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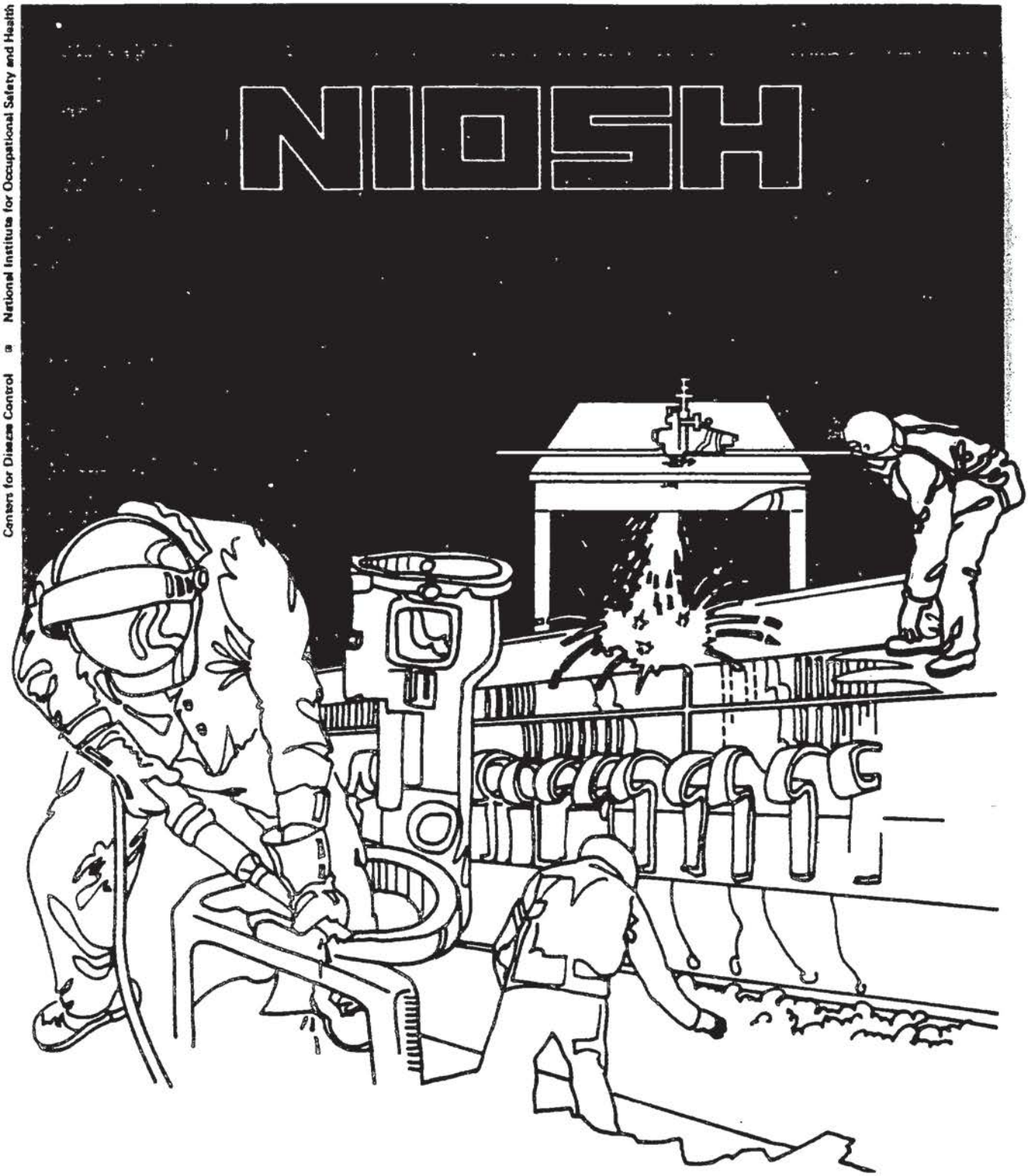
NIOSH



Health Hazard Evaluation Report

HETA 82-359-1382
INDIANA & MICHIGAN POWER COMPANY
ROCKPORT CONSTRUCTION PROJECT
ROCKPORT, INDIANA

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.

