U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
CENTER FOR DISEASE CONTROL
NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH
CINCINNATI, OHIO 45226

HEALTH HAZARD EVALUATION DETERMINATION REPORT NO.77-15-421

LEEDS & NORTHRUP CORPORATION
EXPENDABLE DEVICES DIVISION
ELLWOOD CITY, PENNSYLVANIA

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I. TOXICITY DETERMINATION

A combined environmental-medical evaluation of particulates and vaporous contaminant exposures to workers involved in the manufacture of carbon analysis and temperature determination devices has been completed at the Leeds & Northrup Corporation, Expendable Devices Division, Ellwood City, Pennsylvania. The field investigation was conducted during December 13-15, 1976. The contaminants aerometrically evaluated were crystalline silica, total and respirable particulate, formaldehyde, ammonia, phenol, and hydrogen cyanide. The effects of exposure were evaluated by administering health questionnaires and limited physical examinations.

The airborne concentrations of formaldehyde and ammonia measured are believed to be low enough to prevent respiratory injury, but not necessarily low enough to prevent subjective symptoms of eye and/or upper respiratory tract irritation as reported by persons working at or in areas adjacent to the core machine operation. Increasing the effectiveness of the existing ventilation systems should materially decrease the contaminants' concentrations and degree of sensory irritancy.

The employees involved in cement mixing have direct skin contact with the refractory cements. The dermatologic effects observed were characterized by red, chapped and dry hands, which appears to be secondary to cement particulate exposure. The apparent dermatitis problem can be minimized by strict adherence to the use of protective equipment, work practices and good personal hygiene.

The large mixer operator is exposed to potentially toxic concentrations of respirable crystalline silica. Until environmental controls are implemented to reduce airborne levels of crystalline silica, the mixer operator should wear a half mask respirator with replaceable dust filter. The respirator selected must be approved by NIOSH to provide adequate respiratory protection against the concentrations of crystalline silica measured. Environmental control of the particulate generated by the large mixer operation should also materially decrease work room concentrations with a resultant decrease or elimination of nasal irritation reported by other workers in this area.

Part V of this report offers suggested industrial hygiene practices, engineering controls, and medical surveillance that can help minimize dermal and respiratory effects apparent to the manufacturing processes evaluated.

II. DISTRIBUTION AND AVAILABILITY OF DETERMINATION REPORT

Copies of this Determination Report are currently available upon request from NIOSH, Division of Technical Services, Information and Dissemination Section, 4676 Columbia Parkway, Cincinnati, Ohio 45226. After 90 days the report will be available through the National Technical Information Service (NTIS), Springfield, Virginia 22150. Information regarding its availability through NTIS can be obtained from NIOSH, Publications Office at the Cincinnati address.

Copies of this report have been sent to:

1. Leeds & Northrup Company, Expendable Devices Division, Ellwood City, Pennsylvania 16117.
2. International Molders and Allied Workers of America - Local Number 2, Ellwood City, Pennsylvania 16117.
3. International Molders and Allied Workers of America, 1225 E. McMillan Street, Cincinnati, Ohio 45206
4. U.S. Department of Labor - OSHA - Region III
5. NIOSH - Region III

For the purpose of informing the approximately "twenty affected employees", this Determination Report shall be "posted" for a period of at least thirty calendar days in a prominent place(s) readily available to the workers.

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 an employer or authorized representative of employees, to determine whether a 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 Local No. 2, International Molders and Allied Workers of America, AFL-CIO-CLC, concerning worker exposure to chemical compounds used or evolved from the manufacturing operations in the Tectip® department and cement mixing area. The alleged health problems included eye, nose, throat, and skin irritation; breathing problems; nose bleeds; chest pains; facial flushing; blood pressure problems; loss of voice over the period of an eight hour work shift; and sore throats.

IV. HEALTH HAZARD EVALUATION

A. Process Decription - Conditions of Use

The Leeds & Northrup Corporation, Expendable Devices Division, is engaged in the manufacture of Tectip® expendable cartridges for carbon analysis of metal alloys and Temtip® expendable immersion thermocouples for molten metal temperature determinations.

The body of Tectips® are made from a phenol-formaldehyde resin sand mixture. The operation consists of two basically standard shell core machines, with automation adaptation to this product. Coated phenolic resin sand is blown into a pneumatically controlled metal mold pre-heated to 400 to 500°F, held for 15-30 seconds to allow the binder to polymerize, then the formed cores are automatically discharged onto a conveyor belt and transported to a temporary packing station. The cores are then taken to the pushing and coating areas where a wire thermocouple is inserted and the inner surface coated with a tellurium metal (<10 percent by weight) or an electrical refractory cement slurry. The former coating referred to as "Thiem Kwik Chill" or "Red Coat" is supplied as a ready-to-use slurry; the latter referred to as "White Coat" as a powder requiring preparation. The tellurium and refractory cement coated Tectips® are then cured at approximately 200°F and 140°F, respectively. The shell core making and core packing operations are performed under canopy hoods.

