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. 74-110-306

MORRIS BEAN AND COMPANY
YELLOW SPRINGS, OHIO

JUNE 1976

I. TOXICITY DETERMINATION

It has been determined that exposure to dimethylethylamine (DMEA) in the Core Departments 13 and 68 elicited symptoms in eight employees out of the twenty-three interviewed (35%) on January 19, 1976. One employee reported nausea, five reported sore throats, one reported a headache, and one reported a stuffed nose. Symptomatic persons show a decrement of 41% in total eosinophil count. The biological and medical significance of this change is not clear but may reflect a non specific stress reaction. No significant changes in pulmonary function tests were observed on the day of the study.

At the present time there is little toxicological information on DMEA. No epidemiological studies (prospective or retrospective) have been conducted in regard to repeated exposure to low concentrations of DMEA. For the purpose of providing an adequate safety margin, it is recommended that DMEA concentrations be kept to a minimum through engineering controls (e.g. adequate local exhaust ventilation) and good industrial hygiene work practices.

It has been determined also that these same employees were exposed to concentrations of crystalline free silica which may produce adverse effects upon repeated exposure. In addition to this, the ceiling value for methylene bisphenyl isocynate (MDI) was exceeded in two instances.

It has been determined also that these same employees were not exposed to toxic concentrations of formaldehyde or phenol.

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) Morris Bean and Company
   Yellow Springs, Ohio
b) Authorized Representative of Employees
c) U.S. Department of Labor - Region V
d) NIOSH - Region V

For the purpose of informing the approximately 30 "affected" employees, the employer shall promptly "post" the Determination Report for a period of 30 calendar days in a prominent place(s) near where exposed employees work.

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 regarding Core Department employees' exposure to dimethyethylamine. The request was prompted by employees allegedly experiencing dizziness, nausea and headache as a result of excessive exposure to DMEA.

IV. HEALTH HAZARD EVALUATION

A. Plant Process - Conditions of Use

Morris Bean and Company is an aluminum casting foundry which employs approximately three hundred production workers over three shifts. Of these employees, approximately 30 were in the immediate core production area (Department 13 and 68).

Cores are made by a process known as the "Cold Box Process". The process involves mixing a two part organic binder with sand. This mixture is then blown into a core mold where a catalyst is injected through the sand mixture. The core is complete and ready to use at that point.

In Department 13, mixing is done by using a Muller which is housed in a back work area. All components of the mixture (silica sand, phenol-formaldehyde resin dissolved in a solvent, and MDI dissolved in a solvent) are measured according to the desired batch size.

The binders (added to the sand) are taken in open containers from 55 gallon drums located adjacent to the Muller. Drippings from these drums are collected in small open containers. No local exhaust is provided in this area.

In Department 68, the mixing is done in a closed system. Binders and sand (stored outside the work area) are automatically measured and piped to the mixer.

From this point on, the operation is essentially the same in both work areas.

The mixture (moist sand) is delivered to individual hoppers positioned above the core blow machine.

The damp mixture is blown into the core box where it is hardened in less than one minute by blowing the catalyst (DMEA) for a pre set amount of time (depending on the size of the core) and then flushing with air for a pre set amount of time. A small line is provided to scavenge waste gas.

All core blow machines are provided with a local exhaust system and in all cases DMEA is supplied from a gas cylinder (12% DMEA in carbon dioxide).

There are fewer machines in Department 13 and they are positioned further apart. Included also in Department 13 is a hood type exhaust at ground level.

In Department 68 the 8 core blow machines are positioned much closer together plus there are two full circle machines. In addition to the employees who operate these machines, two trimmers' work stations are located directly behind one of the full circle machines. These employees trim, piece the cores together, and inspect them.

B. EVALUATION PROGRESS

A valid request for a health hazard evaluation was received on September 23, 1974. An initial screening survey was conducted on October 17, 1974; no environmental air measurements were made at that time because there was no sampling or analytical method for DMEA. An environmental/medical evaluation was conducted March 19, 1975. For lack of a better sampling method triethylamine detector tubes were used to measure DMEA concentrations. A sampling and analytical method was developed and made available on March 28, 1975 but the representing union went on strike on April 1, 1975 and remained on strike until October 8, 1975. A follow-up environmental/medical evaluation was conducted on January 19-20, 1976.

C. EVALUATION METHOD

1. Environmental

The initial screening survey included a walk-through of the areas of concern, observing work practices, obtaining general information, and administering confidential employee interviews. During this initial survey, core production by the cold box process was limited to Department 13.

The environmental/medical follow-up conducted March 19, 1975 revealed that the core production (by the cold box process) had shifted almost

entirely from Department 13 to Department 68. Approximately 90% of the cores were and are made in Department 68.

For this reason the major portion of the triethylamine detector tubes measurements for DMEA were made in Department 68.

During the environmental/medical evaluation conducted on January 19-20, 1976 environmental air samples were collected for MDI, DMEA, formaldehyde, phenol, and free silica.

MDI breathing zone samples were collected in impingers at a flow rate of one liter per minute. Two 4-hour samples were collected in the breathing zones of those employees listed in Table IV. Analysis of these samples was by colorimetric determination using a spectrophotometer.

DMEA breathing zone samples were collected on charcoal tubes at approximately 50 cubic centimeters per minute. Two 4-hour samples were collected in the breathing zones of those employees listed in Table I. Analysis of the samples was by gas chromatography.

Formaldehyde and phenol sampling was done by areas. Four samples were collected in Department 68 for each of the substances. Each sample was collected at 1 liter per minute and was collected for approximately six hours. Two samples were collected as described above in Department 13. Formaldehyde samples were analyzed colorimetrically while phenol samples were analyzed by gas chromatography.

Both breathing zone and area samples for free silica were collected. Personal breathing zone samples for the respirable fraction were collected at 1.7 liters per minute. Area samples were collected on the 19th only and were collected at 9 liters per minute. By using a glass-T and two critical orifices both a respirable and total dust sample were collected at each location. Cyclones were utilized to collect the respirable fraction for both the breathing zone and area samples. Analysis of these samples was by X-ray diffraction.

In addition to the environmental air sampling, ventilation measurements of existing local exhaust systems were made as part of the evaluation.

