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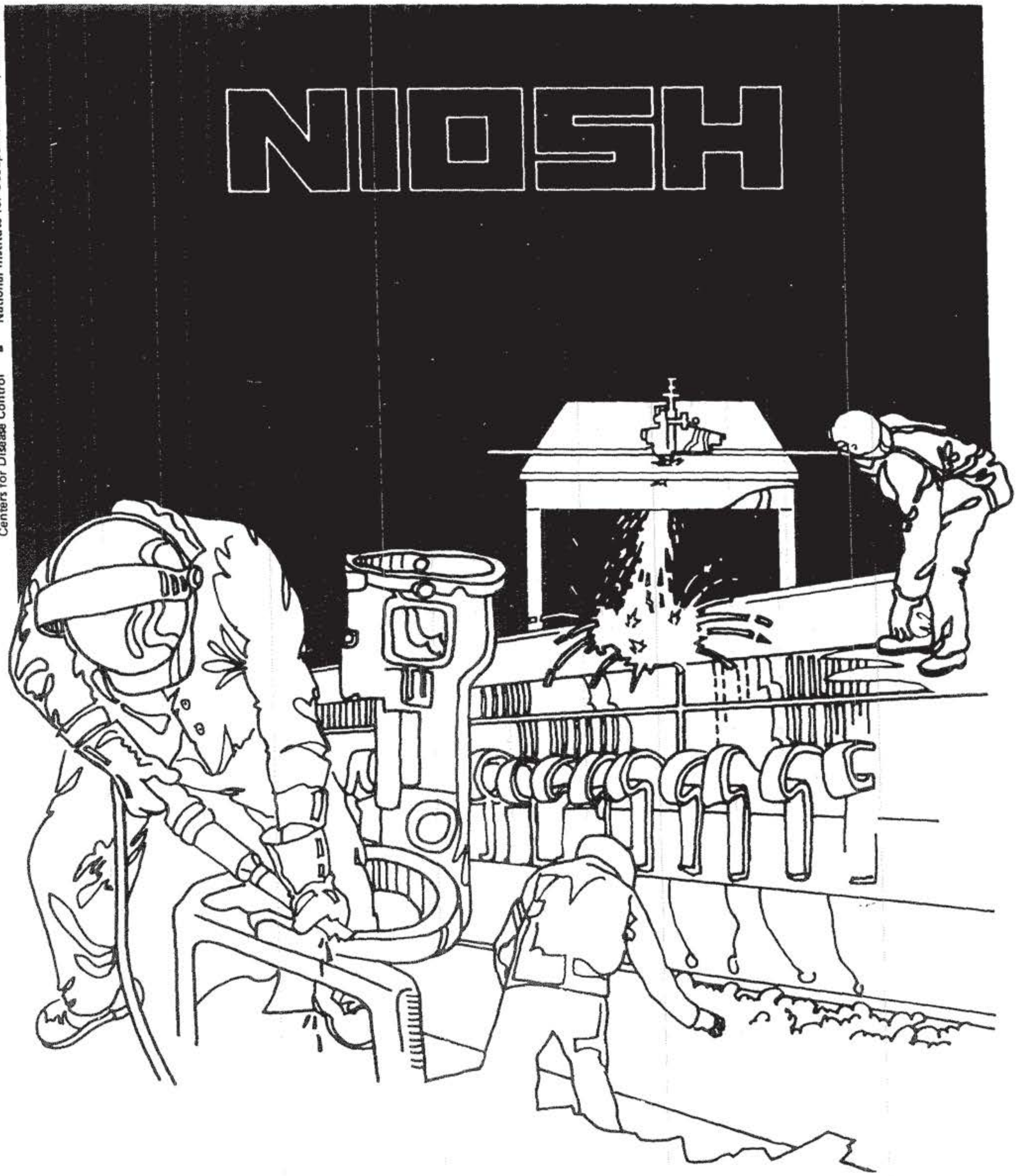

Health Hazard Evaluation Report

HETA 84-477-1824
BUNGE CORPORATION
DECATUR, ALABAMA

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I. SUMMARY

In August 1984, the National Institute for Occupational Safety and Health received a request from the Oil, Chemical and Atomic Workers Union Local 3-906, to evaluate symptoms of respiratory irritation and skin rashes among employees exposed to soybean dusts at the Bunge Corporation in Decatur, Alabama. Medical and environmental surveys were conducted by NIOSH in February and March 1985.

Worker exposures to the soybean dusts were categorized into four components: raw dust, cleaner dust, extracted dust, and mixed dust. Total and respirable dust samples were collected. The range of total dust exposures in the raw soybean dust category was 0.16 to 22.6 mg/m^3 for 34 workers. The average for all samples was 3.73 mg/m^3. The ACGIH TLV for grain dusts is 4 mg/m^3 total dust. The OSHA PEL for nuisance particulates is 15 mg/m^3 for total dust. One utility worker performing cleanup in the head house was exposed to nuisance dust at a level near the OSHA PEL (14.7 mg/m^3), and another was overexposed (22.6 $mg.m^3$). Six bean barge workers had dust exposures exceeding the ACGIH TLV, and one worker's exposure (14.2 mg/m^3) approached the OSHA PEL. The use of respiratory protection was at the discretion of the worker in all plant areas.

Respirable raw dust exposures ranged from 0.02 to 1.02 mg/m^3 and averaged 0.26 mg/m^3 for 35 samples. Bean barge cleanup workers and utility workers in the head house had the highest average respirable exposures at 0.45 and 0.42 mg/m^3, respectively.

The total dust exposure results for workers in the cleaner soybean dust category ranged from 0.18 to 0.72 mg/m^3 and averaged 0.48 mg/m^3 for 13 samples. The respirable dust results ranged from 0.01 to 0.15 mg/m^3, with a mean of 0.08 mg/m^3. This was the lowest exposure category for the soybean dusts.

The total dust exposure sample results for the extracted soybean dust category ranged from 0.18 to 15.0 mg/m^3 and averaged 2.28 mg/m^3. One exposure, to a worker loading railcars with soybean meal, equaled the OSHA PEL of 15 mg/m^3. Respirable dust exposures ranged from 0.02 to 0.38 mg/m^3 and averaged 0.11 mg/m^3.

Six samples, collected from workers who received a mixed exposure to soybean dusts, ranged from 0.76 to 16.2 mg/m^3, and the mean was 5.77 mg/m^3. The higher exposures were to workers who transferred from jobs in the meal house to help set up or clean out bean barges.

Three of these exposures exceeded the ACGIH TLV, and one of them exceeded the OSHA PEL. Respirable mixed dust exposures ranged from 0.06 to 0.47 mg/m^3 and averaged 0.23 mg/m^3.

The medical survey demonstrated a high prevalence of work-related lower respiratory symptoms, although medical evaluations did not confirm these symptoms, pathophysiologically, to have been asthma. A substantial majority of the symptoms were reported to be related to raw soybean dust exposure. A high prevalence of work-related rhinitis was also found, similarly reported to be related to raw soybean dust exposure.

High personal exposures to soybean dusts occurred in the shipping and receiving areas of the plant, presumably to the raw and extracted dusts. Utility workers in general had high exposures to soybean dusts. Lower-respiratory tract symptoms were prevalent among exposed workers. Engineering controls and an improved respiratory protection policy are recommended.

KEYWORDS: SIC 0723 (crop preparation services for market)
soybean dust, asthma, rhinitis, bronchitis, allergy

II. INTRODUCTION

In August 1984, the National Institute for Occupational Safety and Health received a request from the Oil, Chemical, and Atomic Workers Union Local 3-906, to evaluate symptoms of respiratory irritation and skin rashes among employees of the Bunge Corporation's Decatur, Alabama plant. An initial walk-through survey was conducted in October 1984, and a preliminary questionnaire survey was conducted in January, 1985. A follow-up medical and environmental survey was conducted in February 1985. Since unexpected freezing weather caused malfunction of some of the industrial hygiene monitoring equipment, invalidating results for one day's monitoring, the industrial hygiene and pulmonary function testing from this visit were discarded, and those components of the evaluation were re-scheduled for the final survey, in March 1985. Each participant in the medical survey was notified of the results of his medical testing in March 1986. At that time, both company and union representives were informed of preliminary conclusions and recommendations, based upon an examination of the data from the medical survey.

III. BACKGROUND

At the time of this evaluation, the Bunge Corporation was the third-largest grain-handling company in the world. The Decatur, Alabama plant was operated by Goldkist from 1974, when the plant was opened, until it was purchased by Bunge in 1982. At the time of the study, Bunge employed 72 hourly workers.

