INDEPTH SURVEY REPORT

CONTROL TECHNOLOGY FOR RICHARD KLINGER INC.

REPORT WRITTEN BY
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PLANT SURVEYED: Richard Klinger Inc.
2350 Cambell Road
Sidney, Ohio

SIC CODE· 3069 Fabricate Pubber Products

SURVEY DATE: August 1-4, 1983

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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 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 complete 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 is 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

The plant was visited as part of a study of dust control during bag opening, dumping, and disposal. Significant dust exposures can occur during these operations. Although dust can be controlled during bag opening and dumping, bag disposal is a significant source of worker dust exposure. Ultimately this project will result in a concise 10-15 page report describing dust control techniques during bag opening, emptying, and disposal. This report should provide valuable information for those who are responsible for controlling workers' dust exposure.

BACKGROUND FOR THIS SURVEY

The purpose of this survey was to evaluate the control of airborne asbestos generated by bag opening, emptying and disposal. To open bags of pressure packed asbestos, Richard Klinger Co. purchased automatic bag opening equipment from Bel-Tyne Inc., of Great Britain. As a result, this survey is focused on the Bel-Tyne Bag Slitter. This equipment automatically slits and empties the bags of asbestos. Furthermore, this device has provisions for bag disposal.

This equipment was selected for study because it has provisions for dust control during bag opening, emptying, and disposal. During a preliminary survey, the Bag Slitter appeared to work well. Klinger Company told us that asbestos 8-hour, time-weighted average concentrations were generally below 0.1 fibers/cc. Based upon all these facts, a decision was made to conduct a field evaluation of this equipment.

II. PLANT AND PROCESS DESCRIPTION

This plant was built in 1977 and it employs under 50 production workers. The workers produce sheets of gasket material which contain rubber and asbestos or other materials which do not contain asbestos. This company is part of a group of privately held companies.

Process Description

The Bel-Tyne Automatic bag slitter, which is the subject of this study, is part of a process to produce sheets of rubber gasket material. The bag slitter sits in a warehouse material-preparation area. It is an area 80 X 90 feet and has a 22-foot ceiling. The area was quite full of pallets loaded with bales of asbestos. The asbestos in the bales is compressed and wrapped with plastic. The loaded pallets are stacked two high. A forklift truck transports pallets to the bag slitter. A worker lifts bales of asbestos from the pallets and sets the bales on the conveyor. The conveyor feeds the bales of asbestos into the bag slitter. The bag slitter separates the asbestos bale from its wrapping. The discarded wrapping is fed into a plastic bag and the asbestos is then fluffed, fluidized and pneumatically transported to a mixer elsewhere in the plant.

The operation of the Bag Slitter is straight-forward. This equipment's operation has been completely described by Bennison.[1] The operation is as follows:

1. A pallet of 50 kilogram bags of asbestos is set next to the charging conveyor (Figure 1).

2. The bags are placed onto the conveyor which is about a foot above the floor.

3. The conveyor feeds the bags into the mouth of the Bel-Tyne unit.

4. In the Bel-Tyne unit, the bags fall into a reciprocating knife which slits the bags.

5. On both sides of the knife, spiked rollers separate the bag from the asbestos bale.

6. The asbestos is drawn into a fluffer where the asbestos fibers are fluidized and then transported, under negative pressure in a pneumatic conveying system. However, there is no air flow when the pneumatic conveying system is off.

7. After the preceding bag is opened, the conveyor feeds the next bag into the machine.

8. The empty bag halves (which contained asbestos) are fed into a plastic bag on the side of the Bel-Tyne unit (Figure 2).