2. Medical

The medical investigation was conducted on March 19, 1975. All persons employed in Departments 13 and 68 where cores were fabricated, as well as past employees of these areas were interviewed and, when necessary, examined. Thirty-four (34) persons were interviewed and examined.

The follow-up medical investigation was conducted on January 18-20, 1976. A total of 25 persons from Department 68 and Department 13 were interviewed and examined. A non-directed and directed questionnaire was administered and focused on work related illnesses, the acute symptoms associated with work in the area of the core machines, a brief allergic history, a short review of systems, a review of past and present medical illnesses, and a work history. A short pre- and post-shift questionnaire was administered to evaluate the development of symptoms not present at the beginning of the shift. This questionnaire was given in conjunction with chest auscultation, an examination of the eyes, nose and throat, and pulmonary function tests. Blood was drawn at the beginning and end of the shift for total eosinophil determination. The acute signs and symptoms that were sought included: headache, irritation of the eyes, nose and throat; nausea and/or vomiting, shortness of breath, difficult breathing, chest discomfort and wheezing. Persons were interviewed on the day following the study to evaluate whether any symptoms had developed at home after the shift.

The pre- and post-shift pulmonary function tests were performed by employing a Vitalograph spirometer. Three to five expiratory maneuvers were carried out and the "best" curve was chosen and analyzed for forced vital capacity (FVC), forced expiratory volume in one second ($FEV_{1.0}$), and maximal mid-expiratory flow rate (MMEF 25%-75%). These measurements were corrected to body temperature and standard barometric pressure of 760mm Hg (BTPS). The predicted values for each person were calculated according to the formulae of Morris, Koski and Johnson and Lapp, et. al.

D. EVALUATION CRITERIA

1. ENVIRONMENTAL

The primary environmental evaluation criteria considered in this report are (1) NIOSH criteria documents recommending occupational health standards (2) American Conference of Governmental Industrial Hygienist (ACGIH) Threshold Limit Values (TLV's) and supporting documentation and (3) Federal Occupational Health Standards promulgated by the U.S. Department of Labor (29 CFR Part 1910.1000). Only the recommended standard, TLV, or Federal Standard considered most applicable is listed along with its source.

	Formaldehyde[a]	3 mg/M^3
	Phenol[a]	19 mg/M^3
C	Methylene bisphenyl isocyanate[a]	0.2 mg/M^3
	Free silica[b]	50 $\mu g/M^3$*

a) ACGIH Threshold Limit Values for Chemical Substances in Workroom Air Adopted by ACGIH for 1975
b) NIOSH Criteria for a Recommended Standard...Occupational Exposure to Crystalline Silica, 1974
C Ceiling Value
* Respirable fraction as determined by a full shift sample for up to a 10 hour workday, 40 hours work week

At the present time there is no established standard or guideline, nor has one been proposed, for dimethylethylamine. Concentrations should be kept to a minimum.

For evaluation of local exhaust systems, a minimum capture velocity of 100 feet per minute was considered acceptable. This is based on information extracted from the ACGIH Ventilation Manual.

2. MEDICAL

Formaldehyde: Exposures to formaldehyde may produce irritation of the mucous membranes of the eyes, nose, throat and respiratory tract. Its odor is detectable at 1 ppm and at 4-5 ppm, lachrimation and burning sensation of the nose and throat may occur. At concentrations greater than 10 ppm, difficulty in breathing, intolerable burning sensation of nose and throat as well as substernal discomfort may occur. These symptoms may persist for several hours after high exposures have ceased. Dermal sensitization to formaldehyde may occur following repeated, direct contact with skin. Skin sensitization to formaldehyde vapor is rare.

Methylene bisphenyl isocyanate (MDI): Exposure to high concentrations of MDI may produce irritation of the skin and the mucous membrane of the eyes, nose, throat and respiratory tract, as well as chemical pneumonia. In certain individuals, respiratory tract sensitization to low levels of MDI may occur so that once sensitization has occurred, exposure to even minimal concentrations may provoke a severe asthmatic reaction. Individual susceptability to developing sensitization is variable but does not appear to be related to atopic status. Sensitization may follow several episodes of severe irritation.

Dimethylethylamine (DMEA): As a member of the amine family, DMEA exerts its effects in man as a primary irritant. DMEA is very volatile and, therefore, may produce irritation of the mucous membranes of the eyes, nose, throat, as well as the respiratory tract, producing cough, substernal distress and perhaps asthmatic-type symptoms. Direct contact with DMEA may produce primary skin irritation and dermatitis. Exposure to amine vapors may also produce headache, nausea, faintness, and anxiety symptoms. These systemic symptoms may be related to the pharmacologic action of amines. Animal experiments confirm the irritant properties of DMEA to the mucous membranes and lower respiratory tract.

Silica (SiO_2): Exposure to excessive amounts of silica may produce irreversible lung damage and fibrosis, known as silicosis. The clinical signs of silicosis are not unique. The symptoms may include cough, sputum production, progressive dyspnea, wheezing and repeated nonspecific chest infections. Impairment of pulmonary function may be progressive. In individual cases there may be little or no decrement in pulmonary function or symptoms where only simple discrete nodular silicosis (simple silicosis) is present. The two main threats posed by simple silicosis are the development of tuberculosis and complicated silicosis. Massive fibrosis may develop in about 20-30% of subjects with simple silicosis even in the absence of further exposure to dusts containing free silica. In addition, it has been found that the mortality of foundrymen with simple silicosis is double that of coal workers with similar radiographic category of disease. Simple silicosis should not be considered as entirely benign. Occasionally, exposures to very high concentrations of free silica may result in an acute, rapidly developing silicosis which is associated with severe respiratory failure and death.

Phenol: Due to a relatively low volatility, phenol does not frequently constitute a serious respiratory hazard in industry. Vomiting, dizziness, delirium, convulsions, collapse, loss of consciousness, and oliguria are common signs and symptoms in severe cases of poisoning, which usually occurs through ingestion. An early sign of mild poisoning is dark colored urine. Phenol is readily absorbed through the skin producing an initial numbness and blanching. Later the skin becomes reddened and necrotic.