Soybeans are received by railcar, truck, and/or barge, and conveyed to the head house, where they are distributed to storage, drying, or processing areas of the plant. In the processing/prep area the soybeans are cleaned, dried, and cracked to loosen the seed coat or hulls. Then they are dehulled, flaked, and transferred to the processing/extraction area, where the oil is extracted using hexane in a stationary-basket extractor. The spent flakes are desolventized, toasted, processed as meal by cooling, grinding, and screening, and then sent to the meal house for storage and disposition. Soybean meal is shipped from the plant by railcar and truck. The hexane solvent is recovered from the extracted oil, which is then stored for shipping. Soybean oil is shipped from the plant by truck and barge. A typical process diagram is pictured in Figure 1.

The workers are divided among the Shipping and Receiving, Processing, and Maintenance departments. Workers in all of these departments have potential exposures to soybean dusts. The primary differentiation to be made among the dust exposures is whether the source is unprocessed or processed soybeans. The unprocessed (raw bean) dust will contain foreign materials such as hulls, dirt, fungal spores, and insect parts. Processed soybean dusts, which are "cleaner", are generated after the beans have been dehulled or extracted.

Generally speaking, worker exposures to raw soybean dust will occur during unloading of raw soybeans (from barges, trucks, and railcars), work in the head house and storage tanks, or as a maintenance mechanic in these areas. The exposures to processed soybean dust would occur in the prep building, the meal house, the truck and railcar loading area, or as a maintenance mechanic in these areas. Mixed exposures are not uncommon since workers move around during a shift according to staffing needs. For example, during the NIOSH evaluation, second shift workers from the meal house also did cleanup work inside a bean barge at the harbor, resulting in exposure to both processed and raw soybean dusts.

Because of the potential for exposures to the various dusts, the company provided 3M Model 3710 single-use respirators. In the extraction process area there were self-contained breathing apparatus and air-line respirators for emergency use. Negative pressure organic vapor cartridge respirators were also provided for the extraction operators.

IV. EVALUATION DESIGN AND METHODS

A. Environmental

Environmental air sampling was conducted beginning with the third shift on March 3, 1985, and concluding with the first shift on March 6, 1985. Personal breathing-zone samples were collected so that individual dust exposures could be matched with medical results. Workers from each exposure category were monitored during the course of two workshifts where possible. Total dust and respirable dust breathing-zone samples were collected from each worker monitored.

1. Total Dust

Personal total dust samples were collected on tared 37-mm, 5-um PVC membrane filters at a nominal flow rate of 2 liters per minute (lpm). Gravimetric analysis was performed on the collected samples. The instrumental precision of the weighings was 0.01 mg (NIOSH Method 0500).[1]

2. Respirable Dust

Respirable dust samples were collected on tared 37-mm, 5-um PVC membrane filters mounted in 10-mm Dorr-Oliver cyclones. Air was drawn through the filter at a flow rate of 1.7 lpm. Gravimetric analysis was performed on the collected samples. The instrumental precision of the weighings was 0.01 mg (NIOSH Method 0600).[1]

B. Medical

Available resources limited the medical study to 50 persons, so not all employees could participate. The following employees were excluded because they constituted gender, age, or employment categories too small for valid comparison with other groups of employees: (1) three women, (2) four employees with dates of birth prior to 1930, and (3) three employees with less than three years duration of employment. Three other employees were excluded because they had non-occupational medical conditions identified by a screening questionnaire administered in January 1985. Fifty of the remaining 59 eligible employees were chosen to approximate 85% of eligible employees from each department. During the February visit, some employees who had been chosen for the study group were on leave or did not want to participate. When available, substitutions were made from the same department. When there were no eligible employees remaining from a department, any eligible employee was added to the study group to keep the total at 50 persons.

During the February 1985 visit, medical interviews for 48 of the 50 participants were completed. A NIOSH interviewer administered a questionnaire that inquired about demographic characteristics, acute irritant symptoms, symptoms associated with diseases of the upper and lower respiratory tract, personal and family medical history, smoking habits, and jobs prior to working at Bunge. The participant was then seen by a NIOSH physician who, without knowing his past or current jobs at Bunge, reviewed the questionnaire responses to assess whether he met pre-determined criteria for being considered a case of possible asthma and/or possible rhinitis. These were:

(1) Possible asthma: Any of the following symptom sets during the last year:

wheeze and chest tightness,
wheeze and shortness of breath,
chest tightness and shortness of breath,
chest tightness and cough, or
wheeze brought on by exercise or cold.

(2) Possible rhinitis: Any three of the following symptoms, at least one of which involved itching, during the last year: runny nose, frequent sneezing, itchy nose, itchy watery eyes, stuffy nose, and itching in the roof of the mouth and throat.

The physician was instructed to evaluate positive responses before classifying employees as possible asthma or rhinitis. For example, a positive questionnaire response to "wheezy or whistling breathing" would not be counted as wheezing if the physician determined that the employee was referring to whistling breathing from a stuffy nose.

The physician was then instructed to determine if the possible asthma and/or rhinitis was temporally related to occupation. Possible occupational asthma or rhinitis cases were possible asthma or rhinitis cases that met all four of the following criteria:

(1) onset of symptoms since beginning employment at Bunge,

(2) symptoms that "never" or "seldom" occurred following certain activities or after exposure to specific materials at home,

(3) symptoms that occurred "sometimes" or "most times" during or after specific jobs at work, and

(4) symptoms that occurred less frequently on vacation and on days away from work than on workdays.

Finally, a second NIOSH physician interviewed the employee regarding his present and past jobs at Bunge.

The March 1985 medical survey included pulmonary function tests and allergy tests. Also, the questionnaire was administered to the two individuals who were on leave during our February visit.

A NIOSH physician administered skin prick tests using preparations of common allergens and various fractions of raw soybeans and soybean products. Blood samples were drawn for determination of serum concentrations of (a) total immunoglobulin E (IgE), and (b) IgE specific to the soybean fractions and products by radioallergosorbent test (RAST) (Table 9). A skin test reaction was classified as positive if the wheal was 2 mm in diameter and a flare was present. The RAST was defined as positive if the percent binding of IgE antibody was greater than three times the mean binding of a negative control. For a given allergen, the skin prick test should be more sensitive than the RAST test, that is, the skin prick test should more often be positive in the presence of allergy, or should be positive earlier in the time course of the allergy, than the RAST. Though more specific for hypersensitivity to an allergen than skin prick tests, a RAST may also be positive in the presence of elevated total serum IgE antibody levels, due to non-specific binding of IgE to the product tested.

Pulmonary function testing consisted of spirometry and peak expiratory flow rate (PEFR) measurements. On return to work after two days off, pre- and post-shift spirometry was performed with an Ohio Medical Model 822 dry rolling seal spirometer. On the last day of each employee's work week, post-shift spirometry was performed. One-second forced expiratory volume (FEV_1) and forced vital capacity (FVC) were measured in accordance with the American Thoracic Society's criteria for screening spirometry.[2] Predicted values for FEV_1 and FVC were calculated using the equations of Knudson, et al.[3] The Knudson values were multiplied by 0.85 to obtain the predicted values for Blacks.

Employees were instructed in the use of a mini-Wright portable peak flow meter and asked to record peak expiratory flow rate and symptoms every three hours while awake for seven consecutive days. On each day for which data were available, for each participant, the difference between maximum and minimum PEFR was calculated as a percentage of maximum PEFR. If that percent difference exceeded 15 percent, then the individual was identified as having reversible airways obstruction.

On the days that individuals had pre- and post-shift spirometry testing, industrial hygiene monitoring was performed for personal respirable and total dust.

Pulmonary function tests and job history

To examine the relationship between medical outcomes such as symptoms and pulmonary function test changes, and job category and job history, we defined organic dust categories according to stages of processing undergone by the soybeans. The various tasks performed by employees were categorized into four "organic dust exposure" categories.

"Raw" dust: All tasks involving exposure to soybeans and soybean dust prior to the soybeans being de-hulled, e.g.,

unloading raw soybeans (from barges, trucks and railcars),

tasks in the storage tanks, head house, and the tunnels which connect the storage tanks to the head house,

loading hulls, or

utility and maintenance work on the cracking rolls, on the first floor of the prep building (where a conveyor system brings unprocessed whole soybeans to the prep house), and in the above areas.

"Cleaner" processed dust: All tasks in the prep building, including utility and maintenance work (except those on the first floor or involving the cracking rolls).

