U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES ■ Public Health Service
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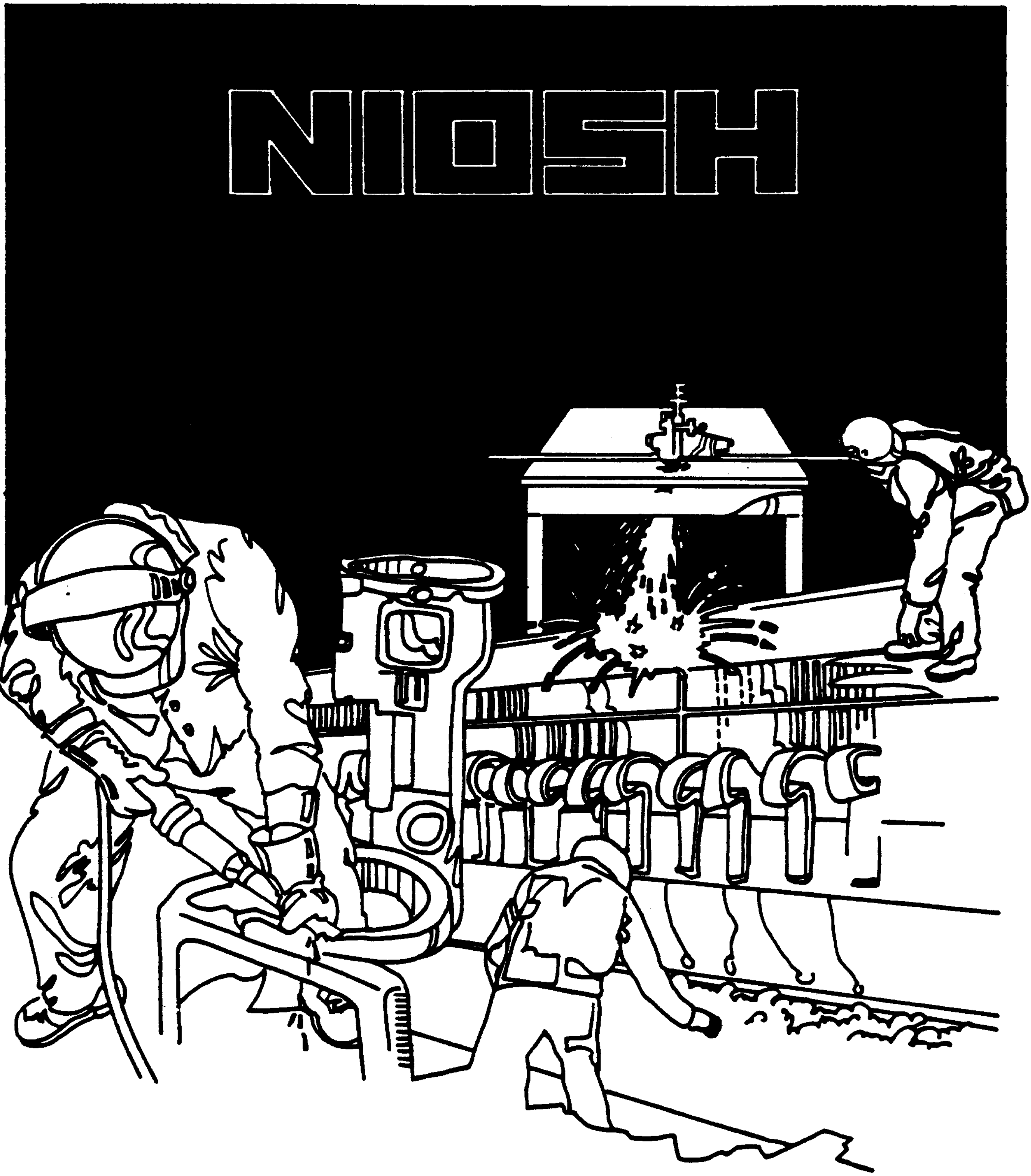

Health Hazard Evaluation Report

HETA 85-171-1710
INTERNATIONAL BAKERS SERVICES, INC.
SOUTH BEND, INDIANA

PREFACE

The Hazard Evaluations and Technical Assistance Branch of NIOSH conducts field investigations of possible health hazards in the workplace. These investigations are conducted under the authority of Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6) which authorizes the Secretary of Health and Human Services, following a written request from 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.

The Hazard Evaluations and Technical Assistance Branch also provides, upon request, medical, nursing, and industrial hygiene technical and consultative assistance (TA) to Federal, state, and local agencies; labor; industry and other groups or individuals to control occupational health hazards and to prevent related trauma and disease.

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INTERNATIONAL BAKERS SERVICES, INC.
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I. SUMMARY

On February 7, 1985, the National Institute for Occupational Safety and Health (NIOSH) received a request from International Bakers Services, Inc., South Bend, Indiana, for a health hazard evaluation. Two young, non-smoking, previously healthy employees in the "mixing room" had developed severe, fixed obstructive lung disease within one year of employment. The onset was insidious, but one second forced expiratory volume (FEV_1) had declined to 1.2 liters and 0.7 liters, respectively, in these two workers within three months of onset of symptoms (eight months from starting work in the plant). There was minimal response to bronchodilators, and there was no significant improvement after 1 and 1 1/2 years, respectively, away from the plant. Forced vital capacity and total lung capacity were relatively less affected, and diffusing capacity initially was normal. Although pathological confirmation was not available, the clinical picture was more compatible with bronchiolitis obliterans than with emphysema.

On March 12, 1985, the NIOSH investigators visited the plant to review the process and to interview the affected workers. The mixing room is a large open room where three employees weigh and load a large variety of fragrances, flavorings, starch, and 50- to 100-pound bags of flour into one of three mixers. The loading and mixing tasks generate considerable dust, previously measured to be 20 mg/m^3. Although employees used a supplied-air respirator while adding ingredients to the mixers, it was not always worn during some clean-up activities. Review of chemicals used in the plant identified no substances known to be associated with bronchiolitis obliterans or emphysema. Samples of rafter and other settled dust, of the foam lining to the respirator used by the two affected employees, and of batches of mixes made by one affected employee in the week prior to his first noticing symptoms, were collected and assayed for proteolytic activity and for endotoxin levels. Immunologic evaluation of the two affected employees revealed unremarkable concentrations of total and specific (to various antigens) IgE and total immunoglobulin. The sera of both cases and of two non-exposed controls precipitated non-specifically with extracts of "Cinna Butter" and various dust samples.

Although bakers are known to develop asthma, and grain workers have been shown to have an accelerated decline in FEV_1 and an increased prevalence of chronic bronchitis in epidemiologic studies, there are no previous reports (to our knowledge) of similar catastrophic,

unexplained obstructive pulmonary disease in the bakery or bakery services industry.

Based on the results presented in this report, the investigators conclude that it is probable that some agent in the mixing room at International Bakers Services produced severe, fixed obstructive lung disease in two employees. The specific etiology was not identified. Recommendations for engineering and work practice changes to prevent respiratory exposure to dusts in the mixing room are presented in Section VIII and Appendix B of this report.