OCTOBER 1983
INDIANA & MICHIGAN POWER COMPANY
ROCKPORT CONSTRUCTION PROJECT
ROCKPORT, INDIANA

Richard L. Stephenson, I.H.
David S. Egilman, M.D., MPH

I. SUMMARY

In August 1982, the National Institute for Occupational Safety and Health (NIOSH) received a request to evaluate employee exposures during spray painting operations of the coal storage silo and transformer firewall at the Indiana and Michigan (I&M) Power Company's Rockport Construction Project in Rockport, Indiana. The request was prompted due to the spray painters' reported exposures to isocyanate paint and reported symptoms of eye irritation and shortness of breath.

NIOSH conducted an environmental/medical survey at the construction site on November 3-4, 1982. Long-term personal breathing-zone (all taken inside supplied-air respirators) and area environmental air samples were collected for measurement of exposure to methylene bisphenyl isocyanate (MDI), xylene, methyl ethyl ketone (MEK), toluene, and total aromatic naphtha. Analysis of these personal and area air samples revealed the following range of concentrations which are compared with their respective environmental criteria (EC): MDI, nondetectable (N.D.) - 16.2 ug/m^3 (EC - 50 ug/m^3); MEK, N.D. - 9.3 mg/m^3 (EC - 590 mg/m^3); toluene, 0.9 - 28.5 mg/m^3 (EC - 375 mg/m^3); total aromatic naphtha, N.D. (EC - 350 mg/m^3); and xylene, N.D. - 2.3 mg/m^3 (EC - 434 mg/m^3). Ideally there should be no detectable concentrations of MDI and/or solvents within the supplied-air respirators. The actual source of the contamination of air supplied to the hooded respirators could not be determined. Bulk sample analysis of the sand used in sandblasting the firewalls prior to spray painting revealed a silica (crystalline quartz) content of 100%.

Medical assessments of the current spray painters revealed no evidence of any isocyanate hypersensitivity or isocyanate related symptoms when supplied-air respirators were used. Interviews with fourteen painters using isocyanate-based paint prior to the use of supplied-air respirators reported experiencing a variety of health effects from exposure to mist. These effects included eye irritation, and the basic syndrome of overexposure to isocyanates, with delayed onset of wheezing, shortness of breath, chest pain, fever, chills and headache. These symptoms reportedly occurred even with the use of half-face charcoal filter respirators. In part this may have occurred because isocyanates have no olfactory warning properties. The symptoms were diagnosed as the flu by several physicians.

On the basis of the data obtained during this investigation NIOSH has determined that the symptoms reported in the request were related to previous isocyanate painting operations when supplied-air respirators were not used and that this constituted a health hazard. Medical assessments of the spray painters did not reveal any isocyanate related symptoms when supplied-air respirators were used. Exposure to MDI under the supplied-air hood is currently within the NIOSH-recommended standards, but MDI might cause adverse effects even at these levels. Recommendations to reduce potential exposures are included in Section VIII of this report.

KEYWORDS: SIC 1629 (Heavy Construction), 4911 (Electric Services), methylene bisphenyl isocyanate, organic solvents, spray painting.

II. INTRODUCTION

On August 23, 1982, the National Institute for Occupational Safety and Health (NIOSH) received a request from the Painters Union, Local #156, to evaluate employee exposures during spray painting operations at the Indiana and Michigan (I&M) Power Company's Rockport Construction Project, Rockport, Indiana. A single-component moisture-cured urethane resin (primer/finisher) paint was used at this site to paint the coal storage silos and transformer firewalls. The request was prompted by the spray painters' reported exposures to the isocyanate paint and their reported symptoms of eye irritation and shortness of breath.