9. After the asbestos is fed to a hopper for the mixing equipment, the pnuematic system is turned off.

10. The transporting air is exhuasted through a baghouse and a HEPA filter.

Figure 1. Picture of the Bel-Tyne bag slitting unit

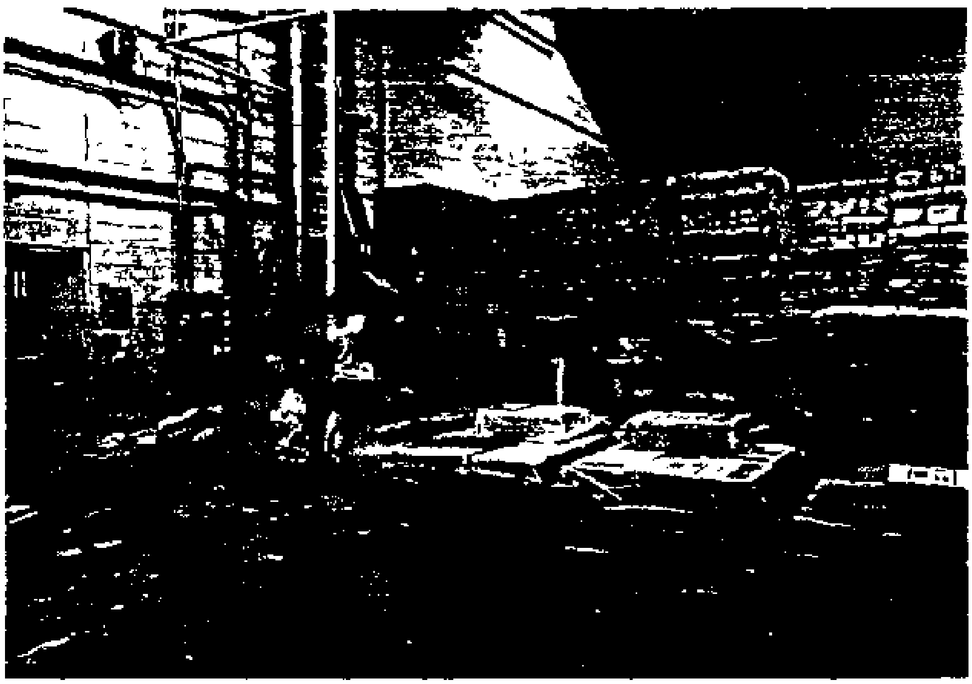


Figure 2. Picture showing bag disposal

III. POTENTIAL HAZARDS

Asbestos exposure is the primary hazard associated with this operation. Asbestos is a well known human carcinogen. OSHA regulates asbestos to prevent a lung fibrosis called asbestosis. This fibrosis impairs the transport of oxygen between the lung and the blood. The NIOSH recommended standard is largely based upon excess cancer among asbestos workers. Such cancers include lung cancer, gastro-intestinal cancer and mesothelioma.[3,4] Table 1 presents a summary of health standards for asbestos.

The workers who operate the bag opening equipment, are potentially exposed to asbestos from numerous sources:

1. Bags of asbestos which have tears or holes. The blades of a forklift truck can lance a plastic bag and cause at least a 10 cm^2 tear in the bag. Such tears are a cause of obvious asbestos spills. These spills are cleaned up with a vacuum cleaner and are immediately repaired with tape. Smaller tears about 2-3 cm^2 were observed on these bags. Of 10 bags examined, 3 had such tears. These tears are not obvious and are not sealed.

2. Resuspension (Figure 3) of settled asbestos: There is some settled dust on the floor, on unused bags and on the equipment. If disturbed, these could become sources of asbestos exposure.

3. Bag opening, emptying and disposal: This creates airborne asbestos inside of the Bel-Tyne unit. The design of the Bel-Tyne unit isolates the worker from this airborne asbestos.

4. Disposing of empty bags: The Bel-Tyne unit feeds empty bags into a plastic bag. When this plastic bag is full, it is taken off of the Bel-Tyne unit. Then, the plastic bag is wetted, compressed, tied shut and placed in a cardboard box. Compressing the bag may create airborne asbestos.

5. Emptying bags of non-asbestos fibers (Figure 4). The emptying of these bags presents a potential for interference in our sampling and subsequent analysis. Bags of these materials were opened, emptied and disposed of with minimal provisions for air containment. These materials were simply poured into a hopper through which fluidizing air is drawn.

6. Asbestos emission from the bag opener during periods of non-use. Air-movement out of the bag opener could be caused by the downstream process equipment. Such air movement could entrain asbestos. This is a potential emission source of unknown significance.

Table 1 Summary of Health Standards for Asbestos

Materials or Agents	PEL[2] fibers/cc	TLV[3] fibers/cc	NIOSH[4] Recommended level fibers/cc	Major Health Effects
Asbestos for fibers longer than 5 μm 8 hr TWA	2.0		0.1	Major health effects include asbestosis, lung cancer, gastro-intestinal cancer, mesothelioma.
Amosite		0.5		
Chrysotile		0.5		
Crocidolite		0.2		
All other forms of asbestos		2.0		

NOTE: The PEL levels are enforced by the Occupational Safety and Health Administration. The TLV and NIOSH Recommended level are suggersted exposure limits and are not enforced by OSHA.

Figure 3. Picture of asbestos bale with settled dust

Figure 4. Picture of non-asbestos fiber dumping

Asbestos Exposure Control Techniques

The control of asbestos at this plant is accomplished through an integrated program which includes personal protective equipment, industrial hygiene engineering controls, housekeeping, education, and air sampling. According to Soule[5], industrial hygiene engineering involves equipment selection as well as ventilation. The Bel-Tyne Automatic Bag Slitter is designed to contain asbestos emissions generated by asbestos bale opening, emptying and disposal. At the plant, asbestos control involves more than just the bag slitter. During periods of peak exposure, workers wear NIOSH-approved respirators and disposable coveralls. A Nilfisk vacuum cleaner is used to clean up spilled asbestos and to routinely remove settled and spilled asbestos from the floor. Air sampling is used to identify asbestos control problems which are then fixed.

