U.S. Department of Health, Education, and Welfare
Center for Disease Control
National Institute for Occupational Safety and Health
Cincinnati, Ohio 45202

Health Hazard Evaluation Determination
Report No. 75-104-325

Olin Corporation
Pisgah Forest, North Carolina

August 1976

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## I. TOXICITY DETERMINATION

On April 5, 1976, an environmental survey was performed in the Fiber Cutting Department and in the digester feeding area of the Digesting Department to evaluate airborne concentrations of flax dust to which workers were exposed. A concurrent medical survey was conducted of the employees of the same two areas to evaluate any adverse health effects of exposure to flax dust. On the basis of this environmental/medical survey it has been determined that the airborne concentrations of flax dust which existed at that time would, without respiratory protection, be toxic to the employees of the Fiber Cutting Department.

Recommendations are offered in this report for control of airborne flax exposures and for medical surveillance of the exposed employees.

## II. DISTRIBUTION AND AVAILABILITY OF DETERMINATION REPORT

Copies of this Determination Report are available upon request from NIOSH, Division of Technical Services, Information Resources and Dissemination Section, 4676 Columbia Parkway, Cincinnati, Ohio 45226. Copies have been sent to:

A. Olin Corporation, Pisgah Forest, North Carolina
B. Authorized Representative of Employees
C. U.S. Department of Labor, OSHA, Region IV
D. NIOSH, Region IV
E. North Carolina Department of Human Resources

For purposes of informing the approximately fifty "affected employees", the employer will promptly "post" the Determination Report in a prominent place near where affected employees work for a period of 30 calendar days.

## III. INTRODUCTION

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

The National Institute for Occupational Safety and Health (NIOSH) received such a request from an authorized representative of employees, of the

United Paperworkers International Union, regarding the exposure of employees to airborne flax dust in the Fiber Cutting Department of the Ecusta Paper Division of the Olin Corporation in Pisgah Forest, North Carolina. The request from the union stated that some of the exposed workers were experiencing chest pain and difficulty in breathing.

## IV. HEALTH HAZARD EVALUATION

### A. Plant Process - Conditions of Use

The troublesome agent is retted flax of foreign origin. This flax arrives at the plant in bales by boxcar, truck, and Seatrain containers. Bales of flax are brought into the Fiber Cutting Department by a forklift truck and placed at any of three stations. The bales are pulled apart manually by the crewmen, and the flax is fed into an enclosed chopper house where the fibers are automatically cut to appropriate lengths. The chopped flax is conveyed in a closed conveyor to a baler machine which rebales the flax. These bales are then conveyed to the Digesting Department.

In the Digesting Department the bales are conveyed past the line of digesters where they can be diverted into the tops of the digesting vats. The loading of the digestors is about the only point in the operation where the Digesting Department employees have any potential for appreciable airborne flax dust exposure.

The Fiber Cutting Department has only been in operation since February of 1975. Prior to that time, U.S.A.-grown flax, pre-treated at a plant in South Dakota, was used exclusively.

### B. Evaluation Design and Methods

#### 1. Initial Survey (May 19 and 20, 1975)

##### a. Environmental Investigation

During the initial survey, the NIOSH industrial hygienists addressed themselves to the problem of identifying any toxic substances to which the employees might be exposed. Bulk samples of a domestic flax and several varieties of foreign flax were collected and shipped to the NIOSH laboratory at Salt Lake City, Utah, for analysis. Analyses of these samples for a number of organophosphorus pesticides revealed only trace amounts of malathion. Analysis for metals revealed no hygienically significant differences between the various flaxes in their content of cadmium, arsenic, lead, and zinc.

A sealed seatrain container and a sealed railroad box car were opened so that the air could be sampled for fumigants. Colorimetric gas detector tubes for arsine and phosphine failed to detect any of these substances. Air was also drawn through tubes of activated charcoal and silica gel to collect vapors of methyl bromide and ethyl bromide. These tubes were shipped to the NIOSH Salt Lake City laboratories, but analyses revealed only very small quantities of methyl bromide.

Samples for airborne pesticides and dust were collected both in the transportation containers and at the employee work stations in the

Fiber Cutting Department. These samplers consisted of a glass fiber filter backed up by a midget impinger containing pesticide grade ethylene glycol through which air was sampled at a rate of one liter per minute by a battery-operated MSA Model G pump. These samples revealed only minute quantities of malathion.

The initial environmental survey failed to identify any toxic material, other than flax dust, to be present in sufficient quantity to produce acute, adverse health effects,

b. Medical Investigation

During the initial survey, the NIOSH medical officers attempted to interview privately all employees in the Fiber Cutting Department on three consecutive work shifts; approximately 12 persons per shift worked in this department at that time. Of the 32 persons interviewed, 13 had no complaints working with the flax, some having worked for much of the time this department has been operating. Eight workers had complaints which were primarily chest tightness, difficulty in breathing, and coughing; these symptoms diminished when the employees were out of the area or when there was "less dust". Another 10 employees had problems when they were initially employed in the department. These workers experienced eye irritation, coughing, hoarseness, and sinus problems which diminished for some of the employees as they worked longer in the area. One worker complained of wheezing at night when working with flax.

