U.S. Department of Health, Education, and Welfare
Center for Disease Control
National Institute for Occupational Safety and Health
Morgantown, West Virginia 26505

Health Hazard Evaluation Determination
Report No. 79-15-678
Celestial Seasonings
Boulder, Colorado

April 1980

I. Toxicity Determination

Based upon an environmental and medical evaluation conducted by NIOSH investigators November 6 to November 14, 1978, it has been determined that respiratory exposure to airborne herbal dusts can cause symptomatic chronic cough and chronic bronchitis, and may in some individuals cause acute chest tightness associated with measurable decreases in pulmonary function over the work shift.

II. Recommendations

A. Evaluate the tea-making and packaging process in terms of dust-control technology and modify present processes and dust-control apparatus where appropriate to minimize worker exposure to herbal dusts, especially in Warehouse 3 and for Bulk Packagers. (See appendix for evaluation and recommendations made by the Control Technology Research Branch, Division of Physical Sciences and Engineering, NIOSH.)

B. Periodically monitor environmental levels of respirable dust to assure that significantly reduced worker exposure is attained by control technology and process modifications and subsequently is maintained.

C. Modify Employee Lung Testing Program to include:

1) pre-placement screening of newly hired workers by medical history for asthma or other allergic history so that those with such a history may be cautioned about the possible greater risk for adverse reaction to the herbal dust;
2) pre-placement and periodic standard respiratory questionnaire administration and pulmonary function testing with criteria for employee removal to non-dusty jobs as suggested by NIOSH for workers exposed to cotton dust (1); and
3) a respiratory protection program including supplying appropriate dust respirators and training in their use to production workers in Warehouse 3, Bulk Packagers, and workers with >10% decline in FEV_1 over the work shift (2).

III. Introduction

In October, 1978, NIOSH received a request* for a Health Hazard Evaluation from an authorized representative of Celestial Seasonings, an herbal tea manufacturer located in Boulder, Co. During cleaning, milling, mixing, and packaging of approximately 70 different herbs, spices, and grains "significant levels of vegetable dusts" were being generated. Provision of effective dust control equipment had been complicated by an unexpected phenomenal growth rate of the company in the 8 years of its existence. An awareness of the etiologic nature of vegetable dusts in certain occupational lung diseases had led management to estabish an Employee Lung Testing Program in November, 1977. The purpose of this program was to screen prospective employees and to serially follow pulmonary function of workers. When a dust-exposed worker was documented to have an acute airway response over a work shift, physician assistance in evaluation was sought. In the year that the testing program had been in effect 14 employees had been referred to physicians, only seven of whom were still employed by Celestial Seasonings. A NIOSH physician reviewed the Program's surveillance data and interviewed several affected workers during a preliminary visit to Celestial Seasonings. Because of objective documentation of shift decrements in FEV_1, histories of chronic bronchitis apparently unrelated to smoking, frequent upper respiratory symptoms, and at least one striking case history suggestive of occupational asthma, a cross-sectional morbidity study of the entire worker population was undertaken.

IV. Health Hazard Evaluation

A. Plant Process

At the time of the NIOSH investigation in early November 1978, Celestial Seasonings employed 227 persons on two shifts and operated out of several buildings. Nearly 70 different herbs (Table 1) from throughout the world are used in their tea products. Raw materials (leaves, flowers, seeds, stems, barks, oil, and whole plants) are received in bulk form. Processing occurs in several steps (cleaning,

*Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669 (a)(6), authorizes the Secretary of Health, Education, and Welfare, following a written request by any employer or authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

milling, sifting, blending, and packaging), all of which generate airborne vegetable dusts.

After milling the material is conveyed to a sifter feeder hopper. Sifters are used to sift the material by oscillating action of enclosed screens. Several size distributions of the milled material are separated in this process. One is appropriate for use in bagged tea and another for use as bulk tea. The sifted material falls by gravity into storage drums.

The blending operation begins with manual filling of feeder hoppers which are discharged into large enclosed blenders. Blended material is discharged to a hopper which feeds a drum filling station.

The above processes (cleaning, milling, sifting, and blending) all take place in a single building - Warehouse 3. All processes were noted to have at least some dust control apparatus. However, it was obvious from visual inspection that large quantities of airborne dust were escaping into the general work place air.

Blended material is transferred to another building - Warehouse 1 - where packaging is done. There are two basic processes here: tea bagging and bulk packaging.

Tea bagging is significantly automated. Material to be bagged is conveyed from drums to the machine which automatically bags it. Workers are needed in the immediate vicinity to box the bagged tea and to pack the boxes in corrugated cardboard cartons. In a nearby room some of the tea bags are "sample" packed - 4 bags to a paper envelope.

Bulk packaging was done manually at the time of our visit. Blended material was scooped from an open bin onto a weighing scale and then deposited through a funnel into a container. Dust control apparatus was inefficient here, and visible clouds of airborne dust were evident in the immediate vicinity of bulk packagers.

Some production workers, especially those in Warehouse 3, wore particulate removing half mask respirators with replaceable filters for some or all of the shift. More frequently, production workers wore a bandana tied over the mouth and nose, or no mask at all.

The offices were for the most part located in Warehouse 1, physically separated from the production areas. An intermittently opened and closed door connected the offices with the area of the kitchen, store, and break room which were adjacent to production areas of Warehouse 1. Most employees, including office workers, took their breaks and ate lunch in the break room area which was open to Warehouse 1.

B. Evaluation Design and Methods

1. Medical

An environmental and medical survey was conducted between November 6 and November 14, 1978. A total of 227 persons were employed by Celestial Seasonings at the time of the study. Excluding seven on vacation, two on leave, three regional managers located in other parts of the country, one out of town on business, and one ill for the duration of the study, 213 were available for study. Of these, six refused to participate, and one other, who worked an odd schedule, did not participate. Of the 206 employees who participated, complete questionnarie and pre- and post-shift spirometry data was obtained on 173. 129 workers consented to have a posteroanterior chest radiograph.

A modified Medical Research Council of Great Britain questionnaire on respiratory disease, with additional questions for byssinotic symptoms and occupational history, was administered by personnel trained in its use. In a separate, self-administered questionnaire history of marijuana smoking was acquired. In this self-administered questionnaire, subjects were also requested to rank separately the five dustiest and the five most irritating herbs from a complete list of 67 used at Celestial Seasonings. Likewise they were asked to rank blends from a list of 11 produced by Celestial Seasonings.

Subjects' heights and weights were measured and recorded. Standard 14 X 17 inch PA chest roentgenographs were taken by registered radiology technicians.

On return to work after a weekend off, pre- and post-shift forced expiratory maneuvers were performed on Ohio 840 waterless spirometers under the supervision of trained technicians. Each worker's post-shift pulmonary function was measured on the same spirometer used to measure his pre-shift function. At least five maximal expiratory flow-volume curves were recorded for each session and corrected to BTPS. For analysis, a "maximum envelope" flow volume curve (3) was generated from curves obtained at each session. Where used, normal prediction equations were those of Knudson, et al. (3).

At each session subjects were asked about smoking during the previous hour. At the pre-shift session subjects were asked if they had developed chest tightness that day, and at the post-shift session questions were asked about the number of cigarettes smoked during the shift, whether chest tightness had developed during the shift, and whether the worker had worn any kind of a mask during the shift. Two physicians auscultated workers' chests posteriorly at both the pre- and post-shift sessions, just prior to spirometry. Subjects walked between buildings to the area where spirometry and auscultation was done, on days when outdoor temperatures ranged between about -5° and 5° centigrade.

Based upon estimates of exposure to airborne herbal dust, participants in the study were grouped for analysis into five categories as follows:

1. Sixty-two Office workers. This category includes all non-production workers except those with offices in Warehouse 3, engineers, food store, and kitchen help. (It should be noted that almost one third of Office workers had previously held jobs in other categories.)

2. Sixty-four Warehouse 1 workers. Included here are all production workers in Warehouse 1 except bulk packagers.

3. Fourteen Warehouse 3 workers (millers and mixers).

4. Eighteen Bulk Packaging workers.

5. Forty-eight Miscellaneous workers. This cateogry includes labor pool, custodians, maintenance mechanics, receivers, shippers, truck drivers, engineers, kitchen and food store workers, non-production workers with offices in Warehouse 3, and quality control inspectors.

Several individual workers from the Miscellaneous group were placed into either the Warehouse 1 or Warehouse 3 groups if it could be determined that they spent essentially all of their time working in the production area of one of those warehouses.

For analysis of changes in pulmonary function and symptoms occurring over the work shift on the day of spirometry the work categories of nine individuals were reassigned according to the worker's job on the day of testing.

Except when otherwise noted, statistical significance testing was done by Chi-square or Fisher's Exact Test.

Symptom Definition:

A subject was considered to have chronic cough if he said he usually coughed first thing in the morning (excluding a single cough or clearing of the throat), during the day, or at night, on most days for as much as three months a year.

A subject was considered to have chronic bronchitis if he said he usually brought up phlegm from his chest first thing in the morning, during the day, or at night, on most days for as much as three months a year.

A subject was considered to have dyspnea if he said he had shortness of breath walking with people his own age at an ordinary pace on the level or with less exertion.

2. Environmental

a. Personal sampling, including both respirable and total dust, was done during the same work shift as spirometry testing as follows.

1) Respirable Dust

Prepared 37 mm diameter cassettes with 5.0 micron pore size filters (VM-1) were placed into a 10 mm nylon cyclone assembly at the sampling location. Calibrated personal sampling pumps equipped with pulsation flow dampers (MSA, Model G) were used to collect the sample over the work shift at a flow rate of approximately 1.7 liters per minute. At the end of the sampled shifts (approximately 7.5 hours) cassettes were removed from the cyclone assemblies and sealed. Particle size cutoff with this apparatus is estimated to be 6 to 7 µm.

2) Total Dust

Sampling was the same as for respirable dust except that cyclones were not used. Total dust sampling was with closed face cassettes.

b. General area sampling was by three methods including:

1) a high volume sampler and glass fiber filters for bulk dust collection;

2) an Anderson non-viable cascade impactor for particle size distribution;

and 3) three-piece open-faced filter cassettes controlled by critical orifices from a vaccuum source for general area total dust and similar arrangements with the addition of vertical elutriators for airborne dust of <15 µm diameter. All filters were hand carried back to the laboratory for gravimetric analysis.

D. Results

1. Population Profile

Table 2 describes the composition of the Celestial Seasonings work force by major work categories.

Employees of Celestial Seasonings were generally young adults, with an overall mean age of 28.3 years. The range of mean ages was narrow, from 26.0 years in Warehouse 1 to 30.1 years in office workers.

The sexes were essentially equally represented overall. However, by job category, females were the overwhelming majority (89%) in Bulk Packaging, where personal work schedules were relatively flexible due to the entirely manual process involved. Conversely, there was a male predominance in Warehouse 3 and Miscellaneous categories which perform more physically demanding work. Ninety-eight percent of the workers were white.

Tenure averaged only 1.7 years overall. Longest tenures were in Office workers (2.2 years) and Bulk Packagers (3.1 years); shortest were in Warehouse 1 (1.0 years) and Warehouse 3 (1.3 years) workers.

Smokers represented approximately 38% of the interviewed workers, ex-smokers 32%, and non-smokers 30%. Office workers had the greatest fraction of smokers (40%), Warehouse 3 workers had the largest fraction of non-smokers (43%) and the smallest fraction of ex-smokers (21%). Bulk Packagers, on the other hand, had the smallest percentage of non-smokers (22%) and the largest percentage of ex-smokers (44%).

2. Dust Exposure

Table 3 shows the means, range, and number of samples obtained for personal and general area dust levels in the five major categories. Total personal dust concentrations were highest for Warehouse 3 workers (mean of 14.22 mg/m^3) and Bulk Packagers (12.81 mg/m^3). The general area total dust concentration was comparable to personal total dust levels for Warehouse 3 (mean of 12.68 mg/m^3) but not for Bulk Packagers, where only one general area sample (1.23 mg/m^3) was measured. In this regard it had been expected that general area dust measurements would not appropriately reflect Bulk Packager exposure, because area samplers could not be placed close to this manual operation without interferring with it. Total dust exposure for Warehouse 1 was much less (means of 1.67 mg/m^3 by personal sampling and 1.00 mg/m^3 by general area sampling), and, as expected, very low for Office workers (0.15 mg/m^3 by personal sampling). Mean personal respirable dust concentrations ranged from 0.09 mg/m^3 in Office workers to 0.83 mg/m^3 in Bulk Packagers. Vertical elutriators gave a mean dust level of 3.23 mg/m^3 in Warehouse 3, much greater than the personal respirable dust means of 0.58 mg/m^3. This difference is not unexpected for two reasons. First, the personal respirable apparatus has a particle size cut-off of approximatey 7 µm aerodynamic diameter whereas the cut-off for vertical elutriators is about 15 µm. And second, some elutriators were situated in close proximity to dust generating processes which workers approached only intermittently.