The three types of cements that could be used for coating Tectips® or to make Temtip® refractory bodies include sodium silicate, aluminum trihydrate, and calcium aluminate based cements. The cements were determined by NIOSH to have a crystalline silica content (percent by weight) of <0.6, <0.6, and 29, respectively. The cement coatings are prepared in the "cement mixing area" using standard mixing procedures. The cement slurry used to coat the Tectips® is prepared in several locally exhausted mixers and the cement that makes up the refractory body of Temtips® is mixed in a larger non-mechanically ventilated mixer. (Refractory cement mixing was the only Temtip® operation evaluated.)

B. Hazard Identification - Conditions of Exposure

The shell core machine personnel are concurrently exposed to multiple chemical contaminants evolved from the curing and thermal decomposition of the synthetic based sand binder system.[1,2] Included are formaldehyde, phenol, hydrogen cyanide and ammonia. The ammonia is generated from thermal degradation of hexamethylene tetramine; the phenolic resin catalyst. The workers also are exposed to airborne crystalline silica. The siliceous sand used in core preparation was determined by NIOSH to have a crystalline silica content of 94 percent by weight. A bulk sample of settled dust taken from the top surface of the canopy hood at the core packing station, showed a crystalline silica content of 35 percent by weight. The shell core machine operator and a core packer are exposed to the aforementioned contaminants 8 hours per day, 40 hours per week.

The thermocouple wire pushers and cartridge coaters also are exposed to airborne crystalline silica generated by the shell core machine operation. A bulk sample of settled dust taken from a rafter in each of these areas showed a crystalline silica content of 23 and 15 percent by weight, respectively. Due to the nature of the cartridge coaters job, requiring direct contact with the cement slurry, they also are potentially exposed to skin irritants such as hexavalent chromates contained therein. Four pushers and four coaters are normally exposed to the above contaminants 8 hours per day, 40 hours per week.

The cement mixers are exposed to airborne crystalline silica and particulate inherent to the job operation. Approximately 3 cement mixer operators are exposed for less than 3 hours per day, 5 days per week and a fourth operating the larger mixer is exposed 8 hours per day, 40 hours per week. Because the (a) volume of cement mixed, (b) lack of local exhaust ventilation on equipment, and (c) length of exposure the large mixer operator is exposed to significantly higher concentrations of crystalline silica and total particulate. The cement mixer operators also are exposed to the previously mentioned skin irritant, hexavalent chromium.

C. Evaluation Study Design

A combined environmental-medical evaluation was conducted at the Leeds & Northrup Company, Ellwood City, Pennsylvania, during December 13-15, 1976. During an entrance interview on December 13, the rules and regulations (42 CFR, Part 85), which govern the Health Hazard Evaluation Program, were highlighted with special emphasis on NIOSH authority for investigation, employee and employer representation, environmental sampling, employee interviews and medical examinations, review of personnel records, and employer rights and responsibilities relative to trade secret information and material identification. Secondly, the specific areas of the request and affected workers were discussed. Thirdly, information about processes, materials, production data, and basic personnel demographic data were obtained or inquiries made for their attainment.

The environmental evaluation consisted of an aerometric assessment of worker exposure to phenolic resin curing and thermal decomposition products and crystalline silica at the shell core machine operation, and to crystalline silica and particulate in the cement mixing area. The medical evaluation consisted of an interview on essentially every employee in the affected areas of the plant; limited physical examination on interviewed employees; and review of medical records of those employees interviewed.

Difficulties encountered in obtaining production data and basic demographic data have delayed the preparation and dissemination of the report.

D. Evaluation Methodology

a. Environmental Methodology

Exposures to particulate, vaporous and gaseous airborne contaminants were measured using personal and/or work area sampling techniques. The workers wore a personal sampling apparatus consisting of battery-powered vacuum pump and some type of device placed at the breathing zone, such as a filter or glass impinger containing a reagent, appropriate for the air contaminant being measured. Workroom air contaminant levels were measured by placing a stationary sampler at a fixed site in the immediate work vicinity.

1. Crystalline Silica: Personal and workroom respirable samples were collected using two-stage aerodynamic size-selective samplers. The personal samples were collected at the workers' breathing zone on a tared FWS-B filter contained in a 2-piece cassette mounted in a 10 mm cyclonic separator; air was pulled through the sampler at a rate of 1.7 liters per minute (lpm). Workroom samples were collected on a tared FWS-B filter contained in a 3-piece cassette mounted in a one-half inch steel cyclone; the flow rate was regulated at 9 lpm by a critical flow orifice. The mass concentration of dust was determined by weighing the filter before and after sampling using a semi-micro balance. The total crystalline silica content, milligrams (mg), of the dust was determined by x-ray diffraction analysis.[3] Total milligrams of crystalline silica is defined to include all crystalline forms of silica such as quartz, cristobalite, and tridymite.

2. Total Nuisance Particulate: The total particulate level was measured by drawing air at a flow rate of 1.7 lpm (flow rate is consistent with that for respirable samples) through a pre-weighed vinyl membrane filter mounted in a closed face cassette and then weighing the amount of dust collected.