NIOSH investigators conducted a environmental/medical survey on November 3-4, 1982.

III. BACKGROUND

The I&M Rockport Power Plant is located about 45 miles east of Evansville, Indiana in Spencer County. Construction of the coal-fired plant began in August 1977 and is expected to be completed by 1986. The total construction workforce of about 2500 is 99% male. Spray painting of the coal storage silos and transformer firewalls with the isocyanate-based paint started around November 1981 and was nearly completed within one year.

During the NIOSH survey, the spray painting processes operated on a one shift, 5-day, 8-hour per day schedule. Usually three-person paint crews (2 spray painters and 1 paint mixer) work at both the silo and firewall painting operations. The painters wear hooded, supplied-air respirators when spray painting and mixing the paint.

Each of the 28 coal silos are about 30 feet in diameter and 96 feet in height. Both the silos and the various-sized transformer firewalls are located outdoors. The daily painting processes varies with the amount of surface area to be covered and weather conditions.

Prior to painting, the silos are manually wire-brushed and the firewalls are sandblasted. The spray painting equipment consists of Binks hand held compressed-air, paint-atomizing guns fed from paint reservoir pressure pots of either 5-or 7-gallon capacities.

The average daily use of the single component urethane paint is 12-15 gallons on the silos and 20 gallons on the firewalls. The solvent methyl ethyl ketone is used for cleaning up the painting equipment. A two-package, finish (paint) coating system is used on the firewalls. However, no painting occurred using the 2-system final coat during the NIOSH survey.

IV. EVALUATION DESIGN AND METHODS

A. Environmental

During the NIOSH survey on November 3-4, 1982, long-term personal breathing-zone and area air samples were collected for measurement of exposure to methylene bisphenyl isocyanate (MDI), xylene, methyl ethyl ketone (MEK), toluene, and total aromatic naphtha. A bulk sample of the material used in sandblasting the firewalls prior to painting was obtained for analysis for cystalline quartz. The sampling and analytical methodology for these substances, including collection device, flow rate, and referenced analytical procedures are presented in Table I.

B. Medical

NIOSH interviewed 14 of the 15 painters at the construction site. The interviews were conducted in a nondirected manner to elicit complaints and/or symptoms believed, by the painting employees, to be work-related. The interviewees were questioned about their medical history, current symptoms, health problems, possible workplace exposures, and occupational history.

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 susceptibility, a pre-existing medical condition, and/or a hypersensitivity (allergy).

In addition, some hazardous substances may act in combination with other workplace exposures, the general environment, or with medications or personal habits of the worker to produce health effects even if the occupational exposures are controlled at the level set by the evaluation criterion. These combined effects are often not 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. In evaluating the exposure levels and the recommendations for reducing these levels found in this report, it should be noted that industry is required by the Occupational Safety and Health Act of 1970, 29 U.S.C.651, et seq. 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. Methylene Bisphenyl Isocyanate

Methylene bisphenyl isocyanate (MDI), chemical formula C_{15} H_{10} N_2 O_2, 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). This physical characteristic presents both a vapor and particulate (droplet) exposure in the spray painting application of MDI. High molecular weight diisocyanates like MDI present significant vapor hazards when heated or used in exothermic production processes.[1,2]

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; cross sensitization to unrelated materials is not known to occur.[3]

The current federal OSHA standard[4] and ACGIH TLV[5] 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.[1]

B. Organic Solvents (methyl ethyl ketone, xylene, and toluene)

These solvents can cause fatigue, headache, drowsiness, nausea, vomiting, dizziness, loss of coordination and other central nervous system effects. Dermatitis of exposed skin and irritation of the eye, mucous membranes and the respiratory tract can also occur.[6]

Listed below are the environmental evaluation criteria for the four solvents for which NIOSH collected air samples.