The following criteria were used to determine if a significant acute airway obstruction occurred during the work shift: an acute decrease in MMEF and/or $FEV_{1.0}$ greater than 10% of the pre-shift value.

The following criteria were used to diagnose obstructive airways disease: $FEV_{1.0}$ less than 70% of predicted value with normal FVC; and/or MMEF less than 50% of predicted with a normal FVC.

Normal hematologic data (including eosinophil counts) is contained in Table X.

E. EVALUATION RESULTS AND DISCUSSION

1. Environmental

With the exception of one sample, phenol was not detected on any of the samples. This one (exception) sample contained only a trace and could be attributed to contamination or laboratory error.

There was no significant difference between the formaldehyde samples and the blanks.

All samples collected for MDI contained some MDI (see Table IV). The concentration for nine of these samples was at approximately one-half the Threshold Limit Value; two were in excess of the Threshold Limit Value.

It should be noted that the analyst observed a yellow color in some of the samples and a precipitate in other and both in still others. This yellow color and/or precipitate is not typical of MDI sample; therefore, the analyst questions the validity and/or reliability of such samples. However, unknown to the analyst an unidentified blank was submitted as a sample; the results were that the sample contained the yellow color but MDI was not detected. Also one identified blank contained both the yellow color and the precipitate and 0.003 mg of MDI was detected. This is considerably less than most of the other concentrations determined.

Three of the breathing zone samples collected for the respirable silica fraction were more than twice the NIOSH recommended standard of 50 micrograms per cubic meter and one was at 50 micrograms/M^3 (see Table III). Also, crystalline free silica was not detected in four other breathing zone samples. Cristobalite was not detected in any of the samples; the free silica reported is quartz.

With the exception of Sample CT-75, all samples for DMEA were below 8 parts per million and in most samples DMEA was not detected (see Table 1). The high concentrations measured in Sample CT-75 may have been due to a leak in the core box. This is not uncommon even with routine maintenance on the core boxes.

Core boxes are maintained on a periodic basis because they tend to leak. Leaks or mechanic failure (e.g. scavanging line not working or an inadequate local exhaust system) are easily detectable because of the offensive odor of DMEA. The leakage and mechanical failure was more evident on March 19, 1975 when the environmental measurements were done with detector tubes (see Table II). The local exhaust system on one of the full circle machines was not operating. The odor of DMEA was much more evident in Department 68 than in Department 13, simply because of the greater number of machines and much more congestion.

Ventilation measurements in both Department 68 and 13 were made on January 20, 1976. In Department 13, the system was definitely not balanced; capture velocity through the local exhaust duct nearest the fan had the highest capture velocity while the duct furthest from the fan had the lowest. The duct capture velocity at the core blow machine nearest the fan was 2400 feet per minute for a 6" duct; the capture velocity 2" from the 3" duct provided for the core blow

machine furthest from the fan was 50 FPM. Also, the duct entry is about 2 feet from the operators breathing zone.

In Department 68 local exhaust was provided through one exhaust system with branch ducts to each of the eight core blow machines and one full circle (core blow) machine. Each branch duct is equipped with a small 3" X 10" hood positioned above the core box. Capture velocity through these hoods ranged from 400 - 600 FPM and capture velocity for the 4' X 5' hood (provided for the circular core blow machine) ranged from 0 to 50 FPM; the average was about 15 FPM for a 9 point grid. The second full circle machine was equipped with a separate system; however, to the surprise of the operator, the fan did not work. The slight air movement was due to thermal action.

2. Medical

The results from the medical interviews conducted on March 19, 1975 are presented in Table V. Most frequently, employees noted that their symptoms were provoked by "the gas" by which it is assumed they meant DMEA. Symptoms ranged in severity from mild to severe and occasionally lasted into the evening after the shift. Most frequently noted were headaches and irritation of the eyes, nose, and throat. Pulmonary complaints were slightly less frequent. Several persons noted transient substernal chest discomfort with or without wheezing.

During the follow-up survey on January 19, 1976, 25 employees were interviewed. This group is representative of personnel in Department 13 and 68. There were six women and 17 men in this group. The mean age was 33 years (range: 21 to 51 years) and the average employment at Morris Bean Company was 7 years (range: 2 years to 22 years).

Table VI summarizes the responses to that portion of the questionnaire pertaining to possible work-related complaints and/or illness. Most frequently noted was: mucous membrane irritation, eye irritation, nose and throat irritation, sinus irritation. Headache was less commonly mentioned. The above symptoms were related to "the gas." It was frequently noted that these symptoms were of an episodic nature occurring when there were leaks in the gas lines or mechanical difficulties with the core boxes. One person noted episodes of chest discomfort, shortness of breath, nausea and vomiting due to the use of a silicone spray.

Table VII summarizes the employee's past history of symptoms related to DMEA. Again, most commonly noted is irritation of mucous membrane, and the eyes, nose and throat. Less frequently noted are chest discomfort, wheezing, nausea and/or vomiting. There were no significant differences in the frequency of symptoms when smokers and non-smokers were compared.

During the 24-hour period of this medical study, eight persons (35%) out of 23 developed symptoms which they reported: One person reported nausea; five persons reported sore throats; one reported a headache, and one reported a stuffed nose. The operators who were symtomatic on the day of study are the following: the coreblow machine operators A, D, H, J, K, and O, the utility operator A, and the sandmixer A. (Environmental exposures measured by these workers on the days of the study are summarized in Tables I, III, and IV.) All chest examinations, except one, were within normal limits. Of the eight persons who were symptomatic on the day of the study, only one had an injected throat and one had an injected conjunctivae which correlated with their symptoms. On the other hand, nonspecific mucous membrane injection was found in one person and markedly enlarged tonsils were found in two persons. One person (Subject #9) with a history of chronic cough, dyspnea, shortness of breath and wheezing and with a long cigarette smoking history had a markedly abnormal chest examination which showed scattered rales, rhonchi and wheezing. Another employee (Subject #21) who carries a diagnosis of emphysema was asymptomatic and had a normal chest ausultation and mild digital clubbing. No person gave a history suggestive of episodes of acute asthma related to working in the core areas. No person gave a history suggestive of silicosis; however, the symptoms of chronic bronchitis and empnysema may mask those symptoms of silicosis.

