IN-DEPTH SURVEY REPORT:

CONTROL TECHNOLOGY FOR BAG FILLING OPERATIONS

AT

UNION CARBIDE CORPORATION

KING CITY, CALIFORNIA

REPORT WRITTEN BY:

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Division of Physical Sciences and Engineering
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SIC CODE: 1499

SURVEY DATE: January 24 - 28, 1983

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ABSTRACT

An in-depth survey of a manual bagging operation of asbestos was conducted at King City, California. The asbestos being bagged was both in pellet and open fiber form. The packaging system consists of two bagging operations located in separate rooms. Controls include enclosures for the bag filling and bag flattening operations, general isolation of the packaging operations, and the use of shrink wrap on individual paper bags.

Personal, source, and area samples were collected for asbestos fibers. Air velocity, volumetric flowrates, and flow patterns were obtained at the two bagging operations. The relationships between the occupational atmospheric fiber exposures and control systems were evaluated.

The control technology systems at this plant were capable of maintaining average asbestos fiber concentrations at 0.7 fibers/cc while bagging pelletized asbestos and at 0.3 fibers/cc while bagging open fiber asbestos.

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 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 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

Dust concentrations around bagging operations are often high. This causes higher potential exposures to the worker than many other processes. NIOSH Health Hazard Evaluation reports and other study reports involving bag filling operations for dry chemicals often mention the high dust concentration in and around the bagging area.[1-9] These reports describe the bagging process as one of the biggest dust problems in need of effective dust controls and that the highest potential dust exposure is to the operator at the bag filling machine.

It is estimated by packer manufactures that there are over 20,000 dry chemical packaging operations in the United States. Force flow, auger, gravity feed and other types of packers fill open-top and valve-type bags with powders, granules, and fibers. Many of these packer machines are 10 to 20 (some over 40) years old. Built-in dust controls are usually either minimal or nonexistent in the older units. Many of todays packers use only rudimentary measures such as an exhaust hood around the spout to capture airborne dust during bag filling. More complete control measures must be developed by the user to ensure adequate protection for the equipment operators and others who work in the bagging area.

NIOSH has worked cooperatively with firms in many industries to identify and help solve problems in occupational health. The main purpose of this study is to assess and document the strategies used to control airborne dust in the bag filling areas. These control strategies included engineering measures such as ventilation, automation, isolation; monitoring systems; work practices; personal protective equipment; and health and safety programs. The results of these studies will be described in sufficient detail to allow the information to be used to reduce exposures of workers to toxic or hazardous substances that may be encountered in other similar industrial operations.

The product of this research will be resource documents/articles containing practical ideas on control methods. Such documents will enhance the design engineer's understanding of industrial hygiene principles and also enable the industrial hygienist to participate more effectively in the design and improvement of control equipment. The results of the assessment will be disseminated in a manner that will maximize the application of demonstrated control technologies in the workplace. The study will have a positive impact on worker health by pin-pointing and stimulating the across-the-board use of good control methods as solutions to occupational health problems.

BACKGROUND FOR UNION CARBIDE SURVEY

Union Carbide's King City operation was selected because of several exemplary controls used in packaging asbestos fibers. The areas of primary interest were the bag filling operations and related packaging operations such as conveying and palletizing. The controls evaulated were: the enclosures for the bag filling and bag flattening operations; the exhaust ventilation from these enclosures; the use of both shrink wrapping and stretch wrapping; automated palletizing; and the isolation of the bagger rooms. Sampling strategy was geared to evaluate the effectiveness of these methods including the related ventilation systems, and the other controls.

II. PLANT AND PROCESS DESCRIPTION

INTRODUCTION

Union Carbide Corporation (UCC) produces a short fiber chrysotile asbestos product which is used in a variety of applications. This milling and packaging site consists of one processing building, maintenance and office facilities, and two covered storage areas. The packaging operations are located in the processing building and were the areas of interest in this survey. This one story (20' high) building (steel frame with metal sides) has a concrete floor, no basement, and approximately 20,000 square feet of floor space. There are two separate packaging areas (Main Bagger Room and RG-244 Bagger Room), each with a conveyor and palletizing area. The grounds surrounding the building are paved, including areas under the various ancillary structures.

The asbestos mill has a work force of approximately 60 employees. The plant started production in 1963 and presently transports 80% of the product in bags and 20% in bulk railcars.

PROCESS DESCRIPTION

Ore is transported about 60 miles from a massive short fiber chrysotile asbestos deposit located near Coalinga, California. Ore from the mill's stockpile is slurried, crushed, sized, screened, dewatered, pelletized and dried. A portion of the product is sold in pellet form and is shipped either in bulk or in bags. Product not shipped or packaged as pellets is further processed through a hammer mill to produce open fibers which then are packaged and shipped. Packaging is performed in two separate areas of the plant, Figure 1. The "Main Bagger" has three packer units: two twenty year old single spout force flow packers, and one eleven year old single spout auger packer. The second bagging area, "RG-244 Bagger", has one fifteen year old single spout force flow packer. All four packers are manually operated and three of the four packers were manufactured by Stoker, while one of the force flow packers in the Main Bagging Room was manufactured by Black Products Company.

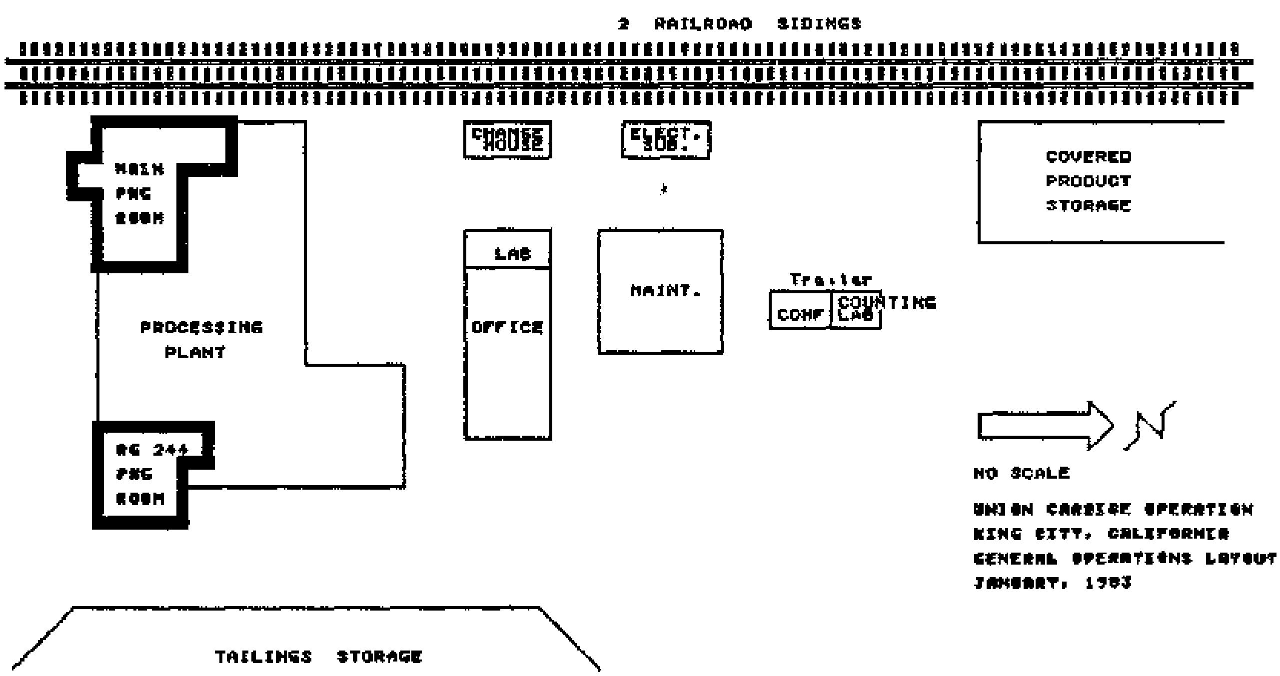

Figure 1: Packaging Rooms

In the Main Bagger Room, a variety of product grades are packaged: pellets (5/8"x1/4"), cracked pellets (pellets which have been fractured), and open fibers (ground pellets). In the RG-244 Bagger Room, only an open fiber product is packaged. During this study, the products being packaged were pellets (SG-103-5 and SG-200) and open fibers (RG-244).

Pellets are packaged in plastic or paper bags and open fiber products are packaged in paper bags. Both bags are equipped with sleeve-type fill valves with RG-244 bags having tuck-in sleeves. The paper bags have mulitply paper layers "punctured" to permit air to escape (punctures are at different locations on different plies to minimize fiber release). Filled bag weights vary from 10 pounds (for RG-244) to 82 pounds, which indicates the bagging complications of packaged densities ranging from 5 lbs/ft^3 for RG-244 to 45 lbs/ft^3 for pellets.

At the "Main Bagger", a bag is placed on the spout, filled, and manually dropped from the packer onto a chain conveyor. The filled bag passes through a bag cleaner, a bag flattener, onto a conveyor exiting the enclosure, and over a series of conveyors to an automatic palletizer, Figure 2. (Either plastic or paper bags may be filled at this station. When a paper bag is filled, it is individually shrink wrapped shortly after leaving the enclosure.) The loaded pallets are forklifted to the stretch wrapper station and then to storage until shipped.

At the "RG-244 Bagger", the Stoker packer spout is enclosed in a hood. A paper bag is manually placed on the packer spout; and, as it starts to fill, the door to the hood is manually closed. Low pressure, 3 to 5 psi, is used to fill the bag. After the bag is full, the door is manually opened, the bag is manually removed, weighed, and set on the chain conveyor. The bag passes through the cleaner and flattener enclosure, is shrink wrapped, and proceeds to the manual palletizing area (a second area different from that of the "Main Bagger"), Figure 3. The loaded pallets are moved by forklift to either the stretch wrap station or storage.

The "Main Bagger" crew consists of one bagger operator and one palletizer operator. The "RG-244 Bagger" crew consists of a bagger operator with other personnel moving the loaded pallets to storage. Packaging is normally performed 3 shifts a day, 5 days a week.

