IN-DEPTH SURVEY REPORT

SOLIDS MATERIALS HANDLING PROJECT

AT

3M COMPANY
GROVE CITY OHIO

REPORT WRITTEN BY:
WILLIAM HEITBRINK

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

PLANT SURVEYED:	3M Grove City Plant 3570 Sunshine Place P.O. Box 489 Grove City, Ohio 43123
SIC CODE:	3069 (Miscellaneous Rubber Products)
SURVEY DATE:	July 24-27 and November 7-11, 1983
SURVEY CONDUCTED BY:	William A. Heitbrink Thomas C. Cooper
EMPLOYER REPRESENTATIVES CONTACTED:	Mr. Ralph Rodgers, Plant Engineer Mr. Robert Peterson, Manufacturing Engineer Mr. Laurence Mastella, Plant Manager Plant Phone No: (614) 875-6343
EMPLOYEE REPRESENTATIVES CONTACTED:	Ms. Joan Martin President, Local 14108 United States Steel Workers Phone No: (614) 253-8731
ANALYTICAL WORK PERFORMED BY:	Utah Biomedical Test Laboratory

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 a number of 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 steps or phases. Initially, a series of 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 This Study

This plant is being studied as part of an in-depth evaluation of controls for dust generated by bag opening, emptying, and disposal. The overall purpose of this study is to develop dust control recommendations for bag opening, emptying and disposal operations. These recommendations will be contained in journal articles.

Background For This Survey

The Taunton Engineering Company RTS-100 automatic bag opener is the subject of this survey. During a preliminary visit, it appeared to control the dust generated by opening, emptying, and discarding bags which contained carbon black and powdered clay.

PLANT AND PROCESS DESCRIPTION

Introduction

This plant is part of 3M's Adhesives, Coatings, and Sealant division. It employs less than 100 people and is less than 3-years old. The plant makes a variety of rubber and addhesive products.

Process Description

This study focusses on the operation of a Taunton Engineering Company (TECO) RTS-100 automatic bag opener and a bag compactor. This equipment is used to empty carbon black, clay, and other material from bags and to charge the bagged materials into a mixer. This equipment is located in a warehouse area which is used to store the final product.

The operation of this equipment is as follows:

1. At a rate of about 2 bags per minute, the worker removes bags of clay, carbon black, and other materials from a pallet and sets them on as inclined conveyor. These bags contain about 50 pounds of material.

2. The inclined conveyor takes the bags from floor level to the RTS-100's conveyor. The RTS-100 is on a platform that is about 15 feet above the floor.

3. The second conveyor, which is in an enclosure, transports the bags into the bag opening machine and through a set of circular knives which open the bags.

4. Then, the conveyor drops the opened bags into a rotating, cylindrical screen.

5. The rotating screen separates the material from the slit bags.

6. The material drops through the holes in the screen on to another conveyor which transports the powdered material to a mixer.

7. The empty bags fall down an enclosed chute and into a trash compactor.

8. The bag compactor stuffs the empty bags into a 30-foot-long plastic tube which is tied off in 10-foot lengths.

This operation is shown schematically in Figures 1 and 2. A total of 45 minutes was needed to empty just over 100 bags.

As shown in Figures 1, 2, and 3, the plant has slightly modified the the bag opener. The wire belt conveyor in Figure 1, is actually in an enclosure. The enclosure is described by Figures 3 and 4.

Figure 2. shows the location of the exhaust ducts. Figures 2 and 5 show the location of the trash compactor with respect to the bag opener. The discarded bags fall down the chute shown in Figures 2 and 5.