IV. METHODOLOGY

This in-depth study was conducted to document and evaluate the control of asbestos as an air contaminant. The Bel-Tyne automatic bag opener is designed to control asbestos emissions while it opens, empties and disposes of bags which contain asbestos. Air monitoring was done to evaluate this machine's capability to contain the asbestos emissions. In addition, the use of the Bel-Tyne Unit was documented (sic). Factors which could affect asbestos concentrations were recorded and are listed in section 2 of this report.

The equipment used to conduct this study is listed in Table 2.

Table 2. Equipment Used In Study

ITEM	USE
Dupont P 4000 pumps	Air sampling
Fibrous Aerosol Monitor	Short term fiber concentration
Smoke tubes	Air flow patterns
TSI Digital Velometer	Air Velocity into (charging) chute

Ventilation Measurements

Smoke tube traces and air velocity measurements were used to document the air flow into the Bel-Tyne Automatic Bag Slitter's charging chute. The charging chute has an average face velocity of 190 feet per minute and a total air flow of 1400 CFM. Air flows through the charging chute only when the unit is emptying bags of asbestos. The air drawn through the charging chute is used to fluidize the asbestos. Consequently, this unit is only ventilated when asbestos is being transported away from the bag opener. The mechanical motion of other process equipment could induce an air flow out of the charging chute. However, smoke tube observations suggest that this is not the case. Released smoke appeared to hang in the inlet and to move very slowly out of the mixers charging chute by eddy diffusion.

Air Monitoring

Asbestos concentration and fibrous aerosol concentrations were measured to resolve a number of issues. Asbestos concentrations were measured to evaluate compliance with the hygienic criteria listed in Table 1 and to determine whether the operation of the bag opening equipment is associated with increased asbestos concentration. The fibrous aerosol concentrations were measured with a Fibrous Aerosol Monitor (FAM).[6] Because this instrument can provide a concentration every 10 minutes, it was used to study associations between activities in the opening area and increased fibrous aerosol concentrations.

Asbestos concentrations were measured using NIOSH method S 239[7]. After a known volume of air is drawn through a filter, the fibers on the filter are counted. These samples were collected at known rates between 3.5 and 3.7 lpm. In this method, all fibers that are longer than five micrometers and have a length to width ratio of at least three, are counted and are assumed to be asbestos. Counting is done under phase contrast microscopy with a magnification between 400 and 450.

The fibrous aerosol monitor was used to take a series of 10-minute average concentrations. In this instrument, an air sample is drawn through a rotating high-intensity electrical field which induces fibers to rotate rapidly. Scattered light is used to identify and count the fibers. Fiber length discrimination is achieved by examining the sharpness of the light pulse from the rotating fibers.[6] The FAM instrument settings recommended on page 56 of the reference manual were used. The instrument will only count fibers longer than 5.0 micrometers.

Application of The Air Monitoring to This Study

Asbestos concentrations were measured to resolve two issues.

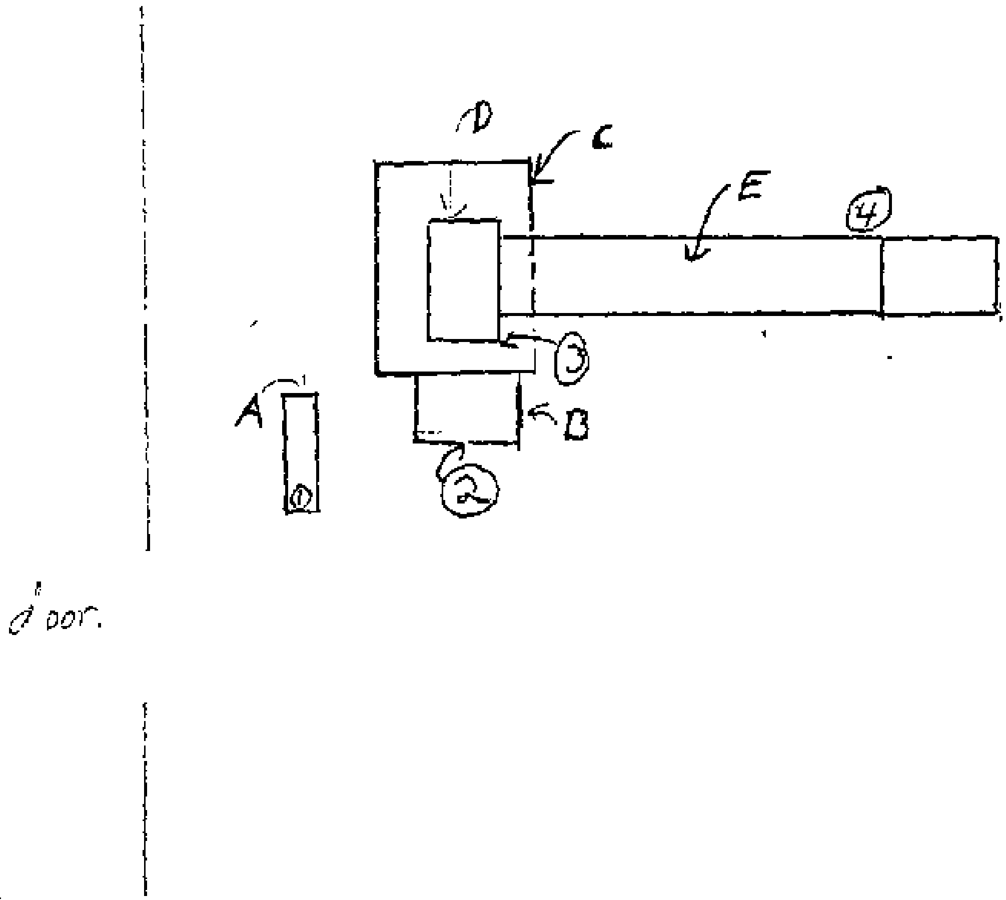
1. Is the worker's environment acceptable?
2. Does the operation of the Bel-Tyne Automatic Bag Opener increase asbestos air contamination?