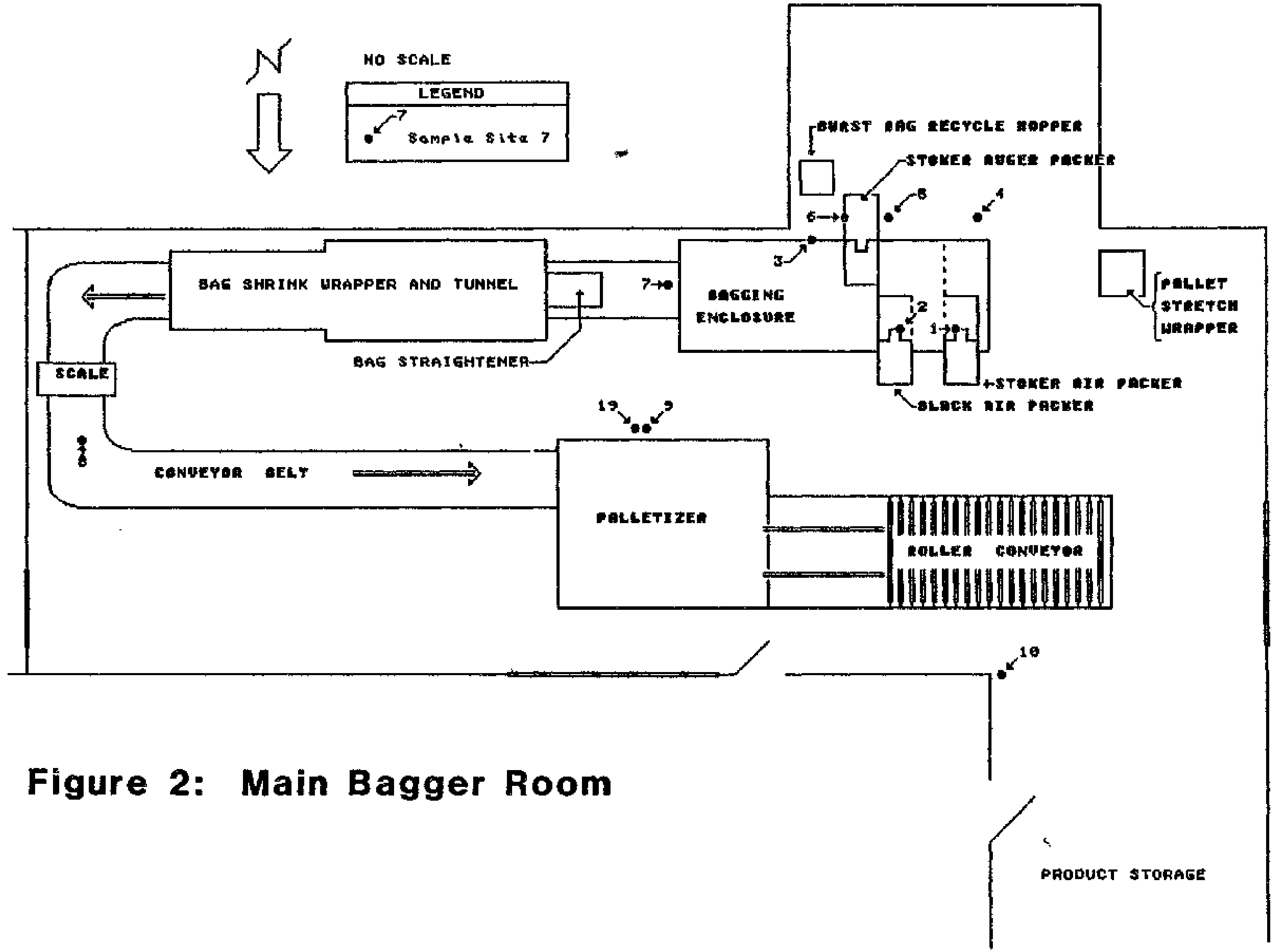

Figure 2: Main Bagger Room

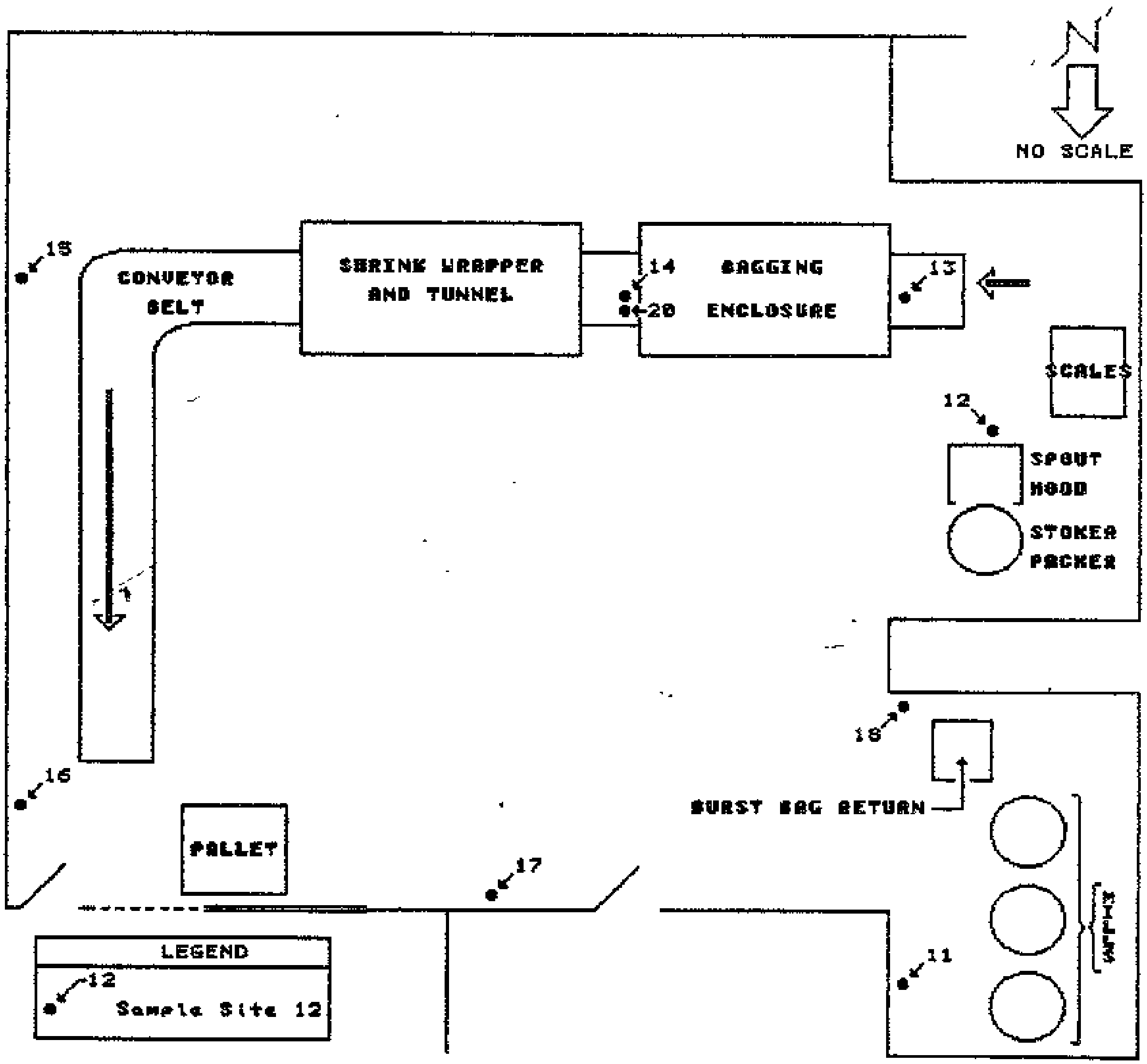

Figure 3: RG-244 Bagger Room

POTENTIAL HAZARDS: The primary potential hazard from the asbestos bagging and handling operations is the inhalation of airborne asbestos fibers. These fibers become airborne during bag filling and subsequent operations such as conveying, burst bag recycling, and handling.

Asbestos is a commerical or generic term used to describe six naturally ocurring minerals which are hydrated metal silicates. The six varieties are divided into two classes, amphibole and serpentine, based on crystal structure. The amphiboles include crocidolite, amosite, anthohpyllite, tremolite, and actinolite. Chrysotile is the only member of the serpentine class and accounts for about 98% of the asbestos used in the United States.

Prolonged exposure to excessive concentrations of chrysotile asbestos fibers can increase the risk of developing asbestosis, a non-malignant scarring of the lung, and lung cancer.[10] It has been established that cigarette smoking significantly increases the risk of developing lung cancer in persons exposed to asbestos.[11] The latency period for disease development is usually 20 or more years.

Union Carbide's ore deposit near Coalinga, California is all chrysotile and is unique in that it is all short fiber. Processed fibers range from two to twenty micrometers in length.

OSHA regulates employee exposure to airborne asbestos as an occupational health and safety standard (Federal Standard 29CFR1910.1001). The established PEL is two fibers, longer than five micrometers, per cubic centimeter of air as an eight-hour time-weighted average, and a ceiling limit of 10 fibers/cc. Both CAL-OSHA and MSHA, with regulations similar to OSHA's, assert jurisdiction over Union Carbide's asbestos mill.

On November 4, 1983, OSHA issued an emergency temporary standard lowering the permissible workplace exposure limit for asbestos to 0.5 fiber per cubic centimeter.[12] NIOSH's recommended asbestos standard is 0.1 fiber per cubic centimeter.[13]

III. METHODOLOGY

EQUIPMENT

The equipment used in the study to measure airborne asbestos concentrations (personal, source, and area) and ventilation rates is listed in Table 1.

Table 1. Equipment Items Used in the Study

Item	Model	Used for
Air Sampling:		
Pumps	MSA Model G	Collecting airborne fiber samples at a nominal flow rate of 1.5 liters/minute
37 mm PVC Filter Cassettes	0.8 u AA Millipore	Open face cassettes to collect airborne samples
Ventilation Measurements:		
Air Vel. Meter	TSI Model 1650	Ventilation measurements
Air Vel. Meter	Kurz Model 441	Ventilation measurements
Pitot Tube		Ventilation measurements
Incline Manometer		Ventilation measurements
Smoke Tubes	Gastec	Determine air movement

MEASUREMENT OF CONTROL PARAMETERS

At the Union Carbide Plant, two separate bag filling operations were studied; "Main Bagger" and "RG-244 Bagger". The effectiveness of the control methods for airborne fibers was evaluated quantitatively by taking airborne samples and ventilation measurements.

