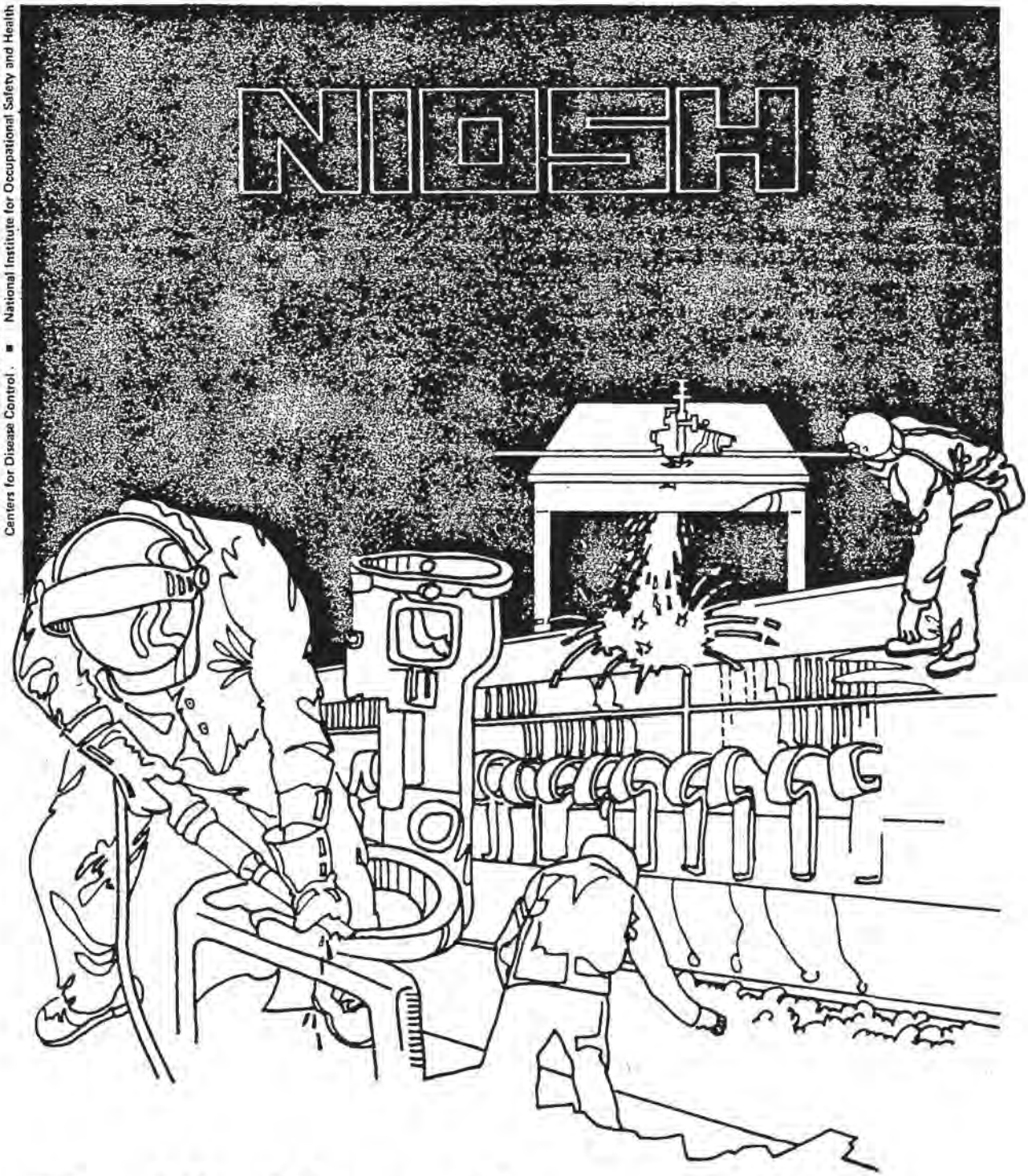
U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES ■ Public Health Service
Centers for Disease Control ■ National Institute for Occupational Safety and Health



Health Hazard Evaluation Report

HETA 82-348-1442
THE DOTSON COMPANY
MANKATO, MINNESOTA

PREFACE

The Hazard Evaluations and Technical Assistance Branch of NIOSH conducts field investigations of possible health hazards in the workplace. These investigations are conducted under the authority of Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6) which authorizes the Secretary of Health and Human Services, following a written request from any employer or authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

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

HETA 82-348-1442
March 1984
THE DOTSON COMPANY
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I. SUMMARY

In August 1982, the National Institute for Occupational Safety and Health (NIOSH) received a request to evaluate employee exposures to contaminants generated during coremaking operations at the Dotson Company foundry, Mankato, Minnesota.

On February 28 - March 2, 1983, NIOSH conducted an environmental/medical survey at the foundry. Long-term personal breathing zone and area air samples were collected for measurement of exposures to acrolein, ammonia, dimethylethylamine, formaldehyde, furfuryl alcohol, hexamethylenetetramine, and methylene bisphenyl isocyanate (MDI). Analysis of these samples revealed the following concentration ranges which are compared to their respective environmental criteria (EC): ammonia, nondetectable (ND) - 1.6 mg/m^3 (EC - 18 mg/m^3); dimethylethylamine, 1.2 - 2.3 mg/m^3 (EC - none); and formaldehyde, 0.3 - 0.9 mg/m^3 (EC - lowest feasible level). No detectable airborne concentrations of acrolein, furfuryl alcohol, hexamethylenetetramine, and MDI were found.

Headache during the workshift was reported by seven of thirteen coremaking workers interviewed, nosebleeds by six, eye irritation or blurred vision by five, cough or dry throat by four, nausea and dizziness by two each, and hand and arm skin problems by one. Medical records of twenty one coremakers showed occasional reports of some of these symptoms. A review of the medical records also revealed four of 21 coremakers with chest x-ray findings consistent with pneumoconiosis.