Keywords: SIC 2099 (Food preparations, not elsewhere classified), bakery supplies, bakers, grains, flour, amorphous silica, flavors, fragrances, endotoxin, proteolytic enzymes, bronchiolitis obliterans

II. INTRODUCTION

On February 7, 1985, the National Institute for Occupational Safety and Health (NIOSH) received a request from International Bakers Services, Inc., South Bend, Indiana, to evaluate two cases of severe obstructive lung disease among employees in the "mixing room." On March 12, 1985, a visit was made to the plant to conduct a walk-through survey. NIOSH investigators observed the work process in the mixing room, interviewed current and former mixing room workers, and collected samples for subsequent analysis. A letter with preliminary recommendations for dust control was sent to the company on March 22, 1985. On July 9, 1985, an engineering evaluation was conducted by NIOSH representatives, and a report summarizing recommended engineering changes was sent in August 1985.

III. BACKGROUND

A. Case histories

Case #1: This 28-year-old white male began work in the mixing room at International Bakers Services in May 1983. He intermittently wore a self-contained breathing apparatus. Approximately five months later he began to notice unusual shortness of breath when playing basketball. He developed a non-productive cough shortly thereafter. In November 1983 he went to a physician for evaluation and was told he had a decreased peak expiratory flow and a normal chest X ray. He was started on bronchodilators and had mild improvement in his cough. He developed a productive cough associated with wheezing and fever (102^{o} F) in late December, at which time he was treated with oral penicillin. His chest X ray was reported to be normal. Upon return to work, he was too short of breath to continue lifting the 100-pound bags of flour used in the mixing room. Pulmonary function testing at that time revealed severe obstructive airway disease with mild response to bronchodilators. Lung volumes were normal, as was diffusing capacity (D_LCO).

The patient continued to work at the plant on the loading dock (away from the mixing room) until April 1984, when he was too short of breath to continue. He was treated with bronchodilators and prednisone with little improvement. Repeat pulmonary function testing in September 1984 and in January and August 1985 showed severe obstructive lung disease with no improvement between the three examinations. There was obstruction to airflow early and late in expiration and increased residual volume (RV) and functional residual capacity (FRC). In August 1985, diffusing capacity was reduced (60% of predicted) for the first time. His chest X ray suggested hyperinflation but was otherwise unremarkable.

He experienced no fever, chills, chest pain or hemoptysis during the insidious progression of his disease. He was a non-smoker. His previous occupational history was unremarkable. He had a history of rhinorrhea, sneezing and tearing associated with playing golf while in college, and he had positive skin tests to several food and non-food allergens. He had no pets. Laboratory evaluation demonstrated no peripheral eosinophilia. Alpha-1-antitrypsin levels and a sweat sodium test were normal. He had normal immunoglobulin levels and negative anti-nuclear antibody (ANA) and rheumatoid factor tests. Continuing symptoms (at the time of our investigation) included dyspnea (shortness of breath) on climbing half a flight of stairs and a productive morning cough which clears as the day progressed.

Case #2: This 30-year-old white male replaced Case #1 in the mixing room at International Bakers Services in May 1984. In September 1984 he first noticed dyspnea when lifting 100-pound bags of flour. Dyspnea with exertion increased and was accompanied by a non-productive cough and retrosternal pain over the next several weeks. Pulmonary function tests in October 1984 demonstrated severe obstructive lung disease with well-preserved forced vital capacity (FVC) and total lung capacity (TLC). He had minimal response to bronchodilators, and his D_LCO was normal. At that time, he was treated with bronchodilators, and he quit his job.

In December 1984 he was hospitalized with fever and a white blood cell count of $14,200/mm^3$ with 65% polymorphonuclear cells, 27% band forms, 5% lymphocytes and 3% mononuclear cells. He responded to antibiotic therapy and was discharged on bronchodilators and prednisone (40 mg daily), but dyspnea and cough continued. He has a history of seasonal rhinorrhea and positive skin allergy tests to several food and non-food antigens. He had a brother with asthma. He had no known previous exposure to pulmonary toxins and was a non-smoker. He had no pleuritic chest pain, wheezing, prior pulmonary disease, or other respiratory symptoms. His chest X ray was normal. His alpha-1-antitrypsin level was normal. Tests for ANA and rheumatoid factor were negative. Serial pulmonary function tests were unimproved. Continuing symptoms (at the time of our investigation) included dyspnea upon climbing one flight of stairs.

The respiratory illnesses described above are very unusual in young, non-smoking, previously athletic men. Although lung tissue was not available, the clinical picture and the relatively fixed obstructive lung disease characterized by decreased one-second forced expiratory volume (FEV_1) and maximal mid-expiratory flow rate (MMEF) with well-preserved FVC and TLC, air trapping, and normal D_LCO were compatible with bronchiolitis obliterans.[1] Although bronchiolitis has been reported as a complication of extrinsic allergic alveolitis,[2,3] the clinical picture in these cases was not suggestive either of asthma or of hypersensitivity pneumonitis. The hyperinflated chest X ray in Case #1 and subsequent fall in D_LCO suggested emphysema. Asthma was considerably less likely.

B. Process description

In the mixing room, batches of liquid and powdered flavorings are mixed in a 300-, 500-, or 1500-pound-capacity mixer. At the time of the site visit, as many as three of the 1500-pound batches, and up to ten of the smaller 300- or 500-pound batches could be mixed per day. Each batch consists of any of approximately 200 FDA-approved flavor ingredients with approximately 80% dextrose and starch as a base. Ventilation in the mixing room consists of supply and exhaust fans located at opposite ends of the room. Two electrostatic precipitators, located near the mixers, are also used.

A new supplied-air respirator system was installed in the mixing room in January 1983. Mixing room employees are required to wear respirators when weighing or adding the flavors or base ingredients to the mixers. During the site visit, however, exposures to the powdered flavors were observed also to be possible during some of the clean-up activities (including pre-disposal movement of the empty sacks). Employees did not always wear respirators during these latter activities.

Environmental monitoring conducted by the Indiana Division of Labor indicated an airborne dust concentration of 20 milligrams/cubic meter of air (mg/m^3) in the breathing zone of an employee engaged in the mixing operation. A sample collected inside the hood of the supplied-air respirator of the employee showed a concentration of 2.5 mg/m^3. (Both were 20-minute samples) An area sample collected on a table in the general work area was reported to show a concentration of 2.5 mg/m^3.

Tables 1 and 2 catalog the various starches, flours, fillers, flavors, and fragrances used in the mixing room. Previous medical consultants had expressed concern regarding the possible role of a synthetic amorphous silica (Syloid 244®) used as a filler (2% by volume) in many bakery mixes. According to the manufacturer, this is a precipitated silica.

IV. EVALUATION DESIGN AND METHODS

A. Environmental

Samples of mixes and ingredients used at the plant (Table 3) were analyzed for the presence of proteolytic enzymes. (Proteolytic enzymes ae substances of plant, animal, or bacterial origin that break down, or "digest," proteins into smaller, simpler compounds.) Analytical details are presented in Appendix A.

Samples of mixes used at the plant were analyzed for the presence of bacterial endotoxins using the quantitative chromogenic limulus amebacite lysate test, QCL-1000 (Whittaker M.A. Bioproducts, Walkersville, Maryland). (Bacterial endotoxins are substances present in bacteria. When exposure occurs, though inhalation of dead bacteria, for example, illness can result.)

B. Medical

The results of a spirometric screening conducted by International Bakers Services for the other four current and former mixing room workers still at the plant were reviewed. Serum was collected from the two respiratory illness cases (described in section III) and analyzed for immunologic evidence of immediate or delayed hypersensitivity (allergy) to mixes used in the plant. Total immunoglobulin levels were quantified using the fluorescent immunoassay system (FIAX) method. Counterimmunoelectrophoresis precipitin assays were conducted against extracts of selected samples. Total IgE was quantified using the paper-radioimmunosorbent test (PRIST). Specific radioallergosorbent tests (RAST) were performed against a variety of antigens.

