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NORTH AMERICAN REFRACTORIES COMPANY
CINCINNATI, OHIO

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PREFACE

The Hazard Evaluations and Technical Assistance Branch of NIOSH conducts field investigations of possible health hazards in the work place. 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 and 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.

Mention of company names or products does not constitute endorsement by the National Institute for Occupational Safety and Health.

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NORTH AMERICAN
REFRACTORIES COMPANY
CINCINNATI, OHIO

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SUMMARY

In February 1995 the National Institute for Occupational Safety and Health (**NIOSH**) received a request from the Aluminum, Brick, and Glassworkers Union for a health hazard evaluation at the North American Refractories Company, a manufacturer of aluminum graphite tubes, in Cincinnati, Ohio. In the request, union members expressed concern about symptoms such as skin rashes, nosebleeds, sore throats, and breathing difficulties that they attributed to furfural exposure in the press and kiln areas of the plant. On April 10-11, 1995, NIOSH investigators conducted a walk-through survey of the facility, collected environmental samples for furfural, respirable dust, and phenol, and conducted confidential medical interviews with 27 of the 31 first- and second-shift employees who work in the press and kiln areas.

Eleven of the 15 (73%) time-weighted average personal breathing zone furfural concentrations exceeded the American Conference of Governmental Industrial Hygienists' Threshold Limit Value of 2 parts per million [ppm] (range: 0.3 ppm to 4.2 ppm). None of the furfural concentrations exceeded the current Occupational Safety and Health Administration (OSHA) Permissible Exposure Limit (PEL) of 5 ppm for furfural. The OSHA PEL had been lowered to 2 ppm in 1989 but a 1992 11th Circuit Court of Appeals decision vacated the 1989 limits. Workers in the wet and dry press rooms had the highest furfural exposures (2.2 ppm to 4.2 ppm). Sample concentrations for respirable particles were well below current occupational exposure limits, and phenol was not detected. In addition to inhalation and skin exposures to furfural-containing materials along the production lines, potential exposures to furfural in the press rooms included evaporation from open drums stored in the area and dusts and aerosols from open overhead blenders.

The most commonly reported symptoms were fatigue or sleepiness (17, 63%), skin symptoms such as rash, burning sensation, itching, sensitivity to sunlight (12, 44%), headache (11, 41%), spotting of blood from the nose (8, 30%), mucous membrane irritation such as burning sensation of the eyes, nose, mouth, or throat (7, 26%), and lower respiratory (lung) symptoms such as shortness of breath, chest tightness, and wheezing (7, 26%).

The findings of the evaluation indicate that worker exposures to furfural at this facility were a health hazard. Measured exposures to furfural exceeded the ACGIH TLV and reported symptoms were consistent with the adverse health effects of furfural exposure. Recommendations for engineering controls and administrative changes to reduce exposures to furfural at this facility are included in this report.

KEYWORDS: SIC 3297 (Nonclay Refractories), furfural, phenol, central nervous system depression, mucous membrane irritation, respiratory irritation, skin irritation, aluminum graphite tube manufacturing.

INTRODUCTION

In February 1995 the National Institute for Occupational Safety and Health (**NIOSH**) received a request from the Aluminum, Brick, and Glassworkers Union for a health hazard evaluation at the North American Refractories Company (**NARCo**), a manufacturer of aluminum graphite tubes, in Cincinnati, Ohio. In the request, union members expressed concern about symptoms such as skin rashes, nosebleeds, sore throats, and breathing difficulties that they attributed to furfural exposure in the press and kiln areas of the plant. On April 10-11, 1995, NIOSH investigators conducted a survey at the facility to address these issues. This report discusses the details of the site visit and presents our findings and recommendations.

BACKGROUND

NARCo produces aluminum graphite tubes that are used in the steel industry to control the flow of hot metal. The company uses a variety of molds and aluminum graphite mixtures in a proprietary process to produce the end product. The facility has approximately 80 employees, the majority of whom work on the first shift. About 20 production workers are assigned to the press and kiln areas over two shifts. About 10 maintenance and quality control employees also work in these areas.