Atmospheric Fiber Measurements - To evaluate the effectiveness of the control system for airborne fibers, samples were collected by NIOSH to 1) locate sources of airborne fiber contamination; 2) determine background fiber levels in the two bagging rooms; and 3) determine personal exposure levels to the bagging and palletizing operators. The sampling was performed over two hour periods, once in the morning and again in the afternoon of the same shift. Sites sampled (shown in Figures 2 and 3) for potential airborne fiber sources were; at the openings of the bag cleaner and flattener enclosures, along the conveyor lines, near the palletizing stations, near the packer spouts and packer hoods, and the grinding and burst bag recycle area in RG-244 Bagging Room. Area samples were located to determine the background levels in these two bagging rooms for camparison with potential source concentrations.

Ventilation Measurements - Ventilation measurements were taken in exhaust ducts using a pitot static tube and manometer to determine airflow from specific exhaust hoods. Air velocity measurements using a hot wire anemometer were taken at hood openings where emissions of asbestos 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 air monitoring was performed along with the ventilation measurements to determine the effectiveness of the control methods.

Smoke tube traverses were made of the air currents in each bagging room, at the openings to the various enclosures, and at the faces of the exhaust ports within the packer hood. Also noted were weather conditions and operating abnormalities.

SAMPLING PROCEDURES

A total of 17 personal, 66 source, and 45 area air samples for airborne asbestos fibers were collected during the second shift (8 AM to 4 PM) for three consectutive days. Eighteen fixed sites and three personnel were sampled twice each day for approximately 2 hours. The original analysis of the air filter samples are shown in Table 6.

IV. CONTROL TECHNOLOGY

INTRODUCTION - PRINCIPLES OF CONTROL

Dust control in all areas requires a combination of good engineering controls and good work practices. As dust emissions from point sources are reduced, it normally follows that the level of personal exposures to atmospheric dust are also reduced proportionately.

Occupational exposures can be controlled by the application of a number of well-known principles, including engineering measures, work practices, and personal protection. 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, supplied-air cabs, work practices, and personal protective equipment.

In general, a system comprised of the above control measures is utilized 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 surveillance 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 Union Carbide for bag filling operations is discussed below.

EVALUATION OF CONTROLS

A. Use of Enclosures Equipped with Exhaust Ventilation to Control Fiber Emissions during Bag Filling and Flattening Operations:

Enclosures with ventilation and operator positioning are two methods used to reduce employees' exposure to contaminated air. During bag filling, displaced dust laden air escapes from the bag's valve and seams. Also, air is entrapped in the bag during filling, resulting in a ballooning effect. The amount of bag ballooning depends on the type of packer (force flow or auger) used and the type of product (open fiber or pellet) being packaged. To deaerate the bags, they are passed through a bag flattener. Therefore, during both bag filling and flattening, asbestos fibers are released from the bag. To contain the fibers released, enclosures with exhaust ventilation are built around the filling and flattening operations.

1. Main Packer Station: The main packer station consists of three (two force flow and an auger-type) single spout packers and one bag flattener. Both bag filling and flattening operations are within the same enclosure, Figure 4. The packer operator sits on top the enclosure, above the potential dust source, in a recessed area between the packer units. Above the spout of each packaging unit is a bag access opening (7"x25" at the force flow packers and 11"x26" plus 18"x26" at the auger packer) with sliding doors, Figure 5. When the bag is filled, the operator reaches through this

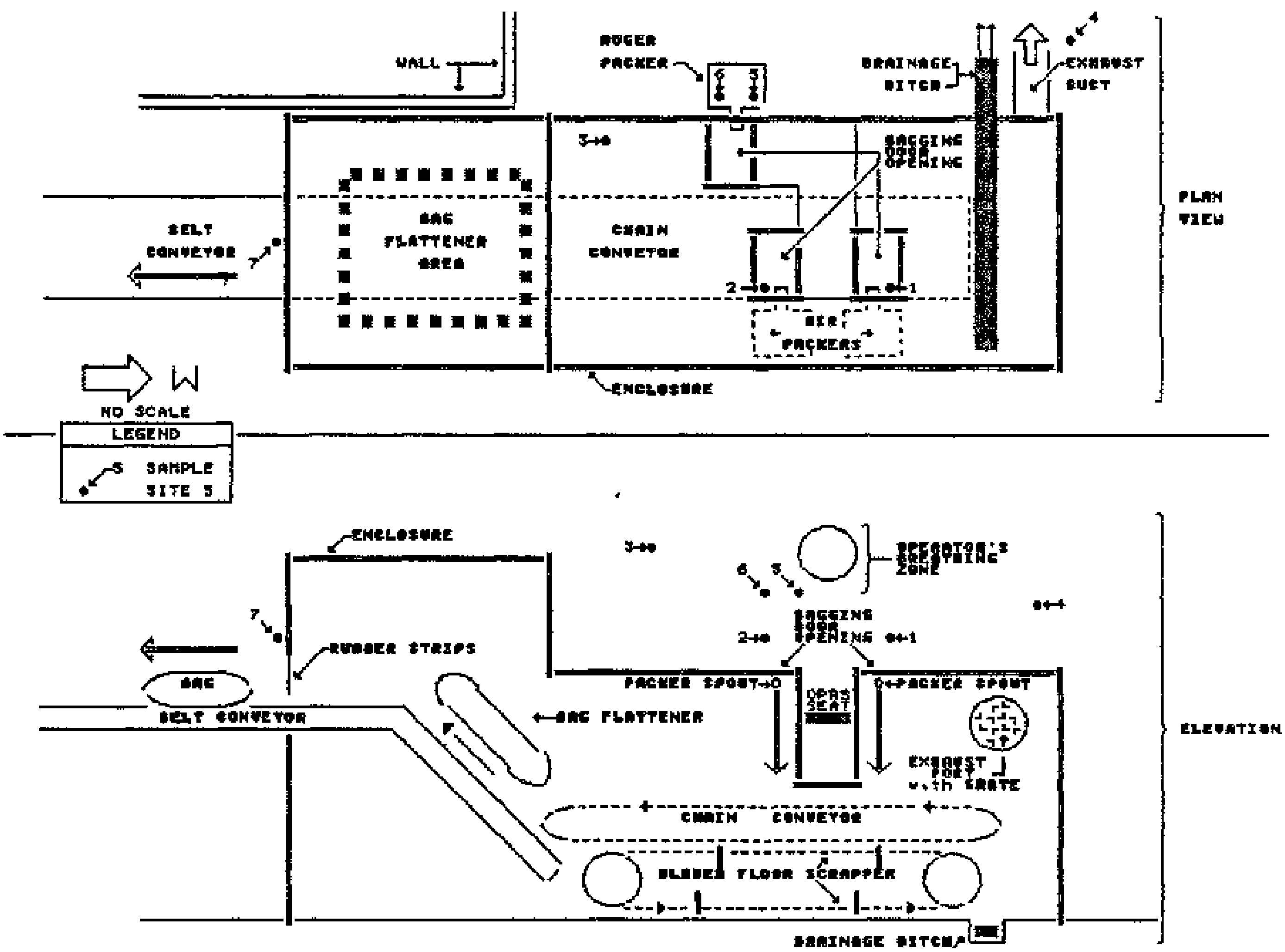

Figure 4: Main Bagger Enclosure

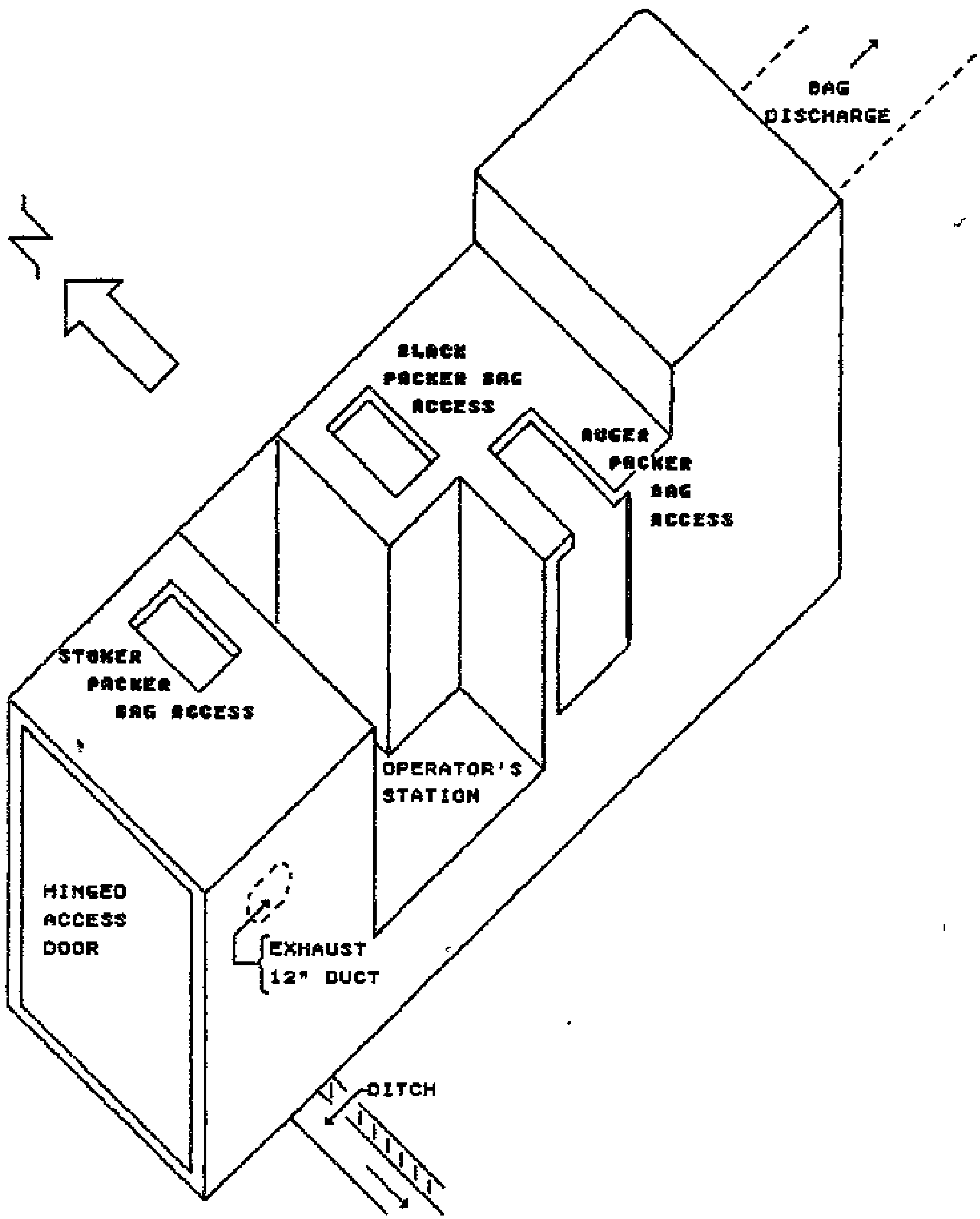

Figure 5: Main Bagger Enclosure - Isometric

opening and manually tips the bag onto the chain conveyor located within the enclosure and beneath the packers. The bags are conveyed a few feet to the belt conveyor and inclined bag flattener unit. The bag discharges onto a horizontal belt conveyor, exits the enclosure, and proceeds toward the palletizing area.