Sampling data indicated employee exposure to detectable formaldehyde levels. Based on NIOSH's recommendation that formaldehyde be considered as a potential human carcinogen and the irritative symptoms reported by the employees, the concentrations of formaldehyde should be reduced. Measures to reduce exposures to formaldehyde, further evaluate silica exposure and improve working conditions are recommended in Section VIII of this report.

KEYWORDS: SIC 3321 (Gray Iron Foundries), 3565 (Industrial Patterns: Foundry Cores), formaldehyde, methylene bisphenyl isocyanate, dimethylethylamine, coremakers, ammonia, silica

II. INTRODUCTION

In August 1982, the National Institute for Occupational Safety and Health (NIOSH) received a request to evaluate employee exposures during coremaking operations at the Dotson Company foundry, Mankato, Minnesota. The original request was prompted by the employees' reported symptoms of headache, dyspnea, eye and nose irritation, nausea, and blurred vision during coremaking operations.

Upon receipt of the health hazard evaluation request and during the validation/preparation period before the initial site visit, it was NIOSH's belief that all employees who signed the confidential request were actively employed (not on lay-off status). However, as the on-site survey progressed, it became evident that the required authorization of three currently employed workers at the time of filing was not met, and hence, the request was "technically" invalid. Dotson Company management, acting in the interest of identifying potential employee exposures in the coreroom processes, requested that NIOSH conduct the health hazard evaluation. Therefore, the environmental and medical assessments were performed by NIOSH as originally anticipated on February 18 - March 2, 1983.

III. BACKGROUND

The Dotson gray iron foundry, operational since 1890, has nearly 65,500 square feet of building under roof. Located in Mankato, Minnesota, it is a specialty foundry that makes machine part type castings to customer specifications. The plant workforce fluctuates with production demands and totaled about 80 during the NIOSH survey (50 production; and 30 office/administrative personnel). The union representation in the foundry is the International Molders and Allied Workers, Local 142.

Coremaking processes operate on a one shift (0700-1530), 5-day, 8-hour per-day schedule. However, production schedules in the coremaking departments fluctuate daily with some procedures not occurring for several weeks. The three types of binder systems used at the foundry are shell core (Faskure® coated sand), phenolic urethane (gas-cured, no-bake, Isocure®), and bench (alkyd-oil) oven-baked. Other binder systems such as the furan no-bake have been used but were either discontinued or nonoperational during the NIOSH on-site survey. Six to nine full-time employees work at the three coremaking operations.

A brief description of each type of coremaking process employed at the foundry is provided below.

A. Shellcore

There are two shell core work stations in the foundry. One operator operates one pneumatic shell core machine in the northeast corner of the plant. Shell cores are formed when the sand,

precoated with a thermosetting resin binder (Faskure®), is placed in a gas-fired core box at 550-600°F for 6-10 minutes. After the polymerized shell cores are manually removed from the machine they are placed on a nearby worktable to cool and off-gas for 2-3 minutes. Two, twenty-four inch pedestal fans, positioned about one foot above the work table, aid in dispersing any emissions from the cores into surrounding work areas. On an as needed basis, a Bink's hand-held compressed air atomizing gun is used to disperse a solvent based parting compound on the core box to help prevent the sand from sticking to the mold pattern. Somewhat smaller shell cores are made at another shell core operation positioned in the northwest corner of the plant where one employee operates one or two shell core machines. The working conditions, production materials, and equipment used are essentially the same in both shell core manufacturing operations.

B. Phenolic Urethane

A phenolic urethane, no-bake Isocure®, system is used at two work stations in the northcentral part of the foundry: U-180 machine and bench Isocure®, each with one operator. The process involves three parts: part I, a liquid phenolic resin; part II, a liquid isocyanate (methylene bisphenyl isocyanate, MDI); and part III, the catalyst, an amine gas (dimethylethylamine). Parts I and II are manually added to and mixed in equal amounts along with sand in a 500 (lb) capacity muller. Sand is gravity fed to the muller from one of two storage silos. Mixed sand from the muller is transported to hoppers above the core machines and is either pneumatically forced or gravity fed into the corebox. Once in the corebox mold, the sand mixture is gassed with varying amounts of the amine catalyst for about 1-10 seconds depending upon the size of the core. The U-180 and bench Isocure® operations are quite similar with the bench Isocure® processes being a little less automated. Both machines, U-180 and bench Isocure® are equipped with local exhaust systems to aid in purging excess amine gas from the cores. Once every 20 to 25 cores made, a solvent-based mold release agent is dispersed into both core machine mold boxes via a hand-held can with a mouth piece so that the employee must blow into the can in order to aerosolize the release agent. The same mold release agent and method of application are used in the bench coremaking operations.

C. Bench Coremaking

Two to three employees work at the bench coremaking processes stationed in the northwest corner of the foundry. Initially, the components of the bench sand, including varying amounts of an alkyd core oil, cereal-binder (ground corn), kerosene , iron oxide, phenolic coated sand, and water are mixed in a 400 (lb) capacity sand muller for about 20 minutes. The sand mixture is transferred

via wheel barrel to one or both of the bench coremaking worktables and the one blow bench machine operation. The bench coremaker uses several hand tools such as mallets, hammers, trowels, and metal "strike-off" bars to hand pack the sand into the core pattern. Blow bench procedures are the same except that the sand mixture is pneumatically forced into the core pattern cavity. Finished cores are placed on transite boards and cured in gas-fired ovens at 420°F for nearly 4 hours on second shift. Cured cores from each coremaking department are sent to the foundry mold floor.

IV. EVALUATION DESIGN AND METHODS

A. Environmental

Long-term personal breathing zone and area air samples were collected on March 1-2, 1983 to characterize employee exposures to formaldehyde, ammonia, hexamethylenetetramine, and furfuryl alcohol in the shell core proccesses; dimethylethylamine, formaldehyde, and methylene bisphenyl isocyanate in the U-180 and bench Isocure® operations; and acrolein in the blow bench and bench oven-baked coremaking systems. The sampling and analytical methodology[1] for these substances, including collection device, flow rate, and referenced analytical procedures are presented in Table I.