The production process begins in the mixing area where the raw materials are blended. Furfural is used in conjunction with various binder systems (some of which contain phenol) to produce a stronger final product. The mixture of raw materials is used immediately or stored in barrels (with or without lids) in the wet and dry press rooms. The blender operator is responsible for remixing the stored materials, using the blender in the dry press room more frequently.

The aluminum graphite tubes are formed in the wet and dry press rooms. Figure 1 shows the floor plan of the general area. The wet press room production line is served by a conveyor system that can handle all sizes of production molds. The wet press operator loads the appropriate mixture into a hopper/vacuum system over the two mold-filling stations. Workers fill molds by directing a hose from the hopper system into the mold and controlling the flow of material. Local exhaust ventilation is built into the vacuum hoses used to fill the molds. The conveyor system moves filled molds through a wash station to the press, where the operator activates the press. The conveyor system then moves pressed molds to two stripping stations, where workers remove the molds and load the formed pieces into metal bins. Smaller pieces are moved by hand, but a chain hoist is used to move the larger pieces. The cleaned molds continue to move along the conveyor system back to the filling stations.

The dry press is an automated system and uses smaller molds. The dry press operator fills the molds and operates the press. A worker removes the molds and loads the formed pieces into metal bins.

The two press rooms have separate general recirculating ventilation systems to control environmental conditions for the molding process. The ventilation systems have separate controls for temperature and relative humidity. The outside air intakes are reportedly set between 15 and 20% outside air. Air is supplied through diffusers in the metal ductwork 20 feet above the floor and exhausted through a filtered bank of return grilles 3 feet above floor level. Before being released outside, exhausted air passes through an incinerator located on the roof. The blenders and hoppers are connected to a dust collector in the wet press room.

A forklift operator moves the metal bins with the formed pieces to the dryer area. Figure 2 shows the floor plan for this area of the plant. After loading, the dryer runs for about 12 hours. After cooling, the pieces are moved to the glazing/kiln area. Depending on customer specifications, the pieces are glazed with a flood glaze (mostly inert material) or a ceramic glaze in the spray booth. The glazed pieces are fired uncovered, but stainless steel covers are used to protect the graphite of unglazed pieces going through the kiln. The fired pieces are machined and finished according to customer specifications. Exhaust from the dryer and the kiln pass through an incinerator on the roof before being released outside. There is no general ventilation for this area of the facility.

METHODS

Medical

On April 10 and 11, 1995, NIOSH investigators conducted confidential interviews with 27 of the 31 first- and second-shift employees who work in the press and kiln areas. The employees interviewed included two of three mix line operators, nine of ten wet press operators and crew, all three dry press operators and crew, all two flood glazers, all three kiln operators, four of five quality control employees, and four of five maintenance workers. The four employees who were not interviewed were not at the plant during the interview schedule. The interviews focused on workers' perceptions of environmental conditions at the plant and on symptoms they attributed to occupational exposures at this facility.

Industrial Hygiene

NIOSH investigators conducted a walk-through survey of the areas of concern and reviewed the facility's Material Safety Data Sheets (**MSDS**). Personal breathing zone (**PBZ**) and area air samples were collected for furfural, respirable particles, and phenol.

Furfural

Fifteen PBZ and four area air samples for furfural were collected at a flowrate of 0.05 liters per minute (**l/min**) using XAD-2 solid sorbent tubes. Samples were collected for periods as near as possible to entire workshifts (6.5 to 7.5 hours). The samples were analyzed for furfural according to NIOSH Method 2529[1] using gas chromatography with a flame ionization detector.

The analytical limit of detection (**LOD**) was 0.4 micrograms (**µg**), which is equivalent to a minimum detectable concentration (**MDC**) of 0.006 parts per million (**ppm**), assuming a sample volume of 18.5 liters. The limit of quantification (**LOQ**) was 1.2 µg, which is equivalent to a minimum quantifiable concentration (**MQC**) of 0.017 ppm, assuming a sample volume of 18.5 liters.