Dust is controlled by having the potential dust sources (packer spout, bag valve, and bag seams during bag filling, dropping onto the conveyor, and bag flattening operations) enclosed. Also, within the enclosure, an open type chain conveyor is used beneath the packer units to reduce product buildup on the conveyor. Spillage from bag leakage or ruptures fall through the conveyor onto the concrete floor. A combination of a blade scraper beneath the chain conveyor and water sprays move this spillage to a ditch where it is pumped as a wet slurry to a thickener for recycle into the process, Figure 4.

To reduce the amount of fibers escaping at the discharge end of the enclosure, there is a curtain of overlapping rubber strips. Internal lighting and plexiglas windows, for observation purposes, make it possible to spot malfunctions that may occur within the enclosure. The access door is interlocked with the packer units so that they will shut off when the door is opened. The system permits simultaneous operation of the two air packers. However, when the auger packer is in use, neither of the air packers are operated.

2. RG 244 Packer Station: In the RG 244 bagging room, the bag filling and bag flattening operations are in separate areas, each within its own enclosure. At the bag filling station, the force flow packer is enclosed in a (20"x40"x34") hood equipped with a manual sliding door (24"x44") and exhaust ventilation, Figure 6. The operator opens the

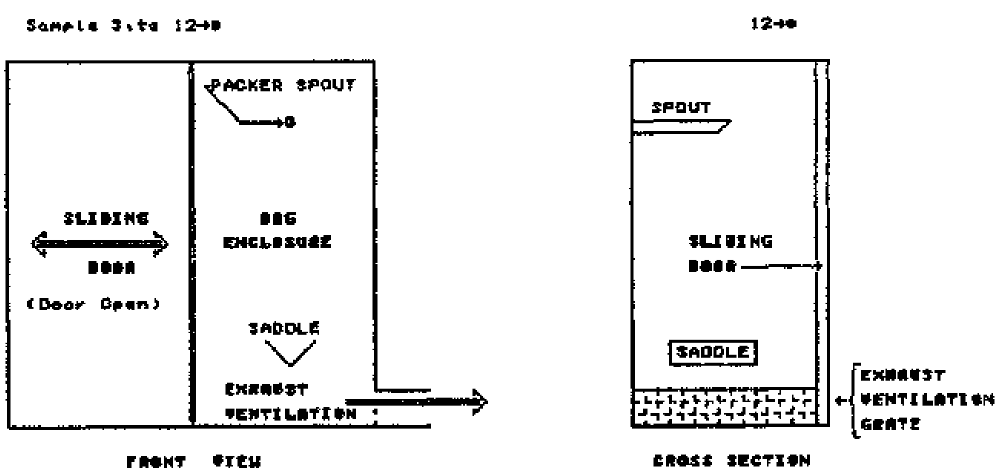

Figure 6: RG-244 Bagger Hood

sliding door, places the bag on the packer spout, closes the door, and fills the bag. After filling, the operator opens the door, manually removes the filled bag, folds in the tuck-in sleeve, weighes, and places the bag on the chain conveyor leading to the cleaner and flattener enclosure, Fig. 7.

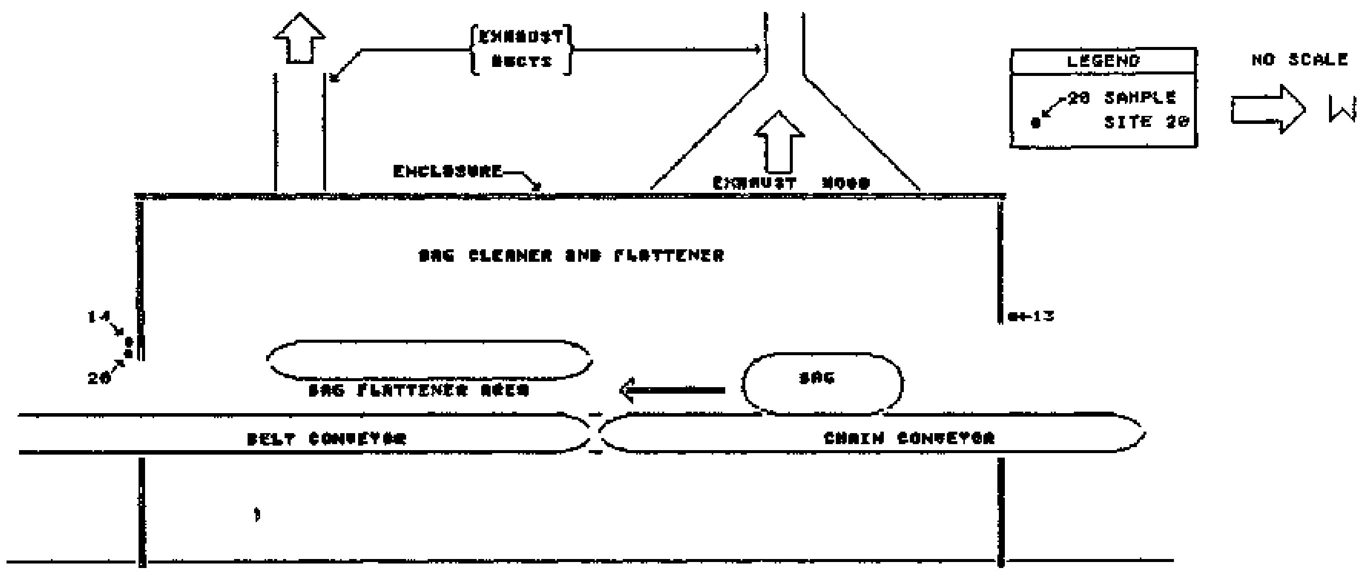

Figure 7: RG-244 Bagger Enclosure

The bag cleaning and flattening operation is located within a separate enclosure equipped with exhaust ventilation. One side of the enclosure has plexiglas windows for observation.

B. Ventilation Controls Within the Bagging Rooms:

Ventilation is an engineering control to reduce fiber emissions into the worker's environment and to control dust that does enter the work environment. In the Main and RG-244 Bagging Rooms, local exhaust ventilation is used at the bag filling and flattening operations and at the burst bag return hoppers. Also, in the Main Bagging Room, exhaust ventilation is located at the bag straightener and palletizer.

1. Main Bagger Room Enclosure (Figures 4 and 5): Air is exhausted through 12" and 6" ducts from this enclosure. Additional air is exhausted from the force flow packers units and the screw conveyors to these packers. The ventilation system is designed to exhaust approximately 4670 cfm of air from the enclosure. There are five openings into this enclosure through which make-up air enters: the bag access area for each of the three packers; the conveyor belt and bag exit; and the drainage ditch for removing spillage from within the enclosure. Table 3 lists the measured velocities and calculated air flows through these various openings as well as the designed versus calculated flows in some of the ducts.

2. Main Bagger Auger Packer: For the auger packer located outside of the Main Enclosure, there is a 6" flexible duct air intake positioned near the packer's fill spout. This part of the ventilation system is designed to operate continuously, exhausting 785 cfm (measured at 955 cfm) of air. Also, air is designed to be exhausted at 350 cfm through a 4" duct from the auger packer's feed screw.

3. Main Bagger Burst Bag Return: This is a ventilated hopper for recycling burst product bags. Air is designed to be exhausted from the hopper at 785 cfm (measured at 245 cfm) through a 6" duct.

4. Main Bagger Palletizer: Air is designed to be exhausted at 1400 cfm through a 6" duct from the automatic palletizer operation.

5. RG-244 Bagger Room Packer Hood (Figure 6): The hood (36"x24"x44") completely encloses the bag during filling. It is fitted with a manually operated sliding door and a grate covered exhaust port (approximately 8"x36") along the bottom and one side of the enclosure. The measured air velocity at the grate exceeded 400 fpm.

6. RG-244 Bag Cleaner and Flattener Enclosure (Figure 7): The enclosure is similar in design to that in the Main Bagger Room except it does not include the packer. The total measured air entering the two openings is 930 cfm.

7. RG-244 Burst Bag Return: A hopper (26"x28") is connected to a 5" duct exhausting air measured at 145 cfm (1000 fpm).

Four dust collectors are used to remove dust from these two bagging areas. An Envirotech-Buell HE 15-6 dust collector with a capacity of 13,000 cfm and a Mikro Pulverizer, Model #I-C-3, 3 compartment Sn 59-386, 7500 cfm capacity exhausts from the Main Bagging Room operations, Figure 8.