B. Medical

On February 28, 1983 NIOSH medical personnel interviewed eight active coreroom employees and five laid-off coremakers. The interviews were conducted in a nondirected manner to elicit complaints and/or symptoms believed by the employees to be work-related. The interviewees were questioned about their medical history, current symptoms/health problems, possible workplace exposures, and occupational history.

On March 1, 1983 NIOSH staff reviewed available medical records of all eight current coremakers, all twelve coremakers laid-off since March 1982, and one coremaker on long-term disability.

V. EVALUATION CRITERIA

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

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

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

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

A. Acrolein

Short-term exposure to acrolein may cause irritation of the eyes, nose, throat, lungs, and skin. It may also cause a feeling of pressure in the chest, headache, dizziness, and upset stomach. Long-term exposure to acrolein may cause occasional skin allergy appearing as hives or a rash. Systemic absorption is unlikely because of the severe irritant effect. The current OSHA standard[2] and ACGIH[3] TLV® for acrolein is 0.1 parts of acrolein per million parts of air (ppm) or 0.25 milligrams of acrolein per cubic meter of air (mg/m^3), for an eight-hour, time-weighted average (TWA).[4]

B. Ammonia[4]

Ammonia vapor is a severe irritant of the eyes, especially the cornea, the respiratory tract, and skin. Inhalation of concentrations of 2500 to 6500 ppm causes dyspnea, bronchospasm, chest pain and pulmonary edema which may be fatal; production of pink frothy sputum often occurs. Consequences can include bronchitis or pneumonia; some residual reduction in pulmonary function has been reported. In a human experimental study which exposed 10 subjects to various vapor concentrations for 5 minutes, 134 ppm caused irritation of the eyes, nose, and throat in most subjects and 1 person complained of chest irritation; at 72 ppm, several reported the same symptoms; at 50 ppm, 2 reported nasal dryness and at 32 ppm only 1 reported nasal dryness. In a survey of 8 workers in a blueprint shop, ammonia concentrations of 4 to 29 ppm caused "barely noticeable" to "moderate" eye irritation; no respiratory irritation was reported. Tolerance to usually irritating concentrations of ammonia may be acquired by adaptation, a phenomenon frequently observed among workers who were previously effected by exposure; no data are available on concentrations that are irritating to workers who are regularly exposed to ammonia and who presumably have a higher irritation threshold. Liquid anhydrous ammonia in contact with the eyes may cause serious eye injury or blindness; on the skin it causes first- and second-degree burns which are often severe, and if extensive, may be fatal. Vapor concentrations of 10,000 ppm are mildly irritating to the moist skin, while 30,000 ppm or greater causes a stinging sensation and may produce skin burns and vesiculation. Increased cancer has been reported in workers exposed to high levels of ammonia and amines, although lack of details makes evaluation difficult.

ACGIH[3] has adopted an 8-hour TLV® of 25 ppm (18 mg/m^3) for ammonia, whereas, the OSHA standard[2] and NIOSH recommended standard[4] are 50 ppm (35 mg/m^3), based on an 8-hour TWA and a 5 minute ceiling level, respectively.

C. 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 on 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, hazy or blurry vision 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.[5]

There are no proposed or existing occupational health standards for exposure to DMEA. The lack of any recommended standard for DMEA is due largely to the small amount of health research conducted on this compound. Triethylamine, an aliphatic amine like DMEA, has an ACGIH recommended standard of 24 mg/m^3 (10ppm) for an 8-hour TLV.

D. Formaldehyde

Formaldehyde gas may cause severe irritation to the mucous membranes of the respiratory tract and eyes. The aqueous solution splashed in the eyes may cause eye burns. Urticaria has been reported following inhalation of gas. Repeated exposure to formaldehyde may cause dermatitis either from irritation or allergy. Systemic intoxication is unlikely to occur since intense irritation of upper respiratory passages compels workers to leave areas of exposure. If workers do inhale high concentrations of formaldehyde, coughing, difficulty in breathing, and pulmonary edema may occur. Formaldehyde has induced a rare form of nasal cancer in two test animal species as reported in a study by the Chemical Industry Institute of Toxicology. Formaldehyde has also been shown to be a mutagen in several systems.[6,7]

In 1976, NIOSH recommended that occupational exposure to formaldehyde be limited to a concentration of 1 ppm for any 30 minute sampling period.[8] This recommendation however, was based solely on the irritant effects of formaldehyde. In 1979, evidence for the carcinogenic potential of formaldehyde became known and in 1980 NIOSH issued a new criteria which considered formaldehyde as a potential occupational carcinogen and recommended that exposures be reduced to the lowest feasible level.[7]

ACGIH[3], in its notice of intended changes for 1983-84, has proposed that exposure to formaldehyde be limited to a ceiling level of 1 ppm (1.5 mg/m^3).

The federal OSHA[2] standard for exposure to formaldehyde is an 8-hour TWA of 3 ppm, a ceiling level of 5 ppm, and an acceptable maximum peak above the ceiling level of 10 ppm for no more than a total of 30 minutes during an 8-hour workshift. This criteria is based on the irritant effects of formaldehyde rather than its potential carcinogenicity.

E. Furfuryl Alcohol[9]

Furfuryl alcohol has been shown to be readily absorbed by inhalation, ingestion, or percutaneous application. The available toxicity information on furfuryl alcohol is largely on acute toxicity. Whether furfuryl alcohol can cause chronic toxicity is

not clear from presently developed information. It may be that chronic injury does not occur, conceivably because of rapid detoxification or excretion. Incomplete information suggests this may be so, but investigations of furfuryl alcohol have been too limited to allow confidence on this point.

In rats, CNS depression leading to respiratory paralysis and death has been observed at furfuryl alcohol concentrations as low as 188 mg/m^3 for 6 hours. Identical exposure of mice and rabbits resulted in no effects. A monkey exposed to furfuryl alcohol vapor for 6 hours at 1,040 mg/m^3 had only very slight lacrimation, but when exposed to 956 mg/m^3 for 6 hours/day for 3 days, it showed no effects whatsoever.

