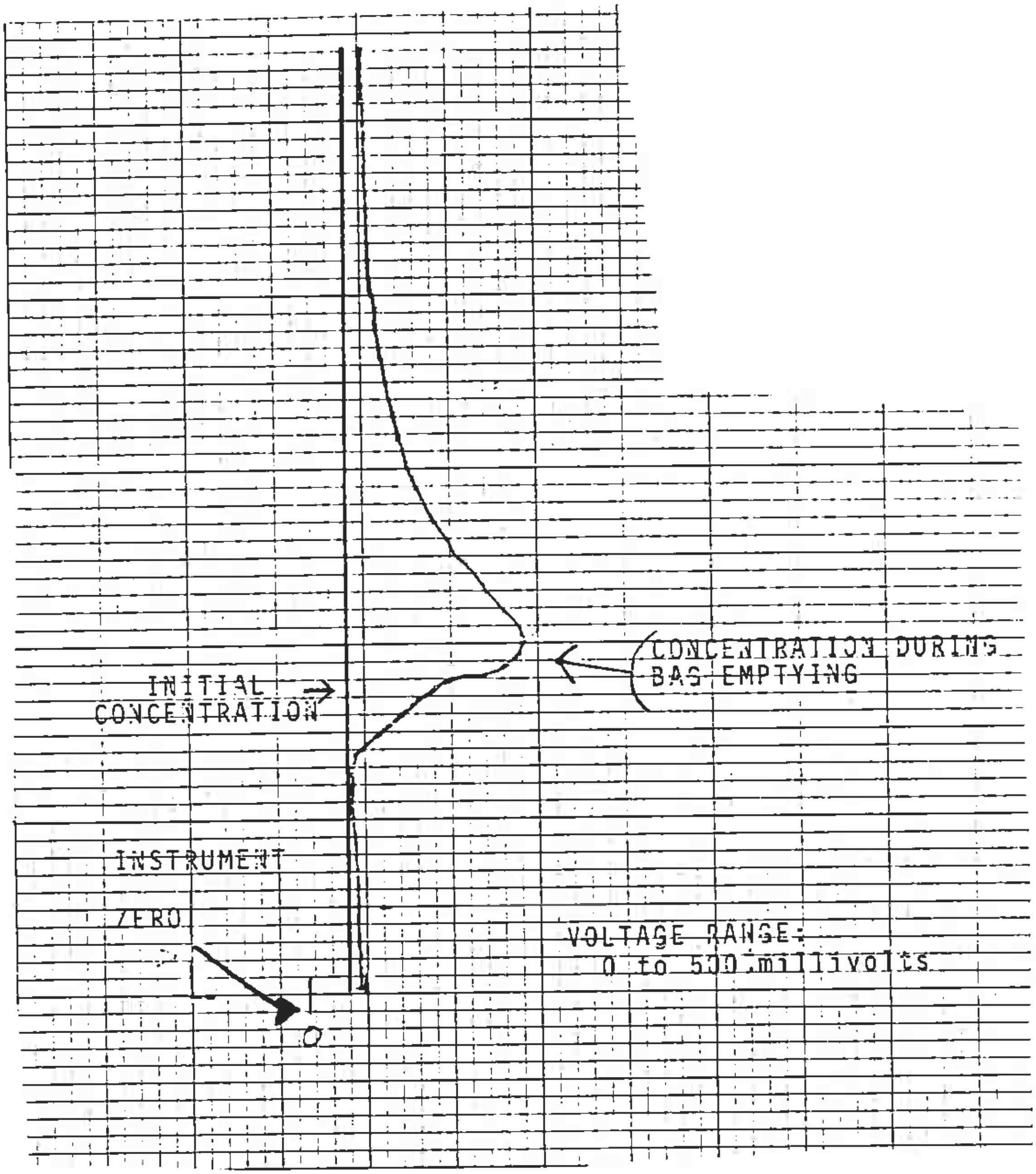


Figure 8.
Tracing of Strip Chart Recording from RAM Located
at Outlet of the Baghouse.