Chest x-rays and medical records of some of the department employees were reviewed with Dr. Ryan, the plant physician. Those x-rays which were reviewed provided no definitive evidence of pulmonary effects. There were two cases where blood counts showed elevated levels of eosinophiles, a particular type of white blood cell. Eosinophiles are often related to allergic reactions or parasitic infections. Elevated levels of eosinophiles are strongly suggestive of an allergic reaction to something; however, it could not be concluded at the time that the two cases of eosinophilia were ascribable to flax.

The employee symptoms were primarily respiratory difficulties and were suggestive of flax dust as the causative agent.

2. Follow-Up Survey (April 4 - 6, 1976)

a. Environmental

Air sampling was performed on the three consecutive work shifts immediately following the weekend shutdown. Each employee of the Fiber Cutting Department and of the digester feeding area of the Digesting Department wore two personal air samplers - one to measure the total amount of airborne dust and the other to measure only the respirable portion of the dust.

The total dust was measured by drawing air at a rate of 1.7 liters per minute (lpm) through a preweighed polyvinyl chloride filter. The amount of collected dust was determined gravimetrically (by weighing). The respirable dust was measured by drawing air at 1.7 lpm first through a 10-mm nylon cyclone to remove the larger, non-respirable particles prior to the collection of the respirable particles on a filter for gravimetric analysis. General room air samples for respirable dust were also collected near the operations using the cotton dust vertical elutriators.[1] Collected dust was also measured by weighing.

b. Medical

Medical tests were performed on three consecutive shifts of workers on a Monday as they returned to work from a 48-hour weekend away from the job. Medical tests were performed on the same flax-exposed workers on the same day as the environmental sampling which was previously described. Thirty-one flax-exposed workers were tested. A similar control group of forty-seven workers from office areas without flax exposure was also given the same tests. These controls were matched as closely as possible with the exposed group for age and smoking history. Adjustments were made to the lung function measurements to account for normal variances between white and black workers.

Since the possibility of byssinosis (brown-lung disease) existed in the workers with a high exposure to flax dust, the medical tests concentrated on respiratory symptoms and pulmonary (lung) function studies. Pulmonary function studies primarily consisted of air spirometry performed on an OHIO 800 waterless spirometer subjecting each worker to five FVC (forced vital capacity) maneuvers. Pulmonary function tests were administered to each worker of the Fiber Cutting Department both before and after the work shift. Employees of the digester feeding area were given only one pulmonary function test sometime during the work shift. All workers were also administered a questionnaire modeled after the respiratory questionnaire shown in the NIOSH criteria document for cotton dust.[1]

C. Evaluation Criteria

Flax, like cotton, is a fibrous vegetable material. When particles of flax become airborne and are inhaled, the particles can produce respiratory irritation and impairment. Flax is known to be capable of producing byssinosis (commonly known as brown-lung disease, Monday fever, or cotton-mill fever). Byssinosis is a syndrome characterized by dyspnea (difficulty in breathing) of gradual onset on the first working days after leave of absence from work in workers exposed to certain vegetable fibers. The dyspnea may be accompanied by cough and tightness in the chest. These symptoms are usually more severe on Mondays and after holidays.[2] In the early stages of the development of byssinosis, the symptoms usually diminish as the week progresses. Later in the course of the disease, the dyspnea is experienced during the entire work week. After many years of exposure, chronic breathing difficulty may develop, with clinical findings indistinguishable from chronic pulmonary insufficiency from other causes. In advanced stages of byssinosis, the victim may suffer from asthma, chronic bronchitis, emphysema, or cardiac insufficiency.[3]

Although detailed results of respiratory function studies have been reported in cotton workers' byssinosis, few data are available on flax workers.[2] Even where rather lengthy and detailed medical data exist, environmental characterization has been inadequate to attempt to establish a dose-response curve from which an exposure standard might be recommended.[4]

1. Environmental Criteria

Werner[3] suggests an exposure limit of 1 $mg/m^3$ (milligram of dust per cubic meter of air) for textile vegetable fibers. This is the same value as the present OSHA standard for raw cotton dust[5] and applies to total airborne dust. In its criteria document for cotton dust[1], NIOSH recommends that the room air concentration of cotton dust, as measured by a cotton dust vertical elutriator, be maintained lower than 0.2 $mg/m^3$ of respirable dust. Both of these levels could be used as guidelines for control of airborne concentrations of flax dust - 1 $mg/m^3$ for total dust by personal exposure samples, and 0.2 $mg/m^3$ for respirable dust by vertical elutriated area samples.

2. Medical Criteria

The procedure for administering the lung function tests consisted of having the workers inhale as much air as possible and then having them blow out the air as quickly as possible until they could push out no more air. The testing instrument, the spirometer, recorded the volume of air forced out as an instantaneous function of time. From this record, a number of pulmonary function parameters could be computed; these parameters can be used to interpret a great deal about the condition of the lungs and their reaction to air contaminants. Some of the parameters used in this study are:

FVC - forced vital capacity: the total volume of air that an individual could force out of his lungs after taking as deep a breath as possible.

$FEV_1$ - forced expiratory volume in 1 second: the total volume of air that an individual could force out of his lungs in the first second after taking as deep a breath as possible.

PKF - peak flow: the maximum instantaneous flow rate of air from the lungs during the exhalation.