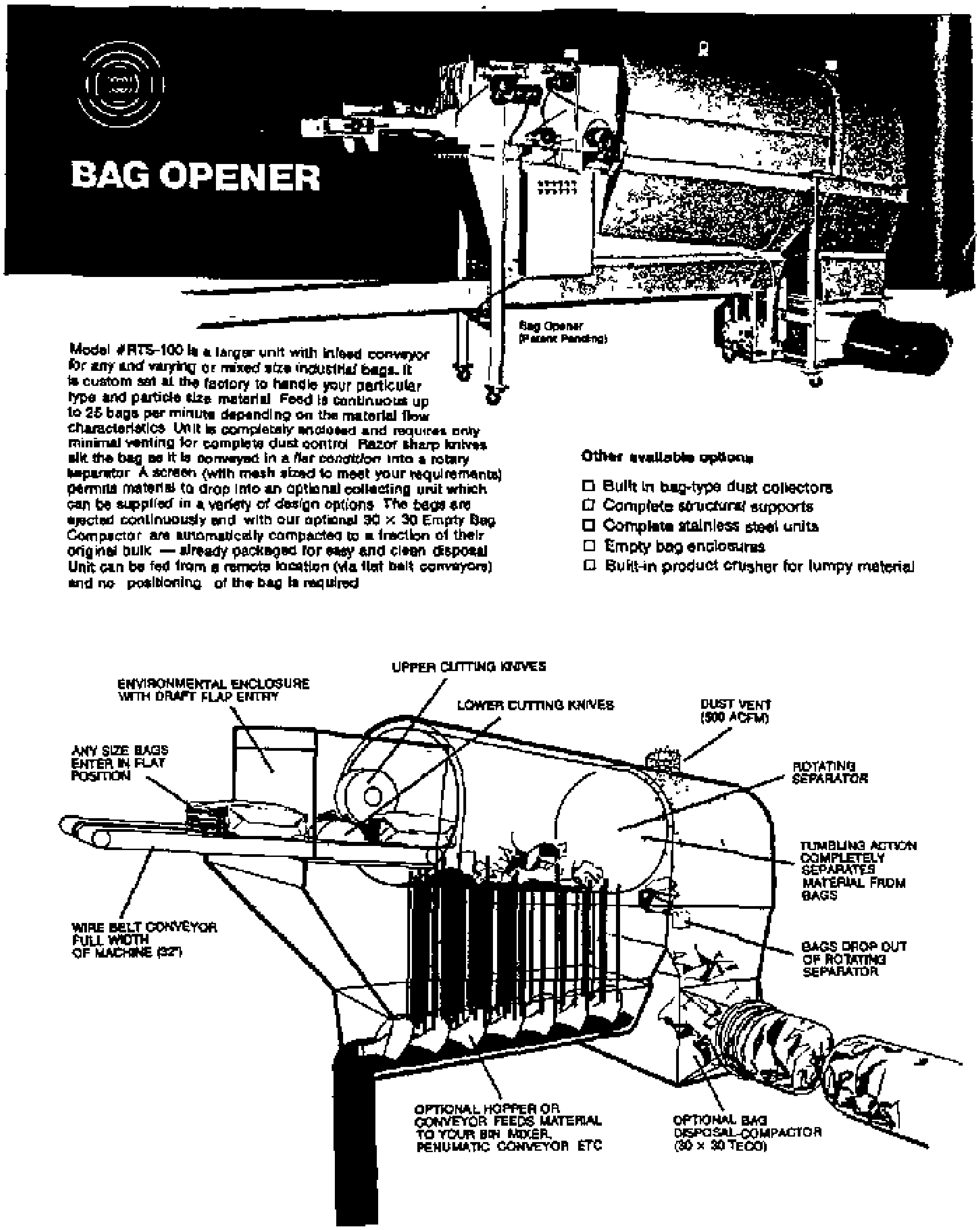

Figure 1. TECO RTS-100 bag opener. Courtesy Taunton Engineering Company, Taunton Massachusetts