Two samples obtained for analysis with the Anderson cascade impactor indicated that approximately 45% (by weight) of airborne dust in Warehouse 3 was less than 10 µm in diameter and 25% was less than 7 µm in diameter. (Figure 1)

3. Symptoms

a. Chronic Cough (Table 4)

This symptom appeared to be related not only to smoking (prevalence increased from 13% in non-smokers, to 22% in ex-smokers, and to 44% in current smokers) but also to work category (prevalence ranged from 20% in Office workers to 50% in

Warehouse 3 workers). Statistically significant ($p<0.05$) differences of prevalence of chronic cough was present between Office non-smokers and Warehouse 3 non-smokers. Sample size was not large enough to allow for meaningful statistical testing of smoking-adjusted rates of chronic cough.

b. Chronic Bronchitis (Tables 5 a,b,c)

Overall, 23% of employees had chronic phlegm production. As with chronic cough, this appeared related not only to smoking (non-smokers - 17%, ex-smokers - 25%, and current smokers - 28%) but also to work category. Overall 50% of Warehouse 3 workers had chronic bronchitis, as did 33% of Bulk Packagers, but only 16% of office workers. Warehouse 3 non-smokers had more chronic bronchitis ($p < 0.05$) than non-smoking Office workers. Overall, Warehouse 3 workers had significantly ($p <0.05$) more chronic bronchitis than Office workers.

Because of statistically significant differences in reporting phlegm production between men and women, separate tables (5 b and c) display chronic bronchitis prevalence by work category and smoking status for each sex. Statistically significant ($p <0.05$) differences occurred for women between Office non-smokers and Warehouse 3 non-smokers. Sample size was not large enough to allow for meaningful statistical testing of rates of chronic bronchitis adjusted for smoking and sex.

c. Dyspnea (Table 6)

The symptom of breathlessness was uncommon, with only 5 of 204 (2%) complaining of shortness of breath when walking with peers. No statistically significant differences were present between work categories either overall or within specific smoking categories.

d. Chest Tightness on Particular Days of the Week (Table 7)

Nine employees had histories of having had chest tightness or breathing difficulty beginning at work on their first day back to work. These nine individuals were from all major work categories except Office, representing 7% of non-office workers with completed questionnaires. Four of the nine had it all first days back, and four had it some first days back. The remaining subject could not be classified as to whether these symptoms occurred on all or only some first days back. Seven of the nine were ex-smokers. None had prior occupational exposure to cotton dust.

Twelve other workers, only one an Office worker, had chest tightness or breathing difficulty on particular days of the week other than their first day back to work. For these individuals onset before or after entering the workplace could not be determined from the questionnaire data.

One individual who complained of Monday symptoms had onset before entering the workplace and he has been treated in the analysis as never having the chest symptoms on a particular day of the week. Treated likewise is another individual who indicated all seven days of the week as particular days for these chest symptoms.

e. Chest Tightness on the Day of Spirometry (Table 8)

Chest tightness with onset after entering the work site on the day of pulmonary function testing was reported by 17 of 168 (10%) workers who were questioned and did not have this symptom upon arriving at work. Bulk Packagers had a significantly ($p < 0.05$) greater incidence (33%) compared to that of Office workers (2%).

Respirator Use on the Day of Spirometry (Table 9)

Overall, 9% of workers wore some kind of mask during the shift. None of these were Office workers, yielding a usage rate of 12% for all non-office workers. Bulk Packagers and Warehouse 3 workers had the highest usage rates. Mask wearing was not qualified by type of respirator or duration of use.

Herb and Blend Dustiness and Irritation

Although an attempt was made to determine which herbs and blends might have been most problematic to the workers' health, it became apparent that many subjects had misinterpreted instructions for ranking herbs and blends. In addition, some workers had essentially no experience with the less frequently used herbs or blends. Also, certain workers had experience with both herbs and blends, others with only one or the other, and the questionnaire was not designed to define each worker's experience in this way. Thus, this part of the investigation provided no useful information.

4. Signs

a. Wheezing, Rales

Of the 206 participating workers, 184 had chest auscultation both pre- and post-shift by a physician. Of these, five had expiratory wheezes on non-forced deep breathing at the pre-shift session. Only one of these five also had wheezing post-shift. One subject who had a clear chest pre-shift had wheezing post-shift. In addition, two subjects were auscultated only post-shift and had no wheezing, and two were auscultated only midway through the shift and were free of wheezes. Nine had auscultation preshift only and had clear lungs. Only one individual had rales, a middle-aged smoker in the Miscellaneous worker category.

b. Chest Radiograph

Excluding skeletal abnormalities (e.g. scoliosis), calcified hilar nodes, calcified granulomata, and one case with parenchymal scarring (a worker with history of sarcoidosis), 4 of 129 PA chest x-rays demonstrated abnormalities. There were increased interstitial markings in one middle aged smoker (Miscellaneous work category) and very small, ill-defined shadows suggesting infiltrates in three other workers (two teabaggers and one office worker).

c. Pulmonary Function

1. Pre-shift Spirometry (Table 10)

Pre-shift spirometry was analyzed for evidence of chronic impairment of respiratory function. Mean FVC was 108.5% of predicted overall with a range from 106.3% in Office workers to 112.4% in Warehouse 3 workers (no statistically significant differences). Similarly, mean FEV_1 was 109.6% of predicted for all employees with a range from 106.6% in Office workers to 112.4% for Warehouse 3 workers (no statistically significant differences). The mean FEV_1/FVC ratio ranged from 79.7% in Miscellaneous workers (significantly lower than Office workers) to 86.9% in Warehouse 1 workers (significantly better than Office workers) with an overall mean of 83.5%, but age and smoking differences confound comparisons between categories.

Categorically, mild obstruction (FEV_1/FVC less than 70% but greater than 60% predicted) was found in eight workers, two in Warehouse 1 and five in the Miscellaneous category, and one in Bulk Pachaging. Of these eight, all had smoking histories except for three who had been asthmatic since childhood. No worker had restrictive impairment (FVC less than 80% predicted).

2. Shift Changes (Table 11)

Shift changes in pulmonary function were determined by comparing pre-shift and post-shift results. Overall, there was a drop over the workshift of 0.7% in FEV_1 which represented a volume of 26 ml. Only Office workers had a mean increase in FEV_1 (+0.1%). The greatest mean fall was in Warehouse 1 workers (-1.2%). There were no statistically significant differences between work categories.

Overall, 15 subjects had a fall in FEV_1 of >5% of the pre-shift value. This represents 9% of the 174 subjects who had both pre- and post-shift spirometry. No subject had more than a 15% fall in FEV_1 and only one had >10% fall (an asthmatic since age 10). Between work categories there were no significant differences in the number of subjects who had an FEV_1 shift drop of five or more percent.

Analysis of covariance was used to test for effects of several variables on the percent fall in FEV_1. Initial analysis found no significant effects of race, sex, age, height, personal respirable dust, marijuana smoking, cigarette smoking (chronic, during the work shift, or within an hour before spirometric testing), recent chest illness, use of a respirator, full or part time status, shift worked, or tenure.

In a separate analysis, personal respirable dust showed no statistically significant correlation to percent fall in FEV_1 when all respirable dust samples of subjects who had both pre- and post-shift spirometry (74 sets of observations $p = 0.3743$) were analyzed. This was also true when estimated dust exposures for specific jobs were assigned to workers whose exposure had not been directly measured (153 sets of data, $p = 0.3373$).

An attempt was made to relate FEV_1 shift change with history of ever having had "asthma" or "attacks of shortness of breath with wheezing." No significant differences were found, even when the analysis was limited to non-Office workers.

Those non-office workers who had histories of chest tightness or breathing difficulty on particular days of the week did not have significant differences in FEV_1 shift changes measured on the first day back (Table 12). However, workers who developed chest tightness during the workshift on the day of spirometry had a significantly greater fall ($p < 0.01$) in FEV_1 over the workshift than those who did not develop chest tightness (Table 13). The difference was signficant for both absolute and percent of pre-shift value declines.

D. Discussion

Respiratory disease in workers occupationally exposed to dusts generated during the processing of tea was first described by Castellani (4). He noted that workers in the tea factories of what was then known as Ceylon were observed to "deteriorate in their general health, losing flesh and becoming easily tired; at the same time they develop a cough with mucopurulent expectoration. If these coolies are taken away from the factory and sent to work in the fields, all the symptoms slowly disappear." Castellani named this entity "tea factory cough" and "tea tasters disease."

The next reference to occupational respiratory disease in the tea industry appeared in 1970. Uragoda (5) described a case report of a tea maker in Ceylon who, after 23 years of occupational exposure, developed classic occupational asthma related to entering the sifting or packaging room. He had a positive immediate-type skin test to tea fluff, the fine dust discharged into the air mainly during the sifting process but also during packaging. Several minutes following a provocative inhalation of tea fluff he had onset of difficulty breathing, with wheezing and cough, and auscultatory findings of rhonchi and crepitations.

Cinkotai, Lockwood, and Rylander (6), in a study of byssinotic symptoms in cotton mill workers, used workers at a tea packing factory as a control for the cotton mills. Eighty five of 89 workers at the tea factory were interviewed and none were found to have byssinotic symptoms. Airborne dust measured by a technique different from that used in this investigation was reported as 2.27 mg/m^3. They cite unpublished findings of shift reductions in FEV_1 on exposure to tea dust.

A survey of pulmonary function in workers at two tea bagging factories has been reported by Grandjean, Hotz, and Lob (7). They found significantly lower expiratory flows (FEF_{25-75}) attributable to tea dust exposure in 59 women studied. It was hypothesized that this flow abnormality may be related to chronic bronchitis induced by the inhalation of dust.

One other reference regarding tea as an etiologic agent in respiratory illness was published in the Japanese literature in 1975 (8). That paper described two case reports, one of allergic rhinitis and one of asthma. These two cases, unlike the previously reported cases, did not work in tea factories. Rather, their symptoms occurred while working outdoors in tea gardens or on tea plantations. Both had positive skin tests to tea-leaf extract and inhalation of the extract provoked an asthmatic reaction in the asthmatic individual.

Tea (black tea), per se, is only one of dozens of various ingredients used in the preparation of Celestial Seasonings products. Two of these ingredients have been specifically implicated in the etiology of occupational lung diseases.

Barley, during the proces of malting, has been known to become heavily contaminated with fungi, the etiologic agent of malt worker's disease, a hypersensitivity alveolitis (9). Barley, as a grain, may also be involved in grain-handlers disease, which may have components of a systemic illness as well as a more limited asthmatic manifestation (10). Hops have been implicated in occupational asthma (11). In addition, any moldy vegetable material may potentially be involved in the etiology of extrinsic allergic alveolitis (12) and in this sense, Celestial Seasonings workers may be at risk depending on conditions under which raw materials are harvested, stored, or shipped prior to arriving at Celestial Seasonings. Finally, chronic exposure to high levels of any respirable dust in an occupational setting may result in chronic bronchitis (13).

Preliminary questioning of workers and management indicated that a systemic syndrome (involving fever and malaise) was not occurring and thus the investigation was not directed beyond the respiratory system. Although the request for a NIOSH Health Hazard Evaluation was related mainly to objective findings of the Employee Lung Testing Program in terms of pulmonary function, our survey indicated a striking relationship between work category and the symptoms of chronic cough and chronic bronchitis. Workers with the greatest dust exposures had the greatest prevalence of symptoms. In all instances where statistically significant differences were found, workers with greater dust exposure had the higher prevalence of symptoms. Here it should be emphasized that Office workers, used as a comparison group, are not entirely unexposed in that many of them take breaks in a room which is contiguous with production areas of Warehouse 1, and many of them had previously held jobs in dusty areas of the plant.

Dyspnea was found to be of very low prevalence which is consistent with the general youth of workers and short duration of exposure to occupational dusts at Celestial Seasonings. Whether much longer durations of exposure might lead to development of significant dyspnea can only be conjectured.

As with dyspnea, which failed to differentiate between work categories, baseline (pre-shift) lung function in terms of FVC (percent predicted) and FEV_1 (percent predicted) also showed no statistically significant differences between work categories. This is not unexpected since tenure of employment was generally very short.