"Extracted" processed dust: All tasks involving exposure to meal (i.e., soybean product after the extraction process), including loading railcars and trucks with meal, working in the meal house control room, and all utility and maintenance work in the meal house, truck loading and railcar loading areas.

No organic dust: All tasks not considered to have exposure to raw or processed soybeans or soybean products, including loading oil into barges or railcars, working in the extraction building, working in the maintenance shop, and maintenance work in the general plant other than the areas classified above.

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 (TLVs), and 3) the U.S. Department of Labor (OSHA) occupational health standards. Often, the NIOSH recommended exposure limits (RELs) and ACGIH TLVs are lower than the corresponding OSHA standards. Both NIOSH RELs and ACGIH TLVs 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 RELs, 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 airborne concentration 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. Grain Dust Exposure Criteria

Currently, neither NIOSH nor OSHA has an exposure criterion for grain dust. The OSHA permissible exposure limit (PEL) for nuisance dusts is 15 mg/m3 for total dust and 5 mg/m^3 for the respirable fraction.[4] Epidemiologic studies of workers who handle grain have reported a variety of clinical syndromes related to environmental exposure. These have included allergic asthma, chronic bronchitis, febrile reactions (grain fever), fibrosis of the lung, rhinitis, and conjuctivitis. An increased prevalence of respiratory symptoms (such as sputum production, chronic cough, wheeze, chest tightness, breathlessness on exertion) has been demonstrated repeatedly in studies of grain elevator workers. Nasal symptoms, eye and skin irritation related to grain dust exposure are also common. Because of the accumulation of evidence regarding the harmful effects of grain dust, the American Conference of Governmental Industrial Hygienists (ACGIH) has recommended a TWA-TLV of 4 mg/m^3 of total dust for grain workers.[5]

In a study recently published by NIOSH, total dust exposures averaged 3.29 mg/m^3 for 209 workers in the grain handling industry.[6] Medical findings from this study led the authors to conclude that exposure to grain dust during a work shift had a dose related acute adverse effect on the worker. The effects, which were largely on the respiratory system, were seen at total dust concentrations below 5 mg/m^3. In addition, susceptible workers (those with pre-existing airways obstruction) experienced significant declines in ventilatory function at dust levels below 10 mg/m^3.

There have been no epidemiologic studies of soybean processing workers. Case reports have described occupational asthma in five soybean mill workers[8] and asthma, rhinitis and conjunctivitis in a bricklayer's helper exposed to soybean dust while working on the reconstruction of a soybean plant.[9] Peters[10] reported on a nurse's aide who developed soybean allergy manifested by asthma, rhinitis, and conjunctivitis after exposure to soybean-containing bath powders. Another case report[11] described a previously non-allergic woman who developed asthma after exposure to soybean flour at a company which manufactured dairy food products. She was a secretary whose symptoms resulted from minimal exposure.

VI. RESULTS AND DISCUSSION

A. Environmental

Worker breathing-zone exposure results for total and respirable dust are presented in Tables 1 through 8. The highest exposures were experienced by workers in the Shipping and Receiving department. Within this department, those who performed work at the harbor unloading bean barges had the highest exposures. This included workers who were assigned to the harbor and those who were transferred from other jobs during their work shift to help in barge unloading and cleanout. It takes about 14 hours to unload a bean barge. Most of the workers' time is spent outside the barge during this operation. The last 1.5 hours of this time are spent doing barge cleanout. Workers use a Bobcat (a small front end loader) and brooms to clean the bottom of the barge. This is a very dusty job.

Single-use respirators were available to all workers. The use of respiratory protection was at the workers' discretion. In dustier jobs the use of respirators was widespread, although a number of the workers had beards which drastically compromises the respirator's efficiency. It is also questionable whether the single-use respirator provides adequate protection on a day to day basis in some of the higher exposure jobs.

Raw soybean dust exposure results are presented in Tables 1 and 2. The range of total dust exposures was 0.16 to 22.6 mg/m^3 for 34 workers in this category (Table 1). The average for all samples was 3.73 mg/m^3. One of the utility workers performing cleanup in the head house was exposed near the OSHA PEL (14.7 mg/m^3) and the other was overexposed (22.6 mg.m^3). Seven total dust samples collected from workers inside the bean barge averaged 7.80

mg/m^3. Six of these seven workers had dust exposures exceeding the ACGIH TWA-TLV of 4 mg/m^3 and one exposure (14.2 mg/m^3) approached the OSHA PEL. The 10 samples collected from workers dockside at the bean barge averaged 1.63 mg/m^3. One of these, 3.34 mg/m^3, was near the ACGIH TWA-TLV.

Respirable raw dust exposures from Table 2 ranged from 0.02 to 1.02 mg/m^3 and averaged 0.26 mg/m^3 for 35 samples. Bean barge cleanup workers at the harbor and utility workers in the head house had the highest average respirable exposures, 0.45 and 0.42 mg/m^3, respectively.

Exposures to the cleaner soybean dust are presented in Tables 3 and 4. The total dust personal exposure results ranged from 0.18 to 0.72 mg/m^3 and averaged 0.48 mg/m^3 for 13 samples (Table 3).

The respirable dust results ranged from 0.01 to 0.15 mg/m^3 with a mean of 0.08 mg/m^3 (Table 4).

Exposures to extracted soybean dust are presented in Tables 5 and 6. The 13 total dust sample results (Table 5) ranged from 0.18 to 15.0 mg/m^3 and averaged 2.28 mg/m^3. One exposure to a worker loading railcars with soybean meal, equaled the OSHA PEL of 15 mg/m^3. This worker loaded six railcars during the shift. Each railcar has three hoppers and it takes about 10 minutes to load each hopper. A load tube is placed over the top hatch, and when it is nearly full the operator must manually move the load tube to distribute the last of the load evenly. This is the dustiest part of the job. Respirable dust exposures (Table 6) ranged from 0.02 to 0.38 mg/m^3 and averaged 0.11 mg/m^3. The highest respirable dust exposure was to the worker who was loading railcars.

Six samples were collected from workers who were exposed to both processed and unprocessed soybean dusts (Tables 7 and 8). Four of these workers spent most of the work shift in the area to which they were assigned. Two of them split the shift evenly between the primary and secondary jobs. The mixed exposure in all cases here was to raw and extracted soybean dusts. The range of total dust exposures was from 0.76 to 16.2 mg/m^3, and the mean was 5.77 mg/m^3 (Table 7). The higher exposures were to those who transferred from jobs in the meal house to help set up or clean out bean barges. Three of these exposures exceeded the ACGIH TWA-TLV, and one of them exceeded the OSHA PEL. Respirable mixed dust exposures ranged from 0.06 to 0.47 mg/m^3 and averaged 0.23 mg/m^3 (Table 8).

Twenty-two personal exposure samples were collected from a group of nine maintenance mechanics. Some of the results (five sample results) have been reported in the above tables when the exposure to a particular type of dust was known. The remaining 17 sample results ranged from 0.25 to 2.51 mg/m^3, averaging 0.81 mg/m^3, for total dust exposure and from 0.01 to 0.72 mg/m^3, averaging 0.22 mg/m^3, for respirable dust exposure.

B. Medical

Response proportions, and participation in each examination: Participants in the February and March, 1985 examinations were drawn from the following departments:

DEPARTMENT	# ELIGIBLE	# in STUDY	(% of ELIGIBLE)
Shipping & Receiving	26	25	(96)
Process	19	15	(79)
Maintenance	14	10	(71)
TOTAL	59	50	(85)

During the March visit, the questionnaire was administered to the two individuals who were on leave and therefore had not been interviewed in February.

These individuals were excluded from the analyses pertaining to possible occupational asthma and possible occupational rhinitis, since the NIOSH physician who had made those clinical assessments in February was not present in March to review these two questionnaires.

The number of employees completing each portion of the medical screening is tabulated as follows:

Questionnaire	50	(48 for asthma and rhinitis analyses)
Peak flow recordings	32	(with adequate data for analysis)
Skin tests	49	
Immunologic tests (RAST and serum total IgE)	49	

Spirometry testing was performed on the following number of workers for each category of tests:

(1) Pre- and post-shift spirometry on the first day back at work: 46 workers.

(2) End-of-week spirometry: 42 workers.

Description of the study participants

Of the 50 participants, 44 were white and 6 were black. All participants were male. Their ages ranged from 24 to 54 years, with a mean of 34.1 years. Length of employment at the plant ranged from 4 to 10 years, with a mean of 8 years.