V. EVALUATION CRITERIA

A. Environmental Criteria

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff employ environmental evaluation criteria for assessment of a number of chemical and physical agents. These criteria are intended to suggest levels of exposure to which most workers may be exposed up to 10 hours per day, 40 hours per week for a working lifetime without experiencing adverse health effects. It is, however, important to note that not all workers will be protected from adverse health effects if their exposures are maintained below these levels. A small percentage may experience adverse health effects because of individual susceptibility, a pre-existing medical condition, and/or a hypersensitivity (allergy).

In addition, some hazardous substances may act in combination with other workplace exposures, the general environment, or with medications or personal habits of the worker to produce health effects even if the occupational exposures are controlled at the level set by the evaluation criterion. These combined effects are often not considered in the evaluation criteria. Also, some substances are absorbed by direct contact with the skin and mucous membranes, and thus potentially increase the overall exposure. Finally, evaluation criteria may change over the years as new information on the toxic effects of an agent become available.

The primary sources of environmental evaluation criteria for the workplace are: (1) NIOSH Criteria Documents and recommendations, (2) the American Conference of Governmental Industrial Hygienists' (ACGIH) Threshold Limit Values (TLV's), and (3) the U.S. Department of Labor (OSHA) occupational health standards. Often, the NIOSH recommendations and ACGIH TLV's are lower than the corresponding OSHA standards. Both NIOSH recommendations and ACGIH TLV's usually are based on more recent information than are the OSHA standards. The OSHA standards also may be required to take into account the feasibility of controlling exposures in various industries where the agents are used; the NIOSH-recommended standards, by contrast, are based primarily on concerns relating to the prevention of occupational disease. In evaluating the exposure levels and the recommendations for reducing these levels found in this report, it should be noted that industry is legally required to meet those levels specified by an OSHA standard.

A time-weighted average (TWA) exposure refers to the average airborneconcentration of a substance during a normal 8- to 10-hour workday. Some substances have recommended short-term exposure limits or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from high short-term exposures.

B. Specific Substances

A priori, the only evaluation criterion applicable to exposures likely to occur in a bakery supplies plant is the one for nuisance dust. However, a review of the literature on related industries (grain handlers and bakers) and on environmental causes for obstructive lung diseases (discussed below) suggests some possible environmental causes for the pulmonary disease in the plant.

1. Nuisance Particulates

So called "nuisance" dusts elicit little fibrogenic or other lung tissue reaction.[4] The TLV's of 10 mg/m^3 for total dust and 5 mg/m^3 for respirable dust are set to prevent injury to skin or mucous membranes by chemical or mechanical action. These limits do not apply to substances which may cause physiological impairment at lower concentrations.

2. Grain Dust

Grain dust inhalation is widely recognized to cause three major respiratory diseases: asthma, chronic bronchitis, and grain fever.[4]

In addition, among grain handlers and other workers exposed to grain dusts, an accelerated decline in pulmonary function (FEV_1) has been demonstrated.[5,6] One study of grain handlers found accelerated decrease in FEV_1 at levels of dust in air below the current nuisance dust permissible exposure limit of 10 mg/m^3.[6]

Work with grain dust results in exposure to a wide variety of potential pulmonary toxins. Of potential relevance to this investigation are allergens capable of causing asthma or extrinsic allergic alveolitis. These include grains, pollens, various fungi, insects, mites, and excreta of rodents and pigeons.[7] Silica is reported to comprise up to 15% of some grains. Silo workers may be exposed to nitrogen dioxide (an acute exposure to which may be followed by a bronchiolitis several weeks later).[8] Neither nitrogen dioxide nor fungicides used to preserve grains are likely to be present by the time grains are ground into flour and reach International Bakers Services.

Grain workers exposed to time weighted average grain dust concentrations of 4 mg/m^3 or less generally do not express respiratory symptoms in excess of those reported among control populations.[4] This is the basis of the recommended TLV of 4 mg/m^3 for grain dust.

3. Amorphous Silica

Crystalline silica has resulted in marked fibrogenic activity in the lung and causes restrictive lung disease (silicosis). This disease is clinically distinct from the primarily obstructive airways disease of interest in this investigation. Although silica can contaminate grain dust, in heavily exposed grain handlers it is rare to find silicosis.[7] The NIOSH recommended standard for free crystalline silica is a 10-hour time-weighted average of 50 ug/m^3.[9]

Amorphous (non-crystalline) silica is less fibrogenic than the crystalline form. At least some animal studies, however, have demonstrated progressive nodular fibrosis, and epidemiologic studies have demonstrated mild silicosis after airborne exposure to diatomaceous earth.[4] The TLV is 10 mg/m^3 for total dust and 5 mg/m^3 for respirable dust (less than 5 um in size). The TLV is based on "good engineering practices."

Synthetic (man made) amorphous silica is made by three different processes: fumed, gel, and precipitate. Although amorphous silica precipitate of the type used at International Bakers Services has generally been considered to be innocuous, there is some evidence from chronic inhalation studies of monkeys that precipitated silica can cause macrophage and mononuclear cell infiltrates in the lung. In some animals, they appeared to significantly reduce the size of the bronchiolar lumen. Although such pathologic lesions could result in physiologic obstruction, there were detectable differences only in TLC and FVC in precipitated silica exposed monkeys. Measurement of pulmonary mechanics in exposed monkeys were not different than those in control monkeys. Synthetic amorphous fume silica has been reported to produce both abnormal lung mechanics and decreased volumes.[10] At least some studies conducted by other investigators have also suggested that synthetic amorphous silicas are fibrogenic.[11,12]

4. Proteolytic Enzymes:

Aerosols of the proteolytic enzyme papain have been used to create an animal model of anatomic emphysema.[13-15] The onset of emphysema is very rapid after acute exposure to papain. The mechanism may involve inhibition of human alpha 1-proteinase inhibitor, as well as direct tissue damage.[16] (Other oxidative chemicals theoretically could have similar inhibitory effects on the lung's defenses against proteolysis.[17]) Such enzymes are likely to be present in fruit extracts used as flavorings, and bacteria producing such enzymes could grow on organic matter such as that present in a bakery supplies plant.

Data on human respiratory effects of exposure to proteolytic enzymes comes largely from the experience with enzymes derived from Bacillus subtilis in the detergent industry, where occupational asthma has occurred as a consequence.[18,19] A longitudinal study of subtilisin-exposed workers demonstrated significant loss of pulmonary elastic recoil (increased lung volumes and increased compliance).[20] The larger 3-year longitudinal decine in FEV_1 (-0.29 liters) among the heavily exposed was not statistically different from that among the less exposed group (-0.14 liters). A case report of pulmonary disease thought to be related to occupational papain exposure did not fully characterize the disease,[21] although diffuse emphysema with abnormal oxygen diffusion has been reported among pharmaceutical workers exposed to the enzyme pancreatin.[22] There is a TLV for subtilisin but not for other proteolytic enzymes. The TLV, 0.06 ug/m^3 of crystalline active subtilisin enzyme (collected by high volume sample over 60 minutes), is set to prevent asthma and skin irritation.[4]

5. Bacterial Endotoxin:

Bacterial endotoxin has been implicated as a cause of obstructive lung disease (byssinosis) among cotton mill workers.[23,24] Although byssinosis results in chronic obstructive airway disease, the early disease is characterized by shortness of breath, wheezing, and chest tightness soon after returning to work after a weekend or vacation. The symptoms resolve as the week progresses.