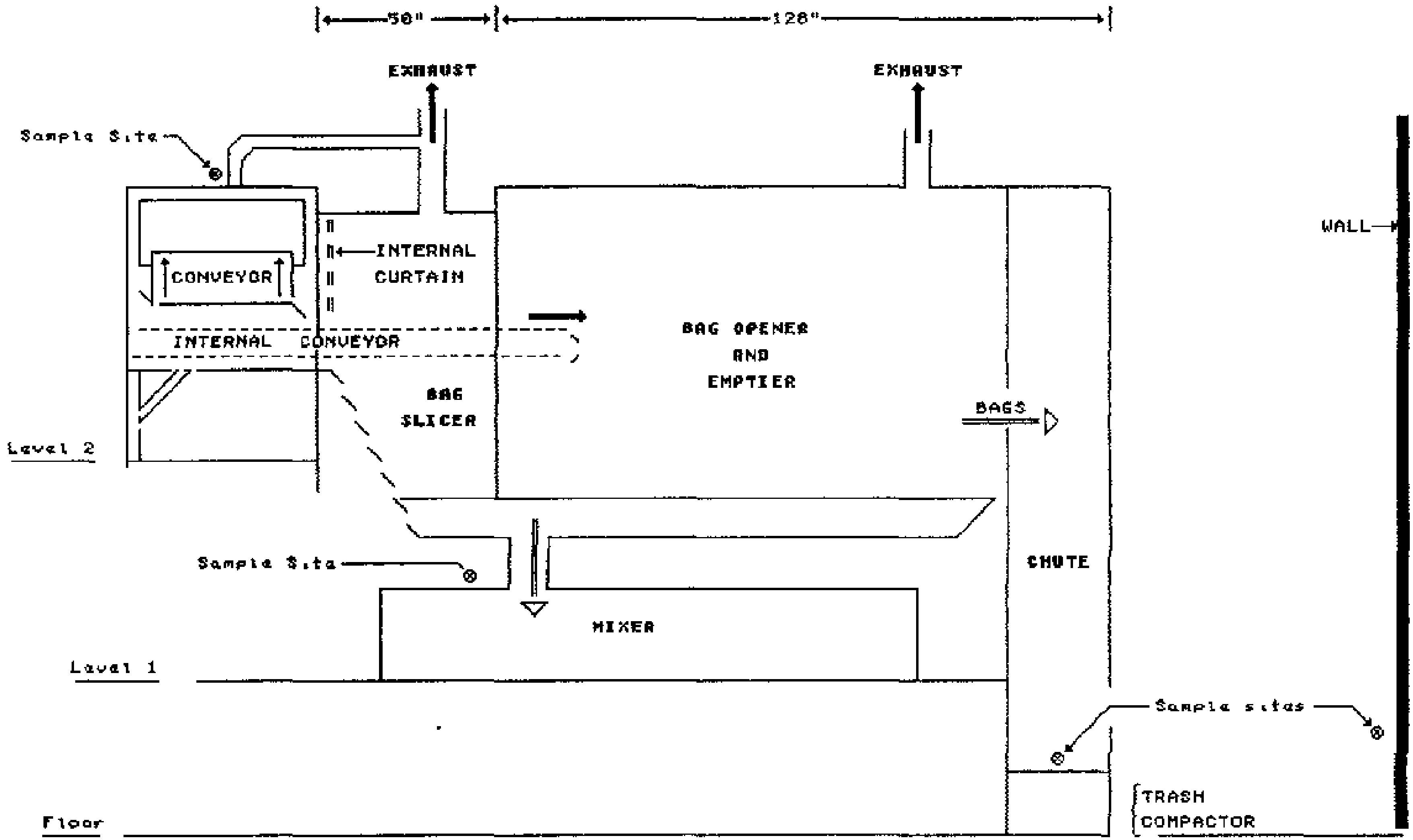

Figure 2. Schematic of RTS-100 as installed.