Environmental Evaluation Criteria[1]

Substance	NIOSH Recommended Standard (mg/m^3)	ACGIH TLV (mg/m^3)	OSHA Standard (mg/m^3)
Aromatic Naphtha	350[2]	-	-
Methyl Ethyl Ketone	590	590	590
Toluene	375	375	750
Xylene	435	435	435

1. All air contaminants are time-weighted average (TWA) exposures for a full workday, 40-hour workweek.

2. The NIOSH recommended standard for occupational exposure to refined petroleum solvents is 350 mg/m^3. NIOSH does not have a specific recommended standard for exposure to aromatic naphthas. Since aromatic naphthas in general, are considered to have greater toxicological effects than aliphatic naphthas, this value (350 mg/m^3) should be regarded as a maximum allowable exposure.

VI. RESULTS

A. Environmental

Analysis of the material used in sandblasting the firewalls prior to painting revealed a crystalline quartz content of 100%. Since the primary concern of the health hazard evaluation request was the characterization of employee exposures during spray painting operations, the NIOSH investigators were not prepared to collect any environmental air samples to determine exposures to free silica. A supplied-air respirator was used by the sandblaster employee at the time of the NIOSH survey. A recommendation is made to further evaluate employee exposures during sandblasting operations.

Results of the environmental air samples obtained on the NIOSH survey are presented in Tables II and III. Personal breathing zone and stationary area air samples were taken for assessment of employee exposures during firewall and silo spray painting operations. All personal samples were breathing-zone air samples taken inside respiratory supplied-air hoods. Only two of six air samples had detectable MDI (analytical detection limit: 0.2 ug/sample), at concentrations of 9.8 and 16.2 ug/m^3 (Table II). Both were personal samples from workers spray painting silos, and both were within the NIOSH recommended standard of 50 ug/m^3. The air sample results for methyl ethyl ketone, toluene, xylene, and total aromatic naphtha are presented in Table III. The air samples for solvents revealed the following concentrations: MEK, N.D. - 9.3 mg/m^3; toluene, 0.9 - 28.5 mg/m^3; total aromatic naphtha, N.D.; and xylene, N.D. - 2.3mg/m^3. All measured concentration of individual solvents were well within NIOSH recommended standards, ACGIH TLVs, and OSHA standards. Also the threshold limit of mixtures of solvents for the highest sample found (0.08) is well below unity (1.0).[2]

B. Medical

NIOSH investigators conducted medical interviews and assessed histories of exposure to MDI-containing paints in fourteen of fifteen painters. Eleven experienced burning eyes each time they painted. Eight of 14 painters regularly experienced shortness of breath while painting or within eight hours after painting. Four of 14 painters experienced the classical isocyanate syndrome of fever, chills, wheezing, shortness of breath and chest pain within four to eight hours after using paints containing isocyanates. These episodes all occurred prior to the use of supplied-air respirators.

C. General

Although the main purpose of the NIOSH investigation was to evaluate employee exposures to paint materials, during the conduct of the survey NIOSH investigators found certain working conditions of the silo spray painters to be hazardous and recommended to management and union representatives in attendance at the evaluation's closing conference on November 4, 1982, that appropriate safety equipment (safety lines and/or safety nets) be installed at the silo painting areas. Spray painters were allowed to work/walk on steel girders, about 60 feet above the ground, adjacent to the coal storage silos, without the protection of safety lines and/or safety nets. Additional complicating factors were that (1) the painters wore supplied-air hoods which limited

some peripheral and vertical vision, (2) painters were required to carry spray painting equipment and five-gallon buckets of paint across the girders, (3) and during cold weather, fogging of the facepieces restricted vision. One fatality due to an accidental fall had occurred at the construction site in September 1982. After further consideration, on November 8, 1982, NIOSH personnel assessed the working conditions of the silo spray painters as an imminent danger and notified management and union representatives and federal OSHA and Indiana State OSHA officials regarding this matter. On November 9, 1982, NIOSH was informed by Indiana and Michigan Power Company management and the painter's union that a safety cable had been installed at the work site, thus remedying the hazard.