No current criteria exist for endotoxin exposure, although it has been suggested that an endotoxin standard might be more appropriate than the current cotton dust standard.[23] In recent studies, cotton characterized by endotoxin levels of 100 ng elutriated endotoxin/m^3, and perhaps less, has resulted in the reproduction of the characteristic acute FEV_1 decrement associated with byssinosis.[23,25]

6. Bakery Flours:

Bakers are known to acquire reversible obstructive lung disease (baker's asthma).[26] Published reports have implicated cereal flours as responsible allergens,[26] although the house mite (Dermatophagoides farinae), the grain mite (Glycophagus destructor), Alternaria, and Aspergillus organisms may also be responsible.[27] Specific IgE antibodies have been demonstrated in these studies. Among bakery workers, oven handlers have a higher prevalence of attacks of wheezing and dyspnea and a higher prevalence of positive prick skin test responses.[27] It has been suggested that a history of prior atopy facilitates sensitization to wheat and other bakery allergens.

There are no environmental evaluation criteria for exposure to bakery flours other than the nuisance dust TLV.

VI. RESULTS AND DISCUSSION

A. Environmental

Airborne amorphous silica was not sampled at the plant because there had been a recent change to a non-silica filler.

No evidence of proteolytic activity was found in any of the samples listed in Table 3. Significant proteolytic activity was defined as greater than twice the increase in absorbance of the assay mixture in the absence of added sample. As a control, a sample of ground papaya was assayed as a source of crude papain, which resulted in a linear increase of absorbance with time. For a 10% solution of ground papaya a value of 0.012 absorbance units per minute was observed. These results provide little support for the theory that exposure to proteolytic enzymes were responsible for the disease encountered among workers at the plant.

Results of measurement of endotoxin levels are presented in Table 4. These are below levels seen in other work places where endotoxin has been associated with large decrements in FEV_1.[23,25]

B. Medical

The company's spirometric screening and our interviews with other mixing room and former mixing room employees still working at the plant revealed normal spirometric function and no symptoms among the other two current mixing room workers, who have have worked between five and six years in the same job. Two former workers in the mixing room have obstructive lung disease, however.

Possible Case 3: This 36-year-old white male worked in the mixing room from 1973 to 1982. He was asymptomatic and had no known history of pulmonary disease. Pulmonary function tests conducted in March 1985 demonstrated a moderately severe obstructive ventilatory defect. He smoked 2 packs of cigarettes daily for eleven years until 1978, when he quit. His chest X ray was normal.

Possible Case 4: This 38-year-old white male had previoulsy worked in the mixing room. He was also asymptomatic and had no known history of pulmonary disease. Pulmonary function tests conducted in January 1985 demonstrated mildly reduced expiratory flow rates with normal lung volumes and normal D_LCO. This worker smoked one pack of cigarettes per day for 10-15 years. He quit smoking in 1980. His chest X ray was normal.

The absence of symptoms and the comparatively mild pulmonary function abnormalities in these two ex-smokers suggest that they do not have the same disease as the two index cases. However, the presence of normal D_LCO is compatible with the airways disease seen in Cases 1 and 2. It is possible that these pulmonary function abnormalities represent subclinical disease in a spectrum of disease where the two index cases represent more severe examples.

Immunologic evaluation of sera from the two affected workers is presented in Table 5. Concentrations of total (PRIST) and specific (RAST) IgE to common organic antigens were normal. Although specific IgE testing (RAST) to extracts of the mixes was not done, the cases' disease is not suggestive of IgE-mediated reversible airways obstruction.

Total immunoglobulin levels (FIAX) were normal, with the exception of a slight increase in IgA level in Case 2, a laboratory abnormality which is probably of no clinical significance. Initial extracts of "Cinna Butter" (mixed by Case 2 on the day he first noticed symptoms), the lining of the sick workers' respirator, recent dust (from the clock), and old dust (from the rafters) all precipitated non-specifically with workers' serum. However, serum from unexposed persons also reacted with the extract. After treatment of extracts with polyvinylpyrrolidone (PVP), there was no precipitation. PVP, a specific insoluble adsorbent for polyphenolic tannins, has previously been shown to prevent a similar "psuedoimmune" artifact among cotton dust-exposed workers.[28,29]

VII. CONCLUSIONS

Examination of affected workers and review of medical records and pulmonary function tests conducted by the plant management identified two workers with no known personal risk factors who developed catastrophic fixed airways disease suggestive of bronchiolitis obliterans or emphysema. Symptoms occurred within five to six months of starting work at the plant. Two workers who have been doing identical jobs have been unaffected. Two former mixing room workers may also have a milder form of the disease, based on a similar pattern of abnormal lung function tests. Both of these workers, however have a history of smoking, a known cause of obstructive lung disease.

None of the chemical ingredients used in the mixes are known causes of bronchiolitis obliterans or emphysema. Immunologic evaluation of the two sick workers was unrevealing. No proteolytic activity was found in a variety of bulk samples representative of airborne exposures in the plant, and there were only low levels of endotoxin in these samples. Based on results of studies in animals, synthetic amorphous silica could be considered potentially a pulmonary toxin.[10-12] However, one would expect to see interstitial disease rather than (or in addition to) the obstructive disease found in workers at International Bakers Services.

In summary, no specific etiology of the workers' illnesses was identified. Because the lung is the only affected organ in these workers, the etiologic agent(s) is most likely airborne. The high total dust levels found in the mixing room (20 mg/m^3) provide ample opportunity for airborne exposure. Because two unaffected workers are reported to do identical jobs, however, the disease may have been caused by a single short-term exposure specific to a particular mix.

VIII. RECOMMENDATIONS

1. In the absence of a specific identified etiology for the two cases of severe obstructive lung disease, every attempt should be made to

control airborne dust exposure in the mixing room. Recommendations for engineering changes are included in the attached report (Appendix B) from the NIOSH Division of Physical Sciences and Engineering (DPSE). In general, engineering changes are superior to personal protective equipment in preventing disease from airborne toxins. Investigators from DPSE are willing to review the design for such engineering changes, and to conduct monitoring of airborne dust levels before and after such changes, to assure optimal dust control.

2. Since the engineering changes alone might not be adequate to prevent exposures, respiratory protective equipment should be worn as well. Employees should wear respiratory protective equipment whenever they are in the mixing room. Observation of the mixing process indicated that supplied air respirators are used during weighing, charging, and unloading tasks. However, exposures to the powdered flavors are also possible during some of the clean-up activities (including pre-disposal movement of the empty sacks). The supplied-air respirators should also be worn during these tasks. During "casual" activities within the mixing room by non-operating personnel, the use of half-face organic filter respirators equipped with pre-filter pads is advisable. Required training and fitting of employees wearing respiratory protective equipment is described in the OSHA regulations (29 CFR 1910.134). The two former mixing room employees with abnormal pulmonary function tests should be especially careful to protect themselves during casual activities within the mixing room.

   Although details of the method used for sampling inside the respirator hood were not available, the measured dust concentrations inside and outside the hood indicate that employee exposures may not be sufficiently reduced. The effectiveness of the personal protective equipment therefore warrants a more thorough evaluation.