MMF - maximum mid-expiratory flow: the maximum air flow rate from the lungs in the interval between the exhalation of 25% and 75% of the vital capacity.

FF - the $FEV_1$/FVC ratio.

F25 or FEF25 - forced expiratory flow, 25%: the instantaneous air flow rate from the lung at the time that 25% of the FVC has been expired.

F50 or FEF50 - the air flow rate when 50% of the FVC has been expired.

F75 or FEF75 - the air flow rate when 75% of the FVC has been expired.

F90 or FEF90 - the air flow rate when 90% of the FVC has been expired.

A decrement of 10% or more in the $FEV_1$, when comparing pre- and post-shift values, correlates quite well with an acute process causing airway obstruction and is compatible with byssinosis.

A history of symptoms such as Monday dyspnea was also considered sufficient criterion to classify a worker as having Grade I byssinosis.

D. Evaluation Results and Discussion

1. Environmental

The results of the environmental sampling on the follow-up survey are given in Tables 1 through 3. Figure 1 shows the locations of the vertical elutriators used for collecting room air samples.

The personal sample results from the Fiber Cutting Department shown in Table 1 indicate that the breathing-zone concentrations of flax dust exceeded 1 $mg/m^3$ in every job category of the department, except for the foreman. By far the most drastic levels were found in the breathing zones of the crewmen who manually pull apart the bales of flax. It was not unusual to measure an average workshift concentration in excess of 100 $mg/m^3$ total dust for the crewmen. The sweepers were also susceptible to very high concentrations, though not so drastic as the crewmen. It is recognized, however, that since all employees of the Fiber Cutting Department are required to wear disposable filter masks, employees do not actually breathe such elevated levels of dust.

The dust levels shown in Table 2 for the Digesting Department represent actual employee exposures since these employees did not wear respiratory protective devices. While the dust levels here were much lower than in the Fiber Cutting Department, exposures still exceeded 1 $mg/m^3$ of total dust.

The results of room air samples for respirable dust using the cotton dust vertical elutriators are given in Table 3. These data show that the respirable dust levels in the air of both the Fiber Cutting Department and the digestor feeding area of the Digesting Department exceeded 0.2 $mg/m^3$ when measured by this technique. A comparison of the room respirable dust levels with the personal respirable dust levels shows that the personal exposures are tremendously higher than ambient levels several feet away from the manual operations. The elutriator sample results do not appear to be representative of actual employee exposure.

2. Medical

The pulmonary function parameters as measured before and after the work shift, as well as the group mean differences, are listed in Table 4 for the control group (office workers unexposed to flax dust). It can be seen that there is no significant difference in the mean values for the 47 controls when before-shift and after-shift pulmonary parameters are compared. Table 5 shows the pulmonary function parameters as measured before and after the work shift, as well as the group mean difference, for the subject group (workers exposed to flax dust). Once again it can be seen that there is no significant difference in the before-shift and after-shift values. In Table 6 the group mean differences in pulmonary parameters for the control group and the subject group are compared. Using the T-test of statistical analysis for groups of this size, no statistically significant difference between the control and subject groups was observed. The probability of obtaining T values this large or larger is at least 0.23.

Table 7 shows the relationship between job categories, mean respirable dust levels, and mean changes in pulmonary function parameters in the subject group. Table 8 shows the same relationships, but in terms of total dust levels. It can be seen that there are decrements in nearly all pulmonary parameters with the highest dust levels. These highest dust levels were associated with job categories 2 and 3 which are the sweepers and crewmen. Again, it should be noted that the dust levels represent employee breathing-zone dust concentrations, but are not actual levels of exposure since the Fiber Cutting Department employees wear dust masks.

Table 9 compares the group mean difference in pre- and post-shift pulmonary function parameters among the various job categories and the controls. Again, there appear to be no statistically significant differences between the various groups. To show a significant difference, the P, or probability value, must be less than 0.05. However, the sensitivity of this statistical analysis to detect differences is not very good for small numbers of subjects in each job category, as is the case here.

Table 10 shows the correlation coefficient between dust levels and pulmonary parameter changes for the workers exposed to flax dust. The points of significance are marked by an asterisk. This table shows that as the total and respirable dust levels increase, there is a significant decrease in the $FEV_1$, $FEV_1/FVC$ ratio (FF), FEF75, and MMF. In this particular study the MMF had the highest and most consistent correlation.

The employee questionnaires revealed only three workers in the Fiber Cutting Department who admitted to any Monday morning symptoms suggestive of byssinosis. Of these three workers, one showed a 10% drop in $FEV_1$, one an 8% drop, and one showed no change in pre- and post-shift pulmonary parameters. The questionnaires for the other workers in the department revealed no symptoms related to Monday cough or chest tightness, but did reveal chronic cough, eye irritation and skin irritation.

## E. Conclusions

In comparing the results of pulmonary function tests in the group of workers exposed to flax and a comparable control group, it was found that there were no significant differences in the test parameters between the two groups. Table 10 shows that there was a significant correlation between increasing dust levels and a drop in several pulmonary parameters. However, the observed drops were small, in the range of 70 to 100 cc, and did not exceed the criterion of a 10% drop in FVC or $FEV_1$ used to establish the diagnosis of byssinosis. If the employees had not been wearing dust masks, the drops would probably have been larger. Exposure to the observed airborne flax dust concentrations, without respiratory protection, would have a very high potential for the production of byssinosis.