Respirable Particles

To assess if there was a dust component to the workers' furfural exposures, four area air samples for respirable particles (aerodynamic diameter less than 10 micrometers [**µm**]) were collected and analyzed for particulate total weight by gravimetric analysis according to NIOSH Method 0600[2] with the following modifications: (1) The filters and back-up pads were stored in an environmentally controlled room for several days to obtain stabilization and the samples were weighed 5-10 minutes apart. (2) The back-up pads were not vacuum desiccated. (3) The samples were not vacuum desiccated 15 minutes prior to final weighing. The LOD was 0.02 milligrams (**mg**), which is equivalent to a MDC of 0.03 milligrams per cubic meter (**mg/m3**), assuming a sample volume of 796 liters.

Phenol

Three PBZ and three area air samples were collected and analyzed for phenol according to NIOSH Method 2546[3] using gas chromatography with a flame ionization detector.
The LOD was 3 µg, which is equivalent to a MDC of 0.06 ppm, assuming a sample volume of 13.5 liters. The LOQ was 9.4 µg, which is equivalent to a MQC of 0.1 ppm, assuming a sample volume of 13.5 liters.

EVALUATION CRITERIA AND GUIDELINES

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff employ environmental evaluation criteria for the 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 even though 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 criterion. These combined effects are often not 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 Recommended Exposure Limit (**REL**),[4] (2) the American Conference of Governmental Industrial Hygienists (**ACGIH**) Threshold Limit Value (**TLV**),[5] and (3) the United States Department of Labor, Occupational Safety and Health Administration (**OSHA**) Permissible Exposure Limits (**PEL**).[6] In July 1992 the 11th Circuit Court of Appeals vacated the 1989 OSHA PEL Air Contaminants Standard. OSHA is currently enforcing the 1971 standards which are listed as transitional values in the current Code of Federal Regulations; however, some states operating their own OSHA approved job safety and health programs continue to enforce the 1989 limits. NIOSH encourages employers to follow the 1989 OSHA limits, the NIOSH RELs, the ACGIH TLVs, or whichever are the more protective criterion. The OSHA PELs reflect the feasibility of controlling exposures in various industries where the agents are used, whereas NIOSH RELs are based primarily on concerns relating to the prevention of occupational disease. It should be noted when reviewing this report that employers are legally required to meet those levels specified by an OSHA standard and that the OSHA PELs included in this report reflect the 1971 values.

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 (**STEL**) or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from higher exposures over the short-term.

Furfural

Furfural (Chemical Abstracts Service [**CAS**] number 98-01-1), an aromatic heterocyclic aldehyde used in synthetic resins, is a colorless to reddish-brown oily liquid with an almond-like odor. It is an irritant to the eyes, nose, throat, and skin. During a NIOSH health hazard evaluation at a resinoid mixing department of a grinding wheel manufacturer, 10-minute average air concentrations of furfural ranged from 3.5 to 18.5 ppm. Furfural-exposed workers in the department reported itching, burning, and tearing of the eyes; nasal congestion, dryness, soreness, and occasional nasal bleeding; dryness of the mouth or throat; and dryness and yellow discoloration of the skin, and increased tendency for sunburn.[7] These findings are consistent with animal studies that have shown eye and nose irritation, nasal bleeding, breathing difficulty, and yellowish discoloration of fur.[8] Furfural is also a central nervous system depressant and can cause headache and fatigue. The primary routes of furfural exposure are inhalation and skin absorption. About 78% of inhaled furfural is retained by the body.[9] Skin exposure to airborne furfural can result in skin absorption corresponding with 20-30% of the inhaled dose.[9] The exposure potential for liquid furfural by direct skin contact is even higher. An experimental study showed that the amount absorbed by one hand dipped in furfural liquid for 15 minutes is approximately equal to the amount absorbed by inhaling furfural at a concentration of 2.5 ppm (10 mg/m^3) over an 8-hr workday.[10]