3. The periodic spirometric testing recently instituted at International Bakers Services is a good idea. Although it is difficult to specify an appropriate testing interval, the rapid onset of disease in the two cases suggests that the shorter the interval between testing the more likely that pre-clinical disease would be recognized and preventive measures taken to prevent further deterioration of lung function. Careful attention in the interpretation of these tests should be directed to serial measurements of large and small airways dysfunction. Accelerated decline in FEV_1 should prompt a more thorough investigation and perhaps removal from work in the mixing room, as should <u>any</u> employee complaint of cough or shortness of breath with exercise.

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XI. DISTRIBUTION AND AVAILABILITY OF REPORT

Copies of this report are currently available upon request from NIOSH, Division of Standards Development and Technology Transfer, 4676 Columbia Parkway, Cincinnati, Ohio 45226. After 90 days, the report will be available through te National Technical Information Service (NTIS, 5285 Port Royal, Springfield, Virginia 22161). Information regarding its availability through NTIS can be obtained from NIOSH Publications Office at the Cincinnati address. Copies of this report have been sent to:

1. International Bakery Services
2. NIOSH, Region V
3. OSHA, Region V
4. Indiana Division of Labor

For the purpose of informing affected employees, copies of this report shall be posted by the employer in a prominent place accessible to the employees for a period of 30 calendar days.

TABLE 1

INGREDIENTS COMMONLY USED IN BAKERY MIXES, PERCENTAGE BY VOLUME, 1984

INTERNATIONAL BAKERS SERVICES
SOUTH BEND, INDIANA
HETA 85-171

Ingredients	Approximate Levels of Usage
Dextrose	49 -71 %
Corn Starch	20 -40 %
Vanillin	0 -16 %
Beatreme 743	0 - 4 %
Citric Acid	0 - 2 %
Sodium Citrate	0 - 2 %
Orange Terpenes	0 - 2 %
California Lemon Oil	0 - 2 %
Citral	0 - 1 %
lemon Solids	0 - 1 %
Ethyl Butyrate	0 - 1 %
Butyric Acid	0 - 1 %
Linalool	0 -Less than 1 %
Linalyl Acetate	0 - " " "
Butter Esters	0 - " " "
Butter Derivitives	0 - " " "
Anhydrous Butter Fat	0 - " " "
Propenyl Guaethol	0 - " " "
Ethyl Vanillin	0 - " " "
Diacetyl	0 - " " "
Butyl Butyrl Lactate	0 -" " "
Silicon Dioxide (amorphous synthetic silica)	0 - " " "
Terpeniol Super	0 - " " "
Butylated Hydroxyanisole	0 - " " "
Vertraldehyde	0 - " " "
Benzodihydropyrone	0 - " " "
Heliotropine	0 - " " "
Benzaladehyde	0 - " " "
Nutmeg Oil	0 - " " "
Turmeric	0 - " " "
Beta Carotene	0 - " " "
Apo Carotenal	0 - " " "
Pure Vanilla Extract	0 - " " "

TABLE 2
INGREDIENTS OCCASIONALLY USED IN BAKERY MIXES, 1984

INTERNATIONAL BAKERS SERVICES
SOUTH BEND, INDIANA
HETA 85-171

Acetaldehyde
Acetic Acid
Acetyl Propionyl
Aldehyde C-6
Aldehyde C-8
Aldehyde C-9
Aldehyde C-10
Aldehyde C-14
Aldehyde C-16
Aldehyde C-18
Allyl Caproate
Allyl Cyclohexylpropionate
Allyl Heptoate
Allyl Phenoxy Acetate
Almond (2X)
Amyl Alcohol
Amyl Butyrate
Amyl Caproate
Amyl Iso Valerate
Amyl Propionate
Anethol
Anisic Aldehyde
Anisyl Acetate
Apo Carotenal 20%
Apple Essence
Apple Juice Concentrate
B H A
Balsam Peru (Resin)
Banana Essence
Beatreme #743
Beatreme 2622
Benzaldehyde
Benzodihydropyrone
Benzyl Acetate
Benzyl Propionate
Beta Carotene 30%
Butter (Level Valley)
Butter Derivatives
Butter Esters
Buttermilk
Butyle Butyrate
Butyl Butyrl Lactate
Butyric Acid
Caroic Acid
Caprylic Acid
Caramel Color
Caramel Color #100
Caramel Color (Williamson)
Cedrol Crystals
Cherry Essence 150 Fold
Cherry Juice
Chez-Tone
Chocolate (PAV)
Chocolate Extract (Star Kay White)
Cinnamic Alcohol
Cinnamic Aldehyde
Cinnamon (Micra Milled)
Cinnamyl Acetate
Citral (Natural)
Citric Acid
Citronellol
Cocoa
Cocoa (Ambrosia)
Coconut Oil (Natural)
Delta Decalactone
Dextrose
Diacetyl
Diacetyl (Spray Dried)
Diethyl Malonate
Ethyl 2-Methyl Butyrate
Ethyl Acetate
Ethyl Aceto Acetate
Ethyl Benzoate
Ethyl Butyrate
Ethyl Caprylate
Ethyl Formate
Ethyl Heptoate
Ethyl ISO Valerate
Ethyl Levuliate
Ethyl Maltol

TABLE 2 (continued)
INGREDIENTS OCCASIONALLY USED IN BAKERY MIXES, 1984

INTERNATIONAL BAKERS SERVICES
SOUTH BEND, INDIANA
HETA 85-171

Ethyl Oenanthate
Ethyl Oxyhydrate
Ethyl Propionate
Ethyl Vanillin
2-Ethyl 5 & 6 Methyl Pyrazine
EugenolFlavor Blend #581-A
Flavor Blend #602
Flour
Furfuraldehyde
Gamma Dodecalactone
Gamma Octalactone
Geranyl Acetate
Gum (Xanthan) (Merezan)
Ham Flavor
Heliotropine
(Trans-2) Hexenoic Acid
Hexyl Acetate
Honey (2X)
Honi-Bake 705
ISO Amyl Acetate Blend
ISO Valeraldehyde
ISO Valeric-Acid
Ionone Alpha
Jasmin Maroc Absolute
Lactic Acid
Leaf Alcohol
Lemon Solids
Linalool
Linalyl Acetate
Linalyl Butyrate
Linalyl ISO-Valerate
Maltol
Maple Syrup (Natural)
Methyl 3 Methyl Thiopropionate
4-Methyl-5 Hydroxy Ethyl Thiazole
Methyl Amyl Ketone
Methyl Anthanilate
Methyl Chavicol (Estragole)
Methyl Cinnamate
6-Methyl Coumarin
Methyl Cuclopentanolone
Methyl Heptenone
Methyl Heptine Carbonate
Natural Linalyl Acetate
Natural Strawberry Extender #111P
Natural Terpeniol (Super)
Nutmeg
Octyl ISO Butyrate
Oil Anise
Oil Balsam
Oil Bitter Almond
Oil Cinnamon Leaf
Oil Clove
Oil Cinnamon (Cassia)
Oil Corn
Oil Davana
Oil Grapefruit
Oil Guaiacwood
Oil Lemon
Oil Lime
Oil Mandarin
Oil Nutmeg
Oil Orange (1x) (Valencia)
Oil Orange (5x) (Valencia)
Oil Rose #7275
Oil Tangerine
Oil of Sage
Orange Solids
Orange Terpenes
Ortho Methoxy Cinnamic Aldehyde
Para Cresyl Phenyl Acetate
Para hydroxy Phenyl Butanone
Peach Essence 150 Fold
Peach juice Concetrate
Peanut Butter Flavor Base
Peanut Butter Flour
Phenyl Acetic Acid
Phenyl Ethyl Acetate
Phenyl Ethyl Alcohol
Phenyl Ethyl Phenyl Acetate
Phenyl Ethyl 2-methyl Butyrate
Phenyl Propyl Aldehyde
Pineapple Juice Concentrate
Propylene Glycol
Propenyl Guaethol
Propionic Acid