It would be quite difficult to make the diagnosis of acute impairment of lung function in this group of workers as a whole since flow rate drops were not significant and since the employee questionnaires revealed only three workers with Monday symptomatology. However, in the three workers with Monday symptomatology whose drops in $FEV_1$ were 10%, 8%, and unchanged in one case, the diagnosis of byssinosis grade I is evident.

Since the pulmonary function decrements correlated significantly with the increasing dust levels as shown in Table 10, it is postulated that although few employees had byssinotic symptoms, the flax dust was acting as a primary irritant to those employees exposed to the highest levels of flax dust. The drops in pulmonary function values were not significant in most of the exposed workers. The role of flax dust acting as a primary irritant is strengthened by the findings of cough, eye, and skin irritation.

F. Recommendations

1. Reduction of airborne dust exposures. Dust levels in the Fiber Cutting Department should be lowered to prevent byssinosis and other respiratory and cutaneous symptoms. Since the crewmen and sweepers have the highest exposures and the highest prevalence of adverse symptoms, priority should be given to lowering the exposures of these individuals. Due to the wearing of dust masks and to the small size of the exposed population in this study, the environmental and medical data are not sufficient to provide the basis for a really sound, safe dust level to be recommended. It is clear that the dust reduction must be substantial enough to prevent adverse symptoms among the workers without resorting to respirators. While there were a couple of high dust exposures measured in the Digesting Department, most levels were in the range of 1 to 3 $mg/m^3$ of total dust. Since no significant symptoms of byssinosis were found in these workers, it appears that reduction to a level of 1 $mg/m^3$ of total dust (as measured by personal samplers) may be sufficient.

2. Medical surveillance of employees. Individuals assigned to the Fiber Cutting Department should be routinely evaluated prior to employment and at least annually with pre- and post-shift pulmonary function tests to find those who are reacting to the dust. Since new local exhaust systems and other forms of dust control are being implemented, a continued medical surveillance program is important to measure the success of such control measures.

3. Use of respiratory protective devices. The goal of the control measures, such as local exhaust ventilation and process enclosure, should be to reduce exposures sufficiently to prevent adverse symptoms among the workers without resorting to respiratory protective devices. Until such reduction can be achieved, the wearing of respiratory protection should be required for all jobs with exposures greater than 5 $mg/m^3$ to total dust, and supplied, or made available, to all other employees with exposure to flax dust. Prior to requiring the use of respirators, all affected employees should be evaluated medically to insure that they are able to withstand the increased stress of breathing with a respirator.

   Although disposable dust masks were being worn by all Fiber Cutting Department employees during the study, adverse effects were observed among the crewmen and sweepers. These effects were probably caused by leakage around the mask as a result of improper wearing of the dust masks. For the masks to be efficient, both head bands must be in place, the nose bridge tightly clamped over the ridge of the nose, and the edges of the mask held against bare skin free from facial hair such as beards and sideburns. Improper wearing practices such as using only one head band and not sealing around the nose were observed to be very common. One reason is the discomfort which many people experience from wearing such masks. These masks are hot, itch, and cause fogging of eyeglasses.

The use of half-mask respirators with replaceable filter cartridges should be considered. These are not expensive, seal very well with a variety of facial sizes and shapes, do not cause fogging of eyeglasses when properly fitted, and are often more comfortable than disposable masks. If used, such respirators must be frequently cleaned and maintained.

## V. REFERENCES

1. Criteria for a Recommended Standard: Occupational Exposure to Cotton Dust, HEW Publication No. (NIOSH) 75-118, National Institute for Occupational Safety and Health, Cincinnati, Ohio, 1974.

2. Bouhuys, A., J. Van Duyn, and H. T. Van Lennep, "Byssinosis in Flax Workers," Arch. Environ. Health, Vol. 3, 499, 1961.

3. Werner, G. C. H., "A Propos des Concentrations Maxima Tolérables pour les Poussières Textiles Végetales," Archives des Maladies Professionnelles de Médecine du Travail et de Securité Sociale, Vol. 24, 644, 1963.

4. Noweir, M. H., A. El-Dakhakhni, H. A. Osman, and M. Moselhi, "Seasonal Exposure to Dust in Flax Processing in Egypt," Amer. Ind. Hyg. Assoc. J., Vol. 36, 318, 1975.

5. Title 29, Code of Federal Regulations, Part 1910.93, Federal Register, Vol. 39, 23541, 1974.

## VI. AUTHORSHIP AND ACKNOWLEDGEMENTS

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TABLE 1

Air Sampling Results (Personal Samples)

Fiber Cutting Department
Olin Corporation - Ecusta Paper Division
Pisgah Forest, North Carolina