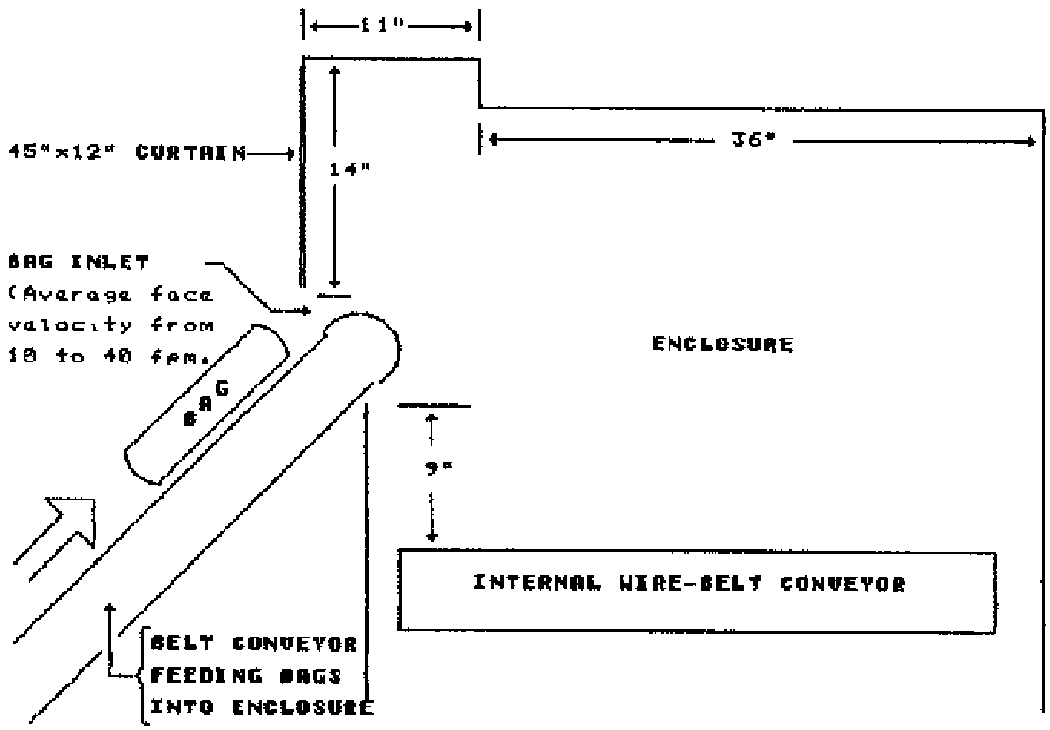

Figure 3. Sketch of entry enclosure.

Figure 4. Photograph of entry enclosure.

Figure 5. Picture of trash compactor.

Potential Hazards

The hazard associated with this operation are the airborne dusts generated by bag handling and the physical stresses caused by manual lifting. The major health effects associated with the dusts are listed in Table 1. The potential dust exposures during this operation are:

1. Handling full bags outside of the bag opener. Frequently, these bags come to the plant coated with dust. Handling these bags creates small puffs of dust in the worker's breathing zone.

2. Accidental bag breakage outside of bag opener.

3. Opening and emptying bags. This inevitably creates dust which the RTS-100 is designed to control by partial enclosure and local exhaust ventilation.

4. Empty bag disposal. This inevitably creates dust that the bag compactor is designed to control. Occasionally, the plastic tube may rupture and this exposes a dusty bag to the environment. However, this did not appear to create a dust problem.

5. Settled dust on the bag opener. The equipment vibrates and some of the dust may be resuspended into the air.

6. The conveyor belts which feed the bags into the the bag opener. Dust of the the outside of these bags contaminates the belts. Consequently, dust may be dispersed when the belt is turned upside-down to return to pick-up another bag. In Figure 6, the dust pile under the conveyor suggests this may be a source of dust emissions. A similar dust accumulation was observed under the entry enclosure. The conveyor belt forms the bottom of the entry enclosure.

Figure 6. Photograph of worker placing bags on the conveyor.
Note that dust is being collected on cardboard placed under the conveyor.

Table 1.
Summary of Limits for Dust Exposures Associated With the Operation of TECO RTS-100 Automatic Bag Opener

Substance	PEL[1] (mg/m^3)	TLV[2] (mg/m^3)	NIOSH Recommended Standard[3] (mg/m^3)	Major Health Effects
carbon black	3.5	3.5	3.5	Electrocardiographic changes reported among laboratory animals. Carbon blacks do contain traces of polycyclic aromatic hydrocarbons (PAH) the TLV is set to keep the PAH concentration below $0.2 mg/m^3$.[2]
Nuisance Dust	15	10		irritation.[2]

Notes: 1. All of these limits are for full, 8-hour shifts.
2. The PEL refers to the OSHA standards which are legally enforced.

Manually lifting the 50 pound bags and placing them on the conveyor involves potential back injury. Such injuries result in low back pain and much disability.[4,5,6,7] Because 15% to 30% of all workman's compensation claims are attributed to back injuries, NIOSH has developed and published a guide for manual lifting.[6,7]

This guide proposes two lifting limits, an action limit (AL) and a maximum permissible lift (MPL). Lifts below the AL are believed to pose minimal hazard to the worker. Over 75% of women and 99% of men can lift loads described by the AL. Lifts between the AL and MPL are believed to be dangerous for some workers. Such lifts are thought to be unacceptable without administrative and engineering controls. Lifts above the MPL are believed to increase injury rates and are unacceptable.