TABLE 2 (continued)
INGREDIENTS OCCASIONALLY USED IN BAKERY MIXES, 1984

INTERNATIONAL BAKERS SERVICES
SOUTH BEND, INDIANA
HETA 85-171

Methyl Phenyl Acetate	Pure Honey (Kitchen)
Mild (Non-Fat Dry)	Raspberry Juice Concentrate
Molasses	Rose maroc Absolute
N-Butly Acetate	Rum (4X)
Natural Linalool	Rum Base
Salt	Styralyl Acetate
Silicon Dioxide (Syloid 244)	Sugar (Granulated)
Sodium Benzoate	Terpeniol (Super)
Sodium Citrate	Terpinyl Acetate
Solid Extract Coffee	2,3,5 Trimethyl Pyrazine
Solid Extract Foenugreek	Turmeric (T-050)
Solid Extract Lovage	Vanilla Concentrate #065
Solid Extract St. John's Bread	Vanilla Extract (1X) (Petran)
Soy Sauce	Vanillin
Starch (Corn)	Vertraldehyde
Starch (Tapioca)	Worcestershire Sauce
Strawberry Juice	Yellow #5 (F.D.C)
Strawberry Juice Concentrate	Yellow #6 (F.D.C.)

TABLE 3
MIXES AND INGREDIENTS ANALYZED FOR PROTEOLYTIC ACTIVITY

INTERNATIONAL BAKERS SERVICES
SOUTH BEND, INDIANA
HETA 85-171

March 1985

MIX	DATE MIXED
CINNA BUTTER	9-18-84
SWEET ROLL AND DANISH	9-17-84
4X NATURAL VANILLA	9-13-84
CINNAMON EMULSION	9-11-84

OTHER INGREDIENTS ANALYZED

APPLE ESSENCE

APPLE JUICE CONCENTRATE

PINEAPPLE JUICE CONCENTRATE

LEMON SOLIDS

ORANGE SOLIDS

FOAM LINING TO AIR SUPPLIED RESPIRATOR UNIT USED BY SICK WORKERS

RAFTER DUST (REFLECTS EXPOSURE OVER SEVERAL YEARS)

DUST FROM CLOCK (CLEANED APPROXIMATELY JULY, 1984)

TABLE 4
ANALYSIS OF DUST EXTRACTS FOR ENDOTOXIN

INTERNATIONAL BAKERS SERVICES
SOUTH BEND, INDIANA
HETA 85-171

March, 1985

SAMPLE	ENDOTOXIN LEVELS (Endotoxin units/mg)
CINNA BUTTER	16.91
FOAM LINING TO AIR SUPPLIED RESPIRATOR UNIT USED BY SICK WORKERS	0.01
DUST FROM CLOCK	2.26
DUST FROM RAFTER	0.57

TABLE 5
IMMUNOLOGIC EVALUATION OF CASES OF OBSTRUCTIVE LUNG DISEASE

INTERNATIONAL BAKERS SERVICES
SOUTH BEND, INDIANA
HETA 85-171

March, 1985

	CASE 1	CASE 2	NORMAL VALUE
PRIST (Total IgE)	24.9 KU/liter	33.7 KU/liter	
RAST - Gluten	0	0	
Penicillium notatum	0	0	
Maize	0	0	
Cladosporium herbarium	0	0	
Aspergillus fumigatus	0	0	
Mucor racimosus	0	1/0*	
Candida albicans	0	0	
Alternaria alternata	0	0	
IMMUNOGLOBULINS			
IgG	755	1438	600-1450
IgA	140	502	60-340
IgM	99.7	112.0	25-200

*1/0 = equivocal or very low levels of IgE antibodies

APPENDIX A

Analysis of Proteolytic Enzymatic Activity

Plant and animal proteolytic enzymes hydrolyse a wide variety of ester and amide bonds. This property forms a common basis for measurement of proteolytic activity. A chromogenic functional group is linked to an enzyme substrate, usually a peptide (e.g., tripeptide). Upon proteolytic cleavage of the substrate, the functional group is released and quantitated colorimetrically. Nearly all proteolytic enzymes studied to date have been shown to have either a tryptic or chymotryptic specificity. The substrate is cleaved by the proteolytic enzyme at the carboxyl group of the P1 amino acid residue. Tryptic substrates are those with an arginyl or lysyl residue at the P1 site, while chymotryptic substrates have a hydrophobic residue such as tyrosine or phenylalanine at this site.

In this investigation the commercially available Spectrozyme series of substrates were used. These substrates utilize p-nitroanaline on thechromogenic functional group, measured at 405 nm. Optimal concentrations of chymotryptic and tryptic substrate were determined. EDTA and Cysteine were added to increase the sensitivity of the assay to plant-derived thiol proteases. The chymotryptic substrate chosen was succinyl-alanyl-alanyl-prolyl-phenylalanylnitroanilide. Catalytic and affinity constants k_{cat} and K_M were 9.2 s^{-1} and 25 uM for chymotrypsin, respectively, and 94 s^{-1} and 171 uM for subtilisin, respectively. The tryptic substrate chosen was Spectrozyme Xa, with k_{cat} and K_M for bovine trypsin of 68 s^{-1} and 171 uM for subtilisin, respectively. Spectrozyme Xa was also found to be efficiently hydrolyzed by papain, ficin, and bromelain, although bromelain consistently showed about 1/10 the activity of the other two enzymes (Table A-1).

Selected samples from the working area (Table 6) were made up to a 10% w/v solution of the following buffer: 50 mM HEPES (N-hydroxyethyl-piperazine-N'-ethanesulfonic acid), pH 7.0; 5 mM cysteine hydrochloride, 5 mM EDTA. All assays were performed at 25 ^{o}C. In some cases solutions were clarified by passage through cellulose filters or centrifugation for 10 minutes at 2000 x g. Some samples, such as apple essence, could not be measured due to high interfering color of the plant pigments. The sample solutions were assayed as follows: 1 mM Spectrozyme Xa and 1 mM suc-A-A-P-F in 2 mM sodium bicarbonate - succ-A-A-P-F was dissolved in dimethylsulfoxide at 25 mg/0.1 ml before mixing with bicarbonate. To a semimicro quartz cuvette containing 0.8 ml sample solution was added 0.2 ml of the substrate solution. The solution was rapidly mixed by inverting a few times, then placed in the sample compartment of a Zeiss PM II recording spectrophotometer set to a chart speed of 100 seconds/inch and a full-scale deflection of 0.05 absorbance units. This setting was near the limit of sensitivity of the assay, approximately 1 x 10 M, or 10 nanograms of enzyme (enzyme molecular weight approximately 25,000).