The available exposure data do not indicate the furfuryl alcohol concentration below which there will be no adverse effects in workers. In humans, the only effects reported to be associated with exposure to furfuryl alcohol have been slight lacrimation, bronchitis, and mild sore throat. In the case of lacrimation, it is not clear whether it was caused by formaldehyde, by furfuryl alcohol, or by the combined action of the two. The exposure concentrations associated with the respiratory irritation are not known.

The current ACGIH[3] TLV® for furfuryl alcohol is 40 mg/m^3 (10 ppm) based on an 8-hour TWA.

The federal OSHA standard[2] like the NIOSH recommended standard[9], is 50 ppm (200 mg/m^3) as an 8-hour and up to a 10-hour TWA, respectively. The 200 mg/m^3 level was deemed adequate to prevent systemic effects. The ACGIH 40 mg/m^3 TLV was selected to protect against eye irritation and is more appropriate.

F. Hexamethylenetetramine

Hexamethylenetetramine (HMTA) is a tertiary aliphatic amine made by reacting aqueous formaldehyde with liquid or gaseous ammonia. Approximately one-third of the HMTA made is used in phenolic thermosetting-resin curing agents.[10]

HMTA is a known skin sensitizer and some individuals develop skin irritation from contact with the chemical, its vapors, or its solutions. Inhalation of HMTA may cause an asthma-like condition in previously sensitized individuals.[10]

No proposed or existing occupational health standards have been established for exposure to HMTA.

G. Methylene Bisphenyl Isocyanate

Methylene bisphenyl isocyanate (MDI), chemical formula C_{15} H_{10} N_2 O_2 and normally a solid material at room temperature, is white to pale yellow in color. This odorless substance, with a molecular weight of 250.3, has a low but significant vapor pressure of 0.05 mm/Hg at 20°C (68°F). High molecular weight diisocyanates like MDI present significant vapor hazards when heated or used in exothermic production processes.[11,12]

MDI vapor is a potent respiratory sensitizer. It is also a strong irritant of the eyes, mucous membranes, and skin and can cause pulmonary edema. Excess exposure to humans causes cough, dyspnea, increased pulmonary secretions, and chest pain. Isocyanates cause pulmonary sensitization in susceptible individuals and others exposed to concentrations above the NIOSH recommended standard. Should this occur, further exposure should be avoided, since even extremely low concentrations can trigger an asthmatic episode.[4]

The current federal OSHA standard[2] and ACGIH TLV[3] for MDI is a ceiling limit of 0.02 parts of MDI per million parts of air (ppm), (0.2 milligrams per cubic meter of air, mg/m^3). The current NIOSH recommended standard for occupational exposure to MDI is 0.005 ppm (0.05 mg/m^3) for up to a 10-hour workshift, 40-hour workweek, and a ceiling limit of 0.02 ppm (0.2 mg/m^3) for any 10-minute sampling period.[11]

H. Silica

Silicosis is a form of diffuse interstitial pulmonary fibrosis resulting from the deposition of respirable crystalline silica in the lung. Conditions of exposure may affect both the occurrence and severity of silicosis. Although it usually occurs after 15 or more years of exposure, some forms with latent periods of only a few years are well recognized and are associated with intense exposures to respirable dust high in free silica [13]. Early, simple silicosis usually produces no symptoms. However, both acute and complicated silicosis (PMF) are associated with shortness of breath, intolerance for exercise, and a marked reduction in measured pulmonary function. Diagnosis is most often based on a history of occupational exposure to free silica and the characteristic appearance of a chest radiograph. Respiratory failure and premature death may occur in advanced forms of the disease. Individuals with silicosis are also at increased risk of

contracting tuberculosis. No specific treatment is available, and the disease may progress even after a worker is no longer exposed to silica. NIOSH, in its recommendations for a free silica standard, has proposed that exposures to all forms of free silica be controlled so that no worker is exposed to respirable airborne concentrations greater than 0.05 mg/m^3, as averaged over a 10-hour working day, 40-hour work week. This recommendation was designed to protect workers from silicosis. Exposures to free silica greater than one-half the recommended standard, or "action level", should initiate adherence to the environmental, medical, labeling, recordkeeping and worker protection guidelines contained in the NIOSH criteria document, "Occupational Exposure to Crystalline Silica"[14]. The current federal, or OSHA standard for respirable free silica exposure is an 8-hour time-weighted average based upon the 1968 ACGIH TLV formula of 10 mg/m^3 divided by the percent SiO_2 plus 2 (10 $mg/m^3/\%SiO_2 + 2$) for resiirable quartz. One-half this amount was established as the limit for cristobalite and tridymite. As can be seen from the calculation, the OSHA regulation is based on the percentage of free silica contained in the respirable particulate exposure, whereas the NIOSH recommended standard applies directly to the airborne concentrations of respirable free silica.

VI. RESULTS

A. Environmental

Personal breathing zone and stationary area air samples were taken on March 1-2, 1983 for assessment of employee exposures during shell core, phenolic urethane (U-180 and bench Isocure®) and bench (blow bench and bench oven-baked) coremaking operations.

During shell core processes long-term personal and area air samples were collected for measurement of employee exposure to ammonia, formaldehyde, furfuryl alcohol, and hexamethylenetetramine. Ammonia values (see Table II) ranged from nondetectable (ND) to 1.6 mg/m^3, well below the ACGIH[3] 8-hour TLV® of 18 mg/m^3 and the OSHA 8-hour TWA standard[2] and NIOSH recommended 5 minute ceiling standard[4] of 35 mg/m^3.

One area air sample for formaldehyde (see Table III), taken at the shell core workstation in the northeast corner of the plant, revealed a concentration of 0.4 mg/m^3 (range of analytical limits of detection: 2-9 ug/m^3). This value, 0.4 mg/m^3, is well below the ACGIH[3] 1983-84 proposed criteria of 1.5 mg/m^3 and the OSHA standard[2] of 3.7 mg/m^3. Bourne and Seferian [15] found formaldehyde levels between 0.16 mg/m^3 and 0.55 mg/m^3 to

promote eye irritation and lachrymation. NIOSH, however, considers formaldehyde as an occupational carcinogen and as such concludes that an absolute safe concentration cannot be established.