The first issue was addressed by monitoring the worker's asbestos exposure and comparing his exposure to the hygiene criteria listed in Table 1. The second issue was addressed by a combination of area and personal air sampling results. Asbestos air samples were collected at the locations listed in Table 3 and shown in Figure 5. At each location two air samples were collected. One of these air samples was collected while the Bel-Tyne automatic bag opener was off and the other air sample was collected while the automatic bag opener was on.

Periodically non-asbestos fibers were used at this plant. Only the time-weighted personal average sample was collected during this time period. At other sampling locations, the pumps were turned off and filters holders were capped when non asbestos fibers were handled.

Table 3. Location Descriptions

Sampling Location Number in Figure 5	Description
1	On the top of a control panel 5 feet above the floor. This measurement reflects background contamination.
2	On pipe above manual dumping station for non-asbestos fibers
3	About 75 inches above the floor just below the side of the charging conveyor in the area.
4	A stationary sample which should reflect worker exposure if he remained in the area and did nothing. This sample was taken during conditions of non-use.



Legend:

- A Control Panel
- B Charging Chute for Man-made Fibers
- C Body of Bel-Tyne Unit
- D Charging Chute for Bel-Tyne Unit
- E Conveyor
- 1 Sampling Location 5 Feet above Floor
- 2 Sampling Location on Pipe 4 Feet above Floor
- 3 Sampling Location Just Below Conveyor
- 4 Sampling Location On Side of Coveyor

Figure 5. Sketch of layout and sampling locations.

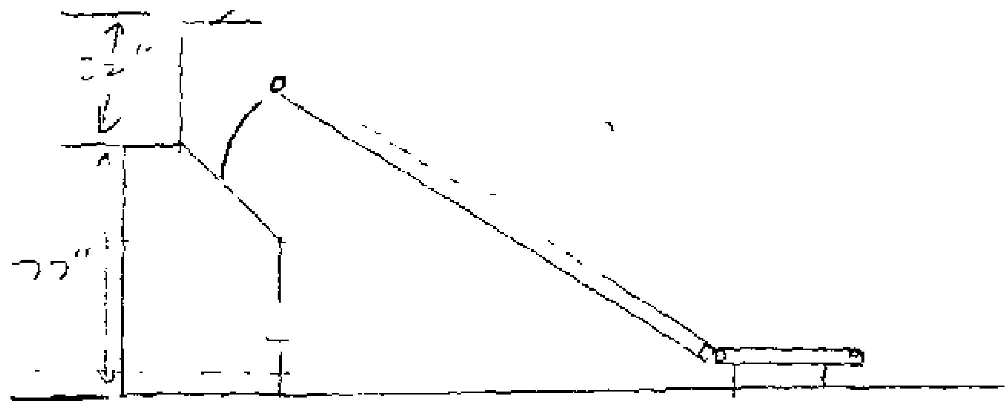


Figure 6. Side view of Bel-Tyne Unit

The combination of area and personal sampling results were used to test a specific hypothesis about asbestos concentrations and machine activity. This data was used to test a number of null hypotheses against an alternate hypotheses. The first null and alternative hypothesis can be stated:

H_0: At each sampling location concentrations (C_A) during machine operation are not different from concentrations measured during off conditions (C_I). (C_A=C_I).