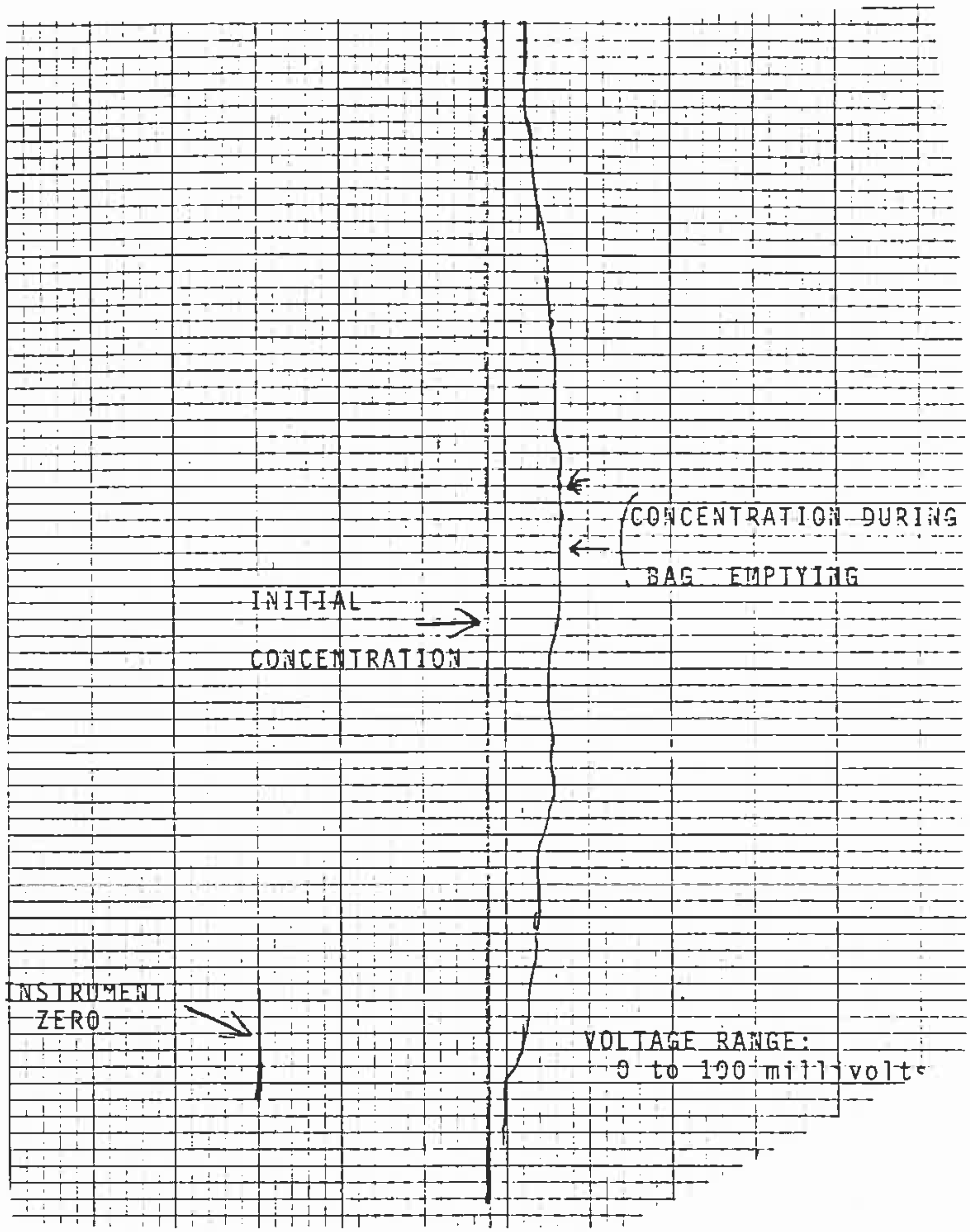


Figure 9.

Tracing of Strip Chart Recording from Ram
Which Was Held in the Worker's Breathing Zone.

VII. DISCUSSION AND CONCLUSIONS

When the Young Industries' Self-Contained Filter/Bag Dump Station is used, bag opening, emptying and disposal can be done with only a slight elevation of worker's dust exposure. As shown in Table 5, the worker's exposure was only elevated by a 0.01 mg/m^3 which was not statistically significant.