VII. DISCUSSION

A. Environmental

NIOSH and the Mine Safety and Health Administration tests and certifies respiratory protective devices to assure that they meet minimum performance requirements necessary to protect workers' health and safety. The hooded supplied-air respirator used by the spray painters is approved by NIOSH/MSHA for use in any atmosphere not immediately dangerous to life or health as long as the respirator and its approved componentss and replacement parts are used as one integral system. If non-certified substituted respirator components are used, the NIOSH/MSHA approval of the entire respirator assembly is voided and the protection offered by the respirator may be compromised.

The hooded supplied-air respirator used by the spray painters is manufactured and distributed with a two lens system (an acetate inner and a mylar outer lens) for abrasive blasting or a one lens system for spray painting, with additional (optional) outer lenses available for easy removal/replacement if necessary. At the time of the NIOSH survey, the supply of replacement facepieces for the respirators was depleted. Improvising, the painters used plastic sheeting which they manually cut to fit the size of the rectangularly shaped viewing area in the hooded respirators. Under these circumstances the respirator no longer had NIOSH/MSHA approved component parts and assembly, and thus the protection afforded the worker wearing the respirator was unknown.

Air sampling at the I&M Power Company found no employee exposures to MDI or organic solvents in excess of the current evaluation criteria. However, two painters had measureable amounts of MDI inside hooded supplied-air respirators. Ideally there should be no detectable concentrations of MDI and/or solvents inside the

supplied-air respirators. The actual source of the contamination within the hooded respirators could not be determined. Possible sources include an improper seal (collar) on the hooded respirators allowing leakage of contaminated air into the hood, and/or contamination of the air supplied to the respirators. Improved respiratory protection, including wearing/using the supplied-air respirators and their components in accordance with the respirators manufacturer's instructions is necessary to reduce the potential for MDI exposures.

After having worked with paints and solvents, some spray painters did not clean their hands before eating lunch. Although construction sites usually do not have permanent washing facilities, it is hygienically appropriate that in lieu of functional washing facilities, the painters be provided with and encouraged to use a waterless hand cleaner before break periods and lunch. Three other deficiencies in work practices and process controls were recognized by NIOSH: smoking was permitted in the coal storage silo area near stored flammable paints and solvents; an inadequate respiratory protection program existed as evidenced by the lack of standard operating procedures for respirator training and use; gloves were not used when spray paint equipment parts were cleaned in organic solvents.

B. Medical

Medical assessments of the current spray painters showed no evidence of any isocyanate hypersensitivity, although painters using isocyanate-based paint prior to the use of supplied-air respirators experienced a variety of health effects from exposure to mist.

These occurred even with use of half-face charcoal-filter respirators. In part this may have occurred because isocyanates have no olfactory warning properties. The symptoms were diagnosed as "the flu" by several physicians.

VIII. RECOMMENDATIONS

In view of the findings of the medical and environmental 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. There should be a respirator 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). In addition, the compressors used for supplying air should be equipped with the necessary safety and standby devices and meet minimum air quality specifications. NIOSH recommends that supplied-air respirators be worn when isocyanate containing paints are sprayed.

2. Respirators and their component parts (with NIOSH/MSHA certification/approval) should be used in accordance with the manufacturer's instructions.

3. Suitable protective equipment should be used for the hands and forearms of the painters who clean the spray painting equipment with organic solvents. Gloves should be of sufficient length, impervious to the solvents, and flexible enough to be used for the task performed.

4. Supervisors (first line) should familiarize themselves and their employees with any manufacturer's recommendations regarding precautionary measures and specific directions before attempting to use any materials in the conduct of their work. Current Material Safety Data Sheets and all available information concerning products used, including health effects should be obtained and made available to all personnel. Furthermore, a continuing education program conducted by a person or persons qualified by experience or special training, 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, and that they know how to use respirators correctly. Materials should be labeled with information on proper use, needed personal protective devices, and descriptions of adverse health effects.