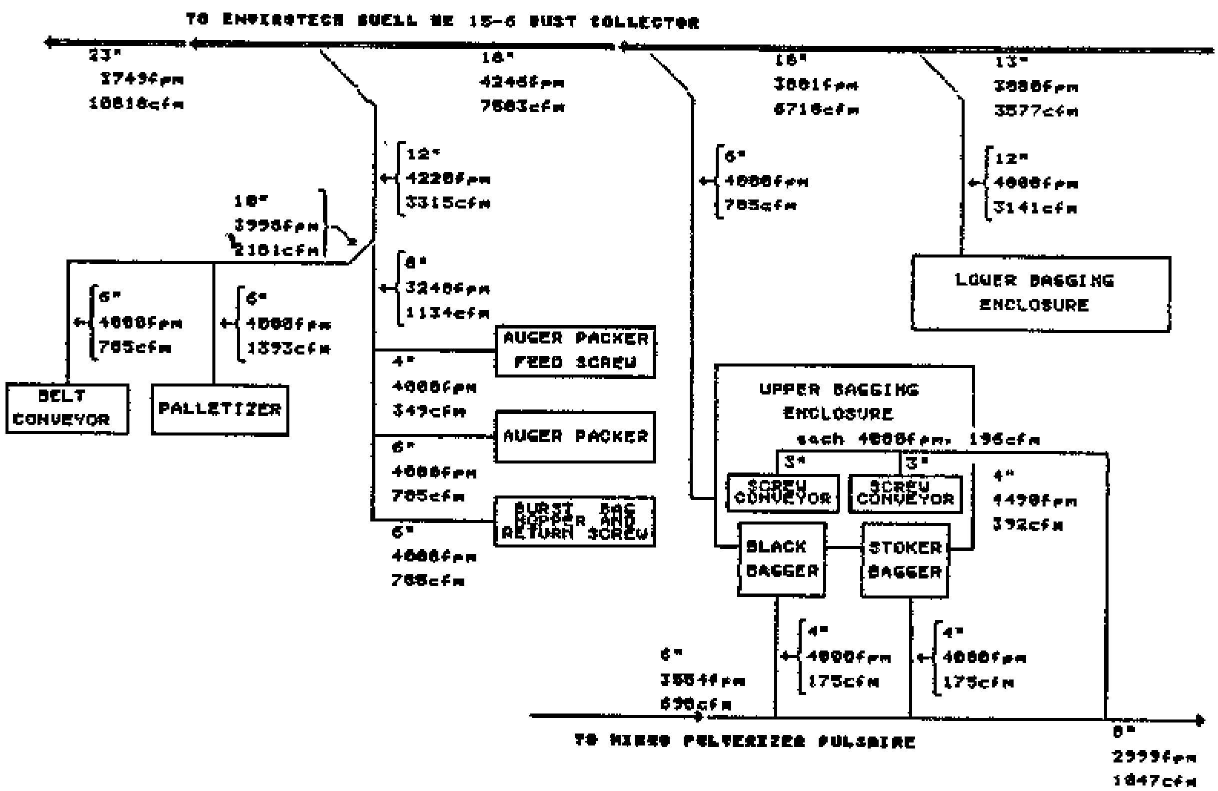

Figure 8: Main Bagger Room Ventilation Flow

A Fuller, Plenum Pulse Collector, 8 foot bags, 2 zones, Sn 74-21037-325, Model A, No, 24, 2500 cfm capacity and a Micro-Pulsaire, Model 1-C-1, Sn 59-592 exhaust from the RG-244 Bagging Room operations, Figure 9.

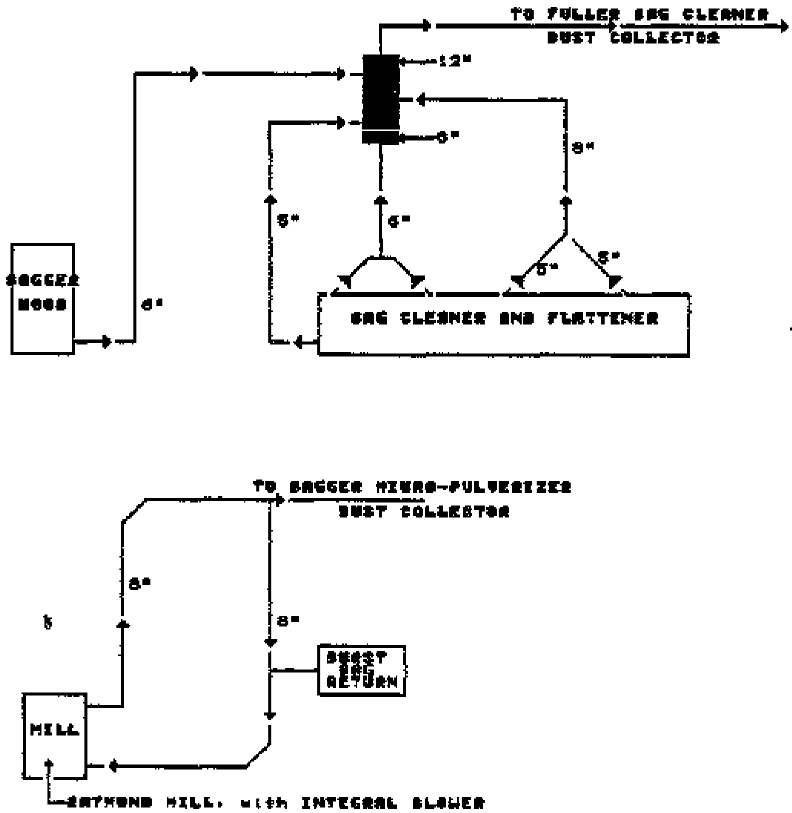

Figure 9: RG-244 Bagger Room Ventilation Flow

These dust collectors also exhaust from other operations within the building. The dust collectors are located outside of the building and exhaust asbestos-free air into the atmosphere.

C. Use of Shrink Wrap and Stretch Wrap to Control Bag Leakage and Strengthen Pallet Load Structures:

The combination of shrink wrap and stretch wrap precludes leakage from the individual bags and pallet loads, provides a more stable load unit, and protects the palletized load from adverse weather.

1. Shrink Wrap of Bags: Of the two types of bags used, plastic and paper, only the paper bags are individually shrink wrapped. The bag leaves the bag flattener enclosure and enters the shrink wrap station. Each bag is automatically shrink wrapped as it proceeds toward the palletizing station where the plastic seal (shrink wrap) is inspected .

2. Stretch Wrap of Pallets: The palletized bags are set on the stretch wrapper turn-table. As the load turns, a 20" wide strip of polyethylene stretch wrap is tightly wound around the load. The strip is started at the bottom of the pallet load, slowly rises to the top, and returns to the bottom, resulting in several overlapping layers of wrap on each loaded pallet. The tops of each load remain uncovered. However, since the bags are either plastic or have been shrink wrapped, they are protected from wet weather conditions. The stretch wrap results in a stable unit structure for each pallet load.

D. Isolation of Packaging Operations from Other Plant Operations.

Union Carbide has two packaging stations; Main Packer and RG-244 Packer. These operations are not only isolated from each other but also from the other operations taking place within the building. Within each room, packaging operations include bag filling, conveying, shrink wrapping (of paper bags), and palletizing. Also, in the Main Packer Room, there is a stretch wrapping station and temporary storage for some of the palletized loads.

Access doors within the interior of the plant leading to the packaging rooms are kept closed. The access doors for forklift traffic within the building are pushed open by the forklift and automatically swing shut. Rubber stripping around these doors reduces air leakage from the bagging room into the rest of the building. Doorways leading directly to the outside of the building from the packaging rooms may be either open or closed, depending on forklift traffic and weather conditions.

E. Use of Automation to Reduce Worker Exposure to Airborne Contamination and Physical Injury:

Automation reduces the potential for exposure to airborne asbestos and minimizes physical injuries such as back strains and tendonitis. Palletizing in the "Main Bagger" room is completely automatic. The filled bags (50 to 82 pounds) are palletized with each pallet load discharging onto a roller conveyor and moved by forklift to the next operation. The only manual handling required is for malfunctions and damaged bags.

F. Control Monitoring - Workplace and Medical:

Monitoring the workplace air and the ventilation systems serves at least four purposes; ventilation control evaluations, contaminated source identification, work area monitoring, and personal exposure monitoring. Medical monitoring systems are designed to detect the earlier stages of long term adverse effects due to inhalation of asbestos fibers, exposure to excessive noises, and other work related health problems.

1. Workplace Monitoring: Personal and area samples to determine airborne asbestos fibers are collected in accordance with regulatory requirements and company policy. Areas or jobs with greater potential for fiber release are sampled more frequently. The samples are analyzed at the plant by a qualified technician.

   The ventilation systems are monitored by installed Magnehelic gauges. Noise levels are monitored in accordance with regulatory requirements and company policy.

2. Medical Monitoring: A pre-employment medical examination is required. Periodic medical examinations are offered to all employees in accordance with regulatory requirements and company policy. Examinations are conducted by members of the Southern Monterey County Medical Group, located in King City. They have reported no indications of asbestos-caused lung disease in any employee. Some personnel have worked at the mill for over 20 years with the average length of employment being over 10 years.

G. Work Practices:

Housekeeping is mainly a combination of vacuum sweeping and wet washing areas inside the building and the surrounding grounds. In the bagging rooms, the operators and helpers are trained in the correct methods for cleaning up spills and dust accumulations. No smoking is permitted on the property and employees are encouraged not to smoke at any time. Safety training is conducted pursuant to MSHA and Corporate requirements and housekeeping is performed continually, emphasizing prompt cleanup of spills.

H. Process Modifications:

The asbestos ore is beneficiated in a wet process and then pelletized. Both of these processes reduce dust emissions.

I. Personal Protective Equipment:

Personal protective equipment required in all plant areas includes hard hats, safety glasses, coveralls, and safety shoes. Respirators and ear protectors are available for use and are required in designated areas, such as the Bagging Rooms.

1. Respirators: Norton Model 7170 disposable (main respirator in use) and Model 7100 with replaceable filters are used. The company tested several types of respirators for employee acceptance before choosing Norton. Replacement respirators and filters are obtained from the employee's supervisor. The Norton 7170 disposable respirators are replaced as needed. Each employee is fit tested and they are required to be clean shaven, if they cannot otherwise obtain a proper fit. Several supervisors have been trained (programs sponsored by the American Industrial Hygiene Association) on how to properly fit respirators.

2. Coveralls: Clean cloth-type coveralls are provided each worker each shift. The use of coveralls reduces asbestos exposures to the worker and their family by providing a protective barrier to the worker's street clothes. When the worker leaves the plant, the contaminated clothing (coveralls) remains at the plant. At the end of the shift, the worn coveralls are collected and placed in plastic bags (to meet California-OSHA standards for transporting asbestos soiled coveralls) and cleaned at a nearby commerical laundry.

V. SUMMARY OF FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS:

FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

The conclusions and recommendations are based on the asbestos airborne concentrations reported in Table 3. (Due to fiber recounting of selected samples and statistical analysis of these recounts, the fiber concentrations originally reported in Table 6 are too low and were increased by a factor of 1.8. See Appendix B.) The ventilation rates, measured and designed, of portions of the ventilation system in the two bagging rooms are reported in Table 2.

Due to the damp weather conditions during the study, the background levels from outside of the plant building, that may affect the fiber concentrations within the bagging rooms, were considered to be insignificant. However, during three testing periods ('26/C' and '27/F' in the Main Bagging Room and '27/E' in RG-244), there were operating abnormalities (equipment malfunctions) which resulted in higher fiber concentrations.