The OSHA PEL for furfural is 5 ppm (8-hr TWA).[6] The vacated 1989 OSHA PEL was 2 ppm (8-hr TWA).[6] The ACGIH TLV of 2 ppm (8-hr TWA) was recommended to prevent significant irritation of the eyes and respiratory passages.[5] All criteria include a skin notation, which indicates that skin absorption may be a significant route of exposure. NIOSH has not established a REL for furfural.[4] NIOSH questions whether the TLV of 2 ppm is adequately protective, citing National Toxicology Program studies that showed evidence that furfural may be an animal carcinogen.[11]

Phenol

Phenol (CAS number 108-95-2), a white, crystalline solid, is an irritant of the eyes, mucous membranes, and skin. Systemic absorption can cause convulsions as well as liver and kidney disease. The skin is a route of entry for the vapor and liquid phases. Phenol has a marked corrosive effect on any tissue. Symptoms of chronic phenol poisoning may include difficulty in swallowing, diarrhea, vomiting, lack of appetite, headache, fainting, dizziness, dark urine, mental disturbances, and possibly skin rash.[12] The NIOSH REL, ACGIH TLV, and OSHA PEL for phenol are 5 ppm as a TWA.[4,5,6] All criteria include a skin notation.

RESULTS

Medical

The interviewed employees reported that the highest potential for exposure to furfural occurs in the press rooms, especially in the wet press room. Exposure sources in both press rooms include dusts and vapors at the mold-filling stations and handling fill or uncured products on the production line. Evaporation from open drums stored in the area, and dusts and aerosols from open overhead blenders (especially the 10-drum blender), are additional exposure sources in the press rooms. Some employees reported that the dust collection and ventilation systems installed in the past year have improved environmental conditions. However, other employees reported that these systems were not fully operational and that environmental conditions still needed improvement. Some employees placed fans in the press rooms to redirect the flow of dust and vapors away from them. Repairing mixers was also reported to be a source of furfural exposure, but these exposures are limited in frequency and duration. Occasional vapors (detected by smell) from leaks in the kiln were also reported. A few employees were concerned about furfural in the recirculated water used in the washers of the wet press room. Employee concerns about other exposures included particulates in the press rooms, the visible mist that hangs in and around the spray booth, and noise from the mixers which makes normal conversation in the maintenance area difficult. Many employees reported eating, drinking, and smoking or chewing tobacco in their work area.

The most commonly reported symptoms were fatigue or sleepiness (17 of the 27 workers, 63%); skin symptoms such as rash, burning sensation, itching, and sensitivity to sunlight (12, 44%); headache (11, 41%); spotting of blood from the nose (8, 30%); mucous membrane irritation such as burning sensation of the eyes, nose, mouth, or throat (7, 26%); and lower respiratory (lung) symptoms such as shortness of breath, chest tightness, and wheezing (7, 26%). Less common symptoms were yellow discoloration of the skin (related to direct contact with furfural), dizziness, nausea, sinus congestion, and abdominal pain. All of these symptoms were attributed by employees to furfural exposure, especially in the press rooms. Employees who used to work in the press rooms reported that their symptoms resolved after they transferred to other work areas. A few press room employees began using respirators or gloves and reported that their symptoms subsequently resolved.

Industrial Hygiene

Furfural

The results of the PBZ and area air samples are presented in Tables 1 and 2. Tables 1 and 2 show the concentrations for the first and second shift sampling, respectively. The eight PBZ air sample concentrations for employees in the wet press room ranged from 2.2 ppm to 3.7 ppm (geometric mean: 2.7 ppm; geometric standard deviation: 1.2 ppm). The PBZ air sample concentrations were generally higher for the dry press employees (.4 ppm and 4.2 ppm); and generally lower for kiln operators (0.3 ppm and 0.6 ppm) and glazers (0.6 ppm and 0.9 ppm). Eleven of the 15 (73%) PBZ air concentrations of furfural exceeded the ACGIH TLV of 2 ppm. All 11 employees worked in the press rooms. None of the furfural concentrations exceeded the current OSHA PEL of 5 ppm. Area sample concentrations around the drying oven and lathe/port drilling machining areas ranged from 0.4 to 1.1 ppm.

Respirable Particles

The results for the respirable particle sampling are shown in Table 3. All of the area sample concentrations measured for respirable dust were low; concentrations ranged from 0.01 to 0.05 mg/m^3.