One participant had an extremely elevated serum total IgE level and a positive skin test for Aspergillis, as well as 20 other positive skin tests. He had 9 positive RASTs. It could not be ruled-out, without further investigation, that the elevated serum IgE level was due to chronic allergic bronchopulmonary aspergillosis, a disease that may or may not be work-related in any given individual. (This was explained to the participant in writing, and he was urged to consult a local physician for further investigation.) Extremely elevated serum IgE levels can result in non-specific binding in the RAST assays and yield positive results that are not due to specific allergy to the substances tested. This participant's data was not removed from the analyses that follow. Were the data to have been eliminated from further consideration, the results would not have been changed.

Possible Asthma

On the basis of their questionnaire responses, 22 of 48 employees were identified as having met the predetermined criteria for possible asthma. Of these, 15 met the criteria for occupational asthma, and 7 were designated non-occupational asthma (Table 10).

To validate the tentative diagnosis of asthma, evidence of reversible airways obstruction was sought in the peak expiratory flow rate data. Thirty-two of the participants submitted adequate PEFR data for analysis. This includes the two employees who answered the questionnaire in March, so only 30 sets of PEFR data are included in analyses concerning possible asthma or rhinitis. Five of these 30 had evidence of reversible airways obstruction on at least one day: three of 13 possible asthmatics and 2 of 17 non-asthmatics. Among the 14 participants with possible occupational asthma who did the spirometric tests, the mean difference between pre- and post-shift FEV_1 (as a percent of predicted) was +0.79 percent, compared to a mean difference of -2.0 percent among the 24 non-asthmatics (Table 11). In this analysis, pre-shift percent FEV_1 was subtracted from post-shift percent FEV_1, so that a positive difference means an increase in one-second forced expiratory volume over the course of a work-shift. Changes in FEV_1 over the course of a workshift, for possible occupational asthmatics and for normals, were in directions opposite to what would be hypothesized, if indeed those persons suspected to have possible asthma, actually had asthma.

Thus, we were unable to demonstrate through any objective data that our designation of asthma was medically valid. In the rest of this report, the symptoms that were tentatively diagnosed as asthma by the questionnaire criteria, will be referred to as lower respiratory symptoms (LRSx), for which the underlying pathophysiology is undetermined.

In the questionnaire interview, employees were asked to identify three specific jobs at work that caused their respiratory symptoms. Fourteen (93%) of the 15 people identified as having work-related lower respiratory symptoms (LRSx) identified jobs involving exposure to raw dust as the jobs during which their symptoms were "most likely to occur." (Table 12.) Overall, of the 45 possible responses, 27 (60%) were for jobs which entailed raw dust exposure.

Of the 15 lower respiratory symptoms (LRSx) cases, 9 were currently working in the shipping and receiving department, three were in processing, and three were maintenance workers. The three processing workers were all utility workers who associated the occurrence of their respiratory symptoms primarily with clean-up tasks. One processing utility worker said specifically that his respiratory symptoms occurred while "shoveling beans with high dust." Similarly, the three maintenance employees specifically reported raw dust exposure jobs as the primary tasks causing their respiratory symptoms.

Possible rhinitis

On the basis of their questionnaire responses, 17 of 48 employees were identified as having possible rhinitis. Of these, 12 met the criteria for being occupational rhinitis, and 5 were designated as non-occupational rhinitis. (Table 10.) There were no specific tests to validate the designation of possible rhinitis by the questionnaire criteria.

In the questionnaire interview, employees were asked to identify three specific jobs at work that caused their rhinitis symptoms. Ten (83%) of the 12 people identified as having possible occupational rhinitis identified jobs involving exposure to raw dust as the jobs during which their symptoms were "most likely to occur." (Table 13.) Overall, of the 36 possible responses, 25 (69%) were for jobs which entailed raw dust exposure.

Lower respiratory symptoms, and skin prick tests:

Thirty-one skin tests were applied to each of 49 participants, to detect immediate, IgE mediated allergy to 11 soybean fractions and products, 3 insects, 6 molds, 7 grains and grasses, and 2 other allergens. Those skin tests for which five or more study participants had positive reactions, were examined to determine if there was a relationship between work-related lower respiratory symptoms and allergy, as evidenced by positive skin prick tests.

Percent of positive skin test responses

Skin test substrate	Work-related lower respiratory tract symptoms? Yes	No
Aspiration baghouse dust	28.6	37.0
Truck dump dust	28.6	29.6
Head house dust, D-27	28.6	29.6
Hulls	21.4	14.8
Barge dust	7.1	18.5
Any soybean reaction	26.7	37.0
Mixed insects	28.6	22.2
Dust mites	28.6	25.9
Grain mites	14.3	11.1
Any insect reaction	33.3	33.3

For each skin prick test, the proportion of positive responses among participants with work-related lower respiratory tract symptoms, was less than or indistinguishably greater than the proportion among participants with no such symptoms. Furthermore, except for the one individual with significantly elevated serum total IgE levels, there were no positive RASTs for any soybean fraction or dust sample. Therefore, the data collected did not demonstrate that the work-related lower respiratory tract symptoms occurred on an allergic basis.

Rhinitis, and skin prick tests

The same analysis was repeated, to examine the relationship between work-related rhinitis, and allergy.

Percent of positive skin test responses

Skin test substrate	Work-related rhinitis? Yes	No
Aspiration baghouse dust	16.7	40.6
Truck dump dust	16.7	34.4
Head house dust, D-27	16.7	34.4
Hulls	8.0	21.9
Barge dust	16.7	15.6
Any soybean reaction	16.7	40.6
Mixed insects	16.7	28.1
Dust mites	8.3	31.3
Grain mites	0.0	15.6
Any insect reaction	25.0	37.5

Again, for each skin prick test, the proportion of positive responses among participants with work-related rhinitis was no greater than the proportion among non-cases. Furthermore, in addition to the one individual with significantly elevated serum total IgE levels, only one individual had a positive RAST for insect parts. Therefore, the data collected did not demonstrate that the work-related rhinitis symptoms were caused by allergic mechanisms.

We examined the acute effect of dust exposure on pulmonary function by comparing pre- and post-shift pulmonary function values among employees, categorized by dust exposure (raw, cleaner, extracted) according to the task they were performing during the day of interest. Only employees who spent the entire shift in one dust exposure category were so categorized. An individual who had spent half of his shift unloading a barge ("raw" dust exposure), and then half the shift loading meal trucks ("extracted" dust exposure) was not considered in the analysis of cross-shift FEV_1 changes, since he would have had a "mixed" exposure. An employee who had worked primarily as a prep operator ("cleaner" dust exposure), but spent one hour relieving the extraction operator ("no organic dust" exposure), was characterized as having "cleaner" dust exposure, since he was exposed to only one "type" of dust.

The pulmonary function change of primary interest in the analysis of acute effects is the cross-shift difference (or change) in the one-second forced expiratory volume (FEV_1), commonly examined as the percent of predicted FEV_1. For the total of 46 workers who participated in the cross-shift spirometery testing done on the first day back at work (after two days off), the mean FEV_1 percent predicted declined from 94.39 to 93.30, a mean cross-shift difference of 1.09 (Table 14). This decrease was statistically significant ($p=.03$).

In an attempt to examine the effects of the various dust categories (raw, cleaner, extracted), we looked at the workers who had performed tasks which exposed them to only one type of dust during their first day back at work. The 15 workers exposed only to raw soybean dust had a very small cross-shift increase (0.40) in the mean percent predicted FEV_1. The mean percent predicted FEV_1 declined cross-shift 1.67 for the 12 workers exposed only to cleaner dust, and 2.75 for the 4 workers exposed only to extracted dust. The mean respirable dust level was greater for the workers exposed to "raw" dust (0.25 mg/m^3) than for the workers exposed to "cleaner" or "extracted" dust (both 0.07 mg/m^3). This finding, namely, improved percent predicted FEV_1 among workers with higher respirable dust exposures, exposed primarily to "raw" dust, is contrary to what we would expect to observe, were the underlying pathophysiology of the symptoms experienced by workers due to asthma from occupational dust exposures. However, when the study participants are broken down into the three separate dust exposure types, the numbers become very small, and the mean differences in FEV_1 percent predicted values are therefore unstable estimates, easily influenced by one or two extreme values in any group. For example, when the extracted and cleaner dust categories were combined, there were changes in both the magnitude and the direction of the mean differences for FVC, FEV_1, and the FEV_1/FVC ratio. In addition, workers who wore respirators (especially cartridge respirators) would not presumably truly have been exposed to the measured dust level. All five participants who wore respiratory protection during the first day back at work were in the raw exposure category (4 workers wore single-use disposable respirators and one worker wore a cartridge respirator). When those 5 workers were not considered in the analysis, the mean increase in precent predicted FEV_1 for the "raw" exposure group was only 0.13. Therefore, it is difficult to ascribe with confidence any meaningful physiological interpretation to the results for the specific dust categories.