1. Management has well-established medical and workplace monitoring programs.

2. Good local exhaust ventilation is essential at the various packaging operations to remove airborne dust. Proper ventilation design requires both sufficient air movement and the development of effective flow patterns. Also, an effective ventilation control program requires preventive maintenance of the ventilation systems, including scheduled evaluation of equipment and designed air flows.

The effectiveness of the ventilation systems at the enclosures and bag recycle hoppers was evaluated by measuring dust concentrations on second shift (twice-a-day over three days) of packaging operations.

a. Main Bagger Room Enclosure - Source dust concentrations (sites 1, 2, and 7) averaged 0.2 fibers/cc (background level of 0.1 fiber/cc). This engineering control completely encloses the dust sources during bag filling, dropping the filled bag onto the conveyor, and bag flattening and cleaning operations. Leakage from the bag's valve and seams, a major source of airborne contamination during these operations, is captured within this enclosure. Face velocities exceed 200 fpm at each of the openings into this enclosure (the 3 bag accesses, bag exit, and ditch).

   During this study, the sliding doors to both air packers were open during bag filling. Closing the door of a packer not in use should further reduce any dust that may escape from the enclosure.

b. RG-244 Bag Cleaner and Flattener Enclosure - Source dust concentration at the entry and exit of this enclosure (sites 13, 14, and 20) was 0.1 fiber/cc (background level of 0.1 fibers/cc.) This engineering control completely encloses the dust sources during bag flattening and cleaning operations. This control is similar in design to the enclosure in the Main Bagging Room except that the bag filling operation is performed in another hood. This enclosure effectively captures the dust when ballooned bags are flattened. The velocities at the faces of these two entries measure 175 and 205 fpm. One possible improvement to this enclosure for abnormal situations, such as a bag rupture within the enclosure, is the installation of an overlapping rubber strip curtain over the entry and exit openings, similar to that on the Main Bagger Enclosure bag exit.

c. RG-244 Packer Hood - The dust concentrations (site 12) and background levels (0.1 fibers/cc) were the same. This hood effectively contains the airborne dust during bag filling operations. However, to reduce the personal fiber count of

1.7 fibers/cc (Table 3) at this hood, improved work practices need to be developed for removing product accumulation from the hood's floor.

d. Burst Bag Returns - Dust concentrations (sites 3, 4, and 5) averaged 0.8 fibers/cc in the Main Bagging Room and 0.3 fibers/cc (sites 11 and 18) in the RG-244 Bagging Room (background levels of 0.1 fibers/cc in each room). Both of these units are probable sources of airborne dust and in need of revisions. The face velocities at each return hopper were less than 100 fpm (28 fpm in the RG-244 Bagger Room).

   In the Main Bagging Room when the dust is damp, bridging tends to occur. As a result, there is a tendency for the exhaust duct from the hopper to plug. Also, this exhaust duct enters the main duct near the same place where several other ducts enter. If there is a pressure difference between these ducts and the hopper duct is lower, dust from the other ducts can fall back into the hopper and into the worker's environment. A down draft collector at this hopper should reduce the dust from this potential source.

   The hopper in the RG-244 Bagger Room has a down draft hood but needs a covering over the top of the hopper. Increasing the face velocity would further improve the efficiency of this unit. Also, the flexible duct from this hopper is wrapped in the shape of a figure "9" where it enters the main duct. This excess curve should be removed to further improve the efficiency of the system.

e. The gate valves used in the various ventilation ducts should be locked into position to prevent them from being inadvertently closed or changed in position once the system has been balanced.

4. The current use of shrink wrap on all paper bags and stretch wrap on most pallet loads eliminates potential airborne dust escaping from the bag's valve and seams. Also, shrink wrapping of the paper bags results in a clean bag surface to be handled during palletizing and at its final destination.

5. Isolating the bagging rooms from each other and from the rest of the operating areas precludes the migration of airborne asbestos. The use of automation (Main Bagger palletizing) reduces worker exposures to dust and potential physical ailments such as back strain and tendonitis. In the RG-244 Bagging Room, where the individual bags are light in weight (10 to 11 pounds) and the bagging rate is low, these physical ailments are not likely to be a problem.

In conclusion, Union Carbide Corporation's asbestos bagging operations have several effective controls which maintain the airborne concentrations below 0.9 fibers/cc in the Main Bagging Room. Under normal operating conditions, without equipment malfunctions, the average fiber concentration would be nearer 0.3 fibers/cc in this area. In the RG-244 Bagging Room, the airborne concentrations were maintained at 0.1 fibers/cc. By improving the less effective controls in the grinding area in the RG 244 bagging room and at the burst bag hopper recyclers in both bagging rooms, lower airborne concentration levels should be attainable.

NOTE: All NIOSH and Union Carbide personnel involved with the study wore respirators when in the bagging rooms.

VI APPENDIXES-DATA TABLES

TABLE 2

VENTILATION

LOCATION	OPENING	DIRECTION	AIR MOVEMENT MEASURED (cfm)	(fpm)	DESIGNED (cfm)	ASBESTOS[1] AIRBORNE CONCENTRATION (fib./cc)
I. Main Bagger Room						
A. Main Bagger Enclosure						
1. Lower Bagging Enclosure	12" duct	exhaust	3180	4050	3140	-
2. Upper Bagging Enclosure	6" duct	exhaust	-	-	785	-
3. Force Flow Packers (FFP)	4" duct	exhaust	-	-	350	-
4. FFP Screw Conveyors	3" duct	exhaust	-	-	390	-
5. Bag Exit from Enclosure	17"x41"	inflow	970	200	-	0.1
6. FFP Bag Access (2)	7"x25"	inflow	1100	545a & 360a	-	0.3
7. Auger Packer Bag Access	11"x26" & 18"x48"	inflow	2485c	310c		0.8
8. Ditch	8"x12"b	inflow	15c	300c	-	-
B. Auger Packer						
1. Packer Spout	6" duct	exhaust	955	4860	785	-
2. Feed Conv.	4" duct	exhaust	-	-	350	-
C. Burst Bag Return						
1. Hopper	14"x24"	inflow	245	100c	785	-
D. Bag Straightener						
1. Belt Conveyor	6" duct	inflow	810	4110	785	-
E. Palletizer						
1. Palletizer	6" duct	exhaust	-	-	1400	0.01
II. RG-244 Bagger Room						
A. Bagger Hood						
1. Hood	20"x40"	exhaust	915	165	-	0.1
2. From Hood	6" duct	exhaust	915	4660	-	-
B. Enclosure						
1. Entry	14"x27"	inflow	535	205	-	0.1
2. Exit	12.5"x26"	inflow	395	175	-	0.1
3. (4) Ducts from Hood	(3) 5" & (1) 6"	exhaust	930c	1535c	-	-
C. Burst Bag Return						
1. Hopper Face	28"x26"	inflow	145	30c	-	0.3
2. From Hopper	5" duct	inflow	145	1000	-	-

[1] Asbestos concentrations corrected by multiplying by a 1.8 factor.

a - Both sliding doors open with the west door averaging 545 cfm and the east door averaging 360 cfm.

b - Ditch nearly plugged exiting from enclosure.

c - Calculated values.

TABLE 3

UNION CARBIDE

AIRBORNE CONCENTRATIONS (fibers/cc) DURING SIX SAMPLING PERIODS

	Site	Day 1		Day 2		Day 3		Avg.	Corr'd Avg. (1.8x)
		SP-1 25/A	SP-2 25/B	SP-3 26/C	SP-4 26/D	SP-5 27/E	SP-6 27/F		
I. MAIN BAGGER ROOM									
A. Personal:	po-1	0.27	0.44	1.22	0.30	0.33	0.39	0.49	0.9
	ph-2	0.09	****	0.24	0.25	0.47	0.53	0.32	0.6
	Avg	0.18	0.44	0.73	0.28	0.40	0.46	0.41	0.7
B. Bagger:									
	3	0.05	0.07	0.28	0.16	0.04	2.18	0.46	0.8
	4	0.02*	0.24	0.98	0.20	0.09	1.43	0.49	0.9
	5	0.05	0.53	0.35	0.29	0.06	1.24	0.42	0.8
	6	0.04	0.03*	0.37	0.14	0.11	0.39	0.18*	0.3
	Avg	0.04*	0.22*	0.50	0.20	0.08	1.31	0.39*	0.7
C. Enclosure:									
	1	0.03	0.14	0.41	0.06	0.02	0.23	0.15	0.3
	2	0.04	0.03	0.18	0.20	0.02*	0.38	0.14*	0.3
	7	0.03*	0.08	0.03*	0.07	0.02*	0.19	0.07*	0.1
	Avg	0.03*	0.08	0.21*	0.11	0.02*	0.27	0.12*	0.2
D. Background:									
	8	0.03*	0.04	0.04	0.04	0.02*	0.15	0.05*	0.1
	[9]	0.08	0.08	0.09	0.05	0.02*	0.10	0.07*	0.1
	[19]	0.06	0.11	0.06	0.03	0.02*	0.16	0.06*	0.1
	10	0.03*	0.03*	0.05	0.07	0.02*	0.08	0.04*	0.1
	Avg	0.04*	0.06*	0.06	0.05	0.02*	0.12	0.06*	0.1
II. RG 244 BAGGER ROOM									
A. Personal:	po-3	1.40	1.00	1.11	0.27	-	0.82	0.92	1.7
B. Bagger Hood:	12	0.06	0.14	0.03*	0.04	-	0.02	0.06*	0.1
C. Enclosure:									
	13	0.07	0.09	0.03	0.04	-	0.02*	0.05*	0.1
	[14]	0.04*	0.03*	0.03*	0.03*	-	0.02*	0.03*	0.1
	[20]	0.04*	0.03*	0.03*	0.05	-	0.02*	0.06*	0.1
	Avg	0.06*	0.06*	0.03*	0.04*	-	0.02*	0.04*	0.1
D. Grinding and Recycling Area:									
	11	0.22	0.58	0.16	0.20	-	0.03	0.24	0.4
	18	0.13	0.13	0.11	0.24	-	0.07	0.14	0.3
	Avg	0.18	0.36	0.14	0.22	-	0.05	0.18	0.3
E. Background:									
	15	0.04*	0.03*	0.03*	0.04	-	0.02*	0.03*	0.1
	16	0.04*	0.03*	0.03*	0.03	-	0.02*	0.03*	0.1
	17	0.04*	0.05	0.08	0.11	-	0.02*	0.06*	0.1
	Avg	0.04*	0.04*	0.05*	0.06	-	0.02*	0.05*	0.1

po Operator
ph Helper
* Less than
**** Contaminated sample, operator wore sampler into baghouse.
Avg Arithmetic average
[ ] Side-by-side samples at same site, averaged and treated as one sample.
1.8x Corrected Averages - Values orginally reported in Table 6 multiplied by 1.8 factor.