As byssinosis has not previously been reported to be due to exposure to tea or herbal dusts, and especially since one previous epidemiologic survey found no one with byssinotic symptoms in a tea packaging plant (5), it is interesting that 7% of non-Office workers had chest tightness or breathing difficulty only on their first day back to work after an absence. Although this is far less than the reported 20% to 40% prevalence of this symptom in card room workers of cotton textile mills (1), it is definitely greater than an expected false positive rate as estimated from studies in synthetic and wool textile mills (14). However, printed materials distributed by the Employee Lung Testing Program had informed the workers about byssinosis. In fact, during the survey many workers spoke humorously of having "Green Lung," their own version of the term "Brown Lung." (Millers and mixers are frequently covered with a fine greenish-brown dust at the end of the work day.) Thus, the reporting of first-day-back symptoms may have been falsely elevated. The finding of a small increase in FEV_1 measured on the first day back for those with questionnaire responses positive for a history of chest tightness or difficulty breathing occurring particularly on the first day back to work is evidence against this being a byssinotic airway reaction. However, there is objective evidence from the spirometry data supporting the validity of the symptom of chest tightness developing during the day of study. This symptom is consistent with occupational asthma as well as with byssinosis.

Although no significant relationships could be found between personal dust exposure or history of asthma and shift change in FEV_1, this does not rule out the possibility that such relationships exist. The analysis was complicated by workers wearing masks of various efficacies for various fractions of the shift and thus personal dust measurements may not reflect actual exposure.

Also, because only some of the many raw ingredients are being processed on any given day, our medical and environmental survey did not characterize all possible exposures at Celestial Seasonings.

Furthermore, it is possible that the Employee Lung Testing Program has achieved its goal of selecting out individuals with significant airways sensitivity to herbal dusts. (Seven of fourteen workers referred to physicians by the Lung Testing Program had left Celestial Seasonings for undetermined reasons. Of the remaining seven, five were available for spirometric testing: three demonstrated mild obstruction, and two had normal pre-shift spirometry. Of these five, four had no decrease in their post-shift spirometry and one was not retested). Even without formal pulmonary function testing it is likely that subtle self selection out of dusty exposures by the most susceptible workers occurs at

Celestial Seasonings. This would tend to decrease the prevalence of illness determined by this cross-sectional survey.

In conclusion, this evaluation demonstrated a relation between dust exposure and the symptoms of chronic cough and phlegm production. There were small decrements in pulmonary function in some dust-exposed individuals during the workshift, especially in those who have the sensation of chest tightness. However, the significance of these findings in terms of risk of chronic impairment cannot be determined from this study.

References

1. NIOSH. Criteria for a recommended standard. Occupational exposure to cotton dust. HEW Publication No. (NIOSH) 75-118, 1974.

2. NIOSH. A guide to industrial respiratory protection. HEW Publication No. (NIOSH) 76-189, 1976.

3. Knudson, R.J., Slatin, R.C., Lebowitz, M.D., Burrows, B.: The maximal expiratory flow-volume curve. Normal standards, variability, and effects of age. Am Rev Respir Dis 113: 587-600, 1976.

4. Castellani, A., Chalmers, A.: Manual of tropical medicine. 3rd ed., New York: William Wood & Company, 1919.

5. Uragoda, C.G.: Tea maker's asthma. Brit J Indust Med 27:181-182, 1970.

6. Cinkotai, F.F., Lockwood, M.G., Rylander, R.: Airborne micro-organisms and the prevalence of byssinotic symptoms in cotton mills. Am Ind Hyg Assoc J 38:554-559, 1977.

7. Grandjean, M., Hotz, P., Lob, M. [Study of pulmonary function in workers of 2 enterprises dealing with the curing of teas, herbal extracts and spices in relation to the time of exposure.] (Fre) Soz Praeventivemed 23(4):289-290, 1978.

8. Ebihara, I.: Study on the inhalative allergy of ciliae of leaves. Inhalative allergy of the ciliae of tea leaves. J Science of Labor 51:661-665, 1975.

9. Grant, I.W.B., Blackadder, E.S., Greenberg, M., Blyth, W.: Extrinsic allergic alveolitis in Scotish maltworkers. Brit Med J 1:490-493, 1976.

10. Pepys, J., Davies, R.J.: Occupational asthma. In: Middleton, E., Reed, C.E., Ellis, E.F. (eds.). Allergy: principles and practice, St. Louis, Mosley, 1978.

11. Brooks, S.M.: Bronchial asthma of ocupational origin. Scand J Work Environ & Health 3:53-72, 1977.

12. Seaton, A., Morgan, W.K.C.: Allergic alveolitis. Morgan, W.K.C., Seaton, A. (eds.). Occupational Lung Diseases, Philadelphia, WB Saunders Company 1975.

13. Lapp, N.L.: Industrial bronchitis. In: Morgan, W.K.C., Seaton, A., (eds.). Occupational Lung Diseases, Philadelphia, W.B. Saunders Company, 1975.

14. Merchant, J.A., Lumsden, J.C., Kilburn, K.H., O'Fallen, W.M., Ujda, J.R., Germino, V.H. Jr., Hamilton, J.D.: An industrial study of biological effects of cotton dust and cigarette smoke exposure. JOM 15:212-221, 1973.

V. Authorship and Acknowledgements

Report Prepared By:

Robert M. Castellan, M.D.
Medical Officer
Clinical Investigations Branch

Brian A. Boehlecke, M.D.
Chief
Clinical Investigations Branch

Terry D. Thedell, Ph.D.
Industrial Hygienist
Environmental Investigations Branch

Martin R. Petersen, M.S.
Statistician
Epidemiological Investigations Branch

James A. Merchant, M.D.
Director
Division of Respiratory Disease Studies
NIOSH
Morgantown, WV 26505

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Division of Respiratory Disease Studies
NIOSH
Morgantown, WV 26505

VI. Distribution and Availability of Determination Report

Copies of this health hazard evaluation determination report are available upon request from NIOSH, Division of Technical Services, Information Resources and Dissemination Section, 4676 Columbia Parkway, Cincinnati, Ohio 45226. After 90 days, the report will be available through the National Technical Information Service (NTIS), Springfield, Virginia 22161.

a) Celestial Seasonings
b) NIOSH - Region VIII
and c) U.S. Department of Labor - Region VIII

For the purpose of informing the employees at Celestial Seasonings, the employer shall "post" the Determination Report in a prominent place near where exposed employees work.

TABLE 1

RAW INGREDIENTS, AS OF NOVEMBER, 1978

Alfalfa
Allspice
Almond Powder
Star Anise
Anise Seed
Barley
Blackberry Leaves
Black Tea
Blueberry Leaves
Carob
Cassia
Cassia Oil
Catnip
Chamomile
Chicory
Clove
Comfrey Leaves
Comfrey Root
Crystal Malt
Dandelion Leaves
Dandelion Root
Elder Flowers
Eleuthro
Eucalyptus
Fennel Seed
Foenugreek
Ginger
Ginseng (Panax)
Golden Rod
Golden Seal
Gotu Kola
Hawthorne
Hibiscus
Hops

Lemon Grass
Lemon Mist Oil
Lemon Peel
Lemon Verbena
Licorice Root
Lovage Root
Matte, Green
Matte, Roasted
Nettles
Orange Blossoms
Orange Leaves
Orange Peel
Papaya
Passion Flower
Peony
Peppermint
Peppermint Oil
Raspberry Leaves
Red Clover
Rosehips
Rosemary
Rose Petals
Sage
Scullcup
Slippery Elm
Spearmint
Spearmint Oil
Strawberry Leaves
Titia
Yarrow Flowers
Wild Cherry Bark
Vanilla Extract
Winterberry Extract

TABLE 2

POPULATION PROFILE

Current Work Category	Number of Workers	Mean Age	Mean Tenure	Sex		Race		Smoking Status			
				Male	Female	White	Nonwhite	Non Smoker	Ex Smoker	Current Smoker	Unknown Smoking Status
Office	62	30.1	2.2[1]	25(40)	37(60)	62(100)	0(0)	19(32)	17(28)	24(40)	2
Warehouse 1	64	26.0	1.0	27(42)	37(58)	62(97)	2(3)	18(30)	20(33)	23(38)	3
Warehouse 3	14	26.9	1.3	11(79)	3(21)	13(93)	1(7)	6(43)	3(21)	5(36)	0
Bulk Packager	18	27.6	3.1	2(11)	16(89)	17(94)	1(6)	4(22)	8(44)	6(33)	0
Miscellaneous	48	29.6	1.6[2]	38(79)	10(21)	47(98)	1(2)	13(28)	16(35)	17(37)	2
All Workers	206	28.3	1.7[3]	103(50)	103(50)	201(98)	5(2)	60(30)	64(32)	75(38)	7

[1]Mean of 61 on whom data is available

[2]Mean of 47 on whom data is available

[3]Mean of 204 on whom data is available

Within parentheses are rounded-off percents of those with known status

TABLE 3

DUST MEASUREMENTS

	Personal		General Area	
	Total	Respirable	Total	Vertical Elutriator
Office	0.15*(2)** (0.12-0.19)***	0.09(2) (0.07-0.10)	--	--
Warehouse 1	1.67(47) (0.32-6.67)	0.12(47) 0.04-0.46	1.00(7) (0.32-1.97)	0.37 (0.21-0.54)
Warehouse 3	14.22(16) (1.32-58.29)	0.58(15) (0.04-2.02)	12.68(22)[1] (1.77-45.51)	3.37(22)[1] (0.76-14.3)
Bulk Packager	12.81(7) (1.33-40.48)	0.83(7) (0.10-4.50)	1.23(1)	0.47(1)
Miscellaneous	2.23(8) (0.53-7.10)	0.17(8) (0.06-0.32)	--	--

Shown are * mean dust concentration, ** number of samples, and *** range for dust concentrations measured in each major work category in mg/m^3

[1]Excluded is one sample taken at the mixer area during a shift that no mixing was done (Total: 0.29, VE: 0.19)

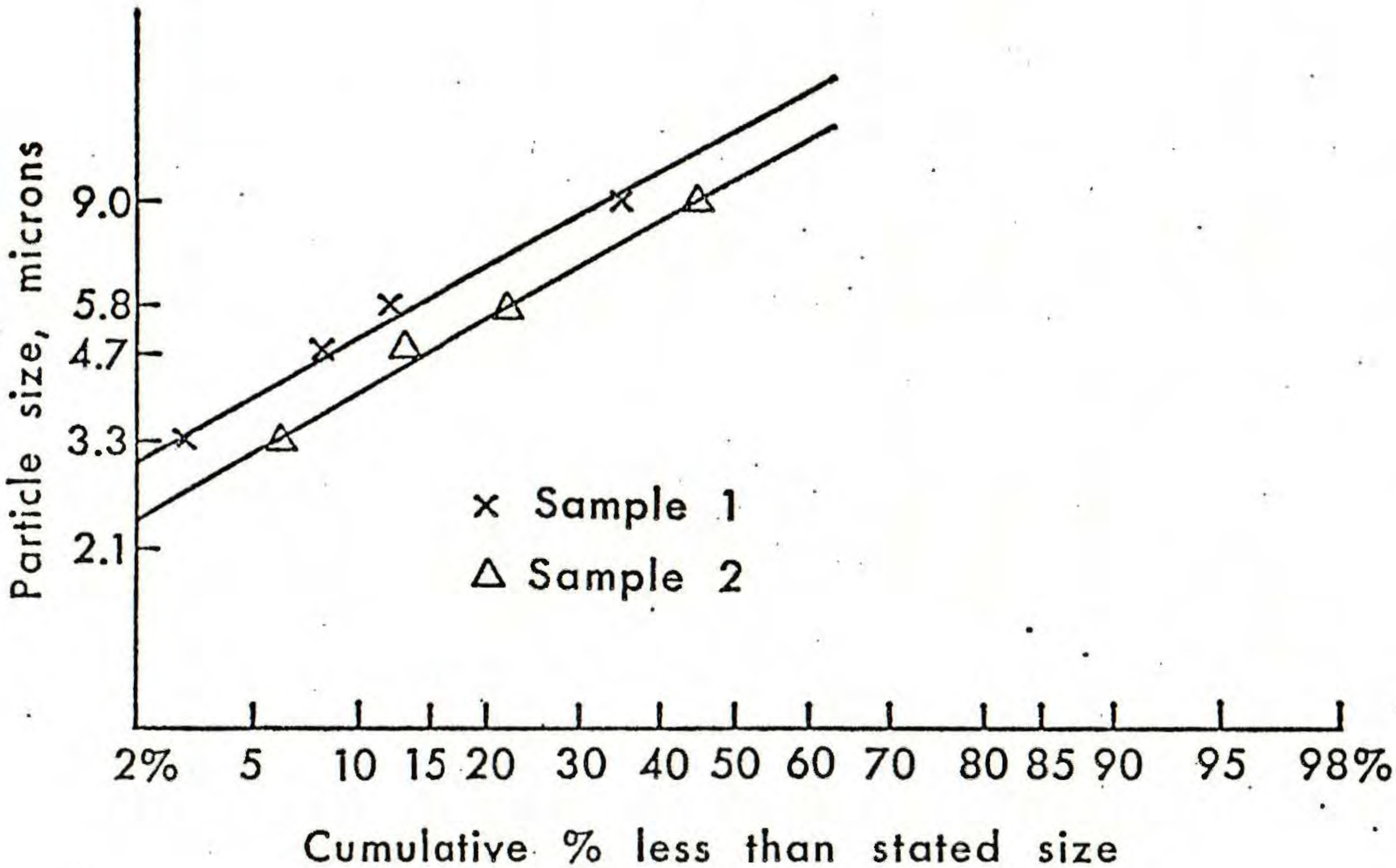

FIGURE 1

Airborne Dust Size Distribution in Warehouse 3

TABLE 4

CHRONIC COUGH BY WORK CATEGORY AND SMOKING STATUS

	Nonsmoker	Exsmoker	Current Smoker	Unknown Smoking Status	Total
Office	0/19[1] (00)	2/17 (12)	10/24 (42)	0/1[2] (00)	12/61[2] (20)
Warehouse 1	3/18 (17)	5/20 (25)	7/23 (30)	0/3 (00)	15/64 (23)
Warehouse 3	3/6* (50)	0/3 (00)	4/5 (80)	0/0 (--)	7/14 (50)
Bulk Packager	1/4 (25)	2/8 (25)	4/6 (67)	0/0 (--)	7/18 (39)
Miscellaneous	1/13 (8)	5/15[2] (33)	8/17 (47)	0/1[2] (00)	14/46[3] (30)
Overall	8/60 (13)	14/63[2] (22)	33/75 (44)	0/5[3] (00)	55/203[4] (27)