Phenol

The results of the phenol sampling are presented in Table 4. Phenol was not detected in any of the three PBZ or three area air samples at a MDC of 0.06 ppm, using a sample volume of 13.5 liters.

Observations/Additional Sampling Data

According to management representatives, some dryer seals were missing but were on order. The missing seals allowed some dryer vapors to escape into adjacent areas. Several drums of aluminum-graphite mixture were stored without lids in the wet and dry press rooms. According to management and employees, this practice controls the moisture content of the molding material. However, it also allows furfural vapors to escape into the plant atmosphere. While performing repair work on the wet press wash station, maintenance workers (wearing fire-resistant clothing and eye/face protection) were welding in an open area with no protective screening. Several nearby workers could have been exposed to the welding arc. The local exhaust ventilation systems for the main blender and the mold-filling stations were working, but the capture velocity was not sufficient to capture airborne particles in these areas. The exhaust ventilation system over one of the dry press blenders was incomplete. Some employees in the press rooms wore cloth or neoprene gloves while handling the aluminum-graphite material. These glove materials are not protective against furfural exposure. Others used their bare hands, a practice that could greatly increase employee exposures to furfural, since it is readily absorbed through the skin. Some of the product pieces did not fit into the glazing spray booth, and were sprayed in the open area without ventilation controls. Workers had difficulty moving hand carts loaded with product over aluminum-graphite spills on the concrete floors. This could lead to muscle strain or injuries from falls. Although noise measurements were not taken during the site visit, conversation in the maintenance area was possible only by shouting over the noise of the adjacent mixers, suggesting excessive noise levels.

There were two additional sources of sampling data for this facility. The Ohio Bureau of Workers' Compensation, Division of Safety and Hygiene, conducted an industrial hygiene survey in March 1993. That survey evaluated employee exposures to furfural, alumina, graphite, and methylene bis(4-cyclohexylisocyanate) [**MCHI**]. PBZ concentrations of furfural, in the mixing area and press rooms, ranged from 1.4 ppm to 1.7 ppm for three samples. The PBZ concentrations of alumina (0.0006 mg/m^3 to 0.003 mg/m^3), graphite (0.1 mg/m^3), and MCHI (not detected) were well below occupational exposure limits. The company had collected area air samples for furfural in December 1994, February 1995, and March 1995. These area air samples were collected for three-hour time periods and may not represent a true estimate of an 8-hour exposure. Area air concentrations in the wet press room were 2.27 ppm- 2.28 ppm (two samples - December 1994); 0.28 ppm (four samples - February 1995); and 0.57 ppm-1.42 ppm (three samples - March 1995). The two dry press area air sample concentrations (collected in December 1994) were 0.57 ppm and 1.13 ppm. The four general plant samples collected in February 1995 had no detectable furfural.

DISCUSSION/CONCLUSIONS

Although none of the environmental sampling results for furfural measured by NIOSH exceeded the current OSHA PEL of 5 ppm, 11 of the 15 (73%) PBZ concentrations exceeded the ACGIH TLV of 2 ppm. Concentrations ranged from 0.3 ppm to 4.2 ppm. As was anticipated, employees in the wet and dry press rooms had the highest exposures. Air concentrations for respirable particles were well below current occupational exposure limits, and phenol was not detected in any of six samples. Most of the symptoms that NARCo employees attribute to furfural are consistent with the known effects of furfural exposure. Some of the symptoms (such as fatigue, rash, headache) could be caused by factors not related to work. However, the finding of symptoms characteristic of furfural exposure (such as nasal bleeding, burning sensations, and increased skin sensitivity to sunlight), especially in the press rooms where the highest furfural exposures were measured, make furfural a likely cause for the reported symptoms. The sampling data results from both the Ohio Bureau of Workers' Compensation, Division of Safety and Hygiene and the company are similar to the results from our investigation.