TABLE A-I

PROTEOLYTIC ACTIVITY OF POSITIVE CONTROLS

SUBSTRATE	ENZYME		
	Bromelain	Papain	Ficin
Benzoyl-arg-pNA	0.003	0.055	0.012
Benzoyl-glycyl-prolyl-arginyl-pNA	0.015	0.189	0.012
Benzoyl-prolyl-phenylalanyl-arginyl-pNA	0.146	20.1	1.95
Spectrozyme TH (CHT-A-R-pNA)		0.488	0.037
Spectrozyme PL (Nle-CHT-K-pNA)	0.045	0.268	0.293
Spectrozyme Xa (MeOCO-CHG-G-R-pNA)	0.20	10	2

All enzymes were assayed in 100 mM imidazole-HCl, pH 6.5 with 5 mM each of added cysteine and EDTA (ethylenediamine tetraacetic acid). Enzymes were made up to 2.5 mg/ml (100 uM) stock solution and diluted as necessary, from 1/10 to 1/1000. Typically, 25 ul enzyme was added to 1 ml assay buffer, and the increase in yellow color monitored in a ZEISS PM II recording spectrophotometer set to a chart speed of 10 s/in and 0.1 absorbance units full-scale.

WALK-THROUGH SURVEY REPORT:

CONTROL TECHNOLOGY FOR MANUAL TRANSFER OF CHEMICAL POWDERS

AT

International Baker's Services
South Bend, Indiana

REPORT WRITTEN BY:
William A. Heitbrink

REPORT DATE:
August 1985

REPORT NO.:
149-32

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

PLANT SURVEYED:	International Bakers Services 1902 North Sheridan South Bend, Indiana
SIC CODE:	5149 (Bakery Products - Wholesale)
SURVEY DATE:	July 9, 1985
SURVEY CONDUCTED BY:	William A. Heitbrink Walter M. Haag
EMPLOYER REPRESENTATIVES CONTACTED:	David Nowicki Vice President Phone: (219)-287-7111
EMPLOYEE REPRESENTATIVES CONTACTED:	None
ANALYTICAL WORK PERFORMED BY:	None

I. INTRODUCTION

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.

II. BACKGROUND FOR THIS SURVEY

This survey was conducted as part of a project to evaluate sources of worker dust exposure during weigh-out and transfer of powders from one container to another. This plant may be implementing dust controls for their weigh-out operation in the near future. Installing engineering controls involves changing the workplace to eliminate sources of worker dust exposure. Also, this survey was conducted to suggest dust control measures for the plant's powdered material handling operations. As requested by the Health Hazard Evaluation and Technical Assistance Branch, this report contains dust control recommendations.

III. PLANT AND PROCESS DESCRIPTION

Plant Description

International Baker's Services manufactures "flavors" for bakers. These "flavors" are cornstarch-coated with organic liquids. The room in which the "flavors" are prepared is a 50 x 20 foot room with a 14-foot ceiling. This room is isolated from the rest of the plant by cinder block walls. The room has no windows and only one door which leads to the packaging area of the plant. The plant was built in 1946; however, the equipment appears much newer. Three production workers mix the ingredients for the "flavors" and prepare them for shipment.

Process Description

Three mixers are used to prepare the various batches of "flavors." Two Day mixers (ribbon blenders) with capacities of 300 and 500 pounds are used along with a 1,500 pound capacity Littleford Mixer.

At the Littleford Mixer, the following procedure is used to mix a batch of "flavors":

1. A fork-lift truck sets a pallet of bags containing cornstarch on the platform above the Littleford Mixer. These bags weigh about 100 pounds each.

2. The bags are emptied manually into the charging chute of the Littleford Mixer and the mixer is turned on. Sometimes preweighed batches of solid materials other than the cornstarch are added to the mixer.

3. Liquid flavoring is poured through a funnel into the mixer.

4. After mixing for a predetermined time, the flavor is discharged from the mixer into a plastic container or directly into poly-lined fiberboard drums which are used for shipping.

5. For quantities larger than 20 pounds, the fiberboard drums are set under the mixer and partially filled. Then, the partially filled drum is set on the weighing scale and its weight is adjusted manually by using a scoop to add or remove material. Any additional material is obtained from a plastic container.

   For poly-lined fiberboard drums which contain less than 20 pounds of flavor, the drums are weighed. Then, the drums are used to scoop material out of the plastic container. The drum is set on a scale and the workers use a scoop to adjust the weight of the flavor in the drum.

6. Steps 4 and 5 are repeated until the mixer is emptied. Then the mixer is opened and the worker brushes the remaining material out of the mixer.

The only differences between the operation of the Day mixers and the Littleford Mixer is the size of the batch and the procedures used to charge the starch into the mixer. At the Day Mixers, the bags of starch are emptied into buckets. The buckets are carried up several steps and poured into the charging chute for the mixers.

Dust Exposure Sources

The mixing and preparation of "flavors" creates dust emissions.

1. Opening bags of cornstarch and pouring it into the mixers. This creates obvious dust emissions. Handling empty bags, particularly compressing these bags, creates airborne dust.

2. Operation of the mixers. At each of the mixers, puffs of dust were observed to come from the vent holes. At the Day mixers, the loosely sealed lids were a source of dust emissions. After the liquid flavoring is poured into the mixer, the dust generation rate appears to decrease.

3. Discharging the flavor from the mixer to the plastic container or poly-lined fiberboard drums. This creates a dust exposure for the worker.

4. Cleaning the inside of the mixer. The worker must place his head in the mixer to use the brush to remove the flavor left in the mixer. This operation probably creates some airborne dust and the worker is exposed because of his proximity to the material.

5. The packaging of the "flavors." Transferring material to and from the flavor's package creates some dust. The work practices used in this step seem to minimize the dust generation. Drop heights are minimized by either placing the full scoop into the powder and removing the scoop or by holding the scoop 1-2 cm above the powder and pushing the powder off of the scoop.

IV. CONTROLS

Principles of Control

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

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

These principles of control apply to all situations, but their optimum application varies from case-to-case. The application of these principles is discussed below.

Respiratory Protection

The worker's dust exposure is controlled during bag opening, mixer operation, and the packaging of "flavors" by wearing a supplied air, positive pressure respirator, a 3M brand White Cap Helmet, model W-3005. This is the primary means of protecting the workers from airborne dust.

General Dilution Ventilation

The room appears to have a balanced dilution ventilation system. Two make-up air diffusers are located in this room. An exhaust fan, mounted in the wall, removes about 3000 cfm (cubic feet of air per minute) from the room. Two TEPCO electronic air cleaners (Model 25000; US Patent 3740926) are located in this room about 8 feet above floor level. Based upon exit air velocity measurements, each unit appears to clean about 3000 cfm. This air is returned to the workplace. The plates of this air cleaner are cleaned once a week.

Work Practices

Several work practices have been instituted to reduce dust emissions.

1. Empty bags are never thrown, they are carefully compressed and stacked carefully. Note: Compressing bags creates airborne dust.

2. During the packaging of the "flavors," drop heights are minimized. When using a scoop to fill a container, the worker does not pour the contents of the scoop into the container; he places the full scoop into the powder at about a 45° angle. To empty the scoop, he simply removes the scoop from the powder.

3. The floor is vacuumed every day and wet-mopped every week.

Other Unique Practices

The workers are trained to wear their respirators. Once a year, meetings are held to reinforce safety rules. Worker's signatures are on file that document they have read the safety rules.

V. DISCUSSION AND CONTROL RECOMMENDATIONS

The general dilution ventilation in this facility appears to confine the dust to the mixing room. The electrostatic precipitator removes some dust from the air; however, when its plates become loaded, the precipitator's efficiency is reduced.