Analysis of the three personal and 4 area air samples for hexamethylenetetramine collected at the 2 shell core work stations (northeast and northwest corners of the plant) indicated positive interferences. Once blank corrections were applied to the air sample results, there were no detectable concentrations of hexamethylenetetramine.

No detectable furfuryl alcohol was found on the 3 area air samples collected at both shell core operations (limit of detection 0.01 mg/sample).

Personal breathing zone and stationary area air sampling was performed at the U-180 and bench Isocure® coremaking processes to assess employee exposure to dimethylethylamine, formaldehyde, and methylene bisphenyl isocyanate (MDI). As depicted in Table IV, dimethylethylamine values for 4 air samples (2 area and 2 personal) ranged from 1.2 - 2.3 mg/m^3. Results for the 4 formaldehyde air samples (2 area and 2 personal) revealed levels from 0.3 to 0.9 mg/m^3. No detectable MDI concentrations were found on any of the 4 personal and 4 area air samples taken at both the U-180 and bench Isocure® operations (limit of detection: 0.3 ug per sample).

Analysis of the 4 personal and 3 area air samples taken for measurement of employee exposure to acrolein during blow bench and bench coremaking operations revealed no detectable levels (limit of detection 0.5 ug/sample).

B. Medical

1. Interviews

Seven of the 13 interviewed workers reported headache during the workshift. Six workers reported nosebleeds, five reported eye irritation or blurred vision, and four reported cough or dry throat. Dizziness and nausea were each reported by two current workers. One worker reported skin problems affecting the hands and arms.

The frequency and severity of symptoms varied among individuals. Three workers reported being affected whenever they would work on a coremaking machine (shell core, Isocure®, or the discontinued no-bake); others reported problems only during periods of heavy production or prolonged work on the machines for 2-3 days in succession.

2. Record Review

A review of medical records indicated that in 1981, sixteen of twenty one audiograms showed some hearing loss, and musculoskeletal problems, especially back injuries, were commonly reported. During the period 1971-1981, four workers had chest x-ray findings consistent with pneumoconiosis. With the exception of a few reports of such symptoms as dry throat, bronchial irritation, dizziness, and nausea, other information on the medical records was not germane to potential chemical exposures from the coremaking operation.

C. General

During the NIOSH survey deficiencies in the use of personal protective equipment and work process controls were recognized. The respirator program was inadequate as evidenced by the lack of standard operating procedures for respirator use, instruction, fit testing, maintenance, and storage. Based on previous OSHA data some areas in the foundry including coremaking, may have excessive noise levels. Ear muffs and plugs were found improperly stored inside open tool boxes on top of worktables in the U-180 Isocure® work area. During end of shift clean-up operations the U-180 Isocure® machine was rid of excess particulates by an employee using compressed air to disperse any dusts off the work surfaces. The small plastic curtain (about 12 inches in height) for the amine catalyst gassing head on the bench Isocure® squeezer machine, doesn't effectively seal the local exhaust system. Recommendations, some of which address these issues are included in section VIII.

NIOSH was not requested to evaluate the foundry workers exposures to respirable silica. However, prior to the NIOSH survey, Minnesota State OSHA personnel conducted an onsite evaluation at the foundry addressing potential silica exposures. On January 15-17, 1980 the Minnesota Department of Labor's State Occupational Safety and Health Division (MOSH) conducted an industrial hygiene investigation at the foundry in response to an employee complaint. Air samples were taken to determine employee exposures to various contaminants throughout the foundry. Several overexposures to silica were documented by MOSH including the 5001 coremaker who was exposed to an airborne silica concentration over 3 times the OSHA permissible exposure level (PEL).

A follow-up investigation was conducted by MOSH on June 9, 15 and 16, 1982 to determine abatement/compliance with the citations issued to the foundry for the excessive respirable free silica exposures documented in 1980. The results of the resampling the

5001 coremaker job processes revealed no overexposure to silica. However, at the time of the MOSH follow-up, lower production had eliminated many of the jobs in the plant and the MOSH inspector felt that the lower dust levels were mainly attributable to the sharply curtailed plant production. When this information is coupled with the fact that the NIOSH's review of available medical records of 21 coremakers revealed that 4 workers had chest x-ray findings consistent with pneumoconiosis, a need for further evaluation is indicated. Recommendations with respect to an environmental/medical follow-up to assess potential silica exposures are included in section VIII.

VII. DISCUSSION

Employee exposure to detectable formaldehyde levels was indicated by the results of the personal and area air samples. Based on NIOSH's recommendation that formaldehyde be considered as a potential human carcinogen and the irritative symptoms reported by the employees, the levels of formaldehyde should be reduced. Feasible engineering controls (installation and utilization of local exhaust ventilation systems) such as those described in Appendix I[16] (Shell Core Molding) and Appendix II[16] (Core Making Machine) should be attempted to minimize exposures.

VIII. RECOMMENDATIONS

In view of the findings of the environmental and medical investigations, the following recommendations are made to ameliorate existing or potential hazards, and to provide a better work environment for the employees covered by this determination.

1. The ultimate reduction of the employee overexposures should be accomplished by the implementation of improved engineering control of workplace contaminants such as substitution of less hazardous process materials, automation redesign or replacement of existing mechanical ventilation systems and/or process equipment, better work practices, or a combination of these measures. Employee exposure to detectable formaldehyde levels within the shell core, bench Isocure® and U-180 Isocure® coremaking areas should be reduced to the lowest level possible through effective engineering controls. The installation and utilization of effective engineering controls (such as that described in Appendix I and II)[16] will serve to help decrease the potential cancer risks, symptoms of irritation, and spread of formaldehyde levels from the coremaking areas. Industrial hygiene and engineering consultants (possibly from the company's insurance carrier) should be retained by the Dotson Company to provide additional formaldehyde air monitoring data to help in determining points of generation of formaldehyde within the coremaking areas and what specific types of local exhaust ventilation systems would be effective.