Personal, source, and area samples for asbestos were collected on open face cassettes using calibrated pumps operating at 1.5 liters per minute. The samples were analyzed by the Utah Biomedical Testing Laboratory (UBTL) according to NIOSH Method P&CAM 239 utilizing Phase Contrast Microscopy. The results were reported in total fibers per filter. The following calculation was used to convert fibers/filter to fibers/cc:

$$\text{Fibers/cc} = \frac{\text{Fibers/Filter}}{\text{(Sample Vol. L)(1000)}}$$

For 78% of the samples, the limit of detection (LOD) has been determined to be 0.01 fibers/field or 1500 fibers/filter. For the remaining 22%, the LOD was 0.03 fibers/field or 4500 fibers/filter. A detection limit is calculted by dividing the minimum observable fibers by the maximum number of fields specified by the method. (It should be noted that the reported LOD is lower than that cited within the previously quoted NIOSH method).

Of the 128 airborne asbestos samples collected, fourteen randomly selected samples were reanalyzied by NIOSH's Measurments Reseach Support Branch (MRSB) using Analytical Electron Microscope (AEM). The filters were prepared for analysis using the procedure outlined in NIOSH Publication 77-204. No fiber counts were attempted. The results showed the amounts of chrysotile asbestos on the filters to vary considerably from very light to very heavy. Not all the asbestos particles qualified morphologically as a fiber. The asbestos consisted largely of short, indistinct fibrils (less than or equal to 50 micrometers) in large clumps and bundles with very few long fibrils being observed. The fibrils tend to blend into one another, having indistinct boundaries. Also, many of the particles are acicular or needle shape.

Of the remaining 114 airborne samples collected by NIOSH, thirteen were selected and counted by NIOSH's MRSB lab, Table 4. NIOSH prepared the samples by using the revised P&CAM 239 Method and phase-contrast microscopy. (The revised changes from the published method in Vol. 1 of the NIOSH Manual of Analytical Methods are: 1) Method of sample preparation - AIA approved acetone/triacetin method for preparing permanent mounts; 2) the graticule was a Walton-Beckett type having a field area of 0.00785 mm^2; and 3) the counting rules were the modified CRS rules with a 5:1 aspect equivalent to the AIA 3:1 rules.) The average of these 13 samples were 183% greater than first reported by UBTL. Samples 9-13 were sent to UBTL for a recount. The average results of UBTL's (0.70 f/cc) recount were within 9% of NIOSH's (0.76 f/cc) count, Table 4.

Table 4. Comparison of Asbestos Results, (fibers/cc)

#	NIOSH SAMPLE NO.	NIOSH (f/cc)	UBTL-O (f/cc)	UBTL-R (f/cc)	COMPARISONS NIOSH/UBTL-O (%)	COMPARISONS UBTL-R/UBTL-O (%)
1	881	2.45	1.40	-	175	-
2	914	1.01	0.30	-	337	-
3	925	0.48	0.33	-	145	-
4	945	0.57	0.25	-	228	-
5	957	0.50	0.24	-	208	-
6	988	1.18	0.53	-	223	-
7	972	0.35	0.24	-	146	-
8	1013	2.33	1.24	-	188	-
9	886	1.75	1.22	1.63	143	134
10	912	0.55	0.35	0.49	157	136
11	946	0.81	0.27	0.64	300	237
12	1005	0.61	0.39	0.63	156	154
13	1055	0.07	0.07	0.12	100	171
Avg. 1-13		0.97	0.53	-	183	-
Avg. 9-13		0.76	0.47	0.70	162	149

Note: These are airborne concentrations collected for sampling times ranging from approximately 1.5 to 2.0 hours.

NIOSH - Samples 1 thru 13 taken, prepared, and counted by NIOSH.

UBTL-O - Same samples (1 thru 13) taken by NIOSH; prepared and counted by UBTL.

UBTL-R - Samples taken and slides prepared by NIOSH, and counted by UBTL and NIOSH. UBTL-O is the originally reported analysis and UBTL-R is the recount of these five samples.

There are many factors that account for these differences. The asbestos fibers are atypical, many of which are very fine and difficult to observe under the phase-contrast microscope. There are individual differences in microscopes, preparation, counting, and the fimilarity of the counter with the particular material's characteristics. These are a few of the factors that would account for the 149% differences between UBTL's initial results and the results of their recount.

Table 5 is a statistical analysis of the paired fiber counts by NIOSH and UBTL of the samples listed in Table 4.

TABLE 5: STATISTICAL EVALUATION OF PAIRED FIBER COUNTS.

Samples Paired UBTL's Count		1-13 Original	9-13 Recount
1. No. of Paired Samples	(N)	13	5
2. Average Value of NIOSH Count	($\bar{X}$)	0.97 f/cc	0.76 f/cc
3. Average Value of UBTL Count	($\bar{Y}$)	0.53 f/cc	0.70 f/cc
A. Student t-Test			
4. Calculated "t-Test" Value	(t)	4.60	1.20
5. Significant "t-Test" Value at .05 level		2.16	2.78
6. Statistical Evaluation:		a	b
B. Sandlers A Test			
7. Calculated "A-Test" Value	(A)	0.120	1.537
8. Significant "A-Test" Value at .05 level		0.271	0.304
9. Statistical Evaluation:		a	b
C. Pearson Product-Moment Correlation			
10. Correlation Coefficient	(r)	0.959	0.992
11. Correlation Evaluation		c	c

a - Significant difference in values.
b - No significant difference in values.
c - Excellent correlation.

FORMULAS :

Student t-Test - For the Student t-Test, if the calculated value for "t" is less than (greater than) the table value, non-directional, at .05 level, the difference is not significant (significant).

$$t = \frac{\bar{X} - \bar{Y}}{\sqrt{\dfrac{\Sigma D^2 - \dfrac{(\Sigma D)^2}{N}}{N(N-1)}}}$$

For the Sandler A Test - if the calculated value for "A" is greater than (less than) the table value, non-directional, at .05 level, the difference is not significant (significant).

$$A = \frac{\Sigma D^2}{(\Sigma D)^2}$$

For the Pearson Product-Moment Correlation - as the calculated value for "r" approaches -1 or +1, perfect linear correlation is also approached.

$$r = \frac{N\Sigma XY - (\Sigma X)(\Sigma Y)}{\sqrt{\left[N\Sigma X^2 - (\Sigma X)^2\right]\left[N\Sigma Y^2 - (\Sigma Y)^2\right]}}$$

D = difference in value between each X and Y pair.
N = number of pairs of values.
$\bar{X}$ = Avg. value of UBTL data.
$\bar{Y}$ = Avg. value of NIOSH data.

The conclusions from the comparisons of these 13 samples listed in Table 4 and the statistical analysis in Table 5 are: (1) When MRSB and UBTL were aware of the nature of the fibers, their results were well within (9% difference) the comparability range of 100% to 120%. (2) There is a significant difference between UBTL's intial count and NIOSH's and UBTL's recounts. (3) There is no significant difference between the recounts performed by NIOSH and UBTL. (4) There is excellent correlation between the intial counts and the recounts performed by NIOSH and UBTL. (5) The results reported in Table 6 (UBTL original results) are too low and need to be increased by a factor of 1.8, as was done in Tables 2 and 3.

APPENDIXES C - DATA ANAYLSIS

TABLE 6

INITIAL RESULTS OF NIOSH AIR SAMPLES FOR ASBESTOS
UNION CARBIDE
KING CITY, CALIFORNIA

JANUARY, 1983

LOC	SAMPLE			PERIOD		RATE	VOL.	ASBESTOS	
#	TYPE	No.	DATE	START	STOP)	(lpm)	(l)	fibr/cc	COMMENTS
1A-a	source main	918	1/25	0805	1004	1.53	182.1	0.03	
1B-p	source main	1000	1/25	1343	1530	1.53	163.7	0.14	
1C-a	source main	907	1/26	0802	1000	1.53	180.5	0.41	
1D-p	source main	892	1/26	1259	1455	1.53	177.5	0.06	
1E-a	source main	927	1/27	0800	1000	1.53	183.6	0.02	
1F-p	source main	1003	1/27	1320	1515	1.53	176.0	0.23	
	Average							0.15	
2A-a	source main	889	1/25	0805	1004	1.53	182.1	0.04	
2B-p	source main	1025	1/25	1343	1530	1.53	163.7	0.03	
2C-a	source main	974	1/26	0802	1000	1.53	180.5	0.18	
2D-p	source main	894	1/26	1259	1455	1.53	177.5	0.20	
2E-a	source main	938	1/27	0800	1000	1.53	183.6	0.02*	
2F-p	source main	1012	1/27	1320	1515	1.53	176.0	0.38	
	Average							0.14*	
3A-a	area main	904	1/25	0805	1004	1.53	182.1	0.05	
3B-p	area main	978	1/25	1343	1530	1.53	163.7	0.07	
3C-a	area main	900	1/26	0802	1000	1.53	180.5	0.28	
3D-p	area main	906	1/26	1259	1455	1.53	177.5	0.16	
3E-a	area main	930	1/27	0800	1000	1.53	183.6	0.04	
3F-p	area main	989	1/27	1320	1515	1.53	176.0	2.18	
	Average							0.46	
4A-a	area main	896	1/25	0805	1004	1.53	182.1	0.02*	(a)
4B-p	area main	993	1/25	1343	1530	1.53	163.7	0.24	
4C-a	area main	908	1/26	0802	1000	1.53	180.5	0.98	
4D-p	area main	916	1/26	1259	1455	1.53	177.5	0.20	
4E-a	area main	968	1/27	0800	1000	1.53	183.6	0.09	
4F-p	area main	1001	1/27	1320	1515	1.53	176.0	1.43	
	Average							0.59*	
5A-a	source main	891	1/25	0805	1004	1.54	183.3	0.05	
5B-p	source main	1019	1/25	1345	1555	1.54	200.2	0.53	
5C-a	source main	912	1/26	0802	1000	1.54	181.7	0.35	
5D-p	source main	956	1/26	1259	1455	1.54	178.6	0.29	
5E-a	source main	943	1/27	0800	1000	1.54	184.8	0.06	
5F-p	source main	1013	1/27	1320	1515	1.54	177.1	1.24	
	Average							0.42	
6A-a	source main	922	1/25	0805	1004	1.52	180.9	0.04	
6B-p	source main	986	1/25	1343	1530	1.52	162.6	0.03*	
6C-a	source main	923	1/26	0802	1000	1.52	179.4	0.37	