For analyses of chronic effects, we determined the <u>cumulative</u> amount of time that an employee had spent in each exposure setting (raw, cleaner, extracted, no organic dust). Most employees at Bunge had not changed departments frequently, but employees within one department may do a variety of tasks that expose them to raw or processed soybeans. Therefore, very detailed job histories were taken from employees. For example, for jobs in the shipping and receiving department, employees were asked what percentage of that time they spent doing unloading, loading or "other" operations.

For loading operations, they were asked what percentage of that time they spent loading meal, hulls, or oil. For "other" operations, they were asked to list every task they remembered performing (cleaning out the storage tanks, working in the head house, etc.) and the percentage of time they spent doing those tasks. Prep operators and utility people were asked to give similarly detailed histories. This information was used to calculate, for every job, the percentage of time spent in each exposure category.

From interviews with the maintenance employees and supervisors, a typical distribution of possible tasks was determined, and all time spent in maintenance jobs was assigned the following percentages for the various dust exposure categories: 5% raw; 5% cleaner; 3% extracted; 87% no organic dust exposure.

First day back-to-work, pre-shift, percent of predicted FVC (FVC%) and FEV_1 (FEV_1%), and FEV_1/FVC ratio, were examined in linear regression models, as functions of:

(1) pack years of smoking, years in shipping and receiving (department 1), years in process (department 2), and years in maintenance (department 3);
(2) pack years of smoking, years of exposure to "raw" dust, years of exposure to "extracted" dust, and years of exposure to "cleaner" dust;
(3) pack years of smoking, years of exposure to "raw" dust, and years of exposure to "extracted" and to "cleaner" dust combined.

Age and race were not included in the regression models, since the FVC and FEV_1 variables were expressed as percents of predicted for age, sex, and race.

In the first set of regression analyses, FVC% and FEV_1% both increased with years in maintenance, and were not correlated with any other variable when years in maintenance was in the regression model. FEV_1/FVC ratio was not significantly explained by any of the exposure variables. We hypothesized that the paradoxical improvement in pulmonary function, as evidenced by increasing FVC% and FEV_1% with years in maintenance, really reflected the converse, that is a decrease in pulmonary function associated with total duration in shipping and receiving, and process, combined.

In the second set of regression analyses, FEV_1% was borderline negatively correlated with pack years of smoking, while FVC% and FEV_1/FVC were not correlated with any of the independent variables. The same results were noted for the third set of regression analyses.

To follow-up on the hypothesis that the paradoxical "protective" effect of years in maintenance on FVC% and FEV_1% was merely the inverse of years in shipping and receiving, and process, we regressed FVC%, FEV_1%, and FEV_1/FVC on

(1) pack years of smoking, and total dust exposure; and

(2) pack years of smoking, and years in either shipping and receiving or in process, combined.

We found, in regard to the first set of regression analyses that FEV% was negatively related to pack years of smoking at a borderline significance level (Table 19). In regard to the second set of regression analyses (Tables 20 and 21), as we hypothesized, FVC% and FEV_1% were negatively related to years in shipping/receiving and process, although at borderline significance levels. The observed effects may be roughly interpreted as a 1 percent loss in FVC and FEV_1, in excess of that predicted for age, sex, and race, for each year of work in shipping/receiving or in process, combined. When years of work in these departments were entered in the analysis, pack years of smoking did not significantly explain any additional amount of variation in lung function.

CASE DESCRIPTIONS

Twelve people reported having been awakened from sleep by respiratory symptoms consistent with nocturnal asthma, that is, delayed onset asthmatic reactions. Case descriptions for the eight who reported this occuring more than twice are given below. Five of these men had work-related lower respiratory symptoms. Two had lower respiratory symptoms exacerbated by work. Another reported that his acute respiratory symptoms were only work-related, but he did not meet the criteria for lower respiratory symptoms.

1. This non-smoking shipping and receiving worker reported that he always experienced wheezing and shortness of breath after working in a bean barge, if he did not wear a dust mask. He had experienced at least five episodes of being awakened from sleep by these symptoms, after working in a barge. By the questionnaire criteria, he was classified as having work-related lower respiratory symptoms. He also reported in his medical interview that his eyes became "red and watery" when he worked with raw beans, although he did not meet the criteria for rhinitis. On the last day of the survey, when he came for his post-shift PFTs, the medical officer observed him

to have bilateral conjunctival inflammation (red eyes), with redness and swelling around his eyes. She also noted that he had audible wheezing and was coughing frequently, although he did not spontaneously complain of respiratory symptoms. He reported that he had been driving the bobcat during clean-out of a
barge. Although his pulmonary function tests were within normal limits for epidemiological purposes, his FEV_1 was 85% of predicted. His peak expiratory flow data did not demonstrate respiratory tract lability characteristic of asthma.

2. This shipping and receiving worker was noted by the medical officer to have bilateral conjunctival inflammation and periorbital redness and swelling when he came for post-shift pulmonary function tests after working in a barge. He reported that his eyes felt burning and scratchy. He met questionnaire criteria for work-related lower respiratory symptoms and work-related rhinitis. He was a cigarette-smoker with normal pulmonary function tests. He did not return his peak flow records for evaluation.

3. This shipping and receiving worker reported shortness of breath, chest tightness, and cough, and reported that he had been awakened from sleep with these symptoms approximately twice a month for the last five years. He associated these symptoms with working in barges, especially with new soybeans in autumn. He met questionnaire criteria for work-related lower respiratory symptoms and work-related rhinitis. He was a cigarette-smoker with normal pulmonary function tests. He did not return his peak flow records for evaluation.

4. This maintenance worker reported chest tightness and cough whenever he was around "irritating unprocessed bean dust," noting the Head House especially. He reported having been awakened from sleep by these symptoms at least twice a year since he started working at Bunge. He was a non-smoker, who met the criteria for work-related lower respiratory symptoms. He did not do the pulmonary function tests or peak flow measurements.

5. This shipping and receiving worker reported wheezing, shortness of breath and chest tightness, that had awakened him from sleep approximately three times a month for the last three years. He reported that raw soybeans were the only thing that caused his problems. He had abnormal FEV_1 and FVC values (less than 80% predicted) and normal peak flow measurements. He was a former cigarette smoker, who met the criteria for work-related lower respiratory symptoms.

6. and 7. Two men with histories of childhood asthma reported both work-related and non-work-related factors causing their acute respiratory symptoms, which awakened them from sleep intermittently. They were classified as non-work-related lower respiratory symptoms. They had normal pulmonary function tests.

8. This maintenance worker reported shortness of breath and cough, that had awakened him from sleep approximately four times a year since starting to work at Bunge. He associated these symptoms with grinding flaking rolls and working on the drags in the Head House. He did not meet the criteria for asthma, but was classified as having work-related rhinitis. He was a cigarette smoker, with normal pulmonary function tests and peak flow records.

FAMILIAL REPORTS

During the questionnaire interview, each employee was asked "Does anyone living in the same house with you have health problems you think may be related to dust you bring home from work?" Thirteen of the fifty participants (26%) described a family member's health complaints, that they thought were related to soybean dust carried home on work clothes and/or boots. Workers reported wives and/or children having experienced the following symptoms (with the frequency in parentheses): asthma (1), eye irritation (2), nasal symptoms such as sneezing or runny nose (5), sinus problem (1), skin rash (5). The largest number of employees reporting familial symptoms were from shipping and receiving (8 workers); four were from maintenance and one was from processing.

VII. CONCLUSIONS

The industrial hygiene monitoring results show that exposures to soybean dusts above the OSHA PEL and the ACGIH TWA-TLV are possible in a number of jobs, particularly working inside bean barges, loading railcars with meal, and utility cleanup jobs. Other jobs with potential for high exposure are unloading railcars and trucks in the receiving area of the head house, and loading meal trucks in the meal house. The medical survey results demonstrated a high prevalence of work-related acute lower respiratory symptoms, and for the group as a whole, there was a small but significant (1.09%) cross-shift decline in FEV_1 during the first day back at work. The peak flow meter and spirometry data did not support the designation of asthma by questionnaire criteria. However, it is well-known that cross-shift spirometric pulmonary function tests may fail to identify occupational asthma cases, depending on the time of onset of the asthmatic reaction. As noted in a recent review of occupational asthma by Moira Chan-Yeung, M.D.[12], "Measurement of change in spirometry over 1 work shift, if positive, is good evidence of work-relatedness. It is not a test on which to exclude work-related asthma."