3. Formaldehyde: Airborne formaldehyde was collected in 15 milliliters (ml) of 1 percent sodium bisulfite solution contained in a midget impinger; flow rate of 1 lpm. The current NIOSH recommended standard of 1 part of formaldehyde (contaminant) per million parts of contaminated air by volume (ppm) over a 30 minute sampling period was not published at the time of the evaluation; therefore, a 30 minute sampling strategy was not used to assess the workers' exposure. The concentration of formaldehyde was determined colorimetrically.[4] The lower limit of analytical detection reported was 0.2 micrograms (ug) per ml.

4. Ammonia: Airborne ammonia was collected in 15 ml of 0.01N sulfuric acid contained in a midget impinger; flow rate of 1 lpm. The concentration of ammonia was determined colorimetrically.[5] The lower limit of analytical detection reported was 5 ug per ml.

5. Phenol: Phenol was collected in 0.1N sodium hydroxide contained in a midget impinger; flow rate of 1 lpm. The concentration of phenol was determined by gas liquid chromatography.[6] The lower limit of analytical detection reported was 2 ug per ml.

6. Hydrogen Cyanide: Hydrogen cyanide was collected in 15 ml of 0.1N sodium hydroxide contained in a midget impinger; flow rate of 1 lpm. The concentration of hydrogen cyanide was determined by ion specific electrode detection for the cyanide ion.[7] The lower limit of analytical detection reported was 2 ug per ml.

b. Medical Methodology

The effects of worker exposure were evaluated by administering health questionnaires and completing limited physical examinations on essentially every affected worker. The questionnaire was structured to obtain personal identification data, an occupational history, and a medical history of complaints related to work. The interviewees were specifically queried on past and present occurrences of skin, eye, nose and throat irritation, and nose bleeds. The physical examination was limited to inspection of the skin; mucous membranes of the eyes, nose and throat; and auscultation of the lungs.

c. Ventilation

Qualitative air flow and visual inspection techniques were used to evaluate the canopy hood at the core packing station; the canopy hood over the two shell core machines; and the enclosed conveyor leading from the shell core machines to the core packing station. The air flow patterns were evaluated using a visual smoke tracer released through a small-diameter hand-held probe.

E. Evaluation Study Criteria

a. Criteria for Assessing Workroom Concentrations of Air Contaminants

Three sources of criteria are used to assess workroom concentrations of the air contaminants evaluated: (1) NIOSH Criteria Documents on Recommended Occupational Health Standards. (2) Recommended and Proposed Threshold Limit Values (TLV's) and Their Supporting Documentation as set forth by the American Conference of Governmental Industrial Hygienists (ACGIH), 1976. (3) Occupational Health Standards promulgated by the U.S. Department of Labor - OSHA (Federal Register, July 1, 1975, Volume 39, Title 29, Part 1910, Subpart Z, Section .1000).

These criteria are based on the current state of knowledge concerning the toxicity of these substances and designed to protect individuals occupationally exposed to these substances for an 8-hour or up to a 10-hour workday, 40-hour workweek over a normal lifetime. Because of wide variation in individual susceptibility, however, a small percentage of workers may experience discomfort from some substances at concentrations at or below the evaluation criteria, a smaller percentage may be affected more seriously by aggravation of a pre-existing condition or by development of an occupational illness.

The criteria represent 8-hour or 10-hour time-weighted averages, i.e. airborne concentrations averaged with regard to their duration, occurring over an 8-hour or 10-hour period. Certain agents are associated with a ceiling designation defined for a short interval (30 minutes or less). Such designations stem from the fact that such agents may provide irritation, sensitization or acute poisioning immediately or after a short latent period, upon even short exposures. For example, the irritant effects from short term exposure to formaldehyde or ammonia.

In the following tabulation of criteria, the most appropriate value (in the opinion of these authors) is presented with its reference and other information footnoted.

Workroom Environmental Criteria

Substance	Time-Weighted Average 8-Hour	Time-Weighted Average 10-Hour	Ceiling Value
[1]Crystalline Silica (Respirable Fraction)	--------------	50 ug/M³	
[2]Phenol	20 mg/M³	----------	60 mg/M³
[3]Hydrogen Cyanide and Cyanide Salts	----------	----------	4.7 ppm
[4]Ammonia	25 ppm		
[5]Total Nuisance Particulates	10 mg/M³		
[6]Formaldehyde	3 ppm	----------	10 ppm

[1]Reference: NIOSH Criterial Document (1974). Federal Occupational Health Standard (1975) is calculated by dividing 10 mg/M³ by the percent Quartz + 2, 8-hour TWA.

[2]Reference: NIOSH Criteria Document (1976). Federal Occupational Health Standard (1975) is 10 ppm, 8-hour TWA.

[3]Reference: NIOSH Criteria Document (1976). Federal Occupational Health Standard is 10 ppm, 8-hour TWA.

[4]Reference: ACGIH TLV (1976). NIOSH Criteria Document recommends a 50 ppm ceiling value determined over a 5 minute sampling period. Federal Occupational Health Standard (1975) is 50 ppm, 8-hour TWA.

[5]Reference: ACGIH TLV (1976). Federal Occupational Health Standard (1975) is 15 mg/M³, 8-hour TWA.