April 5, 1976

| Sample No. | Operator | Sample Volume (liters) | Sampling Period | Dust Concentration ($Mg/m^3$) | Type of Sample |
|---|---|---|---|---|---|
| | | Graveyard Shift (Midnight - 8:00 a.m.) | | | |
| V-1646 | Baler Helper | 614 | 12:29-06:30 | 0.47 | R |
| V-1622 | | | | 3.91 | T |
| V-1652 | Baler Operator | 646 | 12:10-06:30 | 0.39 | R |
| V-1656 | | | | 1.21 | T |
| V-1675 | Crewman | 638 | 12:15-06:30 | 6.60 | R |
| V-1685 | | | | 8.97 | T |
| V-1661 | Crewman | 587 | 12:45-06:30 | 8.93 | R |
| V-1672 | | | | 69.3 | T |
| V-1667 | Crewman | 585 | 12:46-06:30 | 5.37 | R |
| V-1676 | | | | 11.5 | T |
| V-1663 | Crewman | 583 | 12:47-06:30 | 28.8 | R |

| Sample No. | Operator | Sample Volume (liters) | Sampling Period | Dust Concentration ($Mg/m^3$) | Type of Sample |
|---|---|---|---|---|---|
| V-1670 | | | | 63.9 | T |
| V-1643 | Scale Operator | 640 | 12:14-06:30 | 0.25 | R |
| V-1665 | | | | 2.45 | T |
| V-1658 | Sweeper | 643 | 12:12-06:30 | 17.26 | R |
| V-1659 | | | | 31.1 | T |
| V-1683 | Fork Lift Operator | 597 | 12:39-06:30 | 0.30 | R |
| V-1638 | | | | 1.26 | T |
| | | Day Shift (8:00 a.m. - 4:00 p.m.) | | | |
| V-1713 | Baler Helper | 656 | 08:20-02:46 | 0.52 | R |
| V-1760 | | | | 1.05 | T |
| V-1664 | Baler Operator | 632 | 08:33-02:45 | 0.38 | R |
| V-1723 | | | | 1.20 | T |
| V-1763 | Crewman | 641 | 08:21-02:38 | 30.9 | R |
| V-1726 | | | | 166. | T |
| V-1632 | Crewman | 643 | 08:24-02:42 | 16.2 | R |
| V-1774 | | | | 70.6 | T |
| V-1766 | Crewman | 644 | 08:30-02:49 | 2.53 | R |
| V-1754 | | | | 54.2 | T |
| V-1714 | Crewman | 604 | 08:40-02:35 | 21.2 | R |

| Sample No. | Operator | Sample Volume (liters) | Sampling Period | Dust Concentration ($Mg/m^3$) | Type of Sample |
|---|---|---|---|---|---|
| V-1753 | | | | 4.80 | T |
| V-1783 | Crewman | 620 | 08:45-02:50 | 3.34 | R |
| V-1731 | | | | 4.82 | T |
| V-1704 | Scale Operator | 598 | 08:55-02:47 | 0.22 | R |
| V-1756 | | | | 0.69 | T |
| V-1757 | Sweeper | 612 | 08:48-02:48 | 0.60 | R |
| V-1769 | | | | 16.72 | T |
| V-1697 | Fork Lift Operator | 580 | 08:46-02:27 | 0.24 | R |
| V-1739 | | | | 0.67 | T |
| | | **Evening Shift** (4:00 p.m. - Midnight) | | | |
| V-1808 | Baler Helper | 602 | 04:38-10:32 | 0.38 | R |
| V-1865 | | | | 1.84 | T |
| V-1745 | Baler Operator | 602 | 04:17-10:28 | 0.70 | R |
| V-1852 | | | | 4.02 | T |
| V-1748 | Crewman | 622 | 04:34-10:40 | 28.5 | R |
| V-1859 | | | | 111. | T |
| V-1868 | Crewman | 636 | 04:36-10:50 | 5.33 | R |

| Sample No. | Operator | Sample Volume (liters) | Sampling Period | Dust Concentration (Mg/m$^3$) | Type of Sample |
|---|---|---|---|---|---|
| V-1795 | | | | 23.2 | T |
| V-1892 | Crewman | 602 | 04:45-10:39 | 45.6 | R |
| V-1879 | | | | 50.1 | T |
| V-1800 | Crewman | 109 | 04:56-06:00 | 41.7 | R |
| V-1790 | | 474 | 06:00-10:39 | 86.9 | R |
| V-1858 | | 583 | 04:56-10:39 | 171. | T |
| V-1746 | Crewman | 648 | 04:15-10:36 | 17.2 | R |
| V-1798 | | | | 107. | T |
| V-1775 | Foreman | 649 | 04:13-10:35 | 0.20 | R |
| V-1802 | | | | 0.55 | T |
| V-1752 | Scale Operator | 670 | 04:20-10:32 | 0.57 | R |
| V-1784 | | | | 13.37 | T |
| V-1742 | Fork Lift Operator | 641 | 04:11-10:28 | 0.33 | R |
| V-1866 | | | | 0.86 | T |

Mg/m$^3$ - means milligrams of particulate material per cubic meter of air

R - "respirable" portion of total dust

T - total airborne dust

TABLE 2

Air Sampling Results (Personal Samples)

The Hay Loft of the Digesting Department
Olin Corporation - Ecusta Paper Division
Pisgah Forest, North Carolina