2. Plant management should implement a respiratory program consistent with the guidelines found in DHEW (NIOSH) Publication No. 76-189, "A Guide to Industrial Respiratory Protection," and the requirements of the General Industry Occupational Safety and Health Standards (29 CFR 1910.134).

3. Current Material Safety Data Sheets and all available information (including health effects) concerning products used, should be obtained and made available to all personnel. Furthermore, a continuing education program conducted by qualified persons should be instituted to ensure that all employees have current knowledge and understanding of job safety and health hazards, proper work practices, and maintenance procedures.

4. Employees should be encouraged to report every case of dermatitis, no matter how minor, so that immediate and periodic medical attention may be received.

5. Provide vacuum cleaning equipment in the U-180 Isocure® coremaking area for use in collecting particulate debris off of work surfaces instead of the current method of dispersing particulates by using compressed air.

6. Replace the small plastic curtain with a heavier, more durable material such as rubber in order to maintain an effective seal on the local exhaust ventilation system provided for the amine catalyst gassing head on the bench Isocure® squeezer machine.

7. Further monitoring of employee exposure to noise in the coremaking and other areas should be conducted. If excessive noise levels exist, implement and administer a continuing hearing conservation program including pre-employment and periodic, audiometric tests, periodic environmental monitoring, utilization and maintenance of hearing protective equipment, and employment of feasible administrative and/or engineering controls.

8. Skin contact with some of the binder materials used in the coremaking areas can cause skin irritation and rashes. Protective gloves, impervious to the binder components used, and flexible enough to be used for the task performed, should be worn.

9. Although the method of dispersing the core mold release agent into the core machine mold boxes (blowing into a hand-held can with a mouth piece in order to aerosolize the release agent) is functional, it is more hygienically appropriate for this function to be carried out using compressed air.

10. An effective medical and environmental silica program for should be instituted at the Dotson foundry. The components of this program are described in the NIOSH criteria document, A Recommended Standard For Occupational Exposure To Crystalline Silica.[15] The following recommendations are of primary importance.

a. Exposure to crystalline silica should be controlled so that no worker is exposed to a time-weighted average (TWA) concentration of respirable free silica greater than 50 ug/m^3 of air as determined by a full-shift sample for up to a 10-hour workday, 40-hour workweek. Exposure should be determined by a personal (breathing zone) sample. Procedures for sampling, calibration and analyses of environmental samples are specified in Appendices in the NIOSH criteria document for occupational exposure to crystalline silica.[15]

b. Engineering controls should be used to maintain free silica dust exposure within the NIOSH recommended standard. Periodic air sampling for silica is necessary in order to determine the extent of the potential silica problem and the effectiveness of engineering controls and work practices, and to identify particularly hazardous work areas where more frequent monitoring or examination of workers is necessary. Preferably, this should be done at least once every six months. Proper respiratory equipment should be available, evaluated, and maintained when its use becomes necessary.

c. A preplacement medical examination should be instituted and it should include all of the following:

1. A medical and occupational history to elicit data on previous exposure to free silica dust (or other fibrogenic dusts), any other significant occupational exposure, significant past medical illness, cigarette-smoking status, and signs and symptoms of respiratory disease.

2. A baseline 14" x 17" PA chest x-ray, classified according to the ILO U/C system.

3. Pulmonary function tests including at least FVC, FEV_1, and calculation of FEV_1/FVC to provide a baseline for evaluation and to rule out any significant pulmonary disease not identified by history or x-ray. Standardized procedures for calibrating the spirometer, performing the tests, calculating the results, interpreting the observed spirograms, and using accepted predicted normal values are available and should be utilized.

d. A periodic medical examination should be performed at least once every three years, and perhaps yearly or every other year for employees with potentially higher risk jobs. Medical examinations should include a follow-up questionnaire concerning development or progression of respiratory symptoms, a chest x-ray (PA 14" x 17"), and pulmonary function tests as described above. Results of pulmonary function tests should be compared to previous best tests. A 10% reduction in FEV_1 or FVC over a 2-3 year period should be considered a significant change. Chest x-rays should be compared to baseline x-rays and interpreted by a qualified, trained radiologist or chest physician who is familiar with the use of the ILO U/C classification. Medical records should be of such a form that information is easily accessible and retrievable, so that comparisons can be made from one examination to the next.

e. Medical management of an employee with or without x-ray evidence of silicosis who has significant respiratory symptoms or physical findings and/or significant abnormalities on pulmonary function tests should include full evaluation by a physician (preferably a chest specialist) qualified to advise the employee whether he/she should continue working in a dusty trade. Employees with definite or suspected silicosis should be promptly evaluated by a chest specialist.

Anyone with complicated or category I simple silicosis should be removed from further "exposure" to silica dust. Removal of an employee from "exposure" to silica dust does not necessarily require re-assignment to an area free of silica dust, although this is ordinarily the preferred control measure. For persons with simple silicosis who have no pulmonary function impairment, "removal from exposure" can also be accomplished, in effect, by a combination of environmental dust-control measures, reduced exposure time, and respiratory protection equipment.

If an employee has x-ray evidence of silicosis, he should be informed of this finding and of the risks of further exposure to silica dust. If he chooses to return to a silica-exposure area, and has no pulmonary function impairment, he may do so if the silica dust level in the air he is actually breathing meets NIOSH's recommended standard. If respirators are used to accomplish this, there must be an appropriate respiratory program. In general, however, respirators are considered a last resort control method, to be used temporarily pending the implementation of environmental dust-control measures, for operations where sufficient dust control is not feasible, and for short-term or non-routine exposures.

