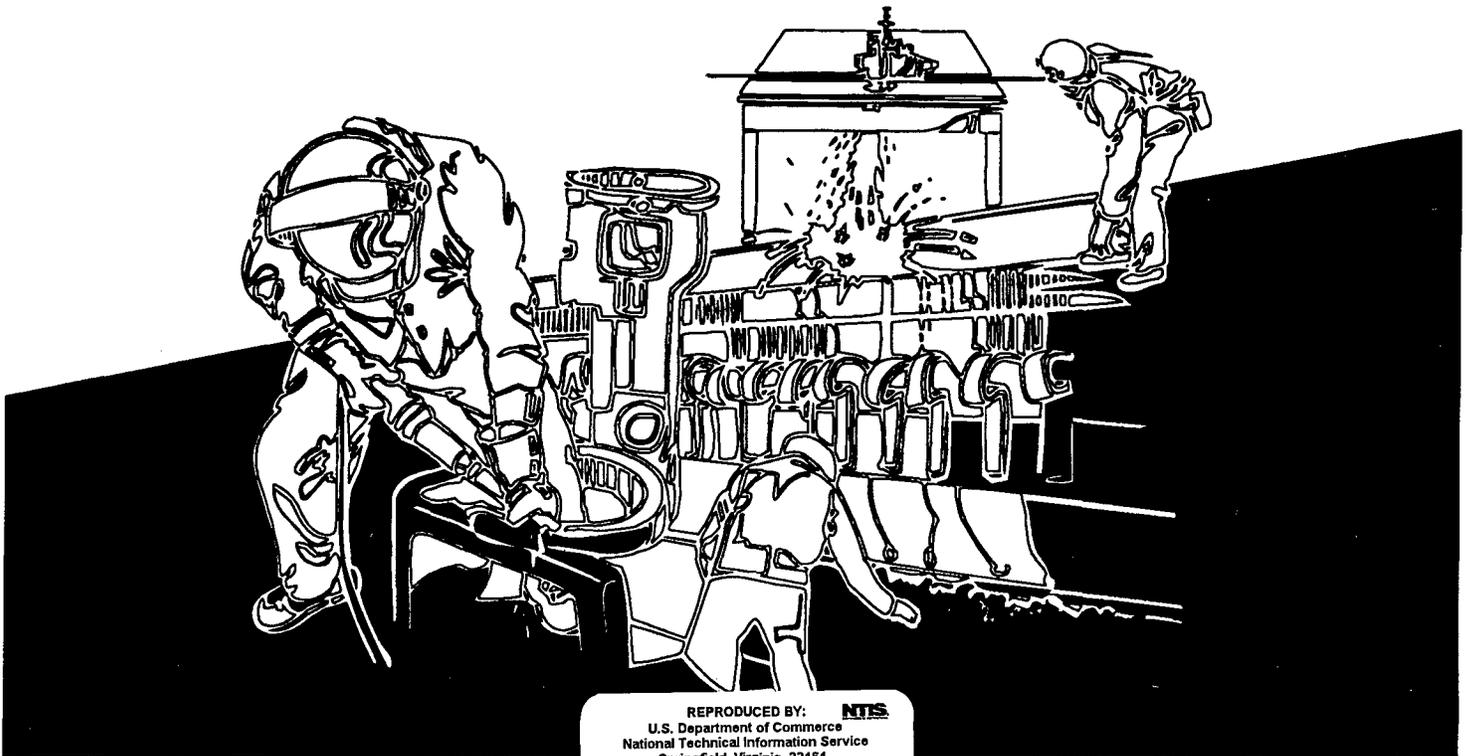




NIOSH HEALTH HAZARD EVALUATION REPORT

HETA 97-0004-2642
Centre Foundry & Machine Company
Wheeling, West Virginia

Nancy Clark Burton, M.P.H., M.S., C.I.H.



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



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, technical and consultative assistance 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.