The results of the pre- and post-shift pulmonary function tests along with total esoiophil counts are contained in Tables VIII and IX. There were three persons (#6, #17 and #24) whose $FEV_{1.0}$ or MMEF changed over the shift. These changes were not associated with pulmonary symptomatology or abnormal chest examinations. They are probably not medically significant changes. Two persons (#9 and #21) with histories suggestive of chronic obstructive lung disease and chronic cigarette smoking fulfilled the criteria used to diagnose obstructive airway disease.

Table XI shows the comparison of the mean values for FVC, $FEV_{1.0}$, MMEF and total eosinophil counts for smokers, nonsmokers and all subjects over the course of the shift. There were no statistically significant changes in these values at the 95% level using the paired t-test. A small overall decline in total eosinophil count is noted.

Six post-shift total eosinophil counts (25%) out of 23 determinations were elevated above the corresponding pre-shift value. These changes were not associated with the acute development of symptoms nor were they associated with statistically significant changes in FVC, $FEV_{1.0}$ or MMEF suggestive of pulmonary sensitization. These data are presented in Tables XII.

Table XIII shows that the development of symptoms was not associated with a statistically significant change in pulmonary function data but was associated with a 41% decrement in total eosinophil count. The biological and medical significance of this change is not clear but may reflect a nonspecific stress reaction. A diurnal variation in total eosinophil count is known to occur. Persons without symptoms on the day of the study

showed only a slight change (2%) in total eosinophil count. Table XIV shows that while there were decrements in total eosinophil change (41%); these changes did not reach the level of statistical significance because of the small sample size.

V. CONCLUSIONS AND RECOMMENDATIONS

Employees in the core making area (of Department 13 and 68) have experienced sporadically the transient development of some or all of the following symptoms: irritation of the eyes, nose, throat, blurred vision, headache, skin irritation, chest discomfort, difficult breathing, wheezing, coughing, worsening of pre-existing sinusitis, frequent chest colds, and nausea. The development of these symptoms was attributed to concentrated exposure to DMEA, most usually after mechanical problems, leaks in lines or faulty ventilation with core machines.

During the follow-up survey eight persons (35%) out of 23 reported the acute development of the following symptoms: one reported nausea; five reported sore throats; one reported a headache, and one reported a stuffed nose.

Because of the frequency of such episodes and the insufficient amount of information on dimethylethylamine along with the free silica concentration measured the following recommendations should be instituted:

(1) Upgrade the local exhaust systems in Departments 13 and 68 by balancing the systems and assuring that the capture velocities are adequate. These systems should be capable of maintaining DMEA and free silica concentrations to a minimum.

(2) Determine the number of air changes per hour in Department 68; it may be necessary to increase this because of the nature of the work, number of employees, and number of core blow machines involved in such a small area. The increase in the number of air changes/hour can be accomplished by providing tempered air as general dillution ventilation.

(3) Provide appropriate protective gloves to reduce skin contact with organic binders during mixing in Department 13.

(4) Clean branch ducts regularly of core materials which become deposited within the duct and subsequently restrict air flow.

(5) Provide medical examinations prior to employee placement and at least once each three years thereafter. Examinations should include:

(a) A medical and occupational history

(b) A chest radiograph (14" X 17")

(c) Pulmonary function tests to include FVC, $FEV_{1.0}$ and MMEF

(d) Body weight

(e) Height

(f) Age

An employee with or without radiographic evidence of silicosis who has respiratory distress and/or pulmonary functional impairment should be fully evaluated by a physician qualified to advise the employee whether he should continue working in a dusty trade.

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TABLE I

Dimethylethylamine Concentration in Workers Breathing Zones
Core Department

Morris Bean and Company
Yellow Springs, Ohio

January 19-20, 1976

January 19, 1976

Job Classification	Sample Number	Time	DMEA Conc. in ppm*	Comments
Coreblow Machine Operator (A)	CT-21	0736-1120	3.6	TWA for CT-21 & CT-22 is 4.4 ppm;
(Dept. 68)	CT-22	1205-1515	5.4	Machine #7
Trimmer (A)	CT-23	0741-1120	N.D.**	
(Dept. 68)	CT-24	1200-1525	N.D.	
Utility Operator (A)	CT-37	0804-1123	N.D.	
(Dept. 68)	CT-38	1204-1525	N.D.	
Coreblow Machine Operator (B)	CT-39	0806-1125	N.D.	
(Dept. 68)	CT-40	1200-1525	N.D.	Machine #4
Coreblow Machine Operator (C)	CT-17	0812-1125	N.D.	
(Dept. 68)	CT-18	1200-1525	N.D.	
Group Leader (A)	CT-19	0825-1125	N.D.	
(Dept. 68)	CT-20	1200-1518	N.D.	
Sand Mixer (A)	CT-25	0753-1125	N.D.	
(Dept. 68)	CT-26	1204-1523	N.D.	
Pattern Maintenance (A)	CT-27	0755-1125	N.D.	
(Dept. 68)	CT-28	1201-1527	N.D.	
Coreblow Machine Operator (D)	CT-29	0742-1120	2.3	TWA for CT-29 & CT-30 is 2.3 ppm;
(Dept. 68)	CT-30	1200-1520	2.2	Machine #3
Trimmer (B)	CT-31	0744-1120	1.1	TWA for Ct-31 & CT-32 is 0.6 ppm
(Dept. 68)	CT-32	1200-1518	N.D.	
Foreman (A)	CT-33	0708-1125	N.D.	
(Dept. 68)	CT-34	1201-1523	N.D.	
Coreblow Machine Operator (E)	CT-35	0711-1122	7.4	Sample for P.M. broken;
(Dept. 68)				Machine #2
Coreblow Machine Operator (F)	CT-5	0713-1120	3.2	TWA for CT-5 & CT-6 is 3.3 ppm
(Dept. 68)	CT-6	1205-1525	3.5	
Assistant Engineer (A)	CT-7	0715-1120	N.D.	Trouble shoots coreblow machines
(Dept. 68 & 13)	CT-8	1215-1518	N.D.	
Coreblow Machine Operator (G)	CT-41	0840-1130	N.D.	
(Dept. 13)	CT-42	1215-1515	N.D.	
Coreblow Machine Operator (H)	CT-43	0843-1130	N.D.	
(Dept. 13)	CT-44	1215-1525	N.D.	
Coreblow Machine Operator (I)	CT-13	0826-1125	N.D.	
(Dept. 68)	CT-14	1200-1518	N.D.	
Coreblow Machine Operator (J)	CT-15	0837-1130	N.D.	Mixes sand also
(Dept. 13)	CT-16	1220-1510	N.D.	
Coreblow Machine Operator (K)	CT-1	0745-1120	N.D.	Full circle core
(Dept. 68)	CT-2	1200-1520	N.D.	
Foreman (B)	CT-3	0752-1120	N.D.	
(Dept. 13)	CT-4	1215-1515	N.D.	
Coreblow Machine Operator (L)	CT-9	0845-1130	N.D.	
(Dept. 13)	CT-10	1225-1515	N.D.	
Coreblow Machine Operator (M)	CT-11	0847-1130	N.D.	Minus 7 minutes for pump change
(Dept. 13)	CT-12	1225-1520	N.D.	