H_A: C_A not equal C_I

If the Bel-Tyne Unit completely controls the asbestos generated by bag opening, emptying and disposal, the concentrations will not change.

Differences in concentration between sampling locations might be due to emission sources. This is particularly true of any differences in concentration between location 1 and the other sampling location. Emission could occur at location 3 from either the mouth of the chute or the charging conveyor as it turns around. The worker's exposure could be elevated above the result at location 1 because airborne asbestos could be generated by handling bales of asbestos. Some of these bales have small tears and others appear to be contaminated with asbestos. For each sampling location, the following null hypothesis could be tested against an alternative hypothesis:

H_0: The concentration (C_1). measured at location 1 (background) is not different from the concentration (C_L) measured at other locations or C_L = C_1.

H_A: C_1 not equal C_L.

As a result of these considerations the asbestos sampling was conducted as 2 x 4 factorial experiment with five replications. This means the asbestos air samples were collected over five full shifts. At each sampling location, an air sample was collected while the bag opener was on and another sample was collected while the bag opener was off.

The FAM was used to monitor temporal changes in fibrous aerosol concentrations. As mentioned earlier, it was used to monitor these concentrations over ten minute periods. Basically, the FAM data was collected to determine what activities are associated with higher fiber concentrations. For each activity which we observed, the statement of null and alternative hypothesis is as follows:

H_0: The fiber concentrations observed during an activity (C_A) equals the background fiber concentration which is measured when there is no activity (C_o).

H_A: C_A is not = C_o.

As a result of this hypothesis, the FAM was used to monitor fiber concentrations during periods of no activity, periods of bag opener use, and periods while other activities occurred. To obtain the data, 99 FAM readings were made during 5 shifts. During each reading the activities in the area were logged with the asbestos concentrations.

V. Sampling Results and Statistical Analysis

Individual asbestos and fibrous aerosol concentrations obtained during this study are listed in Appendices I and II. This data was analyzed statistically to answer the questions and test the hypotheses discussed in the Methodology section. These hypotheses are evaluated by testing the significance of concentration differences. These differences were evaluated by analysis of variance and multiple range tests in an effort to control the overall type I error rate.[8]

Special Preliminary Analysis.

During the course of this study asbestos and non-asbestos fibers were handled. To determine the extent to which these non-asbestos fibers could interfere with the asbestos counting procedure, four filters were analyzed by electron microscopy. Selected area diffraction analysis was used to determine the identity of 15-20 fibers/filter. These analyses showed that only the chrysotile asbestos fibers were longer than 5.0 micrometers.

Asbestos Concentration Data.

Asbestos concentrations were measured as required by the experimental design described in Section 3. The actual data is listed in Appendix I. This data is summarized during the course of the statistical analysis which is presented later in this report.

In addition to the asbestos data listed in Appendix I, some relatively short term asbestos concentration measurements were made during bag disposal. These results are presented in Table 4 and they reflect emission source 4 in the list of emission sources.

Table 4. Summary of Short Term Sampling

ACTIVITY	TIME	ASBESTOS CONCENTRATIONS (fibers/mL)
(1) 8/3 P.M. bag disposal	8 minutes	0.44
(2) 8/2 P.M. bag disposal	5 minutes	0.58

Statistical Analysis of Concentration Data.

Before analysis, these asbestos concentrations from Appendix I were transformed by taking natural logarithms. Next, the General Linear Models (GLM) procedure of SAS was used to determine which factors significantly affected concentration. Table 5 which is directly from the Analysis of Variance Table shows which factors significantly affected asbestos concentration. The specific shift during which the samples were collected is the only factor which appeared to affect concentration.

Table 6 shows how the asbestos concentration varied between the different shifts. In this table, a multiple comparison test is used to evaluate the significance of these concentration differences. During the 3-11 shift on 8/3/83 the highest geometric mean asbestos concentrations were observed. During the first part of this shift, a shipment of compressed asbestos bales was unloaded from a truck. The outsides of some of these bales were coated with asbestos.

The second highest result in Table 6 may also be due to extraneous activities. During the 7-3 shift on 8/2/83, the pneumatic conveying system was clogged. After turning the conveying system fan off, the worker used a rod to break up the jam. This could have caused asbestos emissions out of the mixer's charging chute. As summarized later, an asbestos concentration during this operation in a room adjacent to the mixer was measured to be 0.6. fibers/ml. This contamination could have spread to the room in which the bag slitter was operating.