The MPL and AL are computed in kilograms (kg) as follows:

$AL\ (kg) = 40(15/H)(1-0.004|V-75|)(0.7+7.5/D)(1-F/F_{max})$ - metric units

$MPL = 3(AL)$

where H = horizontal location (cm) forward of midpoint between ankles at origin of lift
V= vertical location (cm) at origin of lift
D= vertical travel distance (cm) between origin and destination of lift.
F= lift frequency(lifts/min)

The term H can be estimated as $H=W/2 + 15$ (cm), where W is the width of the object

Based upon the data presented in Table 2, the AL is computed to be 13 kg and the MPL is 39 kg. The bags being lifted weighed about 23 kg (50 pounds). If these bags were lifted and carried so that the 10-cm long side of the bag determines H, the AL and MPL would be respectively 23.7 and 71 kg respectively. To obtain these higher limits, the workers would need to hold the largest flat surface of the bags against their torso and chest. The workers would probably be somewhat reluctant to hold the bags in such a manner because the dirty bags would soil their clothes. In addition, this could elevate worker dust exposure.

Table 2.
Dimensions used to compute AL

Dimension	Value
W	43.2 cm
V	between 50 and 100 cm
D	25 cm
F	2 lifts/min
F_{max}	18 lifts/min

Methodology

This survey was conducted to document and evaluate the ability of the TECO RTS 100 to control dust during bag opening, emptying and disposal. To document the control performance, observations and ventilation system measurements were made. The ability of the equipment to control dust was evaluated measuring dust concentrations. Table 3 lists the equipment used in this study.

Table 3.
Equipment used in this study.

Item	Model	Used for
Dupont pumps	P-4000	dust sampling
Gast Carbon Vane pumps		dust sampling
critical flow orifices	15 Lpm	dust sampling with Gast pumps
Kurz Velometer	Digital	Face velocity measurements
smoke tubes	Drager	direction of air flow

Ventilation Measurements

The ventilation measurements were made to document air flow into the automatic bag opener. Face velocities were measured at the entry to the enclosure described by Figure 3. Along a line half way between the curtain and the conveyor in Figures 3 and 4, the face velocities were between 40 and 50 feet per minute (fpm). Smoke tube traces showed that the smoke was drifting very slowly into the enclosure.

Air Sampling

At the TECO automatic bag opening machine, total dust concentration was monitored to help resolve a number of issues. These issues are listed below:

1. Is the worker's environment acceptable?

2. Does the operation of the bag opening equipment contribute to the air contamination in this plant?

The first issue was resolved by monitoring the worker's dust exposure while he placed bags of powdered material on the conveyor. The second issue was addressed by a combination of personal and area sampling. Air samples for dust were collected at the locations listed in Tables 4 and 5 and described in Figure 2. At each sampling location, two samples were collected. One sample was collected while the bag opening equipment was off and the other sample was collected while the bag opening equipment was on.

A combination of area and personal sampling results were collected to test specific hypotheses about dust concentrations and machine activity. These hypotheses are stated as null (H_o) and alternative hypotheses (H_a). The first hypothesis can be stated as follows for each sampling location:

H_o: The dust concentrations measured while the bag opening machine is operated are not different than the concentration measured when the machine is not operating.

H_a: The dust concentration increases when the bag opening machine is operated.

If there are no dust emissions associated with the operation of the bag opening machine, dust concentrations should not increase. This hypothesis allows one to evaluate the significance of the dust emission sources listed earlier in this report.

Examining concentration differences between sampling locations also provides some insight into the importance of the possible emission sources. This is particularly true of any differences between locations 5 and C, which should reflect background contamination, and the other sampling locations. For example, the difference in concentration between the worker and location C probably reflects the extent to which handling dirty bags elevates the worker's dust exposure. For each sampling location, a second hypothesis can be stated:

H_o: The concentration measured at background locations (5 and C) are not different than concentrations measured at other locations which are near emission sources.

H_a: The concentration measured near an emission source is higher than the background concentration.

As noted in Tables 4 and 5, two different types of pumps were used for sampling. At some of the area sampling locations, carbon vane pumps were used to draw air through filters at known nominal flow rates of 15 liters per minute (LPM). At other locations, DuPont P-4000 pumps are used to draw air through the filters at a known rate between 3.5 and 3.7 LPM. The dust concentration is simply the filter's weight gain which is adjusted for the weight change of the blank divided by the sample volume. Because samples collected at 15 LPM could be different from samples collected at 3.5 LPM, these samples are treated separately in the statistical analysis to choose between H_o and H_a.