[6]Reference: Federal Occupational Health Standard (1975). NIOSH Criteria Document (1974) recommends a 1 ppm for any 30 minute sampling period.

b. Medical Criteria

The medical criteria used to determine a toxic response to the substances under investigation consists of symptoms and signs which each agent produces when a toxic exposure occurs. A brief review of the known pathophysiological effects of the substances determined to be causing a toxic or potentially toxic exposure to the workers under conditions used or found follows:

1. Crystalline Silica: The most important health concern from excessive inhalation of crystalline silica is an increased potential for developing a form of pneumoconiosis ("dusty lung") termed silicosis.[3] Silicosis has been defined as "a disease due to breathing air containing silica (silicon dioxide), characterized anatomically by generalized fibrotic changes in both lungs, and clinically by shortness of breath, decreased chest expansion, lessened capacity for work, absence of fever, increased susceptibility to tuberculosis (some or all of which symptoms may be present), and by characteristic x-ray findings. This form of pneumoconiosis usually develops after at least seven years of exposure, although a few cases have developed in as short a period of time as 1.5 years from inhalation of very high levels of silica with a high quartz content. At the other extreme, with exposure to low levels of free silica, more than twenty years may have to elapse before the disease develops to a stage when it can be diagnosed.

Early silicosis termed "simple silicosis" is usually first diagnosed by chest x-ray examination. At this stage there is little if any, functional impairment, and there are often no associated symptoms and signs. Symptoms occur when silicosis advances and becomes complicated by infection and emphysema. These changes are marked by intolerance to exertion, episodes of coughing, and production of thick sputum. When silicosis has progressed to this point, the chest x-ray is usually read as "conglomerate silicosis". Conglomerate silicosis many times progresses in spite of termination of exposure, becomes incapacitating to the affected worker, and is irreversible.

2. Ammonia: Inhalation of ammonia can produce effects ranging from mild upper respiratory and eye irritation to inflammation of the entire respiratory tract leading to pulmonary edema.[5] The threshold for olfactory (odor) perception in humans show wide variation (1-50 ppm).[8,9] Thus, many workers can smell ammonia even at safe levels.

3. Formaldehyde: Irritation to the eyes, nose, mouth and throat are the most common worker health effects from inhalation of this gas.[4] Formaldehyde has a very pungent odor which is detectable at levels less than 1 ppm; discomfort is noted at 2-3 ppm, when a tingling sensation in the eyes, nose, and throat may be felt; and a burning of the eyes, nose, and throat with difficult breathing occurs at 10-20 ppm. Considerable variation in individual susceptibility to formaldehyde gas is noticeable.[10,11]

Some workers develop a physical tolerance to the irritant effects and work in concentrations intolerable to others, but others are markedly sensitive and may become more susceptible on repeated exposure. Dermatitis may result from contact with either liquid solutions or with solid materials or resins containing free formaldehyde.

4. Total Nuisance Particulate: Inhalation of excessive amounts may not cause adverse effects in the lung; elevated concentrations reduce visibility and may result in unpleasant deposits in the eyes and nose, plus injury to the mucous membranes through mechanical action.

5. Cement Dermatitis: Skin diseases are very common among those working with cement. These diseases are more frequent among cement users (e.g. construction workers) than among cement manufacturing plant workers. Cement dermatitis refers to dermatitis produced by Portland Cement.[12,13] Cement is hygroscopic ("water loving") and may cause dryness and fissuring of the skin and its high alkaline nature may cause a caustic action. Grains of crystalline silica in cement may mechanically irritate the skin and cause dermatitis. Cement dermatitis is usually a primary irritant dermatitis, but can be complicated by a secondary allergic contact sensitivity to hexavalent chromates, and less often to cobalt and/or nickel. It is characterized by dryness, tightness, redness and thickening of the exposed skin areas.

F. Evaluation Results

a. Environmental Evaluation

Respirable and total particulate concentrations were measured in the breathing zone of the large cement mixer operator. The aerometric results obtained on two consecutive work days are presented in Tables 1 and 2, respectively. The respirable samples were analyzed for crystalline silica content by x-ray diffraction analysis. Quartz was the only polymorph (form) of crystalline silica detected. The results are reported as milligrams of respirable free silica per cubic meter of air (mg/M^3) sampled. The minimum detectable amount of quartz per filter was 0.02 mg.

The average concentration of respirable crystalline silica measured was 0.19 mg/M^3 (range of 0.11 to 0.27 mg/M^3), which is 3.8 times the NIOSH Criteria Document recommended health criteria of 0.05 mg/M^3. The measured levels also exceed the Federal Occupational Health Standard as promulgated by the U.S. Department of Labor - OSHA, as shown in Table 1. The average concentration of total particulate measured was 7.4 mg/M^3 (range of 6.02 to 8.80 mg/M^3), which is less than the ACGIH recommended TLV of 10 mg/M^3. Although the total particulate levels measured were below the evaluation criteria, these measurements were made at only one point in time and may not reflect an occasional excrescence that may occur on other days. According to an interviewed worker, the mixing operation was running about 15 percent below the level of 50 batches per day at noon. The reason was a work slow down due to some defective parts manufactured the day before requiring repairs. Therefore, it is reasonable to assume that the nuisance particulate levels generated with increased production could exceed the 10 mg/M^3 TLV and the crystalline silica would further exceed the 0.05 mg/M^3 NIOSH criteria.