IX. REFERENCES

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XI. DISTRIBUTION AND AVAILABILITY OF REPORT

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

1. The Dotson Company, Mankato, Minnesota
2. International Molders and Allied Workers, Local 142
3. NIOSH, Region V
4. OSHA, Region V

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

Table I
Air Sampling and Analysis Methodology

The Dotson Company
Mankato, Minnesota
HETA 82-348

Substance	Collection Device	Flow Rate (liters per minute)	Analysis	References[1]
Acrolein	XAD-2 Tubes Treated with 2-(Hydroxymethyl)Piperidine	0.1	Gas Chromatography	NIOSH 2501
Ammonia	Silica Gel Tube (treated with H_2SO_4)	0.1	Ion Chromatography	NIOSH S-347
Dimethylethylamine	Silica Gel Tube	0.05	Gas Chromatography	NIOSH P&CAM 221 with modifications*
Formaldehyde	Midget Impinger with 15ml. Sodium Bisulfite	1.0	Spectrophotometry	NIOSH P&CAM 125
Furfuryl Alcohol	Porapak Q Tube	0.05	Gas Chromatography	NIOSH S-365 with modifications
Hexamethylenetetramine	Midget Impinger with 15ml. Distilled Water	1.0	Spectrophotometry	NIOSH P&CAM 263
Methylene Bisphenyl Isocyanate	Glass Fiber Filter impregnated with "Nitro-Reagent"**	1.0	High Pressure Liquid Chromatography	NIOSH P&CAM 347

*The modifications included sample preparation, instrument condition settings, and/or column selection
**Nitro reagent (N-P-nitro benzyl-N-propylamine)

Table II
Results of Environmental Air Samples For Ammonia

The Dotson Company
Mankato, Minnesota
HETA 82-348

Sample Location	Date/time	Sample Volume (liters)	Ammonia (mg/m^3)
Personal Sample N.E. Shell Core Dept. Coremaker	03/01/83 0704-1506	46	1.1
Area Sample N.E. Shell Core Dept. at Coremaker's Work Station	03/01/83 0808-1131 & 1133-1530	43	0.7
Personal Sample N.E. Shell Core Dept. in am N.W. Shell Core Dept. in pm	03/02/83 0749-1157 & 1158-1504	42	0.9
Area Sample N.E. Shell Core Dept. At Coremaker's Work Station	03/02/83 0718-1102	22	0.3
Personal Sample N.W. Shell Core Dept. Coremaker	03/01/83 0731-1512	45	1.6
Area Sample N.W. Shell Core Dept. At Coremaker's Work Station	03/01/83 0735-1207 & 1355-1519	35	ND
Area Sample N.W. Shell Core Dept. At Coremaker's Work Station	03/02/83 1207-1517	19	ND

Evaluation Criteria (normal workday, 40hr/wk): 18

1. ND = nondetectable concentration.
2. Laboratory analytical limit of detection in ug ammonium/sample = 4.0
3. All concentrations are time-weighted averages for the period sampled.

Table III
Results of Environmental Air Samples For Formaldehyde

The Dotson Company
Mankato, Minnesota
HETA 82-348

Sample Location	Date/Time	Sample Volume (liters)	Formaldehyde[1] (mg/m^3)
Area Sample N.E. Shell Core Dept. At Coremaker's Work Station	03/02/83 0829-1102	153	0.4
Area Sample Adjacent to Control Panel U-180 Isocure Machine	03/01/83 0750-1525	455	0.4
Area Sample On Work Bench Bench Isocure	03/01/83 0755-1526	451	0.4
Personal Sample Isocure Coremaker U-180 Machine	03/02/83 0731-1508	457	0.3
Personal Sample Bench Isocure Coremaker	03/02/83 0727-1512	465	0.9

Evaluation Criteria — see note 1 below

Laboratory analytical limit of detection: 2-9 micrograms (ug)/m^3

1. All concentrations are time-weighted averages for the period sampled. NIOSH recommends that formaldehyde be handled in the workplace as a potential occupational carcinogen. An estimate of the extent of the cancer risk to workers exposed to various levels of formaldehyde at or below the current OSHA 3.7 mg/m^3 standard has not yet been determined. In the interim, NIOSH recommends that as a prudent public health measure, engineering controls and stringent work practices be employed to reduce occupational exposure to the lowest feasible limit.

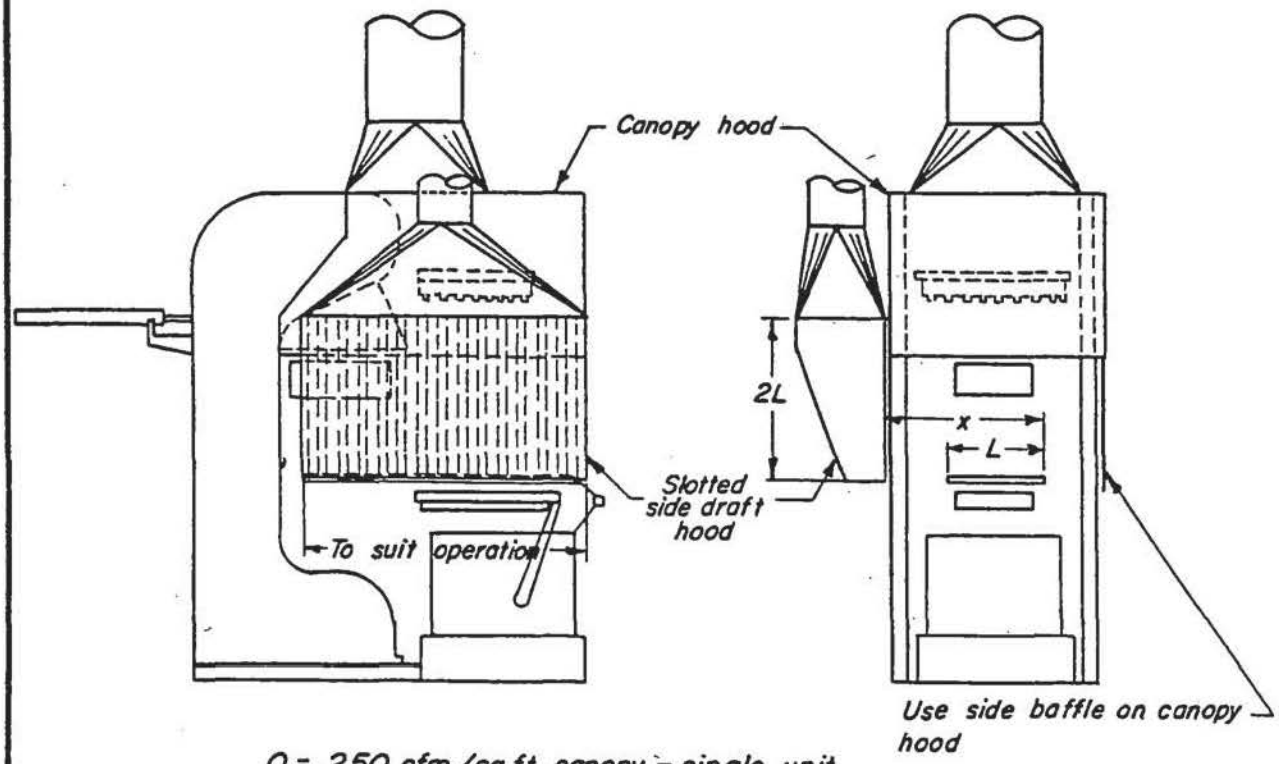
Table IV
Results of Environmental Air Samples For Dimethylethylamine