[1]Represented are number with symptom/total number at risk (% with symptom)

[2]Data missing on one individual, not included

[3]Data missing on two individuals, not included

[4]Data missing on three individuals, not included

*$p<0.05$, compared to Office workers

TABLE 5a

CHRONIC BRONCHITIS BY WORK CATEGORY AND SMOKING STATUS
BOTH SEXES

	Nonsmoker	Exsmoker	Current Smoker	Unknown Smoking Status	Total
Office	1/19[1] (05)	4/17 (24)	5/24 (21)	0/1[2] (00)	10/61[2] (16)
Warehouse 1	2/18 (11)	3/20 (15)	3/23 (13)	0/3 (00)	8/64 (13)
Warehouse 3	4/6* (67)	0/3 (00)	3/5 (60)	0/0 (--)	7/14* (50)
Bulk Packager	0/4 (00)	5/8 (63)	1/6 (17)	0/0 (--)	6/18 (33)
Miscellaneous	3/13 (23)	4/16 (25)	9/17 (53)	0/1[2] (00)	16/47[2] (34)
Overall	10/60 (17)	16/64 (25)	21/75 (28)	0/5[3] (00)	47/204[3] (23)

[1] Represented are number with symptom/total number at risk (% with symptom)

[2] Data missing on one individual, not included

[3] Data missing on two individuals, not included

*$p < 0.05$, compared to Office workers

TABLE 5b

CHRONIC BRONCHITIS BY WORK CATEGORY AND SMOKING STATUS

MALE

	Nonsmoker	Exsmoker	Current Smoker	Unknown Smoking Status	Total
Office	1/6[1] (17)	2/6 (33)	3/13 (23)	0/0 (--)	6/25 (24)
Warehouse 1	0/7 (00)	1/9 (11)	3/10 (30)	0/1 (00)	4/27 (15)
Warehouse 3	2/3 (67)	0/3 (00)	3/5 (60)	0/0 (--)	5/11 (45)
Bulk Packager	0/0 (--)	1/2 (50)	0/0 (--)	0/0 (--)	1/2 (50)
Miscellaneous	3/12 (25)	4/10 (40)	6/14 (43)	0/1[2] (00)	13/37[2] (35)
Overall	6/28 (21)	8/30 (27)	15/42 (36)	0/2[2] (00)	29/102[2] (28)

[1]Represented are number with symptom/total number at risk (% with symptom)

[2]Data missing on one individual, not included

TABLE 5c

CHRONIC BRONCHITIS BY WORK CATEGORY AND SMOKING STATUS

FEMALE

	Nonsmoker	Exsmoker	Current Smoker	Unknown Smoking Status	Total
Office	0/13[1](00)	2/11(18)	2/11(18)	0/1[2](00)	4/36[2] (11)
Warehouse 1	2/11(18)	2/11(18)	0/13(00)	0/2 (00)	4/37 (11)
Warehouse 3	2/3*(67)	0/0 (--)	0/0 (--)	0/0 (--)	2/3 (67)
Bulk Packager	0/4 (00)	4/6 (67)	1/6 (17)	0/0 (--)	5/16 (31)
Miscellaneous	0/1 (00)	0/6 (00)	3/3 (100)	0/0 (--)	3/10 (30)
Overall	4/32(13)	8/34(24)	6/33(18)	0/3[2](00)	18/102[2](18)

[1]Represented are number with symptom/total number at risk (% with symptom)

[2]Data missing on one individual, not included

*$p<0.05$ compared to Office workers

TABLE 6

DYSPNEA BY WORK CATEGORY AND SMOKING STATUS

	Nonsmoker	Exsmoker	Smoker	Unknown Smoking Status	Total
Office	2/19[1] (11)	0/17 (00)	1/24 (04)	0/1[2] (00)	3/61[2] (05)
Warehouse 1	0/18 (00)	1/20 (05)	0/23 (00)	0/3 (00)	1/64 (02)
Warehouse 3	0/6 (00)	0/3 (00)	0/5 (00)	0/0 (--)	0/14 (00)
Bulk Packagers	0/4 (00)	1/8 (13)	0/6 (00)	0/0 (--)	1/18 (06)
Miscellanous	0/13 (00)	0/16 (00)	0/17 (00)	0/1[2] (00)	0/47[2] (00)
Overall	2/60 (03)	2/64 (03)	1/75 (01)	0/5[3] (00)	5/204[3] (02)

[1]Represented are number with symptom/total number at risk (% with symptom)

[2]Data missing on one individual, not included

[3]Data missing on two individuals, not included

TABLE 7

CHEST TIGHTNESS OR DIFFICULTY BREATHING ON PARTICULAR DAY(S) OF THE WEEK

ALL NON-OFFICE WORKERS* WITH COMPLETED QUESTIONNAIRES

	Number	Percent
1st day back only (onset after entering worksite)	9	7
1st day back and other days (but not all seven days)	0	0
Other days only	11	8
Never	113	85
TOTAL	133	

*Only one of 57 Office workers with completed questionnaires had chest tightness or breathing difficulty on particular days (Thursday and Friday) of the week.

TABLE 8

CHEST TIGHTNESS DEVELOPING AFTER ENTERING THE WORK SITE

ON THE DAY OF SPIROMETRY

	Number with symptom / Number at risk	Percent
Office	1/47	2
Warehouse 1	7/57	12
Warehouse 3	2/17	12
Bulk Packagers	4/12*	33
Miscellaneous	3/35	9
Overall	17/168	10

*p <0.05, compared to Office workers

TABLE 9

MASK WEARING ON DAY OF STUDY

	Number*	Wore Mask	Percent
Office	56	0	0
Warehouse 1	63	2	3
Warehouse 3	18	6	33
Bulk Packager	14	5	36
Miscellaneous	36	3	8
Overall	187	16	9

*represents the number of workers questioned about mask wearing

TABLE 10

MEAN PRESHIFT PULMONARY FUNCTION BY WORK CATEGORY

	Number	FVC (% pred.)	FEV_1 (% pred.)	FEV_1/FVC
Office	57	106.3	106.6	82.4
Warehouse 1	61	107.3	111.9	86.9**
Warehouse 3	13	112.4	112.4	82.8
Bulk Packagers	17	108.2	110.5	85.4
Miscellaneous	46	111.9	109.1	79.7*
Overall	194	108.5	109.6	83.5

*$p<0.05$ compared to Office

**$P<0.01$ compared to Office

TABLE 11

MEAN FEV_1 SHIFT CHANGES BY WORK CATEGORY

Work Category On Day of Study	Number	ΔFEV_1 (post-shift minus pre-shift value) (% of preshift value)	(milliliters)
Office	54	+0.1	+1
Warehouse 1	59	-1.3	-44
Warehouse 3	16	-0.7	-33
Bulk Packager	13	-0.0	-6
Miscellaneous	32	-1.1	-45
Overall	174	-0.7	-26

No significant differences in ΔFEV_1 expressed either as percent of preshift value or in absolute volume.

TABLE 12

CHANGE IN FEV_1 ON FIRST DAY BACK BY CHEST TIGHTNESS OR BREATHING DIFFICULTY ON PARTICULAR DAY(S) OF THE WEEK FOR NON-OFFICE WORKERS

Particular day(s) for symptoms	Number*	Mean ΔFEV_1 (postshift-preshift) (% of preshift value)	
1st day only	7	+0.3	N.S.**
Other days only	9	-3.0	N.S.
No particular days	104	-0.9	N.S.

*A total of 120 non-office workers had completed questionnaires and better preshift and postshift spirometry.

**No significant change, $p > 0.05$

TABLE 13

FEV_1 SHIFT CHANGE BY CHEST TIGHTNESS DEVELOPING DURING THE SHIFT

Chest Tightness Developing During Shift	Number	Mean ΔFEV_1 (postshift value--preshift value) % of preshift value	absolute volume(cc)
Yes	15*	-3.4% **	-113 **
No	159	-0.4%	-18
Overall	174	-0.7%	-26

*Two of 17 who developed chest tightness during the shift (see Table 7) had technically invalid post-shift spirometry

**p<.01 compared to those not developing chest tightness

ENGINEERING CONTROL SURVEY

Celestial Seasonings Company
Boulder, Colorado

March 6-7, 1979

Robert T. Hughes
Division of Physical Sciences and Engineering

U.S. Department of Health and Human Services
Public Health Service
Center for Disease Control
National Institute for Occupational Safety and Health
4676 Columbia Parkway
Cincinnati, Ohio 45226

The Celestial Seasonings Company manufactures and markets herb teas. The herb materials are received in bulk form. They are processed to achieve the proper consistency, blended to achieve the desired final product, packaged, and shipped. The various processing and packaging processes can generate and emit significant quantities of herb dust into the workplace. In conjunction with a medical and industrial hygiene study performed by the NIOSH Division of Respiratory Disease Studies, a survey of the processes relative to dust generation and emission potential and dust control was performed. This report briefly descirbes the various processes and provides recommendations for control of dust emissions.

The process descriptions provided herein are not intended to be comprehensive, but rather to provide a brief description of the dust generation points sufficient to support the dust control recommendations. The sketches provided are not intended to be dimensionally correct and in many cases are schematic in nature. The information and sketches are intended to provide recommendations and guidance to the Celestial Seasoning Company for their use in the design and construction of suitable dust control systems. Specific system dimensions and configurations must be determined as a part of the system design process.

Operations of concern were conducted in two separate areas. Warehouse 3 encompasses the basic processing operations. Material is received, milled, sifted, cleaned, and blended. The blended material is packaged and shipped from warehouse 1.

MILLING

The milling area contains four milling operations which are described and discussed below.

Mill No. 1

Mill no. 1 is used for free-flowing or graining materials. Material is manually dumped from drums onto a feed hopper from an elevated platform. The material free-flows onto a horizontal conveyor belt and is conveyed to an inclined conveyor belt. The inclined conveyor belt transfers material to a chute which gravity-feeds the mill. Milled material is conveyed to a sifter feed hopper.

The feed hopper incorporates a side draft hood. The installation is new and not yet connected to a ventilation system. The design hood airflow is reported to be 1,800 ft^3/min. It is believed that this ventilation system could be improved. The hood sides and top should be extended to form a booth over the hopper (Figure 1). Canvas curtains can be incorporated to effectively reduce the booth face area. The actual face area and curtain installation will be dictated by the hopper filling task. However, a face area measuring 5 by 6 foot seems reasonable. Hood airflow should be sufficient to provide a minimun of 100 ft/min face velocity. This suggests approximately 3,000 ft^3/min.