Multiple exposure to crystalline silica and total respirable dust, formaldehyde, ammonia, phenol, and hydrogen cyanide by the shell core machine operator and core packer were aerometrically evaluated by obtaining work area and/or personal breathing zone samples. Because the affected workers were not very receptive to wearing the necessary sampling equipment, personal breathing zone samples were only obtained for formaldehyde (Table 3) and less frequent samples for ammonia (Table 4). The aerometric concentrations of formaldehyde and ammonia were less than 5 and 15 percent of the evaluation criteria, respectively. The aerometric levels of formaldehyde, ammonia, phenol, and hydrogen cyanide measured by stationary samplers positioned at three locations in the immediate areas of the shell core machine operation are presented in Table 5. The concentrations of formaldehyde and ammonia were less than 26 and 19 percent of the environmental criteria, respectively. The levels of phenol and hydrogen cyanide were less than the limit of detection of the method used for analysis.

When a worker is concurrently exposed to two or more substances, their combined effect, rather than that of either individually, should be considered. That is, if the sum of the following fractions,

$$C_1/T_1+C_2/T_2+C_3/T_3+...Cn/Tn$$

exceeds 1, then the "standard of the mixture" should be considered as being exceeded. C_1 indicates the measured air level, and T_1 the corresponding environmental criteria. Because sufficient personal breathing zone data could not be obtained, the combined effect equation could not be used to evaluate such an exposure; however, it was applied to the stationary sampling data. Using the highest formaldehyde and ammonia concentrations measured, the calculated combined exposure was 35 percent of the "standard of the mixture".

Table 6 shows the concentrations of respirable crystalline silica and total respirable dust measured by a stationary sampler positioned in the immediate area of the shell core operation on each of two consecutive days. Neither the levels of crystalline silica or respirable dust exceeded the evaluation criteria of 0.05 mg/M^3 or 5.0 mg/M^3, respectively.

No personal or work area aerometric samples for respirable crystalline silica were collected in the cartridge coating and wire pushing areas. However, settled dust samples showed an average crystalline silica content of 19 percent (range 15-23 percent), indicating that workers in these areas may also be exposed to airborne crystalline silica.

b. Medical Evaluation

A total of 19 workers were examined: one 19-year old male Caucasian, and 18 female Caucasians with an age range of 19-57, and a median of 30.

This included persons who were presently working and who have worked in the cement mixing, shell core machine, cartridge coating, and wire pushing areas. Table 7 presents basic demographic data on this cohort.

The workers were queried on past and present symptoms of skin, eye, nose, and throat irritation, and nose-bleeds. Table 8 summarizes the questionnaire responses.

1. Skin: All 5 employees in the cement mixing area had some form of skin reaction. Their hands were red, chapped, and dry. They indicated that this problem would usually clear up overnight or if they wore gloves while working with the cement. Three workers in the coating area reported that they had experienced some rash on their hands; but after they began wearing gloves, the problem subsided.

Bulk samples of the three types of refractory cements and "Theim Kwik Chill" (the tellurium metal coating) were collected and analyzed for total water soluble hexavalent chromium (Cr^{+6}). The presence of hexavalent chromium (Table 9) suggests that a sensitization to this substance could exist, in addition to the principal irritation, among the aforementioned workers. However, to evaluate the possibility of sensitization patch testing would have to be performed on the affected workers.

The employees working at the shell core machine operation and in the pushing area did not report any work-related skin problems.

2. Eyes: Four (4/19) persons examined complained of eye irritation. Two (2/4) included the shell core machine operator and core packer who stated that the fumes from the core machine operation caused their eyes to burn. The remaining 2 persons who worked in the wire pushing area felt that their eye irritation was not work related.

3. Throat: Four (4/19) persons examined complained of throat irritation. This included the shell core machine operator and core packer, but they did not feel it was work related. One employee in the cement mixing area complained of throat irritation, but there was no objective evidence of this on physical examination. One employee from the coating area who complained of throat irritation was diagnosed as having acute tonsillitis, and was advised to see a physician.

4. Nose: Nine (9) employees complained of nose irritation. Three complaints were of non-related allergic sinusititis. The shell core machine operator and core packer and two workers in the pushing area complained that the fumes from the shell core machine irritated their nasal mucosa, and that the irritation would subside upon leaving the factory. Two persons in the cement mixing area stated that dust caked on the inside of their noses and caused irritation.