TABLE 6 Continued

LOC #	SAMPLE TYPE	No.	DATE	PERIOD START	STOP)	RATE (lpm)	VOL. (l)	ASBESTOS fibr/cc	COMMENTS
6D-p	source main	905	1/26	1259	1455	1.52	176.3	0.14	
6E-a	source main	931	1/27	0800	1000	1.52	182.4	0.11	
6F-p	source main	1064	1/27	1320	1515	1.52	174.8	0.39	
	Average							0.18*	
7A-a	source main	920	1/25	0805	1004	1.51	179.7	0.03*	
7B-p	source main	1020	1/25	1343	1530	1.51	161.6	0.08	
7C-a	source main	921	1/26	0802	1000	1.51	178.2	0.03*	
7D-p	source main	975	1/26	1259	1455	1.51	175.2	0.07	
7E-a	source main	1018	1/27	0800	1000	1.51	181.2	0.02*	
7F-p	source main	998	1/27	1318	1515	1.51	176.7	0.19	
	Average							0.07*	
8A-a	source main	899	1/25	0807	1004	1.50	175.5	0.03*	
8B-p	source main	875	1/25	1343	1530	1.50	160.5	0.04	
8C-a	source main	879	1/26	0802	1000	1.50	177.0	0.04	
8D-p	source main	969	1/26	1259	1455	1.50	174.0	0.04	
8E-a	source main	996	1/27	0800	1000	1.50	180.0	0.02*	
8F-p	source main	1007	1/27	1314	1515	1.50	181.5	0.15	
	Average							0.05*	
9A-a	area main	1016	1/25	0805	1004	1.57	186.8	0.08	
9B-p	area main	1015	1/25	1343	1530	1.57	168.0	0.08	
9C-a	area main	917	1/26	0802	1000	1.57	185.3	0.09	
9D-p	area main	902	1/26	1259	1455	1.57	182.1	0.05	
9E-a	area main	926	1/27	0800	1000	1.57	188.4	0.02*	
9F-p	area main	982	1/27	1313	1515	1.57	191.5	0.10	
	Average							0.08*	
19Aa	dup 9A-a	876	1/25	0805	1004	1.52	180.9	0.06	
19Bp	dup 9B-p	992	1/25	1343	1530	1.52	162.6	0.11	
19Ca	dup 9C-a	924	1/26	0802	1000	1.52	179.4	0.06	
19Dp	dup 9D-p	913	1/26	1259	1455	1.52	176.3	0.03	
19Ea	dup 9E-a	932	1/27	0800	1000	1.52	182.4	0.02*	
19Fp	dup 9F-p	990	1/27	1313	1515	1.52	185.4	0.16	
	Average							0.07*	
10Aa	area main	911	1/25	0805	1004	1.51	179.7	0.03*	
10Bp	area main	979	1/25	1343	1530	1.51	161.6	0.03*	
10Ca	area main	910	1/26	0802	1000	1.51	178.2	0.05	
10Dp	area main	898	1/26	1259	1455	1.51	175.2	0.07	
10Ea	area main	940	1/27	0800	1000	1.51	181.2	0.02*	
10Fp	area main	1053	1/27	1312	1515	1.51	185.7	0.08	
	Average							0.05*	
11Aa	source 244	882	1/25	1035	1157	1.53	125.5	0.22	
11Bp	source 244	994	1/25	1340	1531	1.53	169.8	0.58	
11Ca	source 244	971	1/26	0800	0957	1.53	179.0	0.16	
11Dp	source 244	951	1/26	1300	1459	1.53	182.1	0.20	
11Fp	source 244	1075	1/27	1316	1518	1.53	186.7	0.03	
	Average							0.23	

TABLE 6 Continued

LOC #	SAMPLE TYPE	No.	DATE	PERIOD START	STOP)	RATE (lpm)	VOL. (l)	ASBESTOS fibr/cc	COMMENTS
12Aa	source 244	888	1/25	1033	1157	1.51	126.8	0.06	
12Bp	source 244	985	1/25	1339	1531	1.51	169.1	0.14	
12Ca	source 244	890	1/26	0800	0957	1.51	176.7	0.03*	
12Dp	source 244	936	1/26	1300	1459	1.51	179.7	0.04	
12Fp	source 244	983	1/27	1316	1518	1.51	184.2	0.02	
	Average							0.06*	
13Aa	source 244	903	1/25	1033	1157	1.55	130.2	0.07	
13Bp	source 244	987	1/25	1339	1531	1.55	173.6	0.09	
13Ca	source 244	964	1/26	0800	0957	1.55	181.4	0.03	
13Dp	source 244	941	1/26	1300	1459	1.55	184.5	0.04	
13Fp	source 244	1027	1/27	1317	1518	1.55	187.6	0.02*	
	Average							0.05*	
14Aa	source 244	897	1/25	1033	1157	1.51	126.8	0.04*	
14Bp	source 244	977	1/25	1338	1531	1.51	170.6	0.03*	
14Ca	source 244	960	1/26	0800	0957	1.51	176.7	0.03*	
14Dp	source 244	947	1/26	1300	1459	1.51	179.7	0.03*	
14Fp	source 244	1004	1/27	1316	1518	1.51	184.2	0.02*	
	Average							0.03*	
20Aa	dup 14Aa	878	1/25	1033	1157	1.50	126.0	0.04*	
20Bp	dup 14Bp	997	1/25	1338	1531	1.50	169.5	0.03*	
20Ca	dup 14Ca	919	1/26	0800	0957	1.50	175.5	0.03*	
20Dp	dup 14Dp	967	1/26	1300	1459	1.50	178.5	0.05	
20Fp	dup 14Fp	1033	1/27	1316	1518	1.50	183.0	0.02*	
	Average							0.03*	
15Aa	area 244	887	1/25	1035	1157	1.52	124.6	0.04*	
15Bp	area 244	1021	1/25	1337	1531	1.52	173.3	0.03*	
15Ca	area 244	958	1/26	0800	0957	1.52	177.8	0.03*	
15Dp	area 244	959	1/26	1300	1459	1.52	180.9	0.04	
15Fp	area 244	1002	1/27	1315	1518	1.52	187.0	0.02*	
	Average							0.03*	
16Aa	area 244	885	1/25	1035	1157	1.53	125.5	0.04*	
16Bp	area 244	976	1/25	1337	1531	1.53	174.4	0.03*	
16Ca	area 244	937	1/26	0800	0957	1.53	179.0	0.03*	
16Dp	area 244	962	1/26	1300	1459	1.53	182.1	0.03	
16Fp	area 244	1054	1/27	1315	1518	1.53	188.2	0.02*	
	Average							0.03*	
17Aa	area 244	895	1/25	1036	1157	1.53	123.9	0.04*	
17Bp	area 244	980	1/25	1340	1531	1.53	169.8	0.05	
17Ca	area 244	973	1/26	0800	0957	1.53	179.0	0.08	
17Dp	area 244	949	1/26	1300	1459	1.53	182.1	0.11	
17Fp	area 244	1056	1/27	1315	1518	1.53	188.2	0.02*	
	Average							0.06*	
18Aa	source 244	883	1/25	1035	1157	1.53	125.5	0.13	
18Bp	source 244	984	1/25	1340	1531	1.53	169.8	0.13	

TABLE 6 Continued

LOC	SAMPLE			PERIOD		RATE	VOL.	ASBESTOS	
#	TYPE	No.	DATE	START	STOP)	(lpm)	(l)	fibr/cc	COMMENTS
18Ca	source 244	948	1/26	0800	0957	1.53	179.0	0.11	
18Dp	source 244	972	1/26	1300	1459	1.53	182.1	0.24	
18Fp	source 244	1055	1/27	1316	1518	1.53	186.7	0.07	
	Average							0.14	
p-1a	personal main	877	1/25	0802	0957	1.54	177.1	0.27	
p-1b	personal main	1006	1/25	1340	1530	1.54	169.4	0.44	
p-1c	personal main	886	1/26	0805	1000	1.56	179.4	1.22	
p-1d	personal main	914	1/26	1259	1455	1.56	181.0	0.30	
p-1e	personal main	925	1/27	0800	1005	1.56	195.0	0.33	
p-1f	personal main	1005	1/27	1319	1513	1.56	177.8	0.39	
	Average							0.49	
p-2a	personal main	915	1/25	0814	0958	1.52	158.1	0.09	
p-2b	personal main	1022	1/25	1335	1530	1.52	174.8	2.72	(b)
p-2c	personal main	957	1/26	0801	1000	1.52	180.9	0.24	
p-2d	personal main	945	1/26	1259	1455	1.52	176.3	0.25	
p-2e	personal main	944	1/27	0800	1005	1.52	190.0	0.47	
p-2f	personal main	988	1/27	1322	1513	1.52	168.7	0.53	
	Average							0.32	
p-3a	personal 244	881	1/25	1032	1200	1.52	133.8	1.40	
p-3b	personal 244	1014	1/25	1339	1530	1.52	168.7	1.00	
p-3c	personal 244	966	1/26	0808	0957	1.52	165.7	1.11	
p-3d	personal 244	946	1/26	1300	1459	1.52	180.9	0.27	
p-3f	personal 244	1011	1/27	1320	1516	1.52	176.3	0.82	
	Average							0.89	
b-1	blank	1008	1/25						
b-2	blank	963	1/25						
b-3	blank	893	1/25						
b-4	blank	880	1/25						
b-5	blank	965	1/26						
b-6	blank	935	1/26						
b-7	blank	970	1/26						
b-8	blank	955	1/26						
b-9	blank	1010	1/27						
b-10	blank	1017	1/27						
b-11	blank	1023	1/27						

* - Less Than

a - No backup pad on filter cassette

b - Values omitted from average. Operator wore sampler inside bag house.

Comment - All <u>blanks</u> were below the LOD of 4,500 fibers per filter.

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