ACKNOWLEDGMENTS AND AVAILABILITY OF REPORT

This report was prepared by Nancy Clark Burton of the Hazard Evaluations and Technical Assistance Branch, Division of Surveillance, Hazard Evaluations and Field Studies (DSHEFS). Field assistance was provided by Gregory Burr. Desktop publishing was provided by Ellen E. Blythe. Analytical support was provided by Ardith A. Grote (thermal desorption analysis), Stephanie M. Pendergrass (resorcinol analysis), and Samuel P. Tucker (p-toluenesulfonic acid analysis) of the Measurements Research Support Branch, Division of Physical Sciences and Engineering, and the Data Chem Laboratories, Inc., Salt Lake City, Utah.

Copies of this report have been sent to employee and management representatives at Centre Foundry & Machine Company, the United Steel Workers Union, Local 4842, the confidential requestors, and the OSHA Region III Office. This report is not copyrighted and may be freely reproduced. Single copies of this report will be available for a period of three years from the date of this report. To expedite your request, include a self-addressed mailing label along with your written request to:

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Health Hazard Evaluation Report 97-0004-2642
Centre Foundry & Machine Company
Wheeling, West Virginia
July 1997

Nancy Clark Burton, M.P.H., M.S., C.I.H.

SUMMARY

In October 1996, the National Institute for Occupational Safety and Health (NIOSH) received a confidential health hazard evaluation (HHE) request to investigate several occupational health issues at the Centre Foundry & Machine Company in Wheeling, West Virginia. The company manufactures grey iron castings used in the steel industry. On November 19-21, 1996, NIOSH representatives conducted an industrial hygiene survey. Personal breathing zone (PBZ) and area air samples were collected for respirable silica (quartz), elements, furfuryl alcohol, resorcinol, p-toluenesulfonic acid, carbon monoxide (CO), and volatile organic compounds. Work practices were also observed.

This investigation found that all seven PBZ exposures for respirable silica [quartz] (range: 0.13 to 0.72 milligrams per cubic meter [mg/m^3]) exceeded the NIOSH Recommended Exposure Limit (REL) of $0.05 \text{ mg}/\text{m}^3$ and the American Conference of Governmental Industrial Hygienists (ACGIH®) Threshold Limit Value (TLV®) of $0.1 \text{ mg}/\text{m}^3$. One PBZ sample concentration ($0.41 \text{ mg}/\text{m}^3$) collected on the sand reclamation operator exceeded the Occupational Safety and Health Administration (OSHA) Permissible Exposure Limit (PEL) for respirable silica (quartz). Four of the seven PBZ iron concentrations (range: 0.093 to $37.12 \text{ mg}/\text{m}^3$) exceeded the OSHA PEL of $10 \text{ mg}/\text{m}^3$ for iron and five of the seven PBZ sample concentrations exceeded the NIOSH REL and ACGIH® TLV® of $5 \text{ mg}/\text{m}^3$ for iron. Four of seven PBZ manganese concentrations (range: 0.024 to $2.83 \text{ mg}/\text{m}^3$) exceeded the NIOSH REL of $1 \text{ mg}/\text{m}^3$ and five of these concentrations exceeded the ACGIH® TLV® of $0.2 \text{ mg}/\text{m}^3$. One CO sample collected for the pour/ladle crane operator (37 parts per million [ppm]) exceeded the NIOSH REL of 35 ppm and the ACGIH® TLV® of 25 ppm for carbon monoxide. The air concentrations of resorcinol (0.04 to 0.75 ppm), furfuryl alcohol (trace to 1.83 ppm), aluminum (none detected to $0.862 \text{ mg}/\text{m}^3$), barium (none detected to $0.005 \text{ mg}/\text{m}^3$), chromium (none detected to $0.046 \text{ mg}/\text{m}^3$), magnesium (trace to $1.07 \text{ mg}/\text{m}^3$), nickel (none detected to $0.033 \text{ mg}/\text{m}^3$), phosphorus (none detected to $0.015 \text{ mg}/\text{m}^3$), titanium (none detected to $0.215 \text{ mg}/\text{m}^3$), and zinc (none detected to $0.004 \text{ mg}/\text{m}^3$) were below their current occupational health criteria. p-Toluenesulfonic acid concentrations ranged from 29 to 124 micrograms per cubic meter ($\mu\text{g}/\text{m}^3$). The major volatile organic compounds identified on the thermal desorption tube samples were furfuryl alcohol, toluene, furfural, methanol, 2-methylfuran, and isopropanol. Informal discussions with employees did not reveal any major health issues. During the walk-through inspection, some potential safety and health hazards were identified, such as the use of compressed air to clean loose sand from castings, and cluttered walk-ways.