5. Nosebleeds: Seven persons complained of having some form of nosebleed, i.e. detection of sparse amounts of blood on a handkerchief after clearing of nostrils or less frequent occurrences of free flowing blood. A shell core machine operation employee stated that since September, 1976, upon clearing her nostrils at the end of each work shift sparse amounts of blood would be detected on her handkherchief. A similar type of nosebleed was reported by 2 cement mixers who related this problem to the irritation caused the caking of cement dust inside their noses. The remaining 4 complaints, of which several reported occasional incidents of free flowing nose bleeds, were probably caused by non-work-related problems such as sinusitis, high blood pressure or allergy.

c. Ventilation

Qualitative air flow measurements and visual observations of the canopy hood at the core packing station; the canopy hood over the shell core machine; and the ventilated conveyor system leading from the shell core machines to the core packing station indicate that the existing exhaust systems may not be operating properly or at their designed conditions. There was minimal, if any, removal of a tracer plume generated at the face of the core packing station canopy hood. Most likely the only fumes that are removed are those that enter the hood by heat convection. An approximately 12 to 18 inch diameter fan, positioned on the core packers work table, minimized the packers exposure to the volatile effluents. An attempt made to work without the fan resulted in immediate eye irritation, tolerable for less than several minutes, by the packer and a NIOSH investigator. Although the fan adequately ventilated the core packers breathing zone, it also created a cross-draft which affected the collection efficiency of the shell core machine canopy hood. That is, the cross-draft would interface with the vertical air flow pattern of the canopy hood creating air turbulence, which would cause a portion of the effluent cloud to be blown into adjacent work areas. The problem with cross-drafts was further compounded by a floor fan positioned behind the shell core machine operator. According to the workers the fans were used for personal cooling.

Generation of a tracer plume at the face of the conveyor tunnel hood showed that it had a minimal collection capability. The plume displayed a tendency to disperse away from the collection duct. Large deposits or clumps of particulate were found in the 6 inch exhaust duct, which apparently contributed to its minimal collection efficiency.

G. Discussion and Conclusions

The data from the interviews and physical examination of 19 employees indicate that the persons working at the shell core machine operation are experiencing irritation of the conjunctiva and upper respiratory tract, and those working in the cement mixing area are experiencing dermal and nasal irritation.

Although the levels of formaldehyde and ammonia measured are below the environmental criteria, the symptoms of eye and/or upper respiratory tract irritation reported by persons working at or in areas adjacent to the core machine are not unusual. This is because of variations in individual susceptibility to formaldehyde[11,14] and ammonia[9,15] that may exist. For example, a person exposed to formaldehyde can develop a physical tolerance to the irritant effects and work in concentrations intolerable to others, but others may be markedly sensitive and may become more susceptible on repeated exposure. Furthermore, the irritant nature of these chemicals is compounded because they are occurring together, i.e. the irritant effects are considered to be additive. Increasing the effectiveness of the ventilation systems should materially decrease the contaminant concentrations and degree of sensory irritancy.

The employees involved in cement mixing are in direct skin contact with the refractory cements. The observed dermatologic effects were red, chapped and dry hands, which is characteristic of cement dermatitis. The presence of water-soluble hexavalent chromium in the refractory cements suggests that a sensitization to this substance could exist among these workers. However, in order to evaluate the possibility of sensitization patch testing would have to be completed on the affected workers. Similar dermal effects were reported by the wire pushers until they began using protective gloves. Such appears to be an effective control measure and should be implemented in the cement mixing area.

The large mixer operator is exposed to levels of crystalline silica in excess of the recommended NIOSH criteria and promulgated OSHA standard. Until environmental controls are implemented to reduce the airborne crystalline levels, the mixer operator should wear a half mask respirator with replaceable dust filter. Environmental control of the particulate generated by the large mixer operation should also materially decrease work room concentrations with a resultant decrease or elimination of nasal irritation reported by other workers in this area.

V. RECOMMENDATIONS

The following are suggested industrial practices that can help minimize respiratory and dermal exposures to the contaminants apparent in the operations evaluated.

A. Environmental Control

a. A qualitative air flow and visual evaluation of the shell core machine and core packing ventilation systems indicated that their operating efficiencies should be improved. Results of the ventilation evaluation have been presented in Part IV, Section F, of this report. Based on these results a thorough inspection and evaluation of both the extraction systems should be conducted to insure that conditions such as duct obstructions, leaking duct connections, torn flexible ducts, fan belt slippages, etc., are not preventing the attainment of maximum efficiency. Air flow (velocity and volume) and pressure measurements should be conducted to determine if the system is operating at its designed conditions. All sources of cross-drafts (such as table and floor fans) which create air turbulence under the canopy hoods should be eliminated.

b. Every effort should be made to control contaminants at the source of generation through engineering control. Local exhaust ventilation should be installed at the large cement mixer to control the excessive levels of crystalline silica.

c. Specific design criteria and considerations can be obtained by consulting the "Industrial Ventilation Manual" published by the American Conference of Governmental Industrial Hygienists[16] and "Recommended Ventilation Guidelines" published by NIOSH.[17] A copy of the latter was given to the maintenance supervisor during the December survey.

d. Substitution of non-siliceous cements should be considered. Two of the three cements in use were determined by NIOSH to have a crystalline silica content of <0.6 percent by weight.

e. Periodic cleaning of floors, equipment and overhead structures will prevent settled dust from being an ever-present source of exposure. Air currents will cause settled dust to become airborne and cause an unnecessary increase in exposures. Dry sweeping and compressed air blow-off should be prohibited. Cleaning should be done using wet vacuum methods.