Table 5. Results from Analysis of Variance on Asbestos Concentration Data

FACTOR	PROBABILITY OF A LARGER F The probability of seeing such large differences due to chance
1. Sampling location	0.31 (ns)*
2. Specific shift during which samples were taken	0.0001 (s)**
3. Operation of bag opening machine	0.63 (ns)
Interaction between factors 1 and 3	0.38 (ns)

* not significant
** significant

Table 6. Summary of Geometric Means (GM) Asbestos Concentrations on Different Shifts

SPECIFIC SHIFT	GM fibers/mL	N*	MUTIPLE COMPARISON (Waller-Duncan K-ratio test)
8/3/83, 3-11	0.2	7	A
8/2/83, 7-3	0.06	8	B
8/2/83, 3-11	0.04	8	B
8/3/83, 7-3	0.02	7	B,C
8/1/83, 3-11	0.02	7	C

Note: Geometric means with different letters are significantly different.
N - Number of samples

As seen in Table 6, the operation of the bag opener has little if any effect upon asbestos concentrations. Table 8 shows the effect of bag opening status upon asbestos concentration at the different sampling locations. The effect, if present at all, is too small to be detected.

Table 7.

Summary of Geometric Mean Asbestos Concentrations at Different Sampling Locations

Sampling Location	GM Asbestos Concentration (fibers/ml) Status of Bag Opener: On	Off
worker	0.05	0.03
background	0.060	0.06
near the manual dumping station	0.04	0.04
below charging chute	0.06	0.04

A second statistical analysis was done upon the data in Appendix I using a dependent variable called DIFF. For a given sampling location and specific shift DIFF is computed as follows:

$DIFF = \ln(C_{on}) - \ln(C_{off})$ where $C_{on,\ off}$ = asbestos concentration measured while the bag slitter is respectively on or off.

This variable DIFF is of use because it blocks out the between shifts variability of asbestos concentration and hence, it allows one to more clearly study the effect of bag opener status upon asbestos concentration. As summarized in Table 8, analysis of variance shows that specific shift significantly affected the size of DIFF. Table 9 shows how the ratio of "on to off" asbestos concentrations (inverse logarithms of DIFF) are affected by the specific shift. Such an analysis suggests that on some shifts the operation of the bag opener is associated with increased asbestos concentrations.

Table 8

Results of Analysis of Variance Upon the Dependent Variable DIFF

SOURCE OF VARIATION	PROBABILITY OF A LARGER F	SIGNIFICANCE
Location	0.18	ns*
specific shift	0.0004	s**

* not significant
** significant

Table 9. Summary
Ratio of Operating to Non-Operating
Asbestos Concentrations on Different Shifts

SPECIFIC SHIFT	RATIO OF OPERATING / NON-OPERATING CONCENTRATIONS	GROUPING FROM WALLER-DUNCAN TEST
8/2/83, 3-11	4.0	A
8/1/83, 3-11	1.9	A B
8/3/83, 3-11	0.53	B C
8/3/83, 7-3	0.36	C
8/2/83, 7-3	0.26	C

Statsitical Analysis of FAM Data

The FAM concentrations are listed in Appendix II. This data is summarized in the course of the statistical analysis. After this data is transformed by taking natural logarithms, the GLM procedure of SAS is used to determine which variables affect the FAM concentrations. Table 10 presents the results of the analysis. This table lists factors which determine FAM concentration and it lists the significance of these determinant variables.

Table 10

Results from Analysis of Variance Upon FAM Concentration Data

SOURCE OF VARIATION	PROBABILITY OF A LARGER F	SIGNIFICANCE
Operation of bag opener	4×10^{-4}	Significant
Other factors	8.4×10^{-4}	Significant
Specific shift	10^{-4}	Significant

Table 11
Effect of Bag Opener Status

BAG OPENER STATUS	GEOMETRIC MEAN (Fibers/mL)	GROUPING FROM BONFERRONI (DUNN) T-TEST
Operating	0.09	A
Not operating	0.06	B

The operation of the bag slitter appears to have a significant affect upon FAM concentration. Results presented in Table 11 show that the bag slitter operation is associated with higher FAM concentrations.

In Tables 10 and 12, the variable "other factors" refers to activities peripheral to the bag slitter. Based upon judgment, these activities were thought to affect FAM concentration. Table 12 lists these "other factors" and shows how they affect asbestos concentration. Forklift-truck activity and opening bags of man made fiber appeared to elevate FAM concentrations above background concentrations measured when there is no extraneous activity. However, this increase is not statistically significant.

Table 12
Summary of Other Factors Which Affected Fibrous Aerosol Concentration

Other Activities	GM Fibers/mL	N	GROUPING FROM WALLER-DUNCAN Test*
Forklift truck activities	0.2	7	A
non-asbestos fiber dumping	0.1	18	B
no extraneous activity	0.06	61	B
rubber cutting	0.06	31	B

* Geometric means with same letter are not significantly different.

VI. DISCUSSION

The data in this study was taken to resolve issues described in the methodology section of this report. The most important question is, "Is the worker's environment acceptable?" The data presented in Appendix I and in Table 4 suggest that for the most part the worker's exposure is acceptable. Most of the concentration values did not exceed the exposure limits listed in Table 1. Some of the sampling results presented in both places show that the workers asbestos exposure did exceed 0.1 fibers/cc.