The industrial hygiene sampling data indicate that workers were overexposed to respirable silica (quartz), iron, manganese, and carbon monoxide at this facility. The employees that were overexposed to respirable silica (quartz), iron, and manganese wore NIOSH-approved powered air-purifying respirator (PAPR) helmets with high efficiency particulate air (HEPA) filters which would be expected to reduce their exposures to below the current occupational exposure limits, based on an assigned protection factor of 25. Recommendations to reduce these exposures are provided in the recommendation section of this report.

Keywords: SIC 3321 (Gray and Ductile Iron Foundries), respirable silica (quartz), resorcinol, furfuryl alcohol, p-toluenesulfonic acid, carbon monoxide, iron, magnesium, manganese, volatile organic compounds.





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TABLE OF CONTENTS

Preface	ii
Acknowledgments and Availability of Report	ii
Summary	iii
Introduction	2
Background	2
Methods	2
Respirable Silica (Quartz)	3
Elements	3
Resorcinol	3
Furfuryl Alcohol	3
p-Toluenesulfonic Acid	3
Volatile Organic Compounds	4
Carbon Monoxide	4
Evaluation Criteria	4
Respirable Silica (Quartz)	5
Elements	5
Resorcinol	7
Furfuryl Alcohol	7
p-Toluenesulfonic Acid	7
Carbon Monoxide	7
Results/Discussion	7
Respirable Silica (Quartz)	7
Elements	8
Resorcinol	8
Furfuryl Alcohol	8
p-Toluenesulfonic Acid	8
Volatile Organic Compounds	8
Carbon Monoxide	9
Observations	9
OSHA 200 Logs Review/Health Issues	9
Conclusions	9
Recommendations	9
References	10

INTRODUCTION

In October 1996, the National Institute for Occupational Safety and Health (NIOSH) received a confidential health hazard evaluation (HHE) request to investigate several occupational health issues at the Centre Foundry & Machine Company in Wheeling, West Virginia. The HHE request described concerns about workers' exposure to silica dust, organic vapors, and various metal dusts. Health problems, including general upper respiratory complaints, sinusitis, pneumonia, eye abrasions, cancer, and brain tumors, were listed on the HHE request. In response to this request, a site visit was conducted on November 19–21, 1996.

BACKGROUND

The Centre Foundry & Machine Company is housed in a metal and masonry building and has been in operation at this location since 1890. The company manufactures 1 to 28 ton grey iron castings that are used in steel production. The facility operates three shifts with a total of 52 employees.

The company operates two 55-ton channel induction furnaces. The refractory repair work for the furnaces is done by contractors. The company operates six overhead cranes to move castings, molds, and cores. The scrap yard is located outside the building. The completed molds are placed in pits for pouring. The company uses a no-bake molding process using furfuryl alcohol resin, resorcinol, and p-toluenesulfonic acid (as a catalyst) as the major components. Some of the cores are made of an oil sand mixture on the second shift.

The castings are shaken out during the second half of the second shift and during third shift using an overhead crane and Bobcat®. Castings are struck against a large, heavy iron casting in the middle of the floor by using the crane. Some castings are allowed to cool up to three days before shake-out. The Bobcat® operator also runs the sand reclamation machine. Bag houses are used for dust collection.

About 25–30% of the sand is recycled; the remaining waste sand is land filled in a 13-acre facility on-site.

Individuals in the cleaning department use chippers and various size grinders. Water is frequently used to wet castings to reduce the amount of dust generated. Sometimes, compressed air is used to remove excess sand from the internal cavities of the castings. Three planing machines, which are used to trim the ends of the castings, are located in the cleaning department.