Table 4.
Listing of Sampling Location Where Critical Orifices Were Used

Location Code	Description
1.	On top of the entry enclosure. Concentration measured at this location reflects dust generated by material entering the enclosure and possibly the dust generated by the conveyor.
2.	Under the entry conveyor. This sample probably reflects dust generated by movement of the conveyor which feeds the bags through knives which slit the bags.
3.	On the mixer which is directly below the bag opener. This sample was taken to provide an indication of any dust emissions form the bottom of the bag opener or the top of the mixer. However, dust from the emission sources near locations 1 and 2 appeared to settle on top of the mixer.
4.	On the trash compactor. Dust concentrations at this location probably reflect dust generated by the operation of the trash compactor.
5.	Next to the wall, 15-feet from the trash compactor. Concentrations here probably reflect background air contamination in this plant.

Table 5.
Listing of Sampling Location Where DuPont P-4000 Pumps Were Used

Location Code	Description
a.	Worker. During the time the bag opener was off, the sampler was hung on the post next to the worker.
b.	Post next to worker
c.	Same as location 5 in Table 4.

CONTROL TECHNOLOGY

Principles of Control

Occupational exposures can be controlled by the application of a number of well-known principles, including engineering measures, work practices, personal protection, 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 (material substitution, 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 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 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 durable control system.

These principles of control apply to all situations, but their optimum application varies from case-to-case. The application of these principles at 3M's Grove City Plant for bag opening is discussed below.

Bag opening, emptying, and disposal creates dust which the RTS-100 is designed to control. As shown by Figure 1, these operations are done in almost a complete enclosure. The only opening is for the inlet. As a result, the equipment appears to isolate the worker from the dusty operations.

At the inlet, TECO and 3M have taken steps to reduce the face velocity requirements. Figure 1, which describes the RTS-100 as supplied by TECO, shows draft flaps covering the inlet to the machine. The enclosure described by Figure 3 was installed by 3M. This enclosure covers the conveyor which transports the bags into the bag opening machine. Both of these measures are intended to control dust generated by the operation of the bag opening machine.

The design of the equipment allows the dust to be controlled during bag opening, emptying, and disposal. The bags are opened and emptied in an enclosure. To prevent dust leakage from places where metal parts are mechanically fastened together, a black windshield sealer was used as a caulking compound or gasket material. This windshield sealer is a 3M product. This appears to prevent dust leakage while the bags are opened and emptied.

After the bags have been opened and emptied, they are discarded. The rotating screen discharges the empty bags into a chute. In this chute , the bags fall into a trash compactor which compresses the bags and forces them into a plastic tube which resembles a rather large garbage bag. Periodically, this tube is tied-off and discarded. The plastic tube was observed to tear and some holes were observed. These holes were observed to be the only dust emission source associated with bag disposal.

Air Sampling Results and Resolution of Hypothesis

Dust concentrations were measure to address a number of issues and hypotheses. Examination of the data in the Appendix indicates that the worker's dust exposure is consistently below the concentrations specified in Table 1 for nuisance dust. One dust concentration in the Appendix did exceed the value for carbon black in Table 1. Because the concentration values in Table 1 are for 8-hour time weighted averages and the the data in the Appendix had a one hour nominal sampling period, the workers' dust exposure are within the guidelines listed in Table 1.

Tables 6 and 7 respond to the first hypothesis. These tables summarize the effect of bag opener status upon dust concentration at the different sampling locations. In both Tables, the column labelled "Significance" presents the results of log transforming the data and doing a paired-t test to evaluate these concentration differences. These tests were conducted at the 95% level of confidence. These tables suggest that dust is generated by putting bags on the conveyor and at the inlet to the bag opening machine. Tables 8 and 9 address the second hypothesis.

Table 6.
Effect of Bag Opener Status Upon Geometric Mean Dust Concentrations
Measured With DuPont P4000 Pumps

Location Code	Geometric Mean Dust Concentration (mg/m^3) When Bag Opener is: On	Off	Significance of Difference between On and Off Dust Concentrations
A (worker)	1.03	0.06	significant
B (post)	0.55	0.05	significant
C (background)	0.14	0.10	not significant

Table 7.
Effect of Bag Opener Status Upon Dust Concentrations
Measured with Critical Flow Orifices.

Location Code	Geometric Mean Dust Concentration (mg/m^3) When Bag Opener is: On	Off	Significance of Difference Between On and Off Dust Concentrations
1. (above entry enclosure)	1.3	0.17	significant
2.(under entry enclosure)	1.1	0.16	significant
3. (on mixer)	0.44	0.18	significant
4. (trash compactor)	0.33	0.06*	significant
5.(background)	0.18	0.16	not significant

* Reflects one value where filter weight gain and blank weight gain were nearly the same. When this one value is deleted, the concentration difference is not significant.