April 5, 1976

| Sample No. | Operator | Sample Volume (liters) | Sampling Period | Dust Concentration ($Mg/m^3$) | Type of Sample |
|---|---|---|---|---|---|
| | | Graveyard Shift (Midnight - 8:00 a.m.) | | | |
| V-1687 | Digester Worker | 592 | 01:12-07:00 | 0.41 | R |
| V-1673 | | | | 1.32 | T |
| V-1655 | Digester Worker | 586 | 01:15-07:00 | 0.27 | R |
| V-1651 | | | | 1.13 | T |
| V-1662 | Digester Worker | 582 | 01:18-07:00 | 2.41 | T |
| V-1657 | Digester Worker | 539 | 01:43-07:00 | 0.32 | R |
| V-1741 | | | | 0.56 | T |
| | | Day Shift (8:00 a.m. - 4:00 p.m.) | | | |
| V-1734 | Digester Loader | 604 | 9:10-03:05 | 22.6 | R |
| V-1777 | | | | 1.42 | T |
| V-1717 | Digester Helper | 605 | 09:14-03:10 | 0.17 | R |
| V-1736 | | | | 43.8 | T |

| Sample No. | Operator | Sample Volume (liters) | Sampling Period | Dust Concentration ($Mg/m^3$) | Type of Sample |
|---|---|---|---|---|---|
| V-1765 | Digester Operator | 573 | 09:28-03:05 | 0.30 | R |
| V-1684 | | | | 0.44 | T |
| V-1755 | Digester Helper | 570 | 09:30-03:05 | 51.8 | R |
| V-1653 | | | | 176. | T |
| | | Evening Shift (4:00 p.m. - Midnight) | | | |
| V-1737 | Digester Operator | 697 | 04:15-11:05 | 0.33 | R |
| V-1857 | | | | 0.93 | T |
| V-1897 | Digester Helper | 658 | 04:18-10:45 | 0.85 | R |
| V-1878 | | | | 1.11 | T |
| V-1764 | Digester Helper | 658 | 04:18-10:45 | 0.32 | R |
| V-1862 | | | | 2.39 | T |
| V-1721 | Digester Helper | 648 | 04:24-10:45 | 0.42 | R |
| V-1856 | | | | 1.42 | T |

$Mg/m^3$ - means milligrams of particulate material per cubic meter of air

R - "respirable" portion of total dust

T - total airborne dust

TABLE 3

Area Samples Collected by Vertical Elutriators

Fiber Cutting Department and Digesting Department
Olin Corporation - Ecusta Paper Division
Pisgah Forest, North Carolina

April 5, 1976

| Sample No. | Location* | Sample Volume (Cubic Meters, $M^3$) | Sampling Period | Dust Concentration ($Mg/m^3$) |
|---|---|---|---|---|
| V-1650 | A | 2.19 | 01:05-06:30 | 0.42 |
| V-1758 | A | 3.08 | 09:00-15:56 | 0.003 |
| V-1860 | A | 2.62 | 17:02-22:55 | 0.63 |
| V-1861 | B | 2.31 | 01:06-06:30 | 3.15 |
| V-1780 | B | 2.85 | 09:00-15:55 | 0.82 |
| V-1794 | B | 2.51 | 17:03-22:55 | 0.79 |
| V-1689 | C | 2.09 | 01:07-06:30 | 0.37 |
| V-1761 | C | 2.94 | 09:00-15:52 | 0.33 |
| V-1782 | C | 2.51 | 17:00-22:52 | 1.22 |
| V-1688 | D | 2.25 | 01:04-06:30 | 0.57 |
| V-1773 | D | 2.67 | 09:00-15:57 | 0.43 |
| V-1785 | D | 2.43 | 17:03-22:55 | 1.73 |
| V-1686 | E | 2.84 | 00:36-07:00 | 0.13 |
| V-1732 | E | 3.06 | 09:15-16:09 | 0.14 |

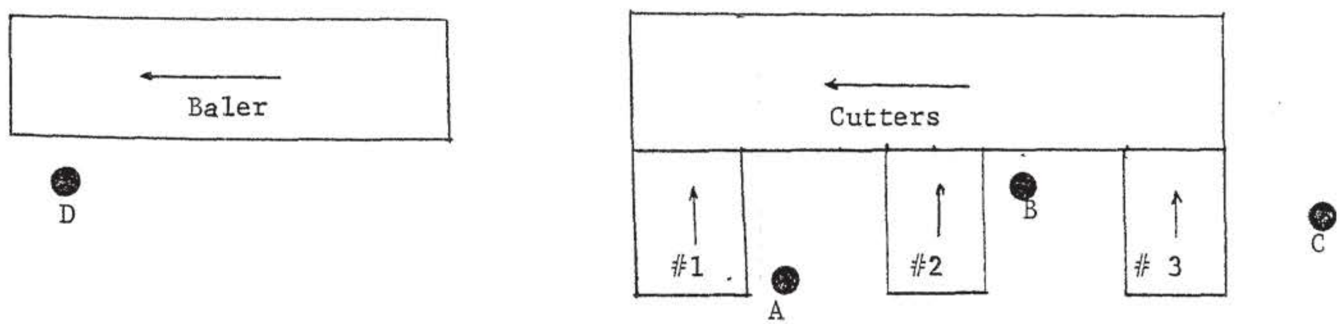
| Sample No. | Location* | Sample Volume (Cubic Meters, $M^3$) | Sampling Period | Dust Concentration ($Mg/m^3$) |
|---|---|---|---|---|
| V-1893 | E | 2.90 | 16:09-22:42 | 0.19 |
| V-1645 | F | 2.98 | 00:35-07:00 | 0.32 |
| V-1762 | F | 3.12 | 09:23-16:06 | 0.10 |
| V-1872 | F | 3.01 | 16:07-22:36 | 0.30 |

$Mg/m^3$ means milligrams of particulate per cubic meter of air.