The Dotson Company
Mankato, Minnesota
HETA 82-348

Sample Location	Date/Time	Sample Volume (liters)	Dimethylethylamine (mg/m^3)
Personal Sample Isocure Coremaker U-180 Machine	03/01/83 0701-1510	27	2.3
Personal Sample Bench Isocure Coremaker	03/01/83 0715-1508	24	1.2
Area Sample Adjacent to Control Panel on the U-180 Machine Isocure System	03/02/83 0806-1144 & 1148-1523	24	2.1
Area Sample On Work Bench Bench Isocure	03/02/83 0812-1138 & 1142-1522	22	1.8
Evaluation Criteria			-
Laboratory analytical limit of detection in mg/sample:			0.01

All concentrations are time-weighted averages for the period sampled.

APPENDIX I

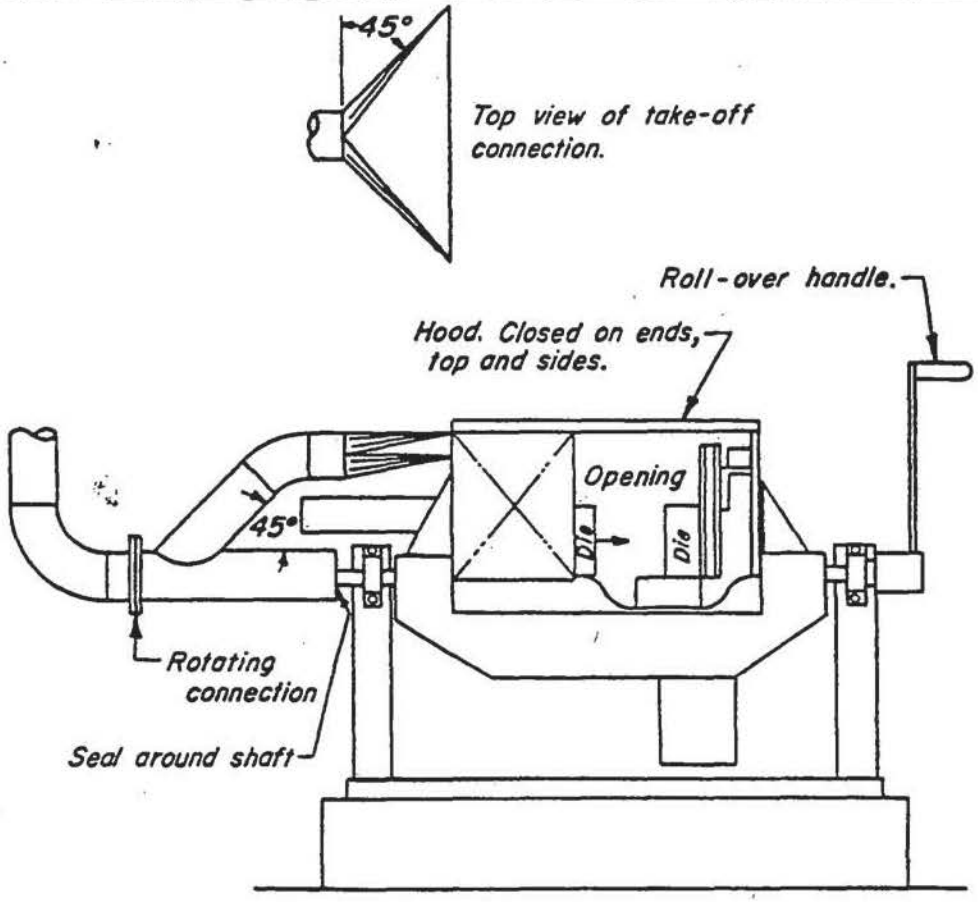


Q = 250 cfm/sq ft canopy - single unit
150 cfm/sq ft canopy - double unit
Entry loss = 0.25 VP for tapered take-off

Slotted side draft hoods required to remove smoke as hot cores emerge from machine.
Capture velocity = 75 fpm minimum
$Q = 75(10x^2 + \text{hood area})$
Entry loss = 1.78 slot VP + 0.25 duct VP

Conveyor or cooling area require ventilation for large cores. Scrap conveyor or tote boxes may require ventilation also.

AMERICAN CONFERENCE OF GOVERNMENTAL INDUSTRIAL HYGIENISTS	
SHELL CORE MOLDING	
DATE 1-72	VS-114



Q=200 cfm/sq ft of open face area
Duct velocity = 3500 fpm minimum
Entry loss = 0.25 duct VP

AMERICAN CONFERENCE OF GOVERNMENTAL INDUSTRIAL HYGIENISTS	
CORE MAKING MACHINE SMALL ROLL OVER TYPE	
DATE 1-70	VS-115