On the 3-11 shift of 8/3/83, the worker time-weighted average exposure while handling bales of asbestos was 0.13 fibers/mL. The arithmetic average asbestos exposure during this operation was 0.06 fibers/mL. Because of the high coefficient of variation of the NIOSH method, known to be over 40%, one of the four asbestos concentration measurements could exceed 0.1 fibers/mL when the true mean is 0.06 fibers/mL. This suggests that the worker's exposure is acceptable while he is placing bales of asbestos upon the conveyor. This does assume that the outside of the asbestos bales are not contaminated with asbestos.

The study also sought to evaluate whether the operation of the bag slitter elevated asbestos concentration. The results presented in the preceding section integrated with observations suggest that the bag slitter operation does not elevate asbestos concentration. Asbestos concentrations measured at the different sampling locations appear to be homogenous as demonstrated by results in Tables 5 and 8. Furthermore, asbestos concentrations at any location do not change when the bag slitter is operated. Again, Tables 4 and 8 support this conclusion.

Other factors appear to be affecting asbestos concentration. The variation in the variable DIFF with the specific shift suggests that this is indeed the case. Analysis of the FAM concentration data suggests resuspended asbestos could be judged a significant emission source. During the shift with the highest GM asbestos concentration in Table 6, a shipment of asbestos was unloaded from a truck. These asbestos bales had small tears and what appeared to be pieces of loose asbestos were setting on top of some of the bales, which were on pallets. Quite possibly the movement of these bales suspended the loose asbestos into the air.

Asbestos emitted from the outside of the plastic wrapping around the bales of asbestos would explain some of the results mentioned earlier. It could explain the effect of bag opener status upon FAM concentration. The FAM was about 5 feet from the point where the worker dropped the bale of asbestos on the conveyor. If loose asbestos was being emitted by this act, it would explain the 50% increase in FAM concentration during the operation of the bag slitter. The analysis of the asbestos concentration data has insufficient power to detect a 50% difference in concentration.

The empty bag handling does appear to elevate the workers' asbestos exposure above the concentrations reported in Appendix I. At the closing conference, the possibility of using the special asbestos vacuum cleaner to suck air out of the plastic bags, which contain the discarded wrapping for the asbestos bales, was discussed. This should eliminate the asbestos dispersed by manually compressing the bags.

VII. CONCLUSIONS

The bag opener can be operated without significantly increasing the asbestos fiber concentrations. The worker's exposure is increased by packaging, for disposal, the bag which contains the discarded wrappings from the asbestos bales.

The unopened bales of asbestos are suspected of being an asbestos emission source. As described earlier, large and small tears in these wrappings do occur. The large tears are promptly fixed and any spilled asbestos is promptly removed by a special vacuum cleaner equipped with HEPA filters. The smaller tears are untreated and may be an emission source when the bale is handled. The emission from the asbestos bales appears to be particularly acute during the receipt of the bales of asbestos. This suggests a need to improve the quality of the wrapping around the asbestos bales or improve handling techniques during shipment. This may be needed to keep asbestos concentration below 0.1 fibers/mL.

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APPENDIX I
Asbestos Concentration Data

Location number Table 3	Location	Date	Shift	Asbestos fiber/mL Bag Slitter Status ON	OFF
1	Control panel	8/1/83	3/11	0.037	0.016
		8/2/83	7-3	0.025	0.080
		8/2/83	3-11	0.12	0.041
		8/3/83	7-3	0.034	0.046
		8/3/83	3-11	0.218	0.315
2.	Pipe above manual dump station	8/1/83	3-11	0.022	0.010
		8/2/83	7-3	0.022	0.272
		8/2/83	3-11	0.116	0.025
		8/3/83	7-3	0.022	0.070
		8/3/83	3-11	0.14	0.338
3.	Under charging convey; just a charging chute	8/1/83	3-11	0.019	0.01
		8/2/83	7-3	0.045	0.173
		8/2/83	3-11	0.047	0.042
		8/3/83	7—3	under 0.001	0.087
		8/3/83	3-11	0.128	overloaded
4 & 5	Worker	8/1/83	3-11	—	0.01
		8/2/83	7-3	0.029	0.037
		8/2/83	3-11	0.042	0.006
		8/3/83	7-3	0.041	overloaded
		8/3/83	3-11	0.13	0.24
– time weighted average on worker		8/1/83	3-11		overloaded
		8/2/83	7-3		0.15
		8/2/83	3-11		overloaded

The samples marked overloaded had too much particulate material for the fibers to be seen.