Because skin absorption to furfural occurs with the direct handling of parts, air concentrations alone would underestimate employees' total exposures. The following sources of exposure need to be addressed: evaporation from open drums stored in the press room, dusts and aerosols from open overhead blenders in the press rooms, dusts and vapors at the mold-filling stations, handling fill or uncured products on the production line, residual furfural in recirculated washer water, and eating, drinking, and use of tobacco in the press rooms. The fans used at individual stations are probably not effective in reducing exposures. Higher exposures in the press rooms might also be related to the recirculating ventilation systems. Dilution ventilation is properly used under the condition that employees are exposed to levels of contamination below the established TLV.[13] If most of the air is recirculated, contaminant concentrations could exceed established exposure limits, as was found in this evaluation.

During the NIOSH site visit, the possibility of biological monitoring for furfural exposure was discussed. Biological monitoring would be useful if the exposures are difficult to detect by other methods. However, this investigation showed airborne furfural exposures above the ACGIH TLV. Therefore, biological monitoring would not change the recommendations to reduce employee exposures. Thus, biological monitoring is not warranted.

Other problems noted during this evaluation include welding without appropriate protection for nearby employees, the missing dryer seals, the spray booth that is too short to accommodate all pieces that need to be glazed, and noise levels in the maintenance area.

RECOMMENDATIONS

The following recommendations are offered as prudent measures to further reduce workers' exposures to furfural and to correct other potential safety and health hazards that were identified at this facility. NIOSH recommends that engineering controls be used to reduce exposures to the extent feasible, followed by work practices, and, if necessary, personal protective equipment.

1. To reduce the airborne contaminants in the wet and dry press rooms, the open and closed drums containing the aluminum-graphite mixtures should be stored in a separate ventilated area. Since this survey found that employees are symptomatic from furfural exposure, local exhaust ventilation should be used to control contaminants at the source of generation. The capture velocity and effectiveness of the controls in the filling stations should be evaluated to see if they are operating at manufacturer's specifications. The exhausts over the blenders should also be evaluated and the exhaust over the small blender in the dry press room should be connected and evaluated. Area fans will interfere with the function of local ventilation control devices, so the location of these controls should be taken into consideration when placing the fans. Personal protective equipment (i.e., respirators) could be used as an interim measure to reduce employee exposures to furfural.

2. To reduce skin exposure, gloves made from butyl rubber, 4H™ (PE/EVAL), or Barricade™ material should be worn in operations where employees handle furfural-containing material. These materials are recommended for exposures greater than 8-hours.[14]

3. To reduce furfural exposures in the kiln and glazing areas, the seals in the dryer should be replaced.

4. To protect other employees from the welding arc, screens should be used when doing maintenance repairs.[15]

5. To accommodate all the pieces that need to be glazed and reduce emissions during glazing, the spray booth should be enlarged.

6. To prevent slips and fall injuries, good housekeeping practices should be used to keep floors free from aluminum-graphite material. An industrial vacuum could be used to pick up this material.

7. A noise survey should be conducted in the maintenance area while the adjacent mixers are running to determine if noise levels are excessive and if hearing protection is needed.

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1. North American Refractories Company, Cincinnati, Ohio
2. Aluminum, Brick, and Glassworkers Union, Cincinnati, Ohio
3. OSHA, Region V, Chicago, Illinois

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 1
Furfural Sampling Results - First Shift
North American Refractories Company
Cincinnati, Ohio
HETA 95-0147