B. Respiratory Protection

a. The large mixer operator should wear a half mask respirator with replaceable dust filter until the exposure level of crystalline silica is reduced below the NIOSH prescribed limit (0.05 mg/M^3) by engineering or administrative controls. The selected respirator should be approved by NIOSH to provide adequate protection against the concentrations of crystalline silica measured.

b. A respiratory protection program meeting the requirements of 29 CFR 1910.134 should be established and enforced by management with union support. A NIOSH document titled, "A Guide to Industrial Respiratory Protection", will serve as reference source with information for establishing and maintaining a respiratory protection program.[18]

C. Protective Clothing and Personal Hygiene

a. Skin contact with the cement should be avoided as far as possible. Protective clothing (gloves with liners and possibly long sleeved shirts) and barrier creams are effective prophylactic measures. The workers should wash the exposed areas of the body (hands and forearms) at lunch and after the shift each day.

D. Medical Management

a. A pre-employment examination should be performed on new employees who may directly work with the cement. Persons with a history of atopic dermatitis, recurrent eczema or who currently have active dermatitis should not be directly exposed to the cement.

b. Any employee who develops dermatitis should have a prompt medical examination and suitable treatment and the cause of the dermatitis should be determined in each case. If the dermatitis appears to be work related, the work exposure should be evaluated carefully to determine where and why contact occurred and what additonal hygiene measures, if any, are necessary.

E. Surveillance

a. Part I, Sections, 1, 2, and 8 of the NIOSH Criteria Document[3] for Crystalline Silica should be used as a guide for establishing environmental and medical surveillance programs.

b. No aerometric samples for crystalline silica were collected in the cartridge coating or wire pushing areas. However, because the settled dust samples collected showed an average crystalline silica content of 19 percent (by weight) and the phenolic-resin sand is 94 percent (by weight) crystalline silica, it is recommended that air sampling be conducted in these areas for this substance. The exposures of the shell core machine personnel also should be characterized.

F. Apprisal of Employees of Hazards

An educational program should be instituted so the employee is made aware of the respiratory and dermal hazards associated with cement. Good work practices and first aid procedures should also be included in this program.

VI. AUTHORSHIP AND ACKNOWLEDGEMENTS

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Table 1

Respirable Crystalline Silica and Total Respirable Dust Concentrations
Measured at the Breathing Zone of the Cement Mixer Operator

Leeds & Northrup Corporation
Expendable Devices Division
Ellwood City, Pennsylvania

December 14 and 15, 1976

Sample Date	Sample Number	Sampling Period	Sample Volume Liters	Total Free Silica mg	Total Free Silica %	Airborne Concentration Data - mg/M^3 [a] Respirable Free Silica	Total Respirable Dust	OSHA Silica Standard mg/M^3
12-14	PV-504	0815 - 1057 1130 - 1510	649.4	0.07	8.6	0.11	1.25	0.94
12-15	PV-396	0725 - 1503	778.6	0.21	17.5	0.27	1.54	0.50

a. Denotes milligrams of contaminant per cubic meter of contaminated air by weight.

Table 2

Total Airborne Particulate Concentrations
Measured at the Breathing Zone of the Cement Mixer Operator

Leeds & Northrup Corporation
Expendable Devices Division
Ellwood City, Pennsylvania

December 14 and 15, 1976

Sample Date	Sample Number	Sampling Period	Sample Volume Liters	Total Particulate Concentration - mg/M^3 [a]
12-14	PV-248	0815 - 1057 1130 - 1510	649.4	3.80
12-15	PV-455	0725 - 1503	778.6	6.02

a. Denotes milligrams of contaminant per cubic meter of contaminated air by weight.

Table 3

Formaldehyde Concentrations Measured at the Breathing Zone
of the
Shell Core Machine Operator and Core Packer

Leeds & Northrup Corporation
Expendable Devices Division
Ellwood City, Pennsylvania

December 14 and 15, 1976

Sample Date	Sample Number	Employee Job Classification	Sampling Period	Sample Volume Liters	Airborne Concentration - ppm[a]
12-14	F-1	Machine Operator	0730 - 1059	209.	0.09
"	F-7	" "	1130 - 1505	215.	0.11
12-15	F-10	" "	0725 - 0900	95.	0.03
"					
12-14	F-2	Core Packer	0738 - 1130	242.	0.13
"	F-8	" "	1211 - 1505	184.	0.10
12-15	F-11	" "	0730 - 0919	109.	0.07

a. Denotes parts of contaminant per million parts of contaminated air by volume.

Table 4

Ammonia Concentrations Measured at the Breathing Zone
of the
Shell Core Machine Operator and Core Packer

Leeds & Northrup Corporation
Expendable Devices Division
Ellwood City, Pennsylvania

December 15, 1976

Sample Number	Employee Job Classification	Sampling Period	Sample Volume Liters	Airborne Concentration ppm[a]
A-10	Machine Operator	0725 - 0900	95	3.02
A-11	Core Packer	0730 - 0919	109	3.71

a. Denotes parts of contaminant per million parts of contaminated air by volume.