Similarly, there are limitations to the interpretability of the peak expiratory flow rate (PEFR) measurements performed during this study. P. Sherwood Burge, M.D., a leading proponent of the use of individual portable peak flow meter testing, seriously cautions over-interpreting negative results from PEFR testing performed over the short time period used in this study[13]. Dr. Burge recommends that the peak expiratory flow rate record should be kept for at least a week at work followed by two weeks away from work, followed by another two weeks at work. This prolonged record may be necessary in order to allow enough time away from possible work-related asthma-causing agents for an individual to regain maximal respiratory function, and then be able to see a pattern of decline in function when the person returns to work. Clearly, it was not possible to arrange for employees to be away from work for two weeks, for a study such as this. As with the cross-shift PFT results, the lack of strongly positive results in the one week of PEFR testing (that was done in this study as a screening approach), cannot be interpreted as excluding the possibiliby of work-related asthma associated with soybean dust exposure.

There was clearly a high prevalence of acute respiratory and rhinitis symptoms among Bunge employees, and the overwhelming majority of the jobs reported "most likely" to cause these symptoms involved exposure to raw soybean dust. Since raw dust exposure jobs at Bunge tend to be higher dust exposure jobs, one can only hypothesize regarding the relative importance of the quantitative level of dust versus qualitative characteristics of raw soybean dust. In studies of grain workers, NIOSH researchers[6] and others[14] have observed dose-related acute adverse effects, mostly respiratory, among workers whose total dust exposures were below 5 mg/m3.

From the multiple regression statistical models, there is a suggestion of an association between years of employment in shipping/receiving and processing and a chronic effect on depression of FEV_1 and FVC. Berry[15] estimates that for a cross-sectional study such as this with a mean exposure time of 8 years, it would require 68 subjects in the study group and a control group to detect a difference of 0.03 liter per year in FEV_1 (with a significance level of 0.05 and power 0.8). The fact that borderline significant declines in FEV_1 and FVC were found in a study group as small as this one suggests that there is a true adverse chronic pulmonary effect from soybean dust exposure. It has been shown in studies of coffee workers[16] and tea workers[17] that exposure to organic dust at relatively low respirable levels similar to this study can result in impaired pulmonary function and increased prevalence of chronic respiratory symptoms.

As noted in the "Environmental Criteria" section, it is certainly biologically plausible that soybeans or contaminants in the raw soybean dust could cause respiratory and rhinitis symptoms. It is not yet clearly understood whether organic vegetable dusts induce respiratory and mucosal reactions by chemical, mechanical, or allergic mechanisms. Since the skin testing in this study demonstrated that this group of workers is not atopic, evidence of acute or chronic responses to occupational exposures at Bunge cannot be attributed to predisposing allergic tendencies among the employees. Also, there was no distinguishable pattern of skin test or RAST reactivity in symptomatic compared to asymptomatic workers. Therefore, possible occupational lower respiratory symptoms and rhinitis were not demonstrated in this study to have occurred on the basis of allergic mechanisms.

It is also unclear which component(s) of the dust from commodities such as soybeans and grain may be responsible for adverse health effects. It is reasonable to anticipate that soybean dust, like other grain dust, will be shown to be a complex misture, consisting of particles of various other types of grain, fungal spores, insect parts, pollens, animal hair, and numerous agricultural chemicals at various stages of degradation. These consistuent contaminants all have their own irritant and/or allergic potential.

Until the role of soybean dust exposure in contributing to chronic or acute respiratory disease is further clarified, it would be prudent to minimize employees' exposure to soybean dust. The use of ventilation in enclosed areas, such as the rail and truck receiving areas and the truck and rail loadout areas, should be studied. It may be possible to use localized ventilation at the receiving stations where the soybeans are dumped. Ventilated enclosed control rooms are feasible for the meal loadout areas. The rail loadout would require automation of the loading chute, so that it would not have to be moved manually. The truck loadout is already controlled from a room which is not ventilated. The current practice at Bunge is to remove (partially) two covers from barges prior to unloading the soybeans. Instead, four covers should be removed completely, in order to decrease the amount of dust trapped inside the barges.

While engineering controls are being instituted, personal respiratory protection should be worn by employees in all raw dust exposure jobs. In addition, respirators should be worn when performing high dust exposure jobs in the prep building, such as clean-up on the first floor and clean-up or maintenance of the cracking rolls.

VIII. RECOMMENDATIONS

1. Engineering controls should be installed in the soybean receiving areas and the soybean meal shipping areas. Local exhaust ventilation would be effective at the soybean dumping stations in receiving. Enclosing the truck and railcar loadout operators in ventilated, glass enclosures is feasible in the meal house. Instead of removing two barge covers partially, four covers should be removed completely prior to unloading. These and other methods to control dust should be investigated.

2. A respiratory protection program should be established in accordance with the OSHA General Industry Standard, section 1910.134. Workers should be provided respirators equipped with dust cartridges in place of the single-use disposable respirators currently used. Powered air-purifying respirators may be an alternative which should be considered. These tend to be more comfortable and also provide eye and face protection. Workers in jobs which require respiratory protection should not have beards.

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TABLE 1

Raw Soybean Dust
Total Dust Personal Exposure Results
Bunge Corporation
Decatur, Alabama
March 3-6, 1985

HETA 84-477

Area	Job	n	Avg Sample Volume (m^3)	Concentration, mg/m^3 Range	Mean
Head House	Control Room	4	1.02	0.37-0.89	0.56
	Dryer	5	1.42	0.16-3.22	1.61
	Receiving	2	1.03	1.39-2.32	1.86
	Utility (cleanup)	2	1.04	14.7-22.6	18.6
Harbor	Bean Barge				
	-Dockside	10	1.06	0.60-3.70	1.63
	-In Barge	7	1.06	1.03-14.2	7.80
	-All	17	1.06	0.60-14.2	4.17
Maintenance	Prep/1st Floor	2	1.10	0.67-3.34	2.00
Process/Prep	Utility (cleanup)	2	1.05	0.41-0.46	0.44
All Samples		34		0.16-22.6	3.73

TABLE 2

Raw Soybean Dust
Respirable Dust Personal Exposure Results
Bunge Corporation
Decatur, Alabama
March 3-6, 1985

HETA 84-477

Area	Job	n	Avg Sample Volume (m^3)	Concentration, mg/m^3	
				Range	Mean
Head House	Control Room	4	0.86	0.03-0.26	0.13
	Dryer	5	1.23	0.03-0.23	0.13
	Receiving	2	0.88	0.10-0.25	0.18
	Utility(cleanup)	2	0.89	0.20-0.64	0.42
Harbor	Bean Barge				
	-Dockside	10	0.90	0.02-0.64	0.20
	-In Barge	8	0.78	0.17-1.02	0.45
	-All	18	0.85	0.02-1.02	0.31
Maintenance	Prep/1st Floor	2	0.94	0.02-0.67	0.34
Process/Prep	Utility (cleanup)	2	0.90	0.09-0.20	0.14
All Samples		35		0.02-1.02	0.26

TABLE 3

Cleaner Soybean Dust
Total Dust Personal Exposure Results
Bunge Corporation
Decatur, Alabama
March 3-6, 1985

HETA 84-477

Area	Job	n	Avg Sample Volume (m^3)	Concentration, mg/m^3	
				Range	Mean
Process/Prep	Operator	3	1.41	0.18-0.47	0.32
	Utility	5	1.18	0.24-0.66	0.48
	Rover	2	1.48	0.32-0.60	0.46
Maintenance	Prep/2nd Floor	3	1.09	0.52-0.72	0.64
All Samples		13		0.18-0.72	0.48

TABLE 4

Cleaner Soybean Dust
Respirable Dust Personal Exposure Results
Bunge Corporation
Decatur, Alabama
March 3-6, 1985

HETA 84-477

Area	Job	n	Avg Sample Volume (m^3)	Concentration, mg/m^3	
				Range	Mean
Process	Operator	3	1.23	0.02-0.15	0.09
	Utility	5	1.04	0.01-0.15	0.08
	Rover	2	1.25	0.04-0.08	0.06
Maintenance	Prep/2nd Floor	3	0.93	0.07-0.09	0.08
All Samples		13		0.01-0.15	0.08