5. Smoking in and adjacent to spray painting and paint mixing areas should be prohibited.

6. Initial environmental assessments of employee exposures during firewall sandblasting operations, including exposures to respirable silica and noise, should be performed. Also, periodic environmental evaluations of employee exposures to isocyanates should be conducted to assure that the above recommendations are adequate to protect the affected employees.

7. The following procedures should be tried to correct the fogging of the lenses of hooded respirators in cold weather:

   a) initially increase the air pressure supplied to the hood, but do not to exceed the allowable maximum pressure recommended by NIOSH/MSHA and the respirator manufacturer.

b) second, obtain and utilize anti-fogging solutions/agents which are usually commercially available through respirator manufacturers or distributors;

c) last, if the first two options do not prevent fogging of the respirator lens, obtain from the respirator manufacturer a vortex tube, a device with which one can vary the temperature of the air supplied to the hood thus help preventing lens fogging.

8. The painting crew should use protective coveralls to prevent contamination of their clothing with paints and solvents.

IX. REFERENCES

1. National Institute for Occupational Safety and Health. Criteria for a recommended standard -- occupational exposure to diisocyanates. Cincinnati, Ohio: National Institute for Occupational Safety and Health, 1978. (DHEW publication no. (NIOSH) 78-215).

2. American Conference of Governmental Industrial Hygienists. Documentation of the threshold limit values. 4th ed. Cincinnati, Ohio: ACGIH, 1980.

3. National Institute for Occupational Safety and Health. NIOSH/OSHA occupational health guidelines for chemical hazards. Cincinnati, Ohio: National Institute for Occupational Safety and Health, 1981. (DHHS (NIOSH) publication no. 81-123).

4. Occupational Safety and Health Administration. OSHA safety and health standards. 29 CFR 1910.1000. Occupational Safety and Health Administration, revised 1980.

5. American Conference of Governmental Industrial Hygienists. Threshold limit values for chemical substances and physical agents in the workroom environment with intended changes for 1982. Cincinnati, Ohio: ACGIH, 1982.

6. Proctor NH, Hughes JP. Chemical hazards of the workplace. Philadelphia: J.B. Lippencott Company, 1978.

X. AUTHORSHIP AND ACKNOWLEDGEMENTS

Report Prepared by:	Richard L. Stephenson Industrial Hygienist Industrial Hygiene Section
	David S. Egilman, M.D., MPH Occupational Physician Medical Section
Field Evaluation:	Pierre Cuendet Visiting Scientist Division of Physical Sciences and Engineering
	Carolyn Bennet Co-Op Student Industrial Hygiene Section
Originating Office:	Hazard Evaluations and Technical Assistance Branch Division of Surveillance, Hazard Evaluations, and Field Studies
Report Typed By:	Jacqueline Grass & Connie Kidd Clerk-Typists Industrial Hygiene Section

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. American Electric Power Service Corporation
2. Indiana and Michigan Power Company Rockport Construction Project
3. J. L. Manta Company
4. Painters Union, Local 156
5. NIOSH, Region V
6. 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

Indiana and Michigan Power Company
Rockport Construction Project
Rockport, Indiana
HETA 82-359

Substance	Collection Device	Flow Rate (liters per minute)	Analysis	References
Methylene bisphenyl isocyanate	Impinger 15ml "Nitro" Reagent	1.0	High Performance Liquid Chromatography	NIOSH 240
Methyl ethyl ketone	Charcoal Tube	0.05 & 0.2	Gas Chromatography	NIOSH P&CAM 127[1] with modifications
Crystalline silica	Bulk Sample Vial	-	X-Ray Diffraction	NIOSH P&CAM 259[1] with modifications
Toluene	Charcoal Tube	0.05 & 0.2	Gas Chromatography	NIOSH P&CAM 127 with modifications
Total Aromatic Naphtha	Charcoal Tube	0.05	Gas Chromatography	NIOSH P&CAM 127 with modifications
Xylene	Charcoal Tube	0.05 & 0.2	Gas Chromatography	NIOSH P&CAM 127 with modifications