However, as previously indicated, if the bag dump station is utilized in a restricted, non-ventilation area, the recirculated baghouse exhaust may become a source of workplace air contamination. This can be greatly minimized by selection of the fabric filter for the baghouse. Because the recirculation of air involves the possibility of reintroducing contaminated air into the workplace, the recommendations of ACGIH and of NIOSH should be consulted for the material being handled before air recirculation is designed and installed.[12,13,14]

Table 3

Analysis of Variance Results For the First Test

Source of Variation	Probability of Seeing Such Large Differences By Chance
Location(L)	under 0.0001
Instrument(I)	0.096
Status(S)	under 0.0001
Runs(R)	under 0.0001
L*I	0.04
L*S	0.0002
R*S	0.2

Table 4

Effect of Location Upon Average Concentration During First Test

Location	Average concentration (mg/m^3)	Groupings from Waller-Duncan Test	n*
Bag house outlet	0.12	A	34
Worker	0.106	B	36
Away from dumpstation	0.104	B	36

NOTE: Averages with same letter for "Groupings" are not significantly different

* n = number of samples

Table 5

Average Concentrations Before and During, Bag Opening, Emptying, and Disposal

Location	Average Concentration mg/M^3 Initial	n*	During Bag Dumping	n*	Probability+ of Seeing Such Large Differences Between the Two Averages
baghouse outlet	0.105	17	0.143	17	0.0006
away from dump station	0.100	18	0.107	18	0.6
worker	0.101	18	0.112	18	0.7

\+ Calculated using the t-test based on contrast from the General Linear Model[10]

* - n equals number of samples.

Table 6

Instrument Variability

Instrument	average (mg/M^3)	n	Grouping from Waller Duncan Test[12]
Ram-1 #1	0.115	34	A
Ram-s	0.112	36	A,B
RAm-1 #2	0.107	36	B

NOTE: Averages with same letter are not significantly different

Table 7

Effect of Location upon Concentration in Second Test
After the Installation of Gortex™ Filter Bags

Location	Average Concentration (mg/m^3)	n	Grouping Based upon Duncan's Multiple Range Test
Away from Dump station	0.055	3	A
Baghouse outlet	0.043	3	B
Worker	0.041	3	B

NOTE: Averages with same letter are not significantly different

REFERENCES

1. Heitbrink, William A. and W. McKinnery, Control of Air Contaminants In Tire Manufacturing, NIOSH document(unpublished).

2. SRI International, Control Technology Assessment of the Pesticides Manufacturing and Formulating Industry, Final Report NIOSH Contract. 210-77-0093, May 1980. (unpublished)

3. First, M. and D. Love, 1982. Engineering Control of Asbestos. American Industrial Hygiene Association Journal 43(9): 632-639.

4. Caplan, Paul C., it al. Control Technology Evaluation of the Silica Flour Milling Industry, December 1981, NIOSH

5. Johanson, J. 1978. Know Your Material - How to Predict and Use the Properties of Bulk Solids. Chemical Engineering, Deskbook Issue. October 30, 1978. pp 9-17

6. Heitbrink W. A. and W. N. McKinnery. Assessment of Effective Controls For Solid Materials Handling - Project Protocol (1982). NIOSH/DPSE/ECTB 4676 Columbia Parkway, Cincinnati, Ohio 45226.

7. The Young Industries. Bulletin 208-377 - Self Contained Filter Bag Dump Station.

8. GCA Corporation Model RAM-1 Real Time Aerosol Monitor - Instruction Manual (1979). Burlington Road, Bedford, MA.

9. GCA Corporation Model RAM-S Real Time Aerosol Sensor - Instruction Manual (1979). Burlington Road, Bedford, MA.

10. Rubos, K.L. and V.A. Marple. 1983. Instrument Evaluation Chamber: Calibration of Commercial Photometers. In: Aerosols In the Mining and Industrial Work Environments. Ann Arbor Science, Ann Arbor, Michigan.

11. SAS Institute. SAS User's Guide: Statistics (1982), Box 8000, Cary, NC.

12. Committee on Industrial Ventilation. Industrial Ventilation - A Manual of Recommended Practice. ACGIH, Cincinnati, Ohio (1982)

13. Hughes, R.T. and A. Amendola. Recirculating Exhaust Air. Plant Engineering, March 18, 1982.

14. Portridge L.S., P.R. Nayak, R.S. Stricott, and J.H. Hagopian. A Recommended Approach to Recirculation of Exhaust Air. NIOSH, Cincinnati, Ohio. 1978.