Table 8
Effect of Sampling Location upon Geometric Mean Concentration

Location	Geometric Mean Concentration (mg/m^3)	N	Grouping*
A (worker)	0.32	8	A
B (post)	0.18	8	A
C (background)	0.12	8	B

* Geometric means which have different letters differ significantly based upon a Duncan-Waller multiple range test.[8]

Table 9.
Effect of Sampling Location upon Geometric Mean Concentration

Location	Geometric Mean Concentration (mg/m^3)	N	Grouping*
1. (above entry enclosure)	0.48	8	A
2. (below entry enclosure)	0.43	8	A
3. (on top of mixer)	0.28	8	A,B
4. (trash compactor)	0.18	8	C,B
5 (background)	0.14	8	C

* Geometric means which have different letters differ significantly based upon a Duncan-Waller multiple range test.[8]

Discussion of Air Sampling Results

The results presented in Tables 6-9 suggest that dust control during bag opening, emptying and disposal involves more than just the selection of enclosed, automated equipment. Observation of the equipment suggests that the Taunton RTS-100 contains the dust generated by the act of opening, emptying, and discarding the bags. However, the exterior surfaces of these bags are contaminated with dust. Puffs of dust are observed when the workers pick-up a bag and sets it on the conveyor. This dust contaminates the conveyor belt and, at conveyor transfer points, the dust falls off of the belt when the belt rolls under a roller to complete a cycle. Figure 6 shows the dust accumulated under one such point. This probably occurs at the conveyor transfer point inside of the entry enclosure. The conveyor belt forms the bottom of this enclosure. Dust is observed to accumulate on the floor under this point. These observations appear to explain the significant elevation of the dust concentrations measured at the inlet (locations 1 and 2) and on the worker. At these locations concentrations were elevated when the bag opener was operated. Futhermore, these concentrations were elevated above background concentrations.

The increased dust concentration at the inlet may also be the result of the relatively low face velocities at the inlet which were between 40 and 50 feet per minute. The air flow may not be high enough to contain dust generated by mechanical motion inside the conveyor. For low speed conveyor transfers, ACGIH recommends capture velocities between 100-200 feet per minute.[9]

CONCLUSIONS

With the exception of dust being emitted at the inlet, the TECO RTS-100 automatic bag opener and its trash compactor did not appear to create dust emissions. Unfortunately, increased dust emissions were associated with the operation of this equipment. These emissions appeared to be caused by activities which are peripheral to the bag opener.

Dust on the exterior surface of bags is a source of dust emissions into the worker's breathing zone and into the industrial environment. This dust on the exterior surfaces of the bags is probably responsible for the dust on the conveyor belts. At transfer points where the conveyor belt wraps around a roller, dust comes off of the conveyor and settles on the floor.

If a conveyor belt moves in and out of the enclosure for an automatic bag slitter, the conveyor belt is a potential emission source. Conveyor belts which feed bags through the actual bag slitting mechanism could become contaminated with dust. When such a conveyor leaves the enclosure and moves around a roller, the dust on the conveyor will probably be emitted into the workplace air.

REFERENCES

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Appendix

Concentration Data

Concentration Data

Date in November of 1983	Concentration (mg/m^3) When Bag Slitter was on	off	Location Code From Tables 4 and 5
7	4.5	0.0604	a
8	0.49	0.11	a
9	0.91	0.06	a
11	0.57	0.06	a
7	3.5	0.109	b
8	0.29	0.03	b
9	0.38	0.06	b
11	0.26	0.06	b
7	0.26	0.20	c
8	0.19	0.11	c
9	0.025	0.03	c
11	0.34	0.159	c
7	2.28	0.3	1
8	0.4	0.14	1
9	1.61	0.16	1
11	2.28	0.14	1
7	1.14	0.27	2
8	0.27	0.14	2
9	1.91	0.14	2
11	2.65	0.149	2
7	0.635	0.28	3
8	0.35	0.19	3
9	0.62	0.126	3
11	0.29	0.158	3
7	0.32	0.11	4
8	0.36	0.01	4
9	0.32	0.09	4
11	0.331	0.16	4
7	0.226	0.166	5
8	0.17	0.084	5
9	0.24	0.129	5
11	0.12	0.42	5