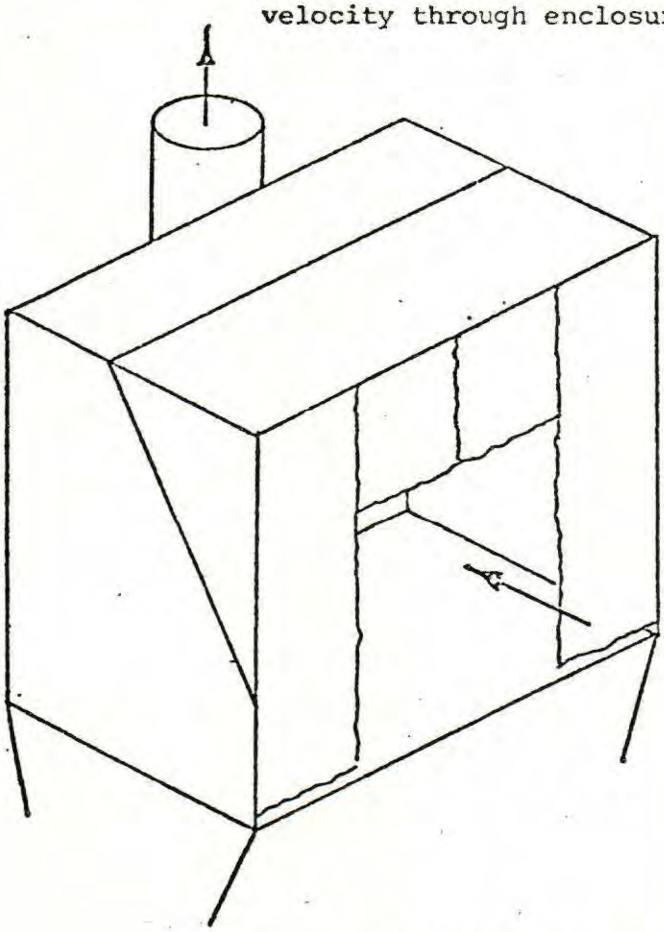

Figure 1. Feed hopper enclosure

There is an approximate 2 to 6 inch opening between the feed hopper and the horizontal conveyor belt. Dust will be generated at this point only when filling an empty hopper. Because dust will be generated for a relatively short time, probably just a few seconds, it is not recommended that any action be taken until ventilation of all other process areas in warehouse 3 have been completed and evaluated. If it is then determined that the dust generated during hopper filling is substantially contributing to an excessive exposure problem, a slot exhaust should be installed along the hopper discharge sides. The slot exhaust rate should be approximately 100 ft/min per foot of slot.

The horizontal-inclined belt conveyor transfer point is enclosed. The total exhaust flow rate from the enclosure should be approximately 500 ft^3/min. The enclosure open area should be sized to provide a minimun indraft velocity of 100 ft/min. Figure 2 shows a typical belt-to-belt transfer enclosure.

The inclined conveyor mill feed chute transfer point should also be enclosed and ventilated. The total flow rate should be approximately 500 ft^3/min with a minimun enclosure opening indraft velocity of 100 ft/min. Care must be taken to assure that the enclosure configuration does not create a negative pressure which might pull air up the mill feed chute. If this occurs, the total flow should be reduced until the problem is corrected.

Mills No. 2 and 3

Mills no. 2 and 3 are used for milling leafy materials. The material is placed on a short horizontal feed conveyor from drums or bags. It is transferred to the feed conveyor by an inclined conveyor to an enclosed feed hopper for mill no. 2. The material is then transferred to the mill no. 2 feed chutes by two inclined conveyors. Milled material is conveyed to a sifter feed hopper.

The feed conveyor and feed conveyor/inclined conveyor transfer point are not ventilated. Depending on the need for accessibility to the feed hopper from both sides, there are two possible recommendations. If access to only one

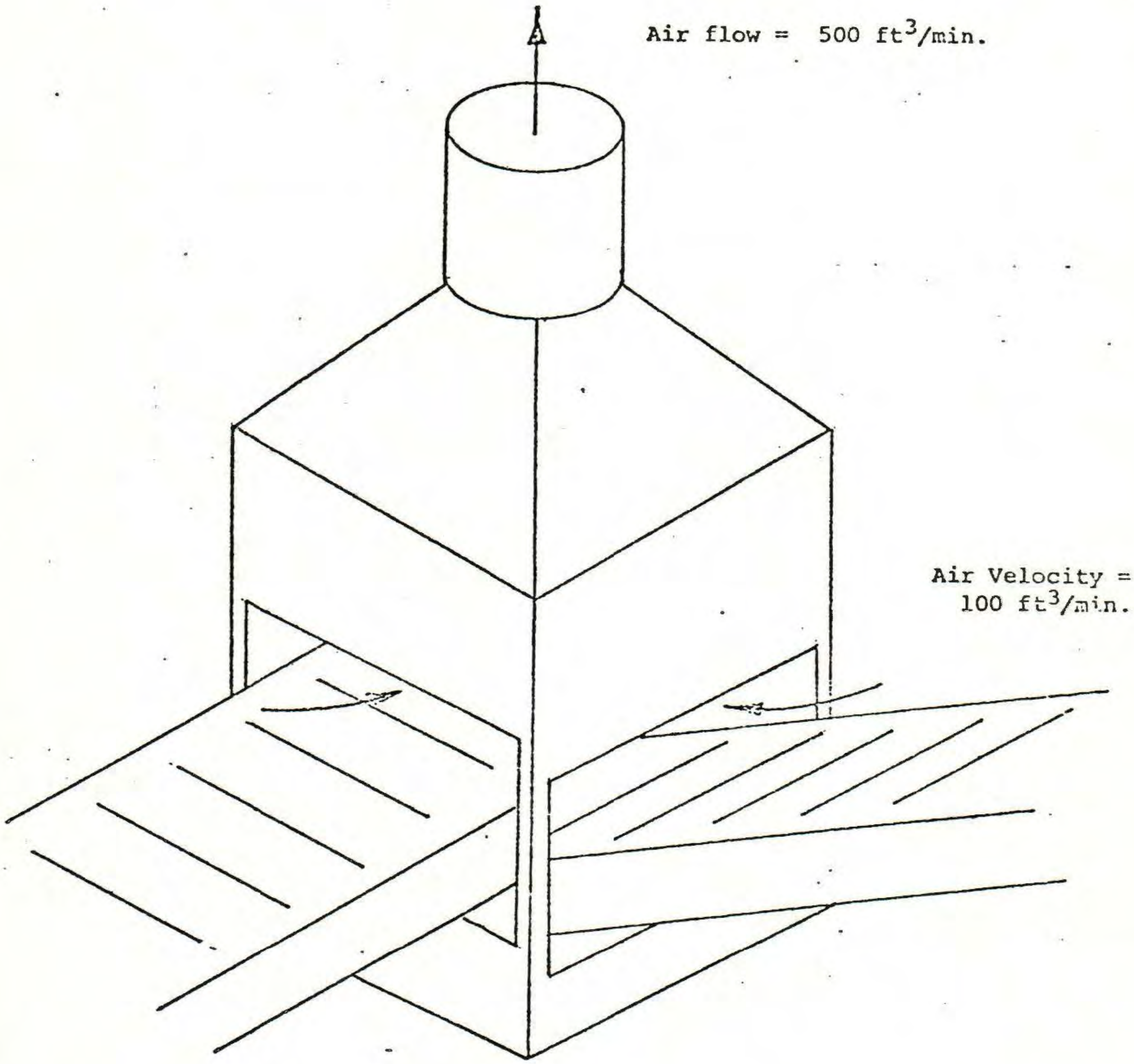

Figure 2. Belt-to-belt transfer enclosure.

side is sufficient, a side draft slot hood can be used (Figure 3). The length of the hood should be sufficient to encompass the material deposit area. Assuming a length of 5 feet, an airflow of approximately 2,500 ft^3/min would be required. If access to both sides of the conveyor is required, a slot plenum along both sides can be used (Figure 4). Again the total flow should be approximately 2,500 ft^3/min.

The feed belt conveyor/inclined belt conveyor transfer point should be enclosed and ventilated as shown in Figure 3. This enclosure is formed by placing a cover over the conveyor and utilizing the conveyor side panels as the enclosure sides. Airflow should be sufficient to achieve 100 ft/min velocity into the enclosure.

The inclined conveyor/feed hopper transfer point is enclosed by means of an enclosed hopper. Exhaust flow from the hopper should be approximately 100 ft^3/min. Minimum hopper opening indraft air velocity should be 100 ft/min.

The hopper discharges into mill no. 2 and then into a short enclosed inclined conveyor. The enclosure has a ventilation take-off at approximately the midpoint between the shredder and the second inclined conveyor. It is believed that the take-off will be more effective nearer to the mill no. 2 discharge (Figure 5). The exhaust airflow should be a minimun of 500 ft^3/min. The enclosure opening indraft airflow should be 100 ft/min minimum. It is noted that the end of the conveyor is partially open. An enclosure covering the open conveyor end is recommended (Figure 5). Airflow should be approximately 500 ft^3/min with an enclosure indraft velocity of 100 ft/min.

The first to second conveyor transfer point is enclosed and should be ventilated using the same requirements as previously recommended for mill no. 1 (Figure 2). The second inclined conveyor discharges into mill no. 3 feed chute.

It is noted that both the first and second inclined conveyors are enclosed with segmented removable covers. If these covers were extended and tightly

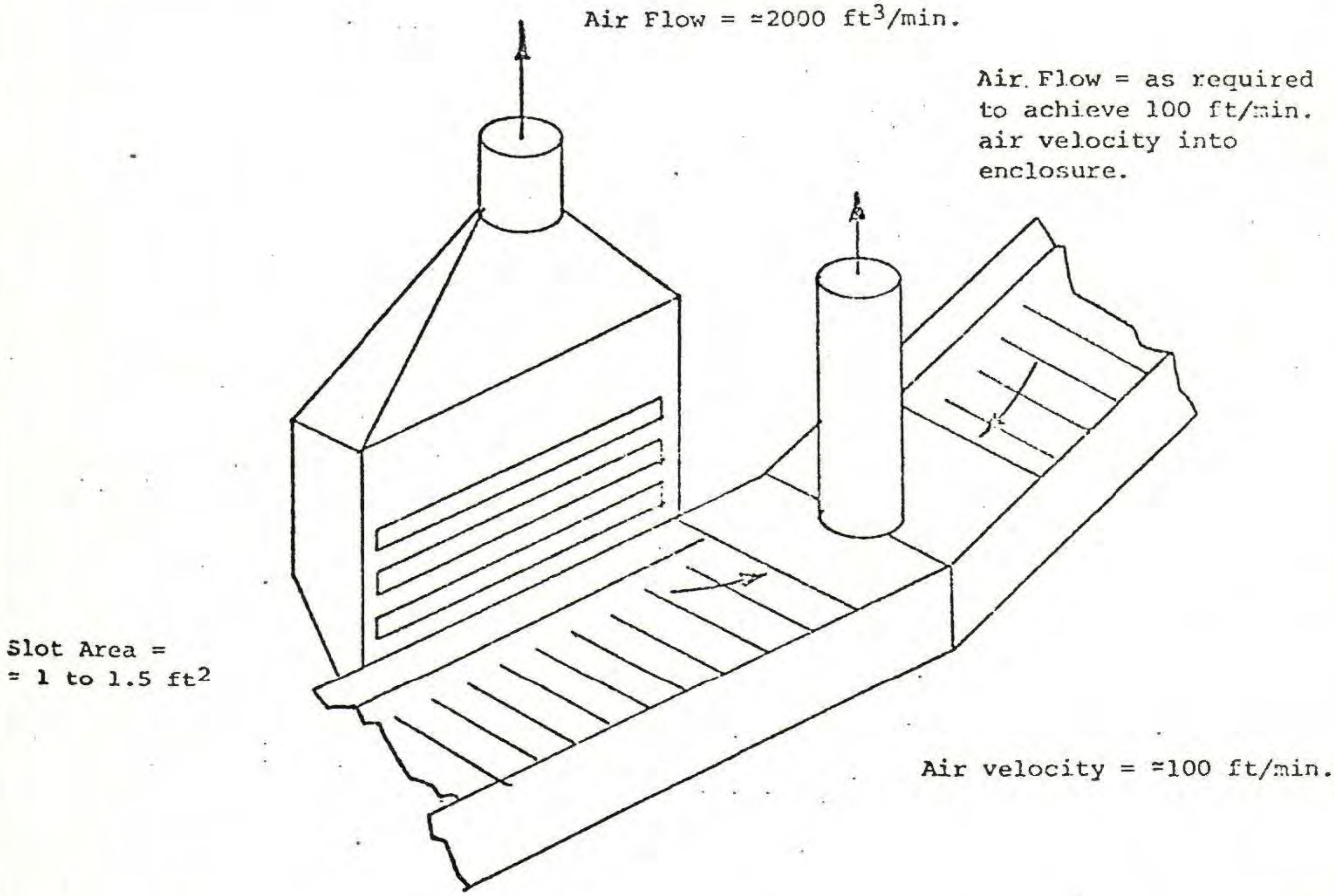

Figure 3. Mill 2 and 3 feed table.