TABLE I (contd)

Morris Bean and Company

January 20, 1976

Coreblow Machine Operator (A)	CT-68	0717-1121	2.6	TWA for CT-68 & CT-69 is 1.8 ppm;
(Dept. 68)	CT-69	1205-1509	0.8	Machine #7
Coreblow Machine Operator (F)	CT-70	0719-1120	2.5	TWA for CT-70 & CT-71 is 1.9 ppm;
(Dept. 68)	CT-71	1205-1512	1.2	Machine #5
Coreblow Machine Operator (K)	CT-50	0727-1127	0.6	TWA for CT-50 7 CT-51 is 0.3 ppm;
(Dept. 68)	CT-51	1205-1515	N.D.	Full circle core
Coreblow Machine Operator (C)	CT-52	0730-1120	0.6	TWA for CT-52 & CT-53 is 0.3 ppm;
(Dept. 68)	CT-53	1204-1506	N.D.	Full circle core
Sand Mixer (A)	CT-58	0737-1130	N.D.	
(Dept. 68)	CT-59	1204-1507	N.D.	
Coreblow Machine Operator (I)	CT-60	0707-1115	0.9	TWA for CT-60 & CT-61 is 0.5 ppm;
(Dept. 68)	CT-61	1208-1508	N.D.	Machine #8
Coreblow Machine Operator (N)	CT-62	0710-1117	1.1	TWA for CT-62 & CT-63 is 0.7 ppm;
(Dept. 68)	CT-63	1210-1511	N.D.	Machine #6
Trimmer (A)	CT-64	0740-1122	0.7	TWA for CT-64 & CT-65 is 0.4 ppm
(Dept. 68)	CT-65	1206-1515	N.D.	
Pattern Maintenance (A)	CT-66	0743-1120	0.7	TWA for CT-66 & CT-67 is 0.7 ppm
(Dept. 68)	CT-67	1210-1505	0.7	
Coreblow Machine Operator (D)	CT-72	0722-1120	2.6	TWA for CT-72 & CT-73 is 1.4 ppm;
(Dept. 68)	CT-73	1205-1510	N.D.	Machine #3
Coreblow Machine Operator (O)	CT-74	0725-1125	0.8	TWA for CT-74 & CT-75 is 15.6 ppm;
(Dept. 68)	CT-75	1200-1505	35.0	Machine #1
Coreblow Machine Operator (L)	CT-82	0751-1122	N.D.	
(Dept. 13)	CT-83	1205-1505	N.D.	
Coreblow Machine Operator (H)	CT-84	0755-1120	N.D.	
(Dept. 13)	CT-85	1205-1505	N.D.	
Foreman (A)	CT-90	0750-1120	N.D.	
(Dept. 68)	CT-91	1200-1510	N.D.	
Trimmer (B)	CT-92	0752-1118	0.9	TWA for CT-92 & CT-93 is 0.5 ppm
(Dept. 68)	CT-93	1205-1510	N.D.	
Coreblow Machine Operator (B)	CT-54	0712-1120	0.8	TWA for CT-54 & CT-55 is 0.8 ppm;
(Dept. 68)	CT-55	1205-1504	0.7	Machine #4
Coreblow Machine Operator (E)	CT-56	0714-1119	1.3	TWA for CT-56 & CT-57 is 1.0 ppm;
(Dept. 68)	CT-57	1210-1507	0.5	Machine #2
Coreblow Machine Operator (M)	CT-86	0757-1125	N.D.	
(Dept. 13)	CT-87	1207-1505	N.D.	
Coreblow Machine Operator (J)	CT-88	0800-1130	N.D.	
(Dept. 13)	CT-89	1210-1423	N.D.	
Assistant Engineer (A)	CT-78	0805-1118	N.D.	
(Dept. 68 & 13)	CT-79	1210-1513	N.D.	
Coreblow Machine Operator (G)	CT-80	0809-1117	N.D.	
(Dept. 13)	CT-81	1208-1516	N.D.	
Core Stacker (A)	CT-76	0840-1118	N.D.	
(Dept. 68)	CT-77	1230-1515	N.D.	

* Dimethylethylamine Concentration in parts per million.
** None Detected; detection limit 0.02 mg per sample.

TABLE II

DMEA Concentrations in the Core Department

Morris Bean and Company
Yellow Springs, Ohio

March 19, 1975

Department #68

Core blow Machine #	Time	Concentration* in ppm	Comments
3	1310	≈ 7 DMEA	
6	1318	≈ 10 DMEA	3 complete cores
Full circle	1324	≈ 25** DMEA	1 stroke only
8	1330	≈ 5 DMEA	
Full circle	1342	≈ 5 DMEA	
Trimming & gluing station	1342	≈ 6 DMEA	
8	1350	≈ 5 DMEA	only 1 core at a time; gen. 2/machine
7	1350	< 5 DMEA	without machine operating
Foreman's desk	1440	≈ 8 DMEA	gen. background
8	1440	≈ 500 CO_2	4 cores made
Foreman's desk	1410	≈ 5 CO	gen. background
Department #16			
CB-16	1435	≈ 2 ppm	only one machine operating

* For lack of a sampling method for DMEA, triethylamine detector tubes were used to measure concentrations.
** Local exhaust system was temporarily out of order.