Job Description/Area	**Sample Time**	**Sample Volume(liters)**	**Concentration (ppm)***
Personal			
Press Operator/ Dry Press	7:25 a.m.-11:52 a.m. 12:41 p.m.-2:46 p.m.	19.6	4.2
Crew Person/ Dry Press	7:24 a.m.-11:52 a.m. 12:40 p.m.-2:43 p.m.	19.6	3.4
Blender Operator	7:21 a.m.-11:55 a.m. 12:42 p.m.-2:17 p.m.	18.5	3.2
Stripper #1/ Wet Press	7:24 a.m.-11:49 a.m. 12:25 p.m.-2:45 p.m.	20.3	2.4
Stripper #2/ Wet Press	7:22 a.m.-11:49 a.m. 12:37 p.m.-2:43 p.m.	19.7	2.3
Fill Operator #1/ Wet Press	7:14 a.m.-11:49 a.m. 12:35 p.m.-2:42 p.m.	20.1	3.7
Fill Operator #2/ Wet Press	7:11 a.m.-11:49 a.m. 12:36 p.m.-2:42 p.m.	20.2	3.3
Press Operator/ Wet Press	7:05 a.m.-11:49 a.m. 12:37 p.m.-2:45 p.m.	20.8	2.2
Glazer	7:30 a.m.-11:54 a.m. 12:31 p.m.-2:47 p.m.	20	0.9
Kiln Operator	7:38 a.m.-11:54 a.m. 12:33 p.m.-2:47 p.m.	19.5	0.6
Area			
Lathe/Port Drill	7:37 a.m.-3:29 p.m.	23.6	0.4
Drying Oven Area	7:35 a.m.-3:15 a.m.	23	1.1
OSHA PEL			5
ACGIH TLV			2

* - ppm - parts per million

Table 2
Furfural Sampling Results - Second Shift
North American Refractories Company
Cincinnati, Ohio
HETA 95-0147

Job Description/Area	Sample Time	Sample Volume (liters)	Concentration (ppm)
Personal			
Fill Operator #1/ Wet Press	3:21 p.m.-7:18 p.m 8:08 p.m.-10:35 p.m.	19.2	3.6
Stripper #1/ Wet Press	3:23 p.m.-7:16 p.m 8:13 p.m.-10:38 p.m.	18.9	2.4
Press Operator/ Wet Press	3:25 p.m.-7:16 p.m 8:12 p.m.-10:37 p.m.	18.8	2.3
Glazer	3:20 p.m.-7:13 p.m 8:06 p.m.-10:41 p.m.	19.4	0.6
Kiln Operator	3:27 p.m.-7:11 p.m 8:07 p.m.-10:46 p.m.	19.2	0.3
Area			
Lathe/Port Drill	3:38 p.m.-10:45 p.m.	21.4	0.5
Drying Oven Area	3:15 p.m.-10:40 p.m.	22.3	0.7
OSHA PEL			5
ACGIH TLV			2

ppm - parts per million

Table 3
Respirable Dust Sampling Results - First Shift
North American Refractories Company
Cincinnati, Ohio
HETA 95-0147

Job Description/Area	Sample Time	Sample Volume (liters)	Concentration (milligrams per cubic meter)
Area			
Machining Area	7:41 a.m.-3:29 p.m.	796	0.01
Wet Press - Filling Stations	7:12 a.m.-3:50 p.m.	881	0.03
Large Dry Press - Blender	7:06 a.m.-3:33 p.m.	862	0.05
Small Dry Press - Blender	7:10 a.m.-3:34 p.m.	857	0.02
OSHA PEL			5
ACGIH TLV			3
Minimum Detectable Concentration *			0.03

* - Assuming a sample volume of 796 liters

Table 4
Phenol Sampling Results - Second Shift
North American Refractories Company
Cincinnati, Ohio
HETA 95-0147

Job Description/Area	Sample Time	Sample Volume (liters)	Concentration (ppm)^
Personal			
Wet Press Filler	3:19 p.m.-7:17 p.m 8:09 p.m.-10:38 p.m.	19.4	ND*
Dry Press Operator	5:26 p.m.-7:17 p.m 8:06 p.m.-10:49 p.m.	13.7	ND
Dry Press Blender	5:27 p.m.-7:14 p.m 8:07 p.m.-10:49 p.m.	13.5	ND
Area			
Wet Press	3:28 p.m.-10:34 p.m.	21.3	ND
Dryer	3:34 p.m.-10:40 p.m.	21.3	ND
Machining Stations	3:38 p.m.-10:45 p.m.	21.4	ND
OSHA PEL			5
ACGIH TLV			5
NIOSH REL			5
Minimum Detectable Concentration **			0.06
Minimum Quantifiable Concentration **			0.1

^ - ppm - parts per million
* - ND - not detected at the minimum detectable concentration
** - Assuming a sample volume of 13.5 liters