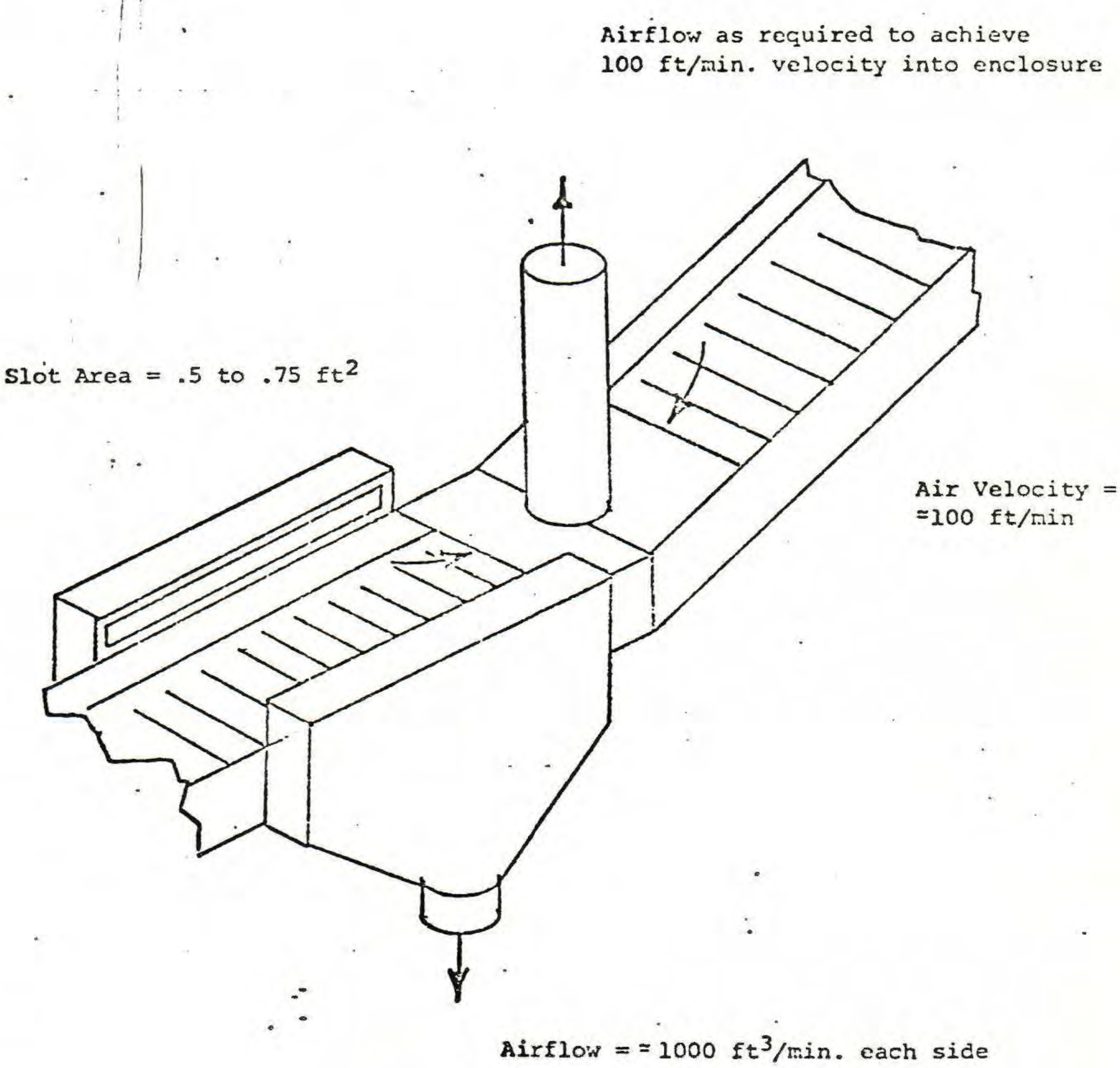

Figure 4. Mills no. 2 and 3 feed table.

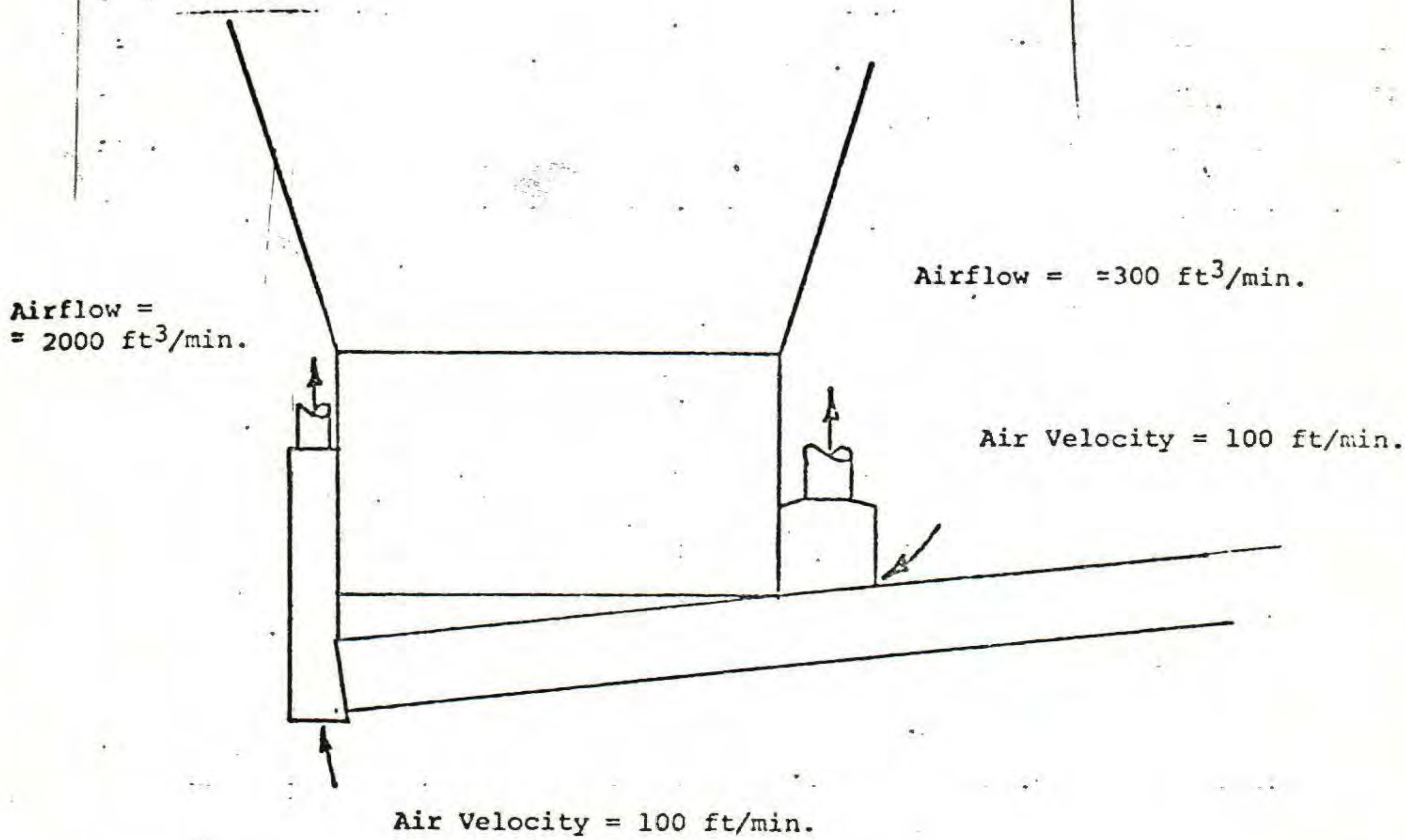

Figure 5. Mill no. 2.

fitted to the transfer point enclosures, the ventilation airflows within the enclosures and conveyors might be adversely affected. It must be noted, however, that there should not be any dust generation on the conveyor belts. The dust will be generated by the material droppings from one belt to the other within the enclosure. Therefore, it is recommended to ventilate the transfer point enclosures rather than the conveyors themselves.

Mill No. 4

The mill no. 4 operation has been largely replaced by the two previously described milling operations. It will be used only occasionally in the future. Material is fed into the mill by a small conveyor. The milled material is conveyed to a drum filler. The mill was not in operation, and as such, its dust emission characteristics were not observed. It is, however, believed that a minor modification to create an "inlet chute" might be beneficial (Figure 6). The current inlet configuration is rather "open" and exposes the rotating member of the mill. A "chute" will reduce the inlet area. It is recommended that this approach be taken and evaluated prior to any further action relative to exhaust ventilation.

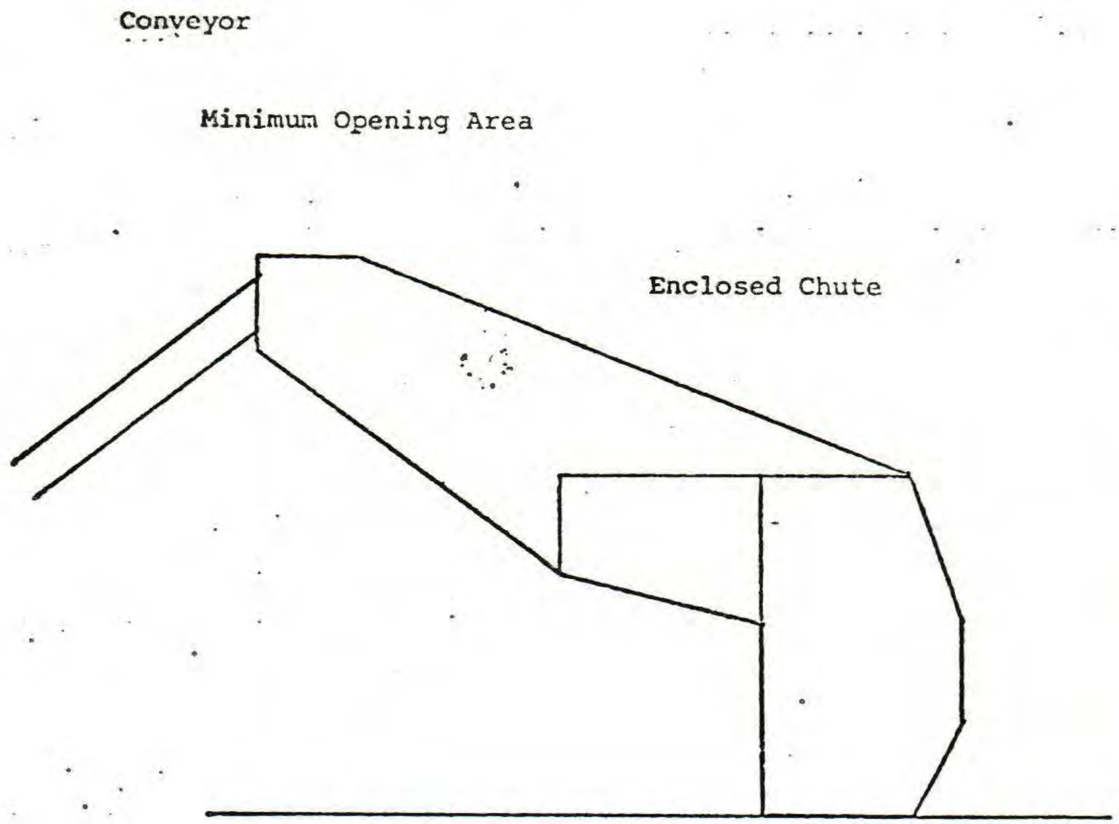

Figure 6. Mill no. 4.

SIFTERS

There are three configurations of sifters located in the sifting/cleaning area. The first two sifters consist of enclosed oscillating rectangular screens. Material is pneumatically fed from drums. The sifted material is fed into drums through canvas chutes located beneath the sifter. The drum fill area is partially enclosed by canvas curtains and is ventilated from one end of the enclosure. The enclosure appears to be satisfactory, but the ventilation must be changed from the single point take-off to a slot plenum along one end and both sides and the end of the enclosure (Figure 7). The ventilation flow rate should be sufficient to result in an average air velocity of 75 ft/min into the enclosure with the drums in place. The minimum air velocity at any point should be 50 ft/min.