TABLE III

Respirable Dust Concentration in Workers' Breathing Zones
(Total Particulate and Free Silica)
Core Department

Morris Bean and Company
Yellow Springs, Ohio

January 19, 1976

Job Classification	Sample Number	Time	Free Silica (Quartz) in ug/M3	Total Particulate in ug/M3	Comments
Trimmer (A) (Dept. 68)	364	0741-1120 1200-1520	28	112	Respirable fraction
Coreblow Machine Operator (I) (Dept. 68)	375	0826-1125 1200-1515	N.D.**	173	Machine #8 Respirable fraction
Coreblow Machine Operator (J) (Dept. 13)	367	0837-1130 1220-1520	50	533	Respirable fraction
Coreblow Machine Operator (L) (Dept. 13)	353	0845-1130 1225-1515	N.D.	270	Respirable fraction
Coreblow Machine Operator (M) (Dept. 13)	352	0847-1130 1225-1515	35	141	Respirable fraction
Area Sample-Near Trimmer (Dept. 68)	358	0900-1515	198	405	Total dust
Area Sample-Near Trimmer (Dept. 68)	417	0900-1515	18	.162	Respirable
Area Sample-Near Mixer (Dept. 13)	366	0925-1500	54	252	Total; respirable sample was discarded - not valid

January 20, 1976

Coreblow Machine Operator (A) (Dept. 68)	392	0717-1121 1205-1509	N.D.	206	Machine #7 Respirable fraction
Coreblow Machine Operator (K) (Dept. 68)	347	0727-1127 1205-1515	41	233	Full circle cores Respirable fraction
Sand Mixer (A) (Dept. 68)	385	0737-1130 1204-1510	14	435	Respirable fraction
Coreblow Machine Operator (N) (Dept. 68)	346	0710-1117 1210-1511	N.D.	249	Machine #6 Respirable fraction
Coreblow Machine Operator (D) (Dept. 68)	357	0722-1120 1205-1510	102	847	Machine #3 Respirable fraction
Coreblow Machine Operator (L) (Dept. 13)	391	0751-1122 1205-1505	32	558	Respirable fraction
Coreblow Machine Operator (E) (Dept. 68)	363	0714-1119 1210-1507	112	711	Machine #2 Respirable fraction
Coreblow Machine Operator (G) (Dept. 13)	379	0809-1117 1208-1516	125	814	Respirable fraction

* Micrograms per cubic meter.
** None Detected; detection limit is 10 µg/sample.

TABLE IV

Methylene Bis Phenol Isocyanate Concentrations in Workers' Breathing Zones
Core Department

Morris Bean and Company
Yellow Springs, Ohio

January 19, 1976

Job Classification	Sample Number	Time	MDI Conc. in mg/M^3	Comments
Coreblow Machine Operator (A)	M-7	0736-1120	0.027	Machine #7
(Dept. 68)	M-25	1205-1525	0.005	
Trimmer (A)	M-8	0741-1120	0.005	
(Dept. 68)	M-26	1200-1515	0.067	
Utility Operator (A)	M-15	0804-1123	0.085	
(Dept. 68)	M-33	1204-1520	0.031	
Coreblow Machine Operator (B)	M-16	0806-1125	0.005	Machine #4
(Dept. 68)	M-34	1200-1520	0.050	
Coreblow Machine Operator (C)	M-5	0825-1125	0.026	Full circle cores
(Dept. 68)	M-23	1200-1520	0.010	
Group Leader (A)	M-6	0825-1125	0.022	
(Dept. 68)	M-24	1200-1520	0.065	
Sand Mixer (A)	M-9	0753-1125	0.009	
(Dept. 68)	M-27	1204-1520	0.020	
Pattern Maintenance (A)	M-10	0755-1125	0.029	
(Dept. 68)	M-28	1201-1527	0.005	
Coreblow Machine Operator (D)	M-11	0742-1120	0.014	Machine #3
(Dept. 68)	M-29	1200-1518	0.005	
Trimmer (B)	M-12	0744-1120	0.010	
(Dept. 68)	M-30	1200-1440	0.006	
Foreman (A)	M-13	0708-1124	0.015	
(Dept. 68)	M-31	1201-1522	0.020	
Coreblow Machine Operator (E)	M-14	0711-1122	0.003	Machine #2
(Dept. 68)	M-32	1200-1524	0.025	
Coreblow Machine Operator (F)	M-3	0713-1120	0.016	Machine #5
(Dept. 68)	M-21	1205-1517	0.010	
Assistant Engineer (A)	M-4	0715-1120	0.033	
(Dept. 68 & 13)	M-22	1215-1515	0.033	
Coreblow Machine Operator (G)	M-17	0840-1130	0.106	
(Dept. 13)	M-35	1215-1515	0.017	
Coreblow Machine Operator (H)	M-18	0843-1130	0.108	
(Dept. 13)	M-36	1215-1333	0.103	
Coreblow Machine Operator (K)	M-1	0745-1120	0.009	Full circle cores
(Dept. 68)	M-19	1200-1520	0.025	
Foreman (B)	M-2	0752-1120	0.082	
(Dept. 13)	M-20	1215-1510	0.108	
January 20, 1976				
Coreblow Machine Operator (F)	M-45	0719-1120	0.017	Machine #5
(Dept. 68)	M-58	1205-1520	0.225	
Coreblow Machine Operator (C)	M-40	0739-1120	0.029	Full circle cores
(Dept. 68)	M-53	1204-1506	0.082	
Sand Mixer (A)	M-42	0737-1130	0.026	
(Dept. 68)	M-55	1204-1507	0.077	
Coreblow Machine Operator (I)	M-43	0707-1115	0.016	Machine #8
(Dept. 68)	M-56	1208-1508	0.072	
Trimmer (A)	M-44	0740-1122	0.023	
(Dept. 68)	M-57	1206-1515	0.136	
Coreblow Machine Operator (O)	M-46	0725-1125	0.054	Machine #1
(Dept. 68)	M-59	1200-1505	0.135	
Coreblow Machine Operator (H)	M-48	0755-1120	0.029	
(Dept. 13)	M-61	1205-1515	0.095	
Foreman (A)	M-51	0750-1120	0.019	
(Dept. 68)	M-63	1200-1510	0.116	
Trimmer (B)	M-52	0752-1118	0.019	
(Dept. 68)	M-64	1205-1510	0.108	
Coreblow Machine Operator (B)	M-41	0712-1120	0.048	Machine #4
(Dept. 68)	M-54	1205-1504	0.134	
Coreblow Machine Operator (M)	M-49	0757-1125	0.034	
(Dept. 13)	M-62	1207-1505	0.066	
Coreblow Machine Operator (J)	M-50	0800-1130	0.019	
(Dept. 13)	M-65	1210-1423	0.068	
Assistant Engineer (A)	M-47	0805-1118	0.041	
(Dept. 68 & 13)	M-60	1210-1513	0.230	