1. The modifications included sample preparation, instrument condition settings, and column selection.

TABLE II

Results of Environmental Air Samples For Methylene Bisphenyl Isocyanate

Indiana and Michigan Power Company
Rockport Construction Project
Rockport, Indiana
HETA 82-359

Sample Location(1)	Date/Time	Sample Volume (liters)	Methylene Bisphenyl Isocyanate (ug/m^3)(2)
Coal Silo Spray Painter	11/3/82 9:19-14:05	286	9.8
Coal Silo Spray Painter	11/3/82 9:18-14:08	290	16.2
Coal Silo Pot Man	11/3/82 12:05-14:13	128	N.D.3
Coal Silo Area Sample on Walkway Adjacent to Silo	11/3/82 12:20-15:15	175	N.D.
Firewall Spray Painter	11/4/82 12:38-14:02	84	N.D.
Firewall Area Sample Attached to Scaffold at Breathing Zone Level	11/4/82 12:53-14:06	73	N.D.

Evaluation Criteria (normal workday, 40 hr/wk time-weighted average) 50

Laboratory analytical limit of detection (ug/sample) 0.2

1. All samples are personal breathing-zone air samples taken inside a respiratory supplied-air hood except those indicated as area samples.

2. The concentrations are time-weighted averages for the period sampled.

3. N.D. = non-dectectable concentration

TABLE III

Results of Environmental Air Samples for Solvents

Indiana and Michigan Power Company
Rockport Construction Project
Rockport, Indiana
HETA 82-359

Sample Location[1]	Date/Time	Sample Volume (liters)	Methyl Ethyl Ketone[2] (mg/m^3)	Toluene[2] (mg/m^3)	Xylene[2] (mg/m^3)	Total Aromatic Naphtha[2]
Coal Silo Area Sample On Walkway Adjacent to Silo	11-3-82 12:20-15:15	34.7	0.9	28.5	0.3	----
Coal Silo Pot Man: Clean Up Operations	11-4-82 14:15-15:09	10.6	5.7	0.9	N.D.[3]	----
Coal Silo Spray Painter	11-3-82 09:19-12:03	9.3	N.D.	7.5	N.D.	N.D.
Coal Silo Spray Painter	11-3-82 09:18-14:59	20.0	3.5	7.0	N.D.	N.D.
Firewall Area Sample attached to scaffold at breathing zone level	11-4-82 12:55-14:06	4.4	6.8	6.8	2.3	----
Firewall Spray Painter	11-4-82 12:38-14:02	4.8	N.D.	6.3	N.D.	N.D.
Coal Silo Spray Painter	11-3-82 12:06-15:01	9.8	3.1	5.1	N.D.	N.D.
Coal Silo Spray Painter: Clean Up Operations	11-4-82 14:15-15:09	2.6	N.D.	---	---	----
Coal Silo Spray Painter	11-4-82 07:38-15:09	25.7	9.3	3.9	N.D.	N.D.
Evaluation Criteria (normal workday, 40hr/wk time-weighted average)			590	375	434	350[4]

1. All samples are personal breathing-zone air samples taken inside a respiratory supplied-air hood except those indicated as area samples.

2. The concentrations are time-weighted averages for the period sampled.

3. N.D. = non-detectable concentrations

4. The NIOSH recommended standard for occupational exposure to refined petroleum solvents is 350 mg/m^3. NIOSH does not have a recommended standard for exposure to aromatic naphthas. Since aromatic naphthas in general, are considered to have greater toxicological effects than aliphatic naphthas, this value, (350 mg/m^3) should be regarded as a maximum allowable exposure.