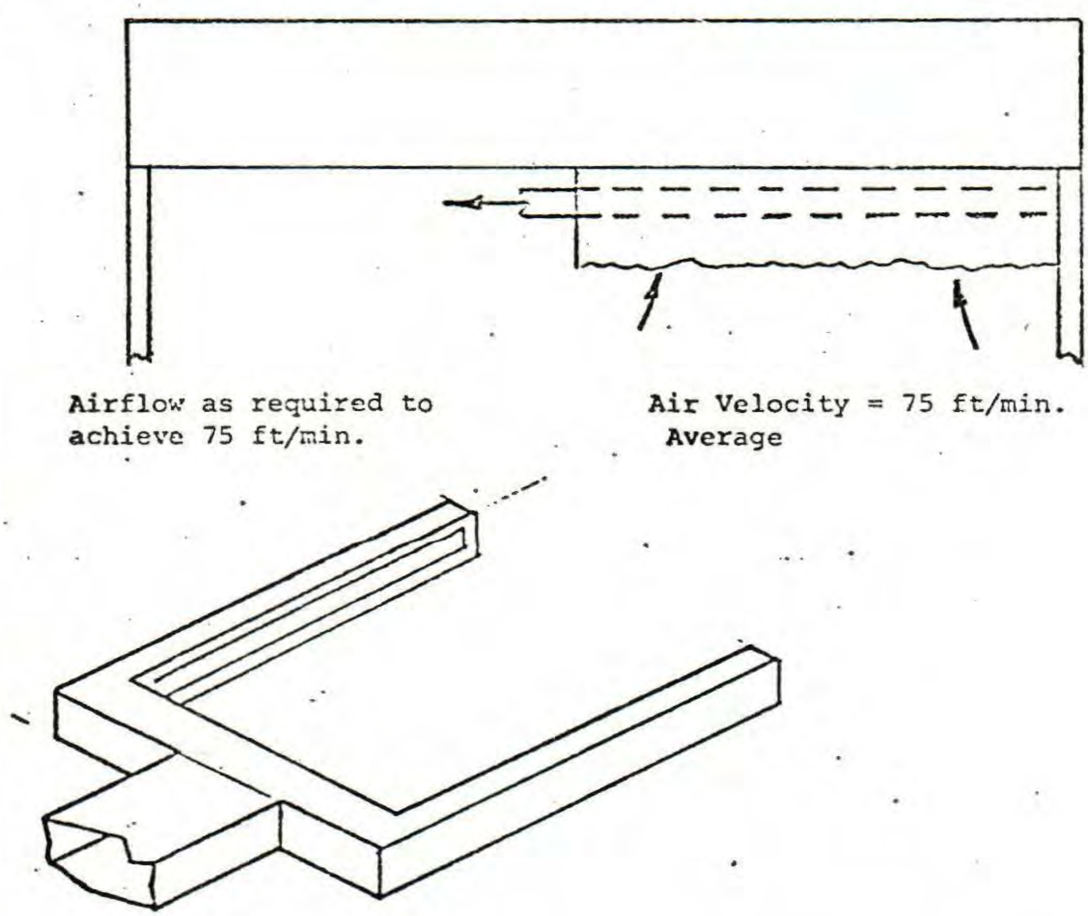

Figure 7. Sifter no. 1.

A third sifter consists of enclosed round oscillating screens. Material is gravity fed from an overhead hopper. Sifted material is fed into drums. A fourth sifter is similar in construction and operation to the first two sifters. Material is fed into the sifter from an overhead hopper. The sifted material is then fed into drums through flexible tubes below the sifter. The fill tubes are fitted to metal plates which cover the drum opening. The drum fill is not ventilated. It is recommended that the drum cover plates be redesigned to permit better "enclosure" of the drum and to incorporate ventilation as shown in Figure 8. The airflow should be approximately 100 ft^3/min.

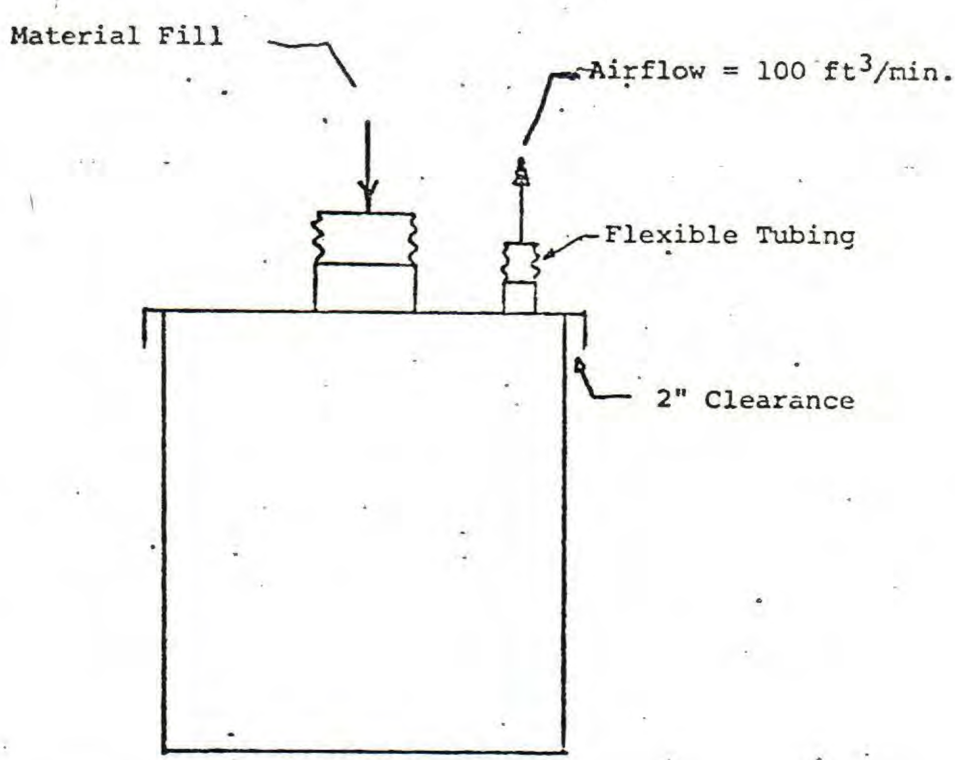

Figure 8. Drum fill ventilation.

CLEANING

Two cleaners are used. Material is fed to a small cleaner from an overhead hopper. The cleaned material is transported from the small cleaner by air induced conveyor to an overhead feed hopper. This hopper gravity feeds a second larger cleaner. The cleaned material is then fed into drums.

The first feed hopper is manually filled from an overhead platform. A side-draft hood is used. This hood appears to be ineffective during filling. It is filled intermittently, but significant quantities of dust are generated during filling. Improved dust capture will result if the sides and top of the hood were extended to form a boot-type hood as previously described for the mill no. 1 feed hopper (Figure 1). Airflow should be sufficient to achieve 100 ft/min hood face velocity. Assuming a face measuring 4 by 4 foot, this requires 1,600 ft^3/min. The drop chutes from the feed hoppers to both cleaners appear to be adequately ventilated.

The cleaning operation is not ventilated and appears to be the most significant dust generating process in warehouse 3. It is recommended that a canopy-type hood be installed on the second cleaner (Figure 9). It appears that both visual and physical access to the material is required. This can be accomplished by the use of clear plastic for the hood construction material. Hood sides can be hinged for physical access. The hood airflow rate should be equal to the airflow rate of the cleaner airflow plus the amount required to achieve a minimum of 100 ft/min through the openings between the hood and cleaner.

The first cleaner utilizes the same cleaning principle. It is configured such that installation of a canopy hood, such as suggested above, may not be possible. However, the external framework can very easily serve as the framework of an enclosure. Also, the enclosure should be extended over the cleaner/-conveyor transfer point as shown. The airflow rate should be as previously described for the second cleaner.

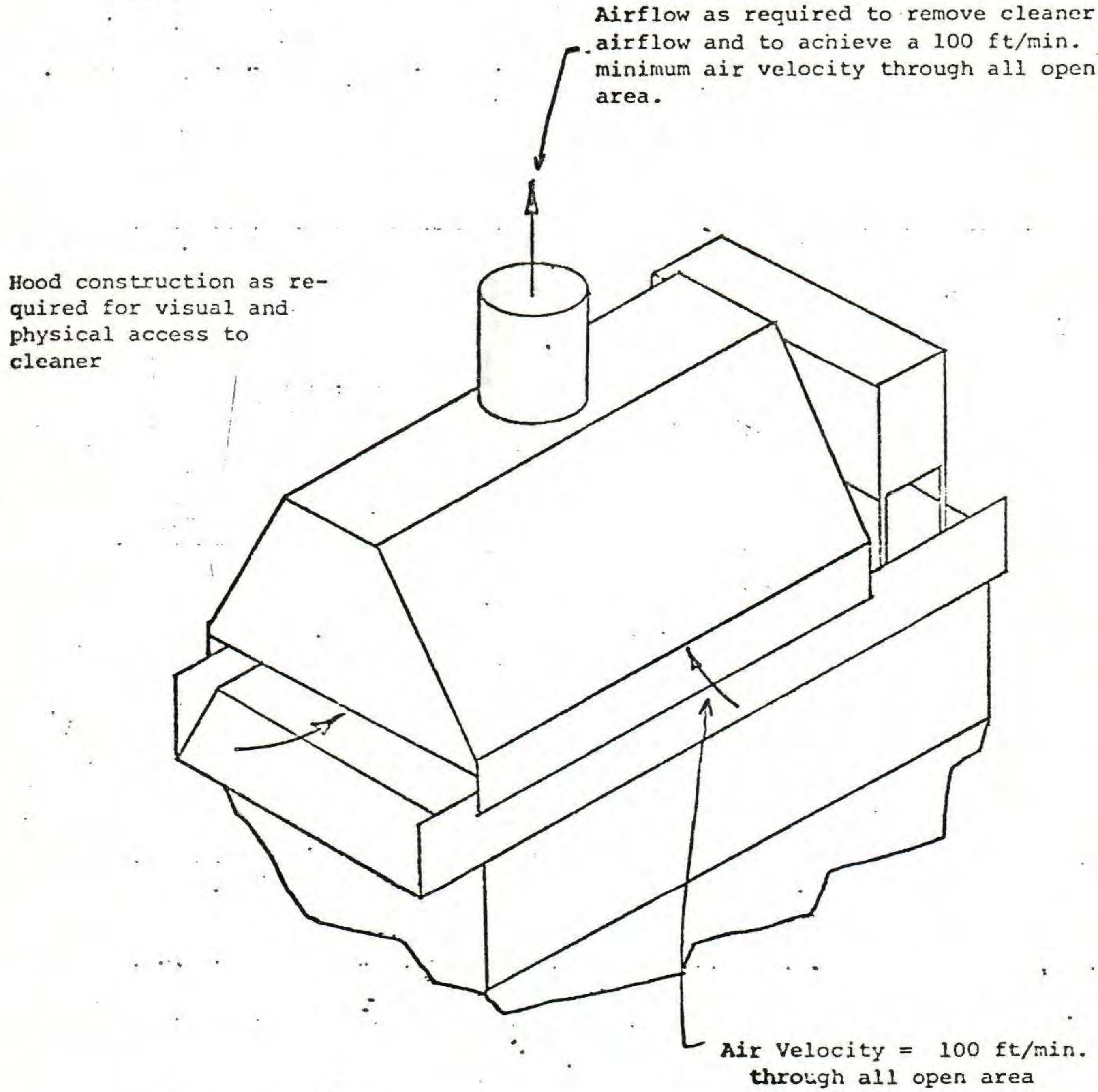

Figure 9. Cleaner ventilation.

The cleaned material from the second cleaner is gravity-fed from the cleaning screen into drums. The transfer point is not enclosed or ventilated. While most of the dust has been removed during the cleaning process, the transfer point should be ventilated. A small portable hood (Figure 10) is recommended. Airflow should be approximately 200 ft^3/min.

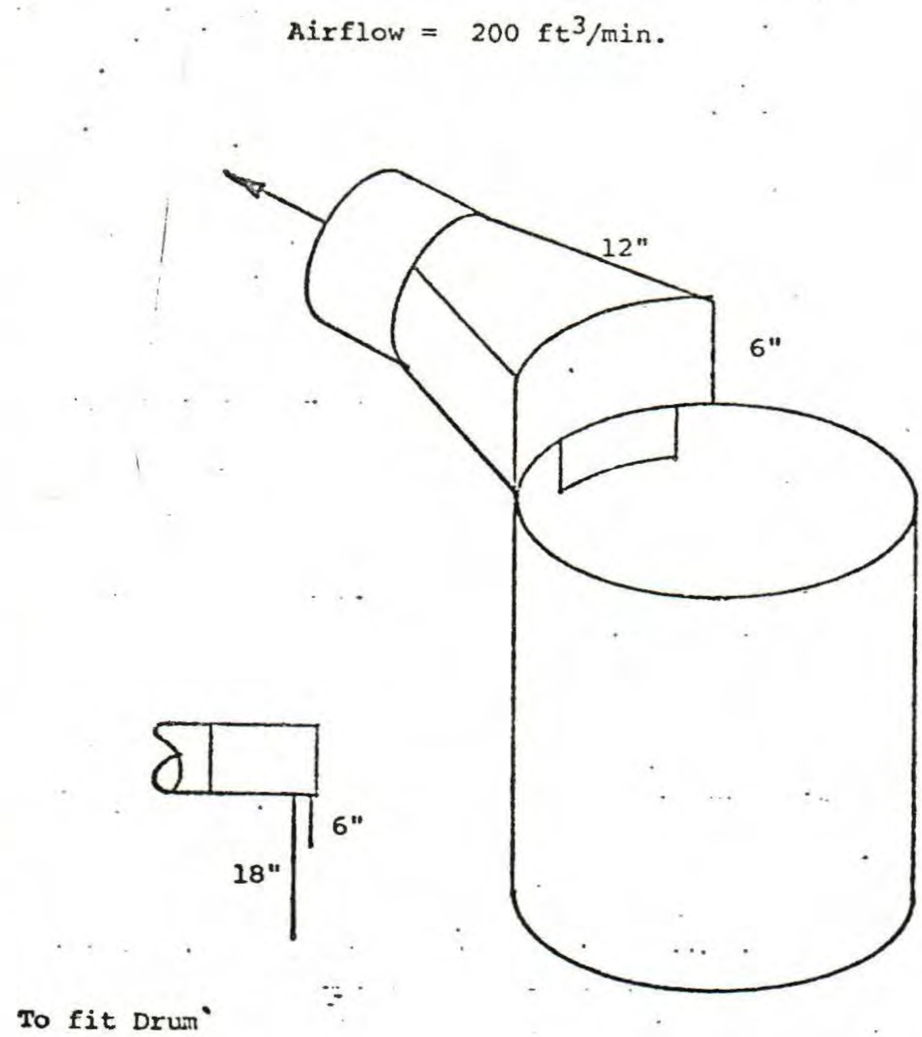

Figure 10. Drum fill ventilation.