TABLE V

Results of Medical Interviews

Symptoms or Complaints Experienced in the Past

Morris Bean Company
Yellow Springs, Ohio

March 19, 1975

Symptom or Complaint	Number of persons with Complaints (%)
Sinus Irritation	3 (9%)
Eye Irritation	14 (41%)
Nasal Irritation	6 (18%)
Throat Irritation	6 (18%)
Chest Discomfort	5 (15%)
Acute Dyspnea	5 (15%)
Cough	2 (6%)
Headache	15 (44%)
Nausea and/or Vomiting	6 (18%)
Dizzy/Lightheadedness	2 (6%)
Frequent Chest Colds	2 (6%)

* Note: Total percentage is greater than 100% since most persons had more than one complaint.

TABLE VI

Summary of Possible Work Related Complaints and/or Illnesses

Morris Bean Company, Yellow Springs, Ohio

19 January 1976

Work-Related Symptoms or Complaints Past or Present	Related To	Allergic History
Mucous Membrane Irritation - 8	"gas" in core room(s)	Hay Fever - 1
Skin Rash - 1	unknown	None - 22 Total - 23
Headache - 3	"gas" in core room(s)	
Chest Discomfort, shortness of breath nausea, vomiting - 1	use of silicone spray "gas" in core room(s)	
None - 10		
Total - 23*		

* Note: Data from two persons not included.

TABLE VII

Summary of Past History of Work Related Symptoms

Morris Bean Company, Yellow Springs, Ohio

19 January 1976

	Throat Irritation	Eye Irritation	Nasal Irritation	Cough	Wheezing or Whistling in Chest	Chest Discomfort	Nausea and/or Vomiting
Symptomatic %	13 (57%)	13 (57%)	9 (39%)	4 (17%)	2 (9%)	3 (13%)	2 (9%)
Without Symptom	10 (43%)	10 (43%)	14 (61%)	19 (83%)	21(91%)	20 (87%)	21 (91%)
TOTAL	23	23	23	23	23	23	23

TABLE VIII

Results of Pulmonary Function Tests and
Total Eosinophil Counts - Non smokers

Morris Bean Company, Yellow Springs, Ohio
19 January 1976

	PRE-SHIFT				POST-SHIFT			NON-SMOKERS
Subject #	FVC (% Pred)	$FEV_{1.0}$ (% Pred)	MMEF (% Pred)	Total Eosinophil Count (Pre)	FVC	$FEV_{1.0}$	MMEF	Total Eosinophil Count (Post)
1	3.29 (101)	2.72 (108)	3.60 (116)	211	3.27 (100)	2.65 (103)	3.40 (110)	158
3	4.10 (88)	3.87 (99)	5.70 (127)	88	4.05 (87)	3.89 (100)	5.90 (131)	53
6	5.31 (110)	4.22 (119)	4.70 (134)	35	4.63 (96)	3.85 (103)	4.50 (128)	35
11	6.59 (120)	4.95 (110)	6.1 (144)	88	6.13 (112)	4.79 (105)	6.1 (144)	106
15	4.72 (117)	3.45 (105)	2.6 (71)	106	4.70 (116)	3.64 (110)	3.40 (92)	105
22	3.94 (90)	3.32 (95)	4.3 (111)	387	3.72 (85)	3.17 (91)	4.4 (113)	475
23	3.96 (79)	3.51 (88)	5.5 (129)	194	3.99 (79)	3.49 (88)	5.5 (129)	264
24	4.61 (90)	3.57 (96)	3.5 (98)	194	5.47 (107)	3.57 (96)	2.10 (59)	70
19	6.55 (103)	5.88 (118)	7.4 (145)	194	6.25 (99)	5.62 (113)	7.40 (145)	123
Mean (N-9)	4.78	3.94	4.82	166	4.69	3.86	4.74	154
± 1 Standard Deviation (SD)	1.16	0.96	1.49	103	1.05	0.88	1.64	138

TABLE IX

Results of Pulmonary Function Test and
Total Eosinophil Counts - Smokers

Morris Bean Company, Yellow Springs, Ohio
19 January 1976

	Pre-Shift			Total Eosinophil Count	Post-Shift			Smokers Total Eosinophil Count
	FVC (% Pred)	FEV (% Pred)	MMEF (% Pred)	Cells ml Blood	FVC	FEV	MMEF	
2	3.72 (108)	2.64 (98)	1.90 (60)	158	3.61 (106)	2.45 (91)	1.70 (54)	53
4	5.48 (102)	4.15 (98)	4.70 (104)	264	5.03 (93)	3.98 (94)	4.30 (96)	158
5	3.33 (101)	2.63 (103)	2.80 (92)	140	3.08 (94)	2.48 (97)	3.00 (99)	123
7	6.01 (111)	5.03 (118)	5.80 (119)	546	6.25 (115)	4.92 (115)	6.80 (140)	211
8	5.67 (101)	4.02 (89)	2.80 (58)	193	5.14 (92)	3.66 (81)	2.80 (58)	88
9	4.95 (91)	2.10 (51)	0.93 (23)	334	4.92 (91)	1.71 (42)	0.69 (17)	106
10	5.94 (145)	4.26 (122)	3.20 (77)	440	5.62 (137)	4.19 (120)	3.50 (84)	722
12	4.33 (82)	3.21 (77)	2.50 (56)	193	4.30 (82)	3.25 (78)	2.60 (58)	141
13	5.10 (99)	4.08 (98)	4.10 (89)	158	4.92 (96)	3.89 (93)	4.4 (95)	123
14	4.56 (109)	2.73 (83)	2.20 (60)	526	4.05 (97)	2.89 (88)	2.70 (74)	598
16	3.19 (85)	2.17 (74)	2.30 (69)	123	3.08 (82)	2.46 (83)	2.75 (82)	70
17	4.59 (124)	3.69 (135)	4.00 (123)	88	4.67 (126)	3.42 (117)	3.40 (105)	
18	4.19 (82)	3.68 (90)	4.60 (105)	510	3.96 (78)	3.68 (89)	4.50 (102)	533
20	4.49 (83)	4.04 (99)	7.00 (168)	123	4.35 (81)	4.01 (98)	7.70 (185)	282
21	4.59 (96)	2.07 (60)	1.20 (36)	282	4.50 (94)	2.05 (59)	1.10 (33)	193
Mean (N=15)	4.68	3.37	3.34	285	4.50	3.27	3.46	242
SD	0.87	0.93	1.69	158	0.88	0.90	1.90	215