The company's strategy to control worker dust exposures emphasizes the use of positive pressure, supplied-air respirators rather than the use of engineering means to reduce and control worker dust exposure. Accepted industrial hygiene practice is to emphasize engineering controls and other means to prevent or control worker dust exposures. Where engineering controls are either unreliable or provide inadequate dust control, respirators are used to protect the worker's health.[1]

Dusts generated by loading, operating, and emptying the mixers can almost certainly be controlled by a local exhaust ventilation system. Dust generated by manual bag opening can be well controlled. Hoods such as those pictured in Figure 1 can provide nearly complete dust control when bags are opened, emptied and discarded.[2,3] Such a hood requires a minimum of 120 feet per minute face velocity and at least 500 cubic feet per minute of exhaust airflow to contain the dust. In order to further reduce worker dust exposure, provisions for dust control during bag disposal are needed. As discussed in reference 3, this can be accomplished by placing a chute in the side of the bag opening hood and attaching a plastic garbage bag to this chute. The only uncontrollable source of worker dust exposure comes from handling the bags which may be contaminated with dust.

Dust is emitted from the mixer's vent tubes when the mixers are loaded and operating. Filling the mixer with powder causes air to flow into the mixer. As a result, dusty air can flow out of the vent. This dusty air can be conveniently captured by a local exhaust ventilation system.

During mixer discharge, dust and entrained airflow is generated. This dust could be controlled by installing a ventilated enclosure around the container or bucket used to collect the "flavors." A door for the enclosure is needed to remove the product. The exhaust airflow rate needs to be larger than volumetric flow rate of powder (estimated from the bulk density of the powder) and any entrained airflow. The entrained airflow can be minimized by reducing the drop heights.[4] Plate VS-303 of the ACGIH Ventilation Manual presents several useful design recommendations for barrel filling.[5]

Two slot hoods which follow the design in the upper left corner of plate VS 303 of ACGIH's Ventilation Manual could be used to control dust generated by weigh-out and transfer.[5] One of these hoods would need to be located at the scale where the weight of the drums is adjusted. The bucket containing the "flavors" could be located nearer to the scale to minimize spillage during the transfer of scoops. The second slot hood, using the design mentioned above, is needed to control the dusts generated by scooping the material from the bucket and returning the material to the bucket. These hoods will need to draw 100-200 fpm of air across the face of the container.

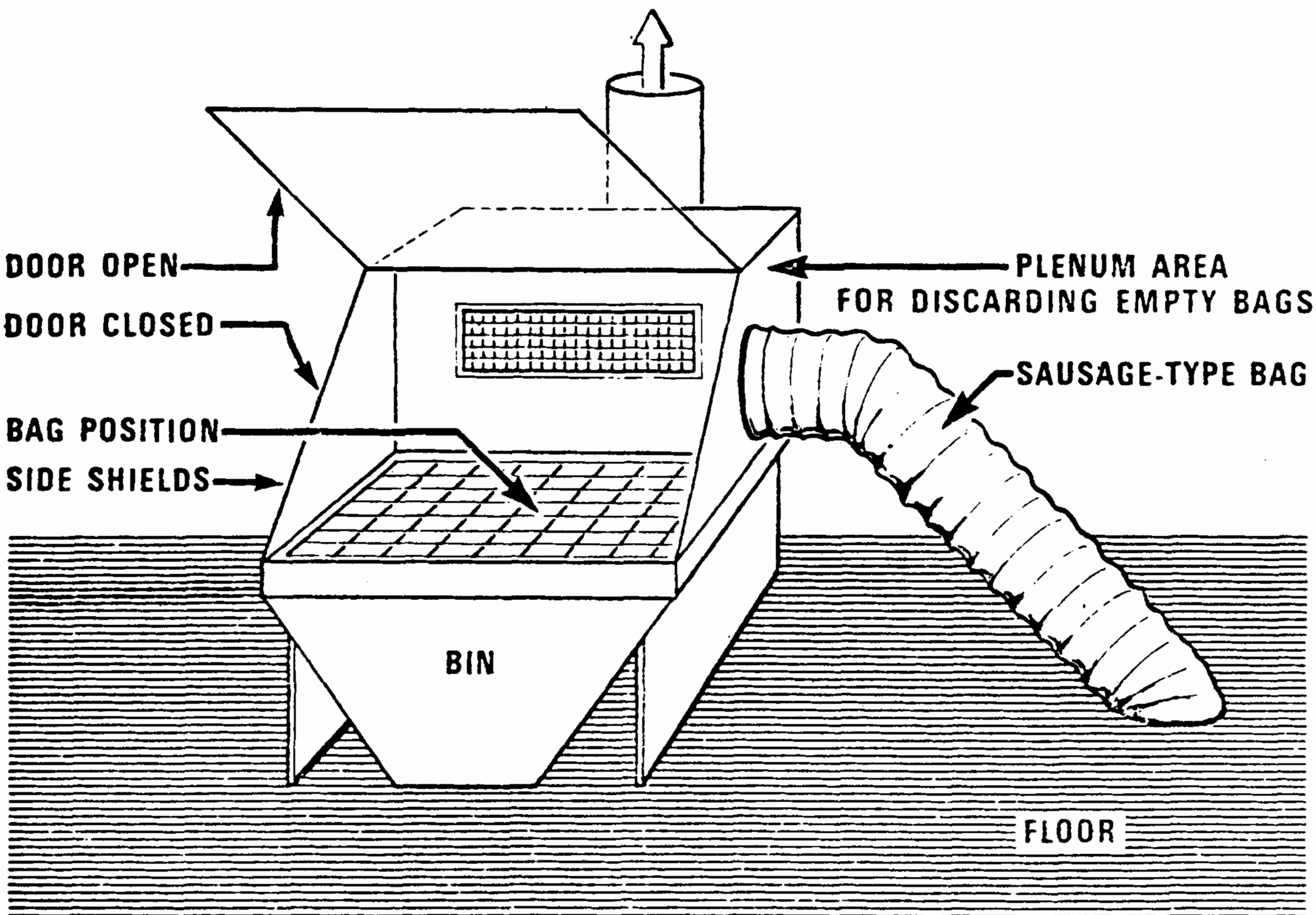

Figure 1. Conceptual Design for Dust Control During Bag Opening.[2]

For weigh-out and transfer operations, such as the packaging of "flavors," the NIOSH Engineering Control Technology Branch has not observed completely effective dust control measures.[6] In spite of apparently well-designed local exhaust ventilation systems, these operations usually cause some increase in worker dust exposures.

The use of the two slot hoods and moving the bucket next to the scale should minimize the reasons for this incomplete dust control. Ventilation at weigh-out and transfer operations usually involves either ventilated weigh-out booths or ventilated weighing scales. At the ventilated booths, the workers can place their heads inside of the booth where the air is contaminated. At a different plant, a "slot" hood is observed to capture dust generated at the scale. However, dust which is generated at the original container is uncontrolled and a second slot hood should be able to control this dust. This suggests that two slot hoods, as described in the last paragraph of page 7, are needed to control dust generated at the scale and at the original container.

VI. CONTROLS

These control recommendations need further elaboration before they are installed. A professional engineer who specializes in the design of local exhaust ventilation systems for the control of dust is needed to develop a detailed design and to supervise the installation of these controls.

NIOSH's ECTB should conduct detailed surveys with sampling before and after the controls have been implemented. The survey conducted before the engineering controls are implemented would evaluate the significance of the worker's dust exposure sources. Such a survey is conducted to make sure that the control measures are properly focused. A survey, conducted after the controls are implemented, would evaluate the usefulness of installed dust controls.

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