* Locations of the elutriators are shown in Figure 1.

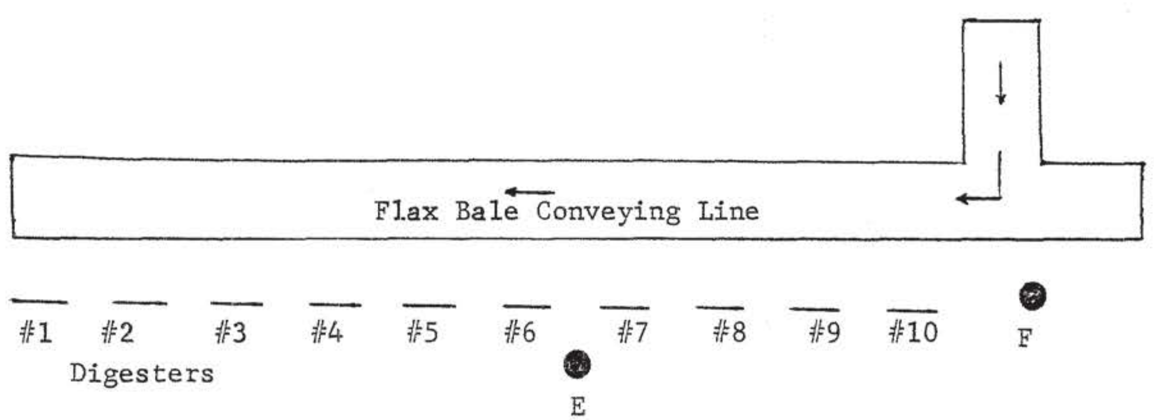
FIGURE 1

POSITIONS OF VERTICAL ELUTRIATOR SAMPLES




#1, #2, #3 are bale separation stations.

FIBER CUTTING DEPARTMENT




DIGESTING DEPARTMENT

TABLE 4

PULMONARY FUNCTION PARAMETERS FOR CONTROL GROUP
BEFORE AND AFTER SHIFT

OLIN CORPORATION
PISGAH FOREST, NORTH CAROLINA

APRIL 6, 1976

CONTROLS = 47 PERSONS

| | BEFORE SHIFT | AFTER SHIFT | DIFFERENCE |
|---|---|---|---|
| FVC | 4.469 | 4.464 | -0.004 |
| $FEV_1$ | 3.441 | 3.438 | -0.002 |
| PKF | 8.048 | 8.234 | +0.185 |
| MMF | 3.395 | 3.332 | -0.063 |
| F25 | 6.786 | 6.637 | -0.149 |
| F50 | 4.033 | 3.899 | -0.134 |
| F75 | 1.594 | 1.536 | -0.058 |
| F90 | 0.594 | 0.550 | 0.044 |

TABLE 5

PULMONARY FUNCTION PARAMETERS FOR SUBJECT GROUP
BEFORE AND AFTER SHIFT

FIBER CUTTING DEPARTMENT
OLIN CORPORATION - ECUSTA PAPER DIVISION
PISGAH FOREST, NORTH CAROLINA

APRIL 5, 1976

SUBJECTS = 31 PERSONS

| | BEFORE SHIFT | AFTER SHIFT | DIFFERENCE |
|---|---|---|---|
| FVC | 4.246 | 4.189 | -0.056 |
| $FEV_1$ | 3.233 | 3.229 | -0.004 |
| PKF | 7.981 | 7.884 | -0.097 |
| MMF | 2.997 | 2.987 | -0.009 |
| F25 | 6.377 | 6.379 | +0.002 |
| F50 | 3.609 | 3.526 | -0.083 |
| F75 | 1.318 | 1.321 | +0.003 |
| F90 | 0.381 | 0.390 | +0.008 |

TABLE 6

MEAN DIFFERENCE IN PULMONARY PARAMETERS
BEFORE AND AFTER SHIFT,
CONTROLS VS EXPOSED

OLIN CORPORATION
PISGAH FOREST, NORTH CAROLINA

APRIL 5 AND 6, 1976

| | CONTROLS | EXPOSED | MEAN DIFF. | T TEST |
|---|---|---|---|---|
| FVC | -0.003 | -0.056 | 0.052 | 1.59 |
| $FEV_1$ | -0.026 | -0.039 | 0.014 | 0.372 |
| PKF | +0.254 | -0.009 | 0.263 | 1.43 |
| F25 | -0.209 | +0.034 | -0.243 | -1.29 |
| F50 | -0.117 | -0.051 | -0.066 | -0.488 |
| F75 | -0.046 | +0.005 | -.051 | -0.841 |
| F90 | -0.049 | +0.008 | -.057 | -1.71 |