TABLE X

Normal Hematologic Values for Complete Blood Counts *

	Red Cell Count, $X10^6$/ml Blood	Hemoglobin gm/100 ml Blood	Vol. Packed Red Blood cells, ml/100 Blood	Total White Cell Count $X10^3$/ml Blood (Range)	Neutrophils (Range) %	Eosinophils (Range) %	Basophils (Range) %	Lymphocytes (Range) %	Monocytes (Range) %
Men	5.4 ± 0.8**	16.0 ± 2.0	47.0 ± 5.0	7.4	4300	230	44	2700	500
				(4.5-11.0)	(1400-7700)	(0-570)	(0-124)	(1000-4800)	(140-860)
					38-70%	0-7%	0-1.6%	21-49%	2-10%
Women	4.8 ± 0.6	14.0 ± 2.0	42.0 ± 5.0						

* Adapted from W.J. Williams, ed., Hematology. New York, McGraw Hill, 1972, and M.M. Wintrobe, Clinical Hematology, Philadelphia, Lea & Febiger, 1967

** ± 1 Standard Deviation (SD).

Table XI

Comparison of Pulmonary Function Test and Eosinophil Counts by Smoking History

Morris Bean Company, Yellow Springs, Ohio
19 January 1976

	Pre-Shift				Post-Shift			
Smoking History	FVC (Liters)	$FEV_{1.0}$ (Liter/Sec.)	MMEF 25-75% (Liter/Sec.)	Total Eosinophil Count	FVC	$FEV_{1.0}$	MMEF	Total Eosinophil Count
All Smokers (N=15)	4.68	3.37	3.34	285	4.50	3.27	3.46	242
SD*	0.87	0.93	1.69	158	0.88	0.90	1.90	215
Non-Smokers (N=9)	4.78	3.94	9.82	166	4.69	3.86	4.74	154
SD*	1.16	0.96	1.49	103	1.05	0.88	1.64	138
All Subjects (N=24)	4.72	3.58	3.89	239**	4.57	3.49	3.94	208**
SD	0.97	0.96	1.75	149	0.93	0.92	1.88	190

* $\pm$ 1 standard deviation

** for this determination, (N=23)

TABLE XII

Comparison of Increases in Eosinophil Counts with Pulmonary Function Tests and Development of Symptoms

Morris Bean Company, Yellow Springs, Ohio
19 January 1976

	Pre-Shift				Post-Shift				
Subject #	FVC (Liter)	$FEV_{1.0}$ (Liter/Sec)	MMEF (Liter/Sec)	Total Eosinophil Count	FVC	$FEV_{1.0}$	MMEF	Total Eosinophil Count	Development of Symptoms over Shift
10	5.94	4.26	3.20	440	5.62	4.19	3.50	772	0
11	6.59	4.95	6.10	88	6.13	4.79	6.10	100	0
18	4.19	3.68	4.60	510	3.96	3.63	4.50	533	0
20	4.49	4.04	7.00	123	4.35	4.01	7.70	282	0
22	3.94	3.32	4.30	387	3.72	3.17	4.40	475	0
23	3.96	3.51	5.50	194	3.99	3.49	5.50	264	0
Mean (N=6)	4.81	3.87	4.70	324	4.55	3.74	4.91	433	0/6
SD	1.03	0.71	1.66	185	0.94	0.65	1.67	228	

TABLE XIII

Comparison of Pulmonary Function Tests with Acute Development of Symptoms

Morris Bean Company, Yellow Springs, Ohio

19 January 1976

Subject #	FVC (Liter)	$FEV_{1.0}$ (Liter)	MMEF (Liter/Sec)	Total Eosinophil Count	FVC	$FEV_{1.0}$	MMEF	Total Eosinophil Count	Acute Symptom on day of Study
1	3.29	2.72	3.60	211	3.27	2.65	3.40	158	dry throat
3	4.10	3.87	5.70	88	4.05	3.89	5.90	53	sore throat
5	3.33	2.63	2.80	140	3.08	2.48	3.00	123	headache
7	6.01	5.03	5.80	546	6.25	4.92	6.80	211	sore throat, eye and chest irritation
8	5.67	4.02	2.80	193	5.14	3.66	2.80	88	sore throat
9	4.95	2.10	0.93	334	4.92	1.71	0.69	106	nose irritation
17	4.59	3.69	4.00	-	4.67	3.42	3.40	-	dry throat
19	6.55	5.88	7.40	194	6.25	5.62	7.40	282	nausea
Mean (N=8)	4.81	3.74	4.12	244	4.70	3.54	4.17	145	
SD	1.21	1.27	2.07	153	1.20	1.28	2.29	79	

TABLE XIV

Changes in Total Eosinophil Counts

Morris Bean Company, Yellow Springs, Ohio

19 January 1976

	Total Eosinophil Count Pre-Shift	Totsl Eosinophil Count Post-Shift	% Change
All Smokers (N=15)	285	242	-15%
All Non-smokers (N=9)	166	154	- 7%
All Employees (N=24)	239	208	-13%
All with Symptoms (N=8)	244	145	-41%
All without Symptoms (N=15)*	230	235	+ 2%

* Data from one person not included.