TABLE 5

Extracted Soybean Dust
Total Dust Personal Exposure Results
Bunge Corporation
Decatur, Alabama
March 3-6, 1985

HETA 84-477

Area	Job	n	Avg Sample Volume (m^3)	Concentration, mg/m^3 Range	Mean
Meal House	Control Room	5	1.06	0.55-0.94	0.71
	Load Railcar	7	1.06	0.18-15.0	3.55
	Load Truck	1	1.02	-----	1.25
All Samples		13		0.18-15.0	2.28

TABLE 6

Extracted Soybean Dust
Respirable Dust Personal Exposure Results
Bunge Corporation
Decatur, Alabama
March 3-6, 1985

HETA 84-477

Area	Job	n	Avg Sample Volume (m^3)	Concentration, mg/m^3 Range	Mean
Meal House	Control Room	5	0.91	0.02-0.21	0.11
	Load Railcar	7	0.89	0.02-0.38	0.11
	Load Truck	1	0.90	-----	0.08
All Samples		13		0.02-0.38	0.11

TABLE 7

Mixed Soybean Dust
Total Dust Personal Exposure Results
Bunge Corporation
Decatur, Alabama
March 3-6, 1985

HETA 84-477

Assigned Area	Job Primary/Secondary	Hours Pri/Sec	Sample Volume (m^3)	Concentration (mg/m^3)
Harbor	Bean Barge/Meal House	6/2	1.03	0.76
Meal House	Control Room/Bean Barge	7/1	1.09	4.16
	Load Truck/Bean Barge	4/4	1.09	16.2
	Load Rail Car/Bean Barge	7/1	0.96	2.67
	Load Rail Car/Bean Barge	4/4	1.05	4.41
	Load Rail Car/Bean Barge	7/1	1.06	1.39
All Samples				5.77

TABLE 8

Mixed Soybean Dust
Respirable Dust Personal Exposure Results
Bunge Corporation
Decatur, Alabama
March 3-6, 1985

HETA 84-477

Assigned Area	Job Primary/Secondary	Hours Pri/Sec	Sample Volume (m^3)	Concentration (mg/m^3)
Harbor	Bean Barge/Meal House	6/2	0.88	0.06
Meal House	Control Room/Bean Barge	7/1	0.93	0.27
	Load Truck/Bean Barge	4/4	0.93	0.47
	Load Rail Car/Bean Barge	7/1	0.81	0.25
	Load Rail Car/Bean Barge	4/4	0.90	0.17
	Load Rail Car/Bean Barge	7/1	0.90	0.11
	Load Rail Car/Bean Barge	5/3	0.92	0.12
All Samples				0.23

Table 9

Number of Positive Reactions			SKIN PRICK TESTS and RAST TESTS
Skin Tests	RASTS		Material Tested
49			Histamine (positive control)
0			Saline (negative control)
15	1	**	Cracker aspiration baghouse: Soybeans and dust from the cracker aspiration baghouse. Beans have come from the dryer to a conveyor that feeds the cracking rolls and have not yet been de-hulled.
13	1	**	Truck dump dust: Mainly dust (not beans) scooped up from around truck dump area (i.e., dust from raw soybeans).
13	1	**	Head house, D-27: Collected directly from the floor beneath the D27 transfer belt to storage. Combined raw soybeans and dust from barges, railcars, trucks and storage tanks. Collected material was a maximum of three days old.
8	1	**	Hulls: Finished product collected directly out of hatch of barge being loaded.
7	1	**	Barge Dust: Mainly dust (not beans) scooped out of indentation in floor of barge being unloaded (i.e., dust from raw soybeans).
4			Soybean sample P-30: De-hulled, cracked beans taken from the P-30 "leg". (The main difference between this sample and sample P-21 is that these are beans that have been de-hulled. Both samples should contain mainly the raw soybeans and its different physical states (whole and cracked beans) rather than a significant amount of dirt and other foreign material.
2			Soy meal: Soy meal (final product) taken from sample bucket under dispensing tube from the automatic sampler in the truck loading operator's house.
1			Soybean sample P-21: Soybeans taken from the P-21 "cracked bean leg," which conveys beans that have been stored in the Head House, dried (possibly more than once), scalped, cracked, but not de-hulled.
1	1	**	Soybean pods: Sample of mainly soybean pods, taken from the corner of the floor of a barge being unloaded.
1	1	**	Soybeans from half-full barge: Sample of mainly raw soybeans (i.e., not with dust, debris, pods, etc.), from barge being unloaded.
1	1	**	Commercial soybean: Commercially available allergy test.

(Continued)

Table 9 (continued)

Number of Positive Reactions			SKIN PRICK TESTS and RAST TESTS
Skin Tests	RAST Tests		Material Tested
11			Mixed insects
11	2	**	Dust mites
5			Grain mites
4			Penicillum
1			Cladosporium
1			Alternaria
1			Aspergillis
0			Fusarium
0			Cephasporium
2			Grass
2			Corn
2			Pyrethrum
2			Ragweed
2			Wheat
1			Barley
0			Oat
1			Cat
1			Rat urine
	2		House dust (RAST only; no skin prick test)

** RAST test also performed.

One participant had all the positive RAST tests to soybean products, plus an extreme elevation of serum total IgE, and a positive skin test response to Aspergillus. The diagnosis of chronic pulmonary aspergillosis, a disease which may or may not be work-related in a given individual, was considered. He was instructed to seek consultation with a private physician. The positive RAST and skin tests could be due to non-specific binding of IgE, not allergy to soybean products.

Table 10

No.	Doctor's Diagnosis	Doctor's Diagnosis	Atopy?	PEFR Variability	Skin Tests Insects	Skin Tests Soybeans	Total IgE	RAST Test
1				2.8 - 8.9	+	+		
2				2.6 - 9.4		+		
3	Bronchitis*			5.8 -18.1				
4	Occ-As	Occ-Rh						
5				1.5 - 6.2				
6		Occ-Rh		1.4 - 8.4				
7								
8	*			1.5 - 3.1				
9	Occ-As			0 - 6.5	+	+		
10	Occ-As	Occ-Rh						
11								
12	Occ-As			1.8 - 3.7				
13	Occ-As	Occ-Rh	Yes	1.7 -13.1	+	+	+++	+(8 soy)
14								
15				2.1 - 4.3		+		
16	Occ-As							
17	N-Occ-As	N-Occ-Rh						
18				0 - 5.5	+	+		
19				3.0 - 5.2	+	+	+	
20		Occ-Rh		2.5 - 4.9				
21	Occ-As							
22	Occ-As				+			
23				2.2 - 3.7**				
24		N-Occ-Rh		5.2 -11.9	+	+		
25	Occ-As			2.0 - 5.8				

(continued)

* Interviewed in March, 1985. Excluded from "possible asthma" and "possible rhinitis" evaluations.
** One aberrant PEFR determination excluded from analysis.
<u>Atopy</u>: A person was defined as atopic if he had a positive skin test to one of the following three common aero-allergens: grass, ragweed, or cat.

Table 10 (continued)

No.	Doctor's Diagnosis	Doctor's Diagnosis	Atopy?	PEFR Variability	Skin Tests Insects	Skin Tests Soybeans	Total IgE	RAST Test
26	Occ-As			4.4 -21.2				
27				3.0 - 4.6		+		
28	Occ-As			3.3 - 8.3	+			
29								
30				6.8 -16.8				
31					+	+		
32	N-Occ-As	N-Occ-Rh						
33	N-Occ-As			1.7 -10.7				
34	Occ-As	Occ-Rh		3.5 -15.1				
35	Occ-As	Occ-Rh		3.2 -10.3				
36		N-Occ-Rh						
37				4.0 - 15.0				
38	N-Occ-As							
39				0 - 5.1				
40			Yes		+	+	+	+(2)
41		Occ-Rh		3.1 -14.0				
42				1.3 - 5.4	+	+		
43	Occ-As			2.9 - 7.1	+	+		
44	N-Occ-As	Occ-Rh		2.6 - 5.2				
45	Occ-As	N-Occ-Rh			---------no data---------			
46	N-Occ-As	Occ-Rh						
47		Occ-Rh	Yes	10.0 -28.1	+			
48				2.9 - 2.9	+	+		
49	N-Occ-As	Occ-Rh		1.4 - 13.6				
50					+	+	+	

Atopy: A person was defined as atopic if he had a positive skin test to one of the following three common aero-allergens: grass, ragweed, or cat.