TABLE 7

PRE AND POST SHIFT CHANGES IN PULMONARY PARAMETERS
RELATED TO RESPIRABLE DUST LEVELS

FIBER CUTTING DEPARTMENT
OLIN CORPORATION - ECUSTA PAPER DIVISION
PISGAH FOREST, NORTH CAROLINA

APRIL 5, 1976

| RESPIRABLE DUST (mg/m$^3$) | FVC | $FEV_1$ | PKF | FEF 25 | FEF 50 | FEF 75 | FEF 90 | MMF | JOB | N |
|---|---|---|---|---|---|---|---|---|---|---|
| .29 | -.003 | .033 | .163 | .023 | 0 | .030 | .016 | .033 | 6 | 3 |
| .34 | -.030 | .050 | -.506 | .190 | .200 | .033 | .010 | .156 | 4 | 3 |
| .47 | -.115 | .105 | .246 | .578 | .450 | .243 | .055 | .416 | 1 | 6 |
| 9.08 | .025 | .140 | -.545 | -.550 | .035 | .170 | .115 | .070 | 2 | 2 |
| 17.8 | -.070 | -.100 | -.256 | -.289 | -.425 | -.126 | .007 | -.279 | 3 | 13 |

Job 1 = Bailer Operator
Job 2 = Sweeper
Job 3 = Crewman
Job 4 = Scale Operator
Job 5 = Foreman
Job 6 = Fork Lift Operator

# TABLE 8

## PRE AND POST SHIFT CHANGES IN PULMONARY PARAMETERS RELATED TO TOTAL DUST LEVELS

## FIBER CUTTING DEPARTMENT
## OLIN CORPORATION - ECUSTA PAPER DIVISION
## PISGAH FOREST, NORTH CAROLINA

APRIL 5, 1976

| TOTAL DUST (mg/m$^3$) | FVC | $FEV_1$ | PKF | FEF 25 | FEF 50 | FEF 75 | FEF 90 | MMF | JOB | N |
|---|---|---|---|---|---|---|---|---|---|---|
| .93 | -.003 | .033 | .163 | .023 | 0 | .030 | .016 | .033 | 6 | 3 |
| 2.2 | -.115 | .105 | .246 | .578 | .450 | .243 | .055 | .416 | 1 | 6 |
| 5.5 | -.030 | .050 | -.506 | .190 | .200 | .033 | .010 | .156 | 4 | 3 |
| 23.91 | .025 | .140 | -.545 | -.550 | .035 | .170 | .115 | .070 | 2 | 2 |
| 57.72 | -.070 | -.100 | -.256 | -.289 | -.425 | -.126 | .007 | -.279 | 3 | 13 |

Job 1 = Bailer Operator
Job 2 = Sweeper
Job 3 = Crewman
Job 4 = Scale Operator
Job 5 = Foreman
Job 6 = Fork Lift Operator

TABLE 9

MEAN DIFFERENCE IN PULMONARY PARAMETERS
IN CONTROLS VS SUBJECTS

OLIN CORPORATION
PISGAH FOREST, NORTH CAROLINA

APRIL 5 - 6, 1976

JOB

| | CONTROLS | 1 | 2 | 3 | 4 | 5 | 6 | 8 | P |
|---|---|---|---|---|---|---|---|---|---|
| FVC | -0.004 | -0.115 | +0.025 | -0.070 | -0.030 | -0.080 | -0.003 | +0.140 | 0.510 |
| $FEV_1$ | -0.002 | +0.105 | +0.140 | -0.100 | +0.050 | -0.040 | +0.033 | +0.130 | 0.416 |
| FF | +0.271 | +4.69 | +2.876 | -1.251 | +1.238 | +0.953 | +1.08 | +0.755 | 0.415 |
| PF | +0.185 | +0.246 | -0.545 | -0.256 | -0.506 | +0.023 | +0.163 | +0.890 | 0.507 |
| F25 | -0.148 | +0.578 | -0.550 | -0.289 | +0.190 | +0.020 | +0.023 | +0.750 | 0.401 |
| F50 | -0.134 | +0.450 | +0.035 | -0.425 | +0.200 | -0.230 | -0.0 | +0.280 | 0.109 |
| F75 | -0.053 | +0.243 | +0.170 | -0.126 | +0.033 | -0.106 | +0.03 | +0.070 | 0.190 |
| F90 | -0.044 | +0.055 | +0.115 | +0.007 | +0.010 | -0.166 | +0.016 | +0.020 | 0.293 |
| MMF | -0.063 | +0.416 | +0.070 | -0.279 | +0.156 | -0.063 | +0.033 | +0.310 | 0.190 |

Job 1 = Bailer Operator
Job 2 = Sweeper
Job 3 = Crewman
Job 4 = Scale Operator
Job 5 = Foreman (Dust Exposure Measured)
Job 6 = Fork Lift Operator
Job 8 = Foremen (Dust Exposures Not Measured)

TABLE 10

SPEARMAN'S CORRELATION COEFFICIENT SHOWING THE RELATIONSHIP OF TOTAL AND RESPIRABLE DUST TO CHANGES IN PULMONARY PARAMETERS

| | FVC | $FEV_1$ | $FEV_1/FVC$ | PF | F25 | F50 | F75 | F90 | MMF |
|---|---|---|---|---|---|---|---|---|---|
| T | -0.032 | 0.358 | *0.370 | 0.239 | 0.217 | 0.305 | *0.451 | 0.144 | *0.424 |
| R | 0.203 | *0.419 | 0.311 | 0.090 | 0.183 | 0.361 | 0.302 | 0.075 | *0.400 |

*Statistically significant $P < 0.05$

T = Total Dust

R = Respirable Dust