Table 5

Summary of Formaldehyde, Ammonia, Phenol, and Hydrogen Cyanide Concentrations
Measured at Three Stationary Sampling Locations

Leeds & Northrup Corporation
Expendable Devices Division
Ellwood City, Pennsylvania

December 14 and 15, 1976

Sample Date	Sample Number	Location of Stationary Sampler	Sampling Period	Sample Volume Liters	Airborne Concentration Data - ppm[a] Formaldehyde	Ammonia	Phenol	Hydrogen Cyanide
12-14	F-3	Shell Core Machine Work Bench	0810 - 1535	445	0.10			
"	A-1	" " " " "	" "	"		2.13		
"	P-3	" " " " "	" "	"			LLD[b]	
"	H-1	" " " " "	" "	"				LLD[b]
12-15	F-14	" " " " "	0725 - 1522	477	0.11			
"	A-14	" " " " "	" "	"		4.64		
"	P-14	" " " " "	" "	"			LLD	
"	H-14	" " " " "	" "	"				LLD
12-14	F-4	White Coat Cement Area Work Bench	0825 - 1525	420	0.11			
"	A-2	" " " " " "	" "	"		1.64		
"	P-4	" " " " " "	" "	"			LLD	
"	H-2	" " " " " "	" "	"				LLD
12-15	F-12	" " " " " "	0725 - 1500	455	0.78			
"	A-12	" " " " " "	0725 - 1522	477		2.25		
"	P-12	" " " " " "	" "	"			LLD	
"	H-12	" " " " " "	" "	"				LLD
12-14	F-5	Post Between Core Machine Operator & Packer	0840 - 1505	385	0.08			
"	A-3	" " " " " "	" "	"		2.09		
"	P-5	" " " " " "	" "	"			LLD	
"	H-5	" " " " " "	" "	"				LLD
12-15	F-13	" " " " " "	0735 - 1522	477	0.07			
"	A-13	" " " " " "	" "			2.55		
"	P-13	" " " " " "	" "	"			LLD	
"	H-13	" " " " " "	"	"				LLD

a. Denotes parts of contaminant per million parts of contaminated air by volume.
b. Denotes a concentration less than the lower limit of detection (2 µg/ml) for the analytical method used

Table 6

Respirable Crystalline Silica and Total Respirable Particulate Concentrations
Measured at a Fixed Sampling Location

Leeds & Northrup Corporation
Expendable Devices Division
Ellwood City, Pennsylvania

December 14 and 15, 1976

Sample Date	Sample Number	Location of Sampling Station	Sampling Period	Sample Volume Liters	Respirable mg	Crystalline Silica %	Airborne Concentration Data - mg/M³ [a] Total Respirable Free Silica	Total Respirable Dust	OSHA Silica Standard mg/M³
12-14	PV-296	Post Between Core Machine Operator & Packer	0835 - 1505	3510.	0.07	3.4	0.02	0.59	1.85
12-15	PV-466	"	0735 - 1525	4320.	0.14	4.5	0.03	0.72	1.54

a. Denotes milligrams of contaminant per cubic meter of contaminated air by weight.

Table 7

Demographic Data

Leeds & Northrup Corporation
Expendable Devices Division
Ellwood City, Pennsylvania

December 14-15, 1976

	Sex		Age (Years)			Length of Employment (Months)		
Work Area	Male	Female	Average	Median	Range	Average	Median	Range
Cement Mixing	1	4	26.8	24	19-44	23.8	9	9-54
Shell Core	0	2	33.5	-	25-42	24.5	-	9-60
Cartridge Coating	0	3	35.0	30	20-55	29.6	24	5-60
Wire Pushing	0	9	37.5	42	20-57	23.1	15	1-96
Total	1	18	25.5	30	19-57	33.8	15	1-96

Table 8

Summary of Complaints

Leeds & Northrup Corporation
Expendable Devices Division
Ellwood City, Pennsylvania

December 14-15, 1976

Work Area	Number of Employees	Irritation								Nose-Bleeds	Percent	Smokers	Percent
		Eye	Percent	Nose	Percent	Throat	Percent	Skin	Percent				
Cement Mixing	5	0	0	2	40.0	1	20.0	5	100.0	2	40.0	2	40.0
Shell Core	2	2	100.0	2	100.0	2	100.0	0	0	1	50.0	1	50.0
Cartridge Coating	3	0	0	1	33.3	0	0	3	100.0	1	33.3	1	33.33
Wire Pushing	9	2	22.2	4	44.4	1	11.1	2	22.2	3	33.3	6	66.6
Total	19	4	21.0	9	47.3	4	21.0	10	52.6	7	36.8	10	52.6

Table 9

Total Water - Soluble Hexavalent Chromium Content of Bulk Samples

Leeds & Northrup Corporation
Expendable Devices Division
Ellwood City, Pennsylvania

December 15, 1976

Sample Number	Material	Sample Weight Grams	Total Hexavalent Chromium ug per gm of cement
B-1	No. 75 Refractory Cement	0.4644	51.0
B-2	Tabular Aluminum Cement	0.4656	4.9
B-3	No. P - 78 Resistor Cement	0.4935	2.3
B-7	Theim Kwik Chill	1.5019	28.0