BLENDING AREA

The blending operation consists of two blenders fed from an overhead feed hopper. Following blending, material is discharged into a common hopper which feeds a drum filling station by means of an inclined conveyor.

The blender feed hopper is manually filled from an air elevated platform. It is ventilated by a side draft hood. Ventilation can be improved by extending the sides and top of the hood to form a booth as previously described for mill no. 1 (Figure 1). Airflow should be sufficient to result in an average 100 ft/min air velocity at the booth face. Assuming a face measuring 5 by 6 foot, 2,000 ft^3/min would be required.

The drums are filled and ventilated through a "valve" on the opposite side. The ventilation rate should essentially be equal to the volume rate of drum fillings. This flow rate should be set with the fill port open and unrestricted. During blending, the drums are essentially sealed. This will result in a negative pressure within the drum and prevent dust leakage.

The blended material is discharged from the drums through a "valve", in the same area as the fill "valve", into an inclined belt conveyor. The transfer point is enclosed and ventilated. The ventilation rate should be approximately 500 ft^3/min with an indraft velocity of approximately 100 ft/min through the enclosure openings. The conveyor discharges into an enclosed and ventilated drum fill hopper. The ventilation requirements for the fill hopper are the same as the drum conveyor transfer hopper. The drums are filled through a closed canvas chute. The drum fill cover ventilated airflow should be approximately 100 ft^3/min.

VENTILATION REQUIREMENTS - GENERAL

Airflow Rates

The ventilation rates and air velocities for the previously discussed operations have been specified as "appropriate" in most cases. The rates and velocities specified are based on information contained in the American Conference of Governmental Industrial Hygienists Industrial Ventilation Manual. It must be noted, however, that the herb materials are very light and might easily be picked up by ventilation airflow if not properly applied. It is therefore imperative that dampers be incorporated in all branch exhaust ducts, not only to assure proper system balance but to "trim" the airflow, if required, to prevent material loss.

System Design

The current ventilation approach in warehouse 3 appears to be two exhaust systems--one for the blending process, the other for the milling, sifting, and cleaning processes. The single system for the blending process is suitable. The current system, however, should be modified as required to achieve the airflow recommendations provided herein. It is recommended that the final system be consistent with the good design practices provided in the Ventilation Manual, i.e., tapered fittings, angled branch fittings, tapered takeoffs, etc.

The milling, sifting, and cleaning exhaust system offers alternatives. First, it is recommended that the existing ventilation system be replaced in its entirety. The existing blower, a Dayton Model 3C111, is a low pressure, high-flow configuration. The pressure drop required for a single exhaust system appears to be beyond the capacity of this blower. (This should be carefully reviewed to assure that this blower will be satisfactory for the final design). Secondly, the system configuration of 90^{o} fittings and the poorly designed blower inlet is extremely inefficient. It is doubtful if this configuration will permit much more than a 60- to 70-percent blower efficiency. The total airflow requirement of approximately 15,000 ft^{3}/min certainly can be achieved with a single exhaust system, but not with the current design.

There are two options to consider in arriving at a final design for the milling, sifting, and cleaning area ventilation systems. The various processes are not necessarily operated simultaneously. A single exhaust system will therefore result in ventilation of non-operating processes and, as such, will be inefficient relative both to ventilation systems and makeup air energy requirements. A more efficient and recommended approach is to use three separate systems: one for the milling process, one for the sifters, and the third for the cleaners. This approach is probably somewhat more costly to install, but the savings in both system operation and makeup air energy costs should more than compensate. However; if the final design incorporates a single blower, chain operated dampers should be incorporated so that the ventilation to non-operating equipment can be shut off. This will result in higher airflows from the operating equipment and would provide better control.

It is understood that the current intention is to discharge the exhaust air indirectly outside the building without cleaning. This approach is not recommended. There is the possibility that current community air standards might be violated. Even if they are not violated, the potential of future standards which might not be met is certainly a possibility. Incorporation of air cleaning equipment during the current system redesign and installation makes sense.

WAREHOUSE

Warehouse 1 houses two packaging processes. Of concern are tea bagging and bulk packaging which are described and discussed in the following paragrpahs.

Tea Bagging

Tea bagging is accomplished by tea bagging machines. The material is received from warehouse 3 and transported from drums to overhead supply hoppers. The material is gravity-fed into automatic tea bagging machines. The dust generating areas of the machines are partially enclosed and ventilated. The exhaust air is filtered to remove product pickup by the ventilation system. The personal respirable dust levels recorded in the tea bagging area appear to be satisfactory. It is, however, believed that extension of the enclosure could improve control. The exhaust flow rate should be set to assure a minimum air velocity of 25 ft/min through the dust generation points.

BULK PACKAGING

Bulk packaging has been accomplished in the past by manual operation. However, the manual operation is being replaced by an automatic operation except for a few specific product mixes. The manual operation consists of scooping the produce from an open bin, weighing it on a small table scale, and depositing it in a container through a funnel. Dust is generated during filling and stirring the bin, scooping the material from the bin, pouring the material into the funnel, and from the funnel discharge after removal of the filled box liner. Exhaust ventilation is used, but it is very ineffective. The ventilation system should be redesigned as shown in Figure 11. The optimum system configuration and airflows are somewhat difficult to specify. The space available is limited due to the task requirements. The close proximity of the exhaust hoods to the product offer the potential of product loss. The suggested design and airflows provided in Figure 11 should provide satisfactory control.

The majority of the manual bulk packaging operation is being replaced by machine filling. The product is manually "dumped" into a feed hopper from an elevated platform. A horizontal belt conveyor feeds the material from the feed hopper to an inclined belt conveyor which feeds the machine feed hopper. The material is measured and gravity-fed into boxes.

The feed hopper, feed hopper/horizontal conveyor transfer, and the horizontal/inclined conveyor transfer points are nearly identical to the mill no. 1 feed system. The same recommendations apply here.

The inclined conveyor feed hopper should be enclosed. A total of 500 ft^3/min airflow is required. Indraft air velocity through enclosure openings should be a minimum of 100 ft/min.

The inclined belt conveyor is covered. It was noted that attempts were made to tightly seal the cover to the lower transfer point enclosure. It is believed that this approach may not offer the optimum enclosure configuration.

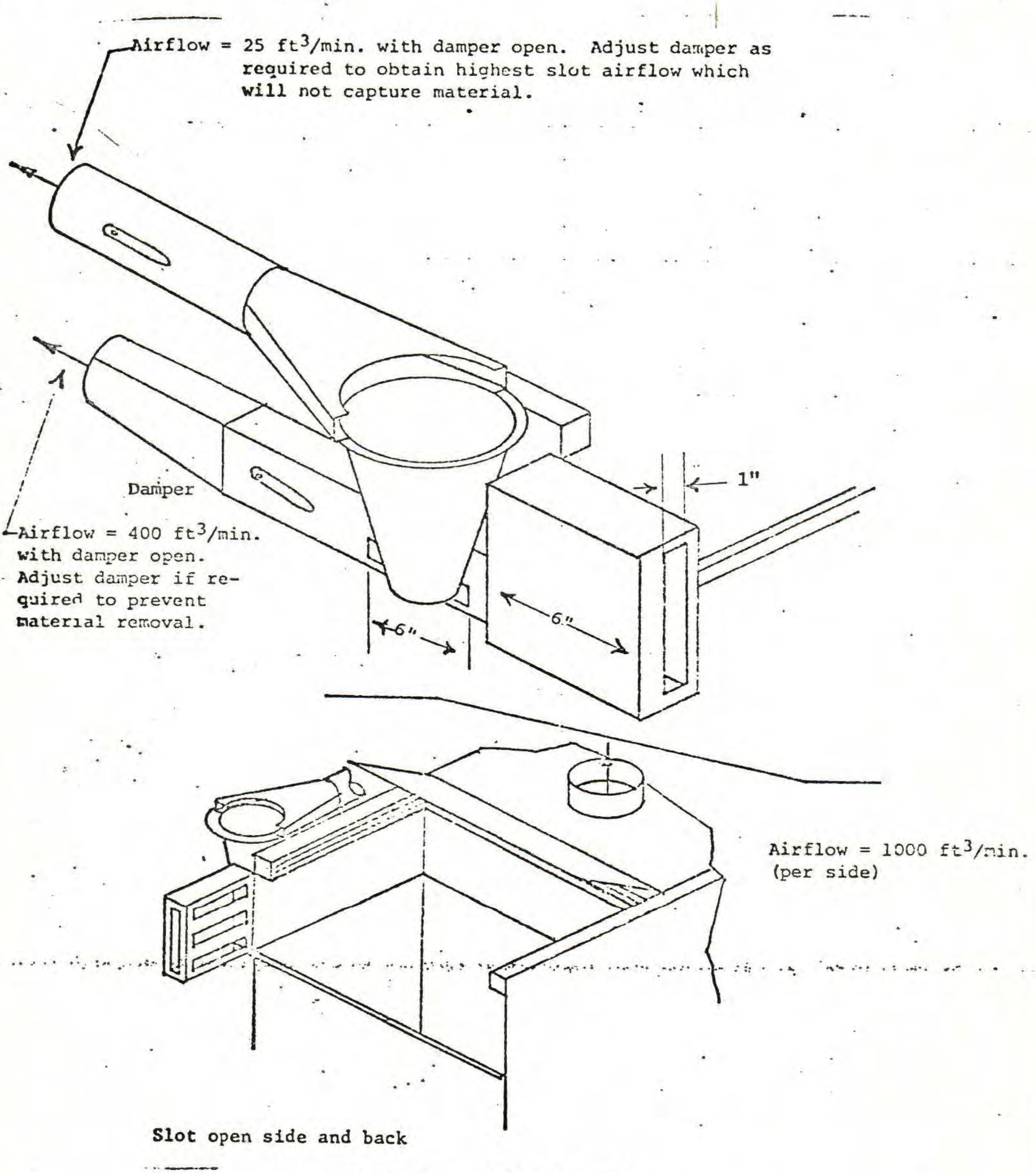

Figure 11. Hand bulk packing

Effective dust capture requires an inward airflow through enclosure openings over the dust generation points. It is recommended that approximately 1 to 2 feet of the inclined conveyor (at the lower end) be open. The upper end should be tightly sealed to the machine feed hopper. The hopper exhaust can then ventilate the conveyor as well as the hopper. The airflow rate might require air increase from the previously recommended 500 ft^3/min to achieve the 100 ft/min air velocity through all openings. However, as the conveyor should not generate dust other than at a discharge point, the conveyor cover should not require ventilation. Leaving the conveyor open for 1 to 2 feet at both ends and ventilating the transfer enclosures might be a more effective use of exhaust air.

The feed hopper transfer point weighing and dumping mechanisms are contained in a relatively compact area and offer several dust generation points. A ventilated enclosure is being designed. This enclosure should be such that there is a minimum of 100 ft/min air velocity through all open areas. It is also recommended that the total airflow rate be 500 ft^3/min. This flow rate should be sufficient to create a small level of turbulent airflow within the enclosure to minimize collection of material. The enclosure should incorporate access doors for periodic vacuum cleaning of collected material.

WAREHOUSE 1 - GENERAL

As with the recommended warehouse 3 ventilation requirements, all exhaust ducts should include dampers to trim flow if there would be a problem with material pickup and loss.

The three systems discussed for warehouse 1 are separate and should remain so. However, all should utilize air cleaners for the reasons discussed for warehouse 3 (tea bagging operation does incorporate an air cleaner).