APPENDIX

Concentration Data

Data Summary for the First Test

Concentration (mg/m^3) During	Initial	Time (min)	Instrument Code	Location Code	Bag Number
0.0843	0.08	1.3	a	1	1
0.0873	0.08	1.338	a	1	2
0.1028	0.08	1.345	a	1	3
0.0807	0.064	1.50	a	3	4
0.0866	0.064	2.125	a	3	5
0.0908	0.064	2.2	a	3	6
0.0661	0.0584	2.525	a	2	7
0.0792	0.064	3.55	a	2	8
0.0865	0.0812	1.35	a	2	9
0.0878	0.0820	2.52	a	1	10
0.0822	0.804	1.13	a	1	11
0.0898	0.0784	2.97	a	1	12
0.2392	0.254	2.6	a	3	13
0.2152	0.224	1.138	a	3	14
0.1924	0.204	4.513	a	3	15
0.0781	0.076	0.525	a	2	16
0.0975	0.0872	1.95	a	2	17
0.0925	0.0868	1.638	a	2	18
0.1327	0.0824	0.875	b	2	1
0.1386	0.0953	0.9	b	2	2
0.1428	0.1131	0.775	b	2	3
0.1130	0.096	2.65	b	1	4
0.1247	0.1072	1.575	b	1	5
0.1373	0.12	3.8	b	1	6
0.1241	0.05	0.85	b	3	7
0.2032	0.056	0.900	b	3	8
0.1087	0.068	1.475	b	3	9
0.1423	0.092	0.825	b	2	11
0.120	0.100	1.025	b	2	12
0.2626	0.244	0.725	b	1	13
0.2388	0.218	1.275	b	1	14
0.224	0.204	1.0	b	1	15
0.0738	0.046	0.9	b	3	16
0.0752	0.05	1.15	b	3	17
0.0827	0.054	1.5	b	3	18
0.0891	0.084	0.793	c	3	1
0.1228	0.084	1.25	c	3	2
0.1279	0.084	1.458	c	3	3

Data Summary for the First Test (Continued)

Concentration (mg/m^3) During	Initial	Time (min)	Instrument Code	Location Code	Bag Number
0.0864	0.076	2.125	c	2	4
0.0941	0.08	1.6	c	2	5
0.0976	0.088	3.95	c	2	6
0.0708	0.060	2.7	c	1	7
0.0896	0.064	3.475	c	1	8
0.0964	0.088	1.85	c	1	9
0.084	0.078	1.163	c	3	10
0.0888	0.070	1.125	c	3	11
0.092	0.080	1.575	c	3	12
0.2241	0.236	1.925	c	2	13
0.2106	0.216	1.963	c	2	14
0.1939	0.208	1.805	c	2	15
0.0729	0.064	2.05	c	1	16
0.0873	0.0712	3.025	c	1	17
0.0918	0.088	2.423	c	1	18

Codes Used To Describe Locations and Instruments
From the First Test

Location Codes	a. Away from the bag opening, emptying, and disposal operations
	b. at the outlet of the air plenum on the Young Industries' Dustless Bag Dump Station
	c. held in the worker's breathing zone.
Instrument Codes	1. A RAM-s
	2. A Ram-1
	3. A Ram-1

Respirable Dust Concentrations From the
Second Test

	Location	A	B	C
	Instrument	1	2	3
Test				
7		0.073	0.041	0.042
8		0.054	0.041	0.043
9		0.059	0.039	0.037

Concentration Data From Test 3 - Bag Openning, Emptying
and Disposal Without Ventilation

Average Respirable Concentration (mg/m^3)	Peak Respirable Concentration (mg/m^3)
0.60	1.16
1.73	5.4
0.55	1.4
0.52	1.04
0.48	0.66
0.25	0.71
0.40	0.99
0.44	1.17

Properties of Crushed Limestone

PARTICLE SIZE DISTRIBUTION

Finer than 44 Microns		
30 Microns	-	
25 Microns	-	
20 Microns	-	
12 Microns	99.9	
10 Microns	95	
8 Microns	91	
7 Microns	88	
5 Microns	74	
4 Microns	63	
3 Microns	50	
2 Microns	36	
1 Microns	17	

TYPICAL PHYSICAL DATA

Specific Gravity (Solids)	2.70-2.71
St. per Gallon - Solid (lbs.)	22.57
Wt. per Gallon - Slurry (lbs.) (at 25°C)	-
Average Particle Dia. (Microns, Sedigraph	3.0
Brookfield Viscosity (100 RPM, No. 3 Spindle)	-
pH of Saturated Solution	9.5
Solubility on Water (%)	0.08
Dry Brightness (Hunter)(Min.)	95
Index of Refraction	1.6
Oil Absorption (cc/100g.)	15
Mho Hardness	3.0
Bulk Density (Loose) lbs/cu.ft. (Approx.)	40
Bulk Density (Loose) lbs/cu.ft. (Approx.) ST	35
Solids, %w	-