Table 11

Work-related Lower Resp. Tract Symptoms	Number	Mean Difference in Percent of Predicted FEV_1, Post-Shift minus Pre-Shift
Yes	14	0.79%
No	24	-2.00%

Table 12

TASKS TO WHICH WORK-RELATED LOWER RESPIRATORY TRACT SYMPTOMS (LRSx) CASES ATTRIBUTED THEIR SYMPTOMS

	Task 1		Task 2		Task 3	
ID #	Dust Category	Job	Dust Category	Job	Dust Category	Job
4	R	unload bean barge	R	unload railcars	E	load railcars
9	R	unload bean barge	R	Head house		no response
10	R	unload bean barge	R	pull beans from tank	E	load rail with meal
12	R	clean-up	O	clay tank	O	extraction
13	R	Head house	R	unload rail & barge	R	unload rail & barge
16	R	Head house	O	boiler room chemical		no response
21	R	Head house	R	raw bean dust		no response
22	R	Head house	E	meal house	C	prep house
25	R	unload bean barge	E	load rail	E	load meal
26	R	unload rail	R	sweep tunnel	E	load railcars
28	R	unload bean barge	R	unload rail	R	unload truck
34	E	load rail	E	load truck	R	unload barge
35	R	shoveling beans	R	clean-up	C	prep building
43	R	clean-up in prep	O	clay tank	C	clean-up 3rd floor prep
45	R	pull beans-tunnel	R	Head house	R	unload barge

R = Raw dust exposure
E = Extracted dust exposure
C = Cleaner dust exposure
O = Other

Table 13

TASKS TO WHICH "PROBABLE OCCUPATIONAL RHINITIS" CASES ATTRIBUTED THEIR SYMPTOMS

	Task 1		Task 2		Task 3	
ID #	Dust Category	Job	Dust Category	Job	Dust Category	Job
4	R	unload bean barge	R	unload railcar	E	load railcar
6	R	unload bean barge	R	unload railcar	R	unload trucks
10	R	unload barge & rail	R	pull beans-tunnel	E	load barge & rail
13	R	unload bean barge	R	clean out dryers	E	loading meal
20	O	grindingflakingrolls	R	drags in Head House	E	drags in meal house
34	E	load railcars	E	load trucks	R	unload barge
35	R	shoveling beans	R	clean-up	C	prep building
41	R	unload bean barge	R	work in baghouse	R	clean-up
44	R	blowing dust	R	measurestoragebins	R	pull samplesfromdryer
46	R	unload barge	R	unload railcar	R	unload truck
47	R	unload barge	E	load rail	E	load truck
49	R	cracking roll dust	E	meal dust	R	clean-up

R = Raw dust exposure
E = Extracted dust exposure
C = Cleaner dust exposure
O = Other

Table 14

Changes is Cross-shift Spirometry, on First Day Back at Work

Category (N)	Change in Percent of Predicted FVC	Change in Percent of Predicted FEV_1	Change in FEV_1/FVC Ratio	Mean Respirable Dust Level on First Day Back
Total Group (46 workers)	-0.04	-1.09	-0.01	---
Raw Dust Exposure (15 workers)	+1.60	+0.40	-0.01	0.25 mg/m^3
Cleaner Dust Exposure (12 workers)	+0.08	-1.67	-0.01	0.07 mg/m^3
Extracted Dust Exposure (4 workers)	-3.25	-2.75	+0.01	0.07 mg/m^3
Cleaner and Extracted Dust Exposure Categories Combined (16 workers)	-0.75	-1.94	-0.01	0.07 mg/m^3

Table 15

Stepwise Regression of Day 1 Pre-Shift FEV_1 percent predicted on Pack-years of smoking and Total Dust Exposure

Parameter	Regression Coefficient	P-value	Model R^2
Intercept	97.26		0.061
Pack-Years	-0.245	0.0990	

Total Dust did not meet the 0.15 significance level for entry into the model

Table 16

Stepwise Regression of Day 1 Pre-Shift FVC Percent Predicted on Pack-years of smoking and Duration of work in Departments 1 and 2 (Duration)

Parameter	Regression Coefficient	P-value	Model R^2
Intercept	101.69		0.078
Duration	-0.949	0.0603	

Pack-Years did not meet the 0.15 significance level for entry into the model

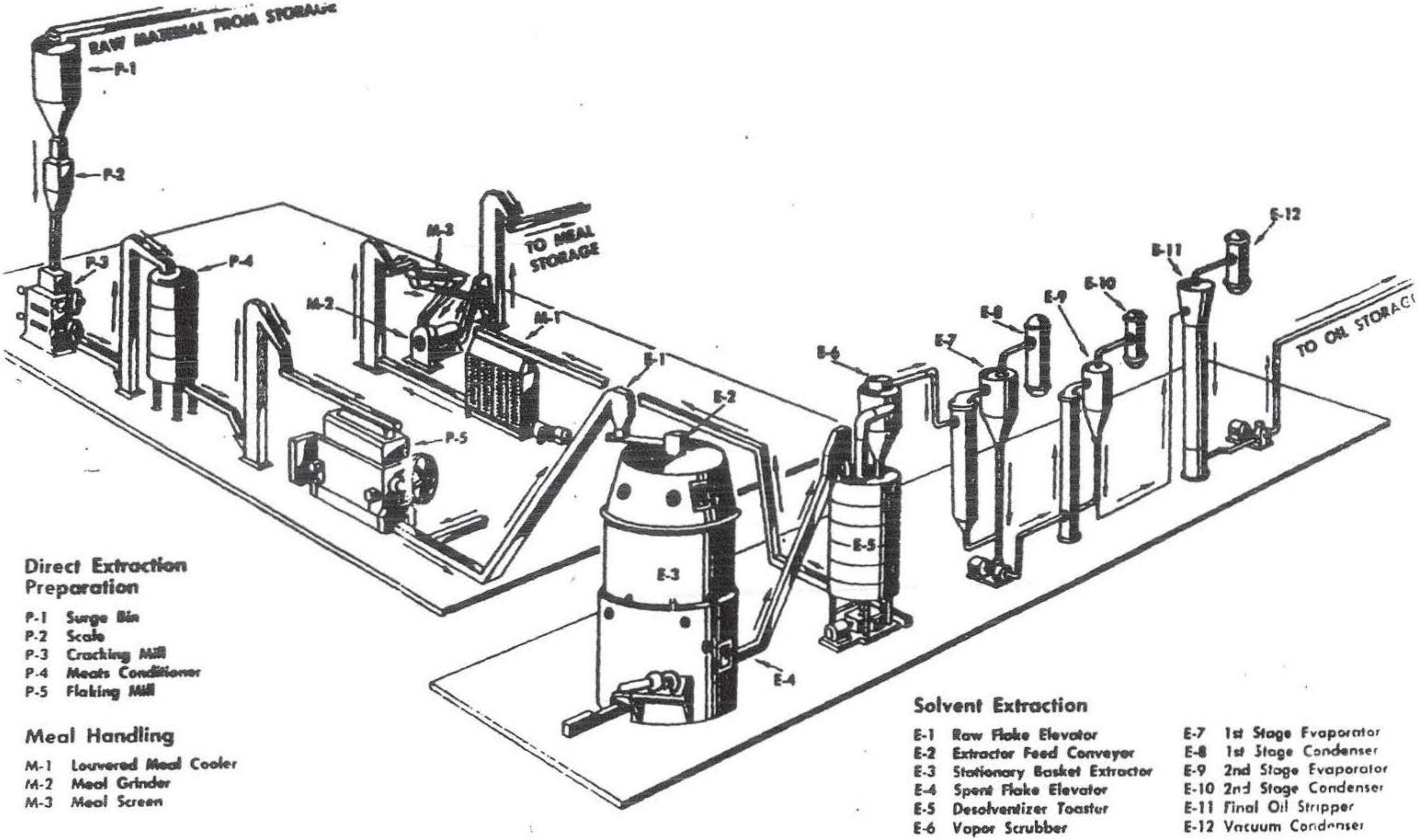
Table 17

Stepwise Regression of Day 1 Pre-Shift FEV_1 Percent Predicted on Pack-years of smoking and Duration of work in Departments 1 and 2 (Duration)

Parameter	Regression Coefficient	P-value	Model R^2
Intercept	101.59		0.074
Duration	-1.038	0.0665	

Pack-Years did not meet the 0.15 significance level for entry into the model

Figure 1



Typical Soybean Processing Diagram