Appendix II.
FAM Concetration Data

CODES IN APPENDIX II

Bag Slitter Status

n - bag slitter not operating
y - bag slitter operating

Other activites

fd - non-asbestos fibers were poured into hopper

m - forklift truck activity

rc - rubber cutting

n - no other activities

Shift

1	7-3 shift
2	3-11 shift

Day

1	8/1/83
2	8/2/83
3	8/3/83

FAM CONCENTRATION DATA

fiber concentration fibers/mL	bag slitter status	other activity	shift	day	time
0.08	n	fd	2	1	not recorded
0.04	n	n	2	1	not recorded
0.02	n	n	2	1	not recorded
0.06	y	n	2	1	17:16
0.02	n	n	2	1	17:30
0.05	y	rc	2	1	18:37
0.03	n	rc	2	1	19:09
0.0	n	n	2	1	19:58
0.06	y	n	2	1	20:18
0.09	y	rc	2	1	20:40
0.01	n	rc	2	1	20:57
0.06	y	rc	2	1	21:02
0.02	n	rc	2	1	21:15
0.04	y	rc	2	1	21:29
0.01	n	n	2	1	21:43
0.01	n	n	2	1	22:00
0.06	y	n	1	2	8:33
0.05	n	fd	1	2	8:43
0.03	n	fd	1	2	8:55
0.05	n	n	1	2	9:05
0.1	n	m	1	2	10:30
0.03	n	n	1	2	11:00
0.0	n	n	1	2	11:25
0.08	y	n	1	2	11:45
0.02	y	n	1	2	12:00
0.03	n	n	1	2	12:30
0.06	n	n	1	2	13:00
0.3	n	n	1	2	13:10
0.2	y	n	1	2	13:25
0.2	y	n	1	2	13:42
0.1	y	n	1	2	14:00
0.13	y	n	1	2	14:10
0.13	n	n	1	2	14:20
0.03	n	n	1	2	14:30
0.09	n	n	2	2	15:12
0.03	n	n	2	2	15:49
0.1	y	n	2	2	16:14
0.03	n	n	2	2	16:25
0.14	y	n	2	2	17:05
0.03	n	n	2	2	17:37
0.16	y	n	2	2	18:29
0.01	n	n	2	2	18:49
0.1	n	fd	2	2	19:16 (one minute sample)

Fam Concentration Data (continued)

fiber concentration fibers/mL	bag slitter status	other activity	shift	day	time
0.03	n	fd	2	2	19:18
0.22	n	rc	2	2	20:05
0.14	n	rc	2	2	29:16
0.08	y	n	2	2	20:26
0.05	n	n	2	2	20:40
0.04	n	fd	2	2	21:14
0.13	n	n	2	2	21:29
0.07	y	n	2	2	21:40
0.03	n	n	2	2	22:00
0.06	n	fd	1	3	7:45
0.11	n	fd	1	3	7:55
0.06	n	fd	1	3	8:10
0.08	n	fd	1	3	8:21
0.23	n	m	1	3	9:03
0.26	n	fd	1	3	9:13
0.03	n	fd	1	3	9:23
0.75	y	fd	1	3	9:50
0.2	y	n	1	3	10:05
0.17	n	n	1	3	10:17
0.18	n	n	1	3	10:28
0.20	n	n	1	3	10:44
0.10	y	m	1	3	10:54
0.55	y	n	1	3	11:06
0.51	n	fd	1	3	11:15
0.29	n	fd	1	3	11:29
0.07	n	fd	1	3	11:41
0.11	n	n	1	3	11:53
0.18	n	n	1	3	12:20
0.1	y	n	1	3	12:36
0.12	n	n	1	3	12:47
0.24	n	m	1	3	12:59
0.27	n	m	1	3	13:10
0.1	y	n	1	3	13:22
0.15	n	n	1	3	13:38
0.14	y	n	1	3	13:49
0.03	n	n	3	2	15:01
0.16	y	m	3	2	15:29
0.43	n	m	3	2	15:40
0.09	n	rc	3	2	15:51
0.07	n	rc	3	2	16:02
0.04	n	rc	3	2	16:21
0.11	y	n	3	2	16:51
0.02	n	n	3	2	17:35

Fam Concentration Data (continued)

fiber concentration fibers/mL	bag slitter status	other activity	shift	day	time
0.04	y	n	2	3	17:55
0.03	y	n	2	3	18:14
0.02	n	n	2	3	18:27
0.07	y	n	2	3	18:49
0.03	y	n	2	3	19:10
0.08	y	n	2	3	19:21
0.02	n	n	2	3	19:40
0.2	n	fd	2	3	19:56
0.09	n	n	2	3	21:10
0.1	y	n	2	3	21:25
0.05	n	n	2	3	21:37
0.02	y	n	2	3	22:09
0.05	n	rc	2	3	22:20