Hard hats and safety glasses were required throughout the facility. NIOSH-approved disposable high efficiency particulate air (HEPA) respirators with impregnated charcoal are used in the molding area to help reduce exposures to particulates and organic vapors, and powered air-purifying respirators (PAPR) equipped with helmets and HEPA filters are used in the cleaning areas. When doing shake-out and sand reclamation work, the Bobcat® operator wears a full-facepiece respirator with a HEPA filter. There is a separate room for respirator storage and one individual is responsible for respirator cleaning and repair. Each employee reportedly is fit-tested and is assigned their own respirator. Hearing protection devices (disposable ear plugs) are required in the facility's cleaning area. Annual audiometric tests are performed. Pre-placement physicals are required for all employees and annual physicals are required for crane operators and the yard man.

General ventilation is supplied by open doors and windows. Large free-standing propeller "man-cooling" fans are used throughout the plant. Heat is provided during cold months by free-standing gas-fired radiant heaters.

METHODS

Personal breathing zone (PBZ) and area air samples were collected for the substances listed below. The facility's Material Safety Data Sheets, respiratory protection policy, and Occupational Safety and Health Administration (OSHA) 200 logs for 1995 and 1996 (year to date) were also reviewed.

Respirable Silica (Quartz)

Seven PBZ and eight area air samples for respirable dust (aerodynamic diameter less than or equal to 10 micrometers [μm]) were collected at a flowrate of 1.7 liters per minute (l/min) using 10 millimeter (mm) nylon cyclones containing pre-weighed polyvinyl chloride (PVC) filters (37 mm diameter, 5 μm pore size). They were analyzed for quartz and cristobalite content with X-ray diffraction according to NIOSH Method 7500¹ with the following modifications: (a) the filters were dissolved in tetrahydrofuran rather than being ashed in a furnace, and, (b) standards and samples were run concurrently and an external calibration curve was prepared from the integrated intensities rather than the suggested normalization procedure. The analytical limit of detection (LOD) was 0.010 milligrams (mg), which is equivalent to a minimum detectable concentration (MDC) of 0.012 milligrams per cubic meter (mg/m^3), assuming a sample volume of 833 liters. The limit of quantitation (LOQ) was 0.030 mg, which is equivalent to a minimum quantifiable concentration (MQC) of 0.036 mg/m^3 , assuming a sample volume of 833 liters.

The seven PBZ and eight area air samples were also analyzed for respirable particulate weight by gravimetric analysis according to NIOSH Method 0600² with a LOD of 0.020 mg, which is equivalent to a MDC of 0.024 mg/m^3 , assuming a sample volume of 833 liters.

Elements

Seven PBZ and six area air samples were collected on mixed-cellulose ester filters (37 mm diameter, 0.8 micrometer [μm] pore size) using a flowrate of 2.0 l/min. The samples were analyzed for 28 elements according to NIOSH Method 7300³, modified for microwave digestion. In the laboratory, the filters were digested in the microwave using nitric acid. The samples were cooled and diluted to volume with distilled water. The resulting sample solutions were analyzed by inductively coupled plasma atomic emission spectrometry. The MDCs and MQCs, using

a sample volume of 700 liters, for the selected elements are listed in Table 3.

Resorcinol

Two PBZ and three area air samples were collected on Occupational Safety and Health Administration (OSHA) Versatile Sampler 13 mm XAD-7 (OVS-7) tubes using flowrates of 0.05 and 0.2 lpm. One bulk sample of material was also collected. The samples were analyzed using gas chromatography with a flame ionization detector. The samples were desorbed using methanol and sonicated for 0.75 hours. The analytical LOD was 4 micrograms (μg) per sample, which is equivalent to a MDC of 0.007 parts per million (ppm), assuming a sample volume of 94.4 liters. The LOQ was 12 μg per sample, which is equivalent to a MQC of 0.028 ppm, assuming a sample volume of 94.4 liters.

Furfuryl Alcohol

Three PBZ and two area air samples were collected on Porapak Q solid sorbent tubes using flowrates of 0.05 and 0.2 lpm. The samples were analyzed for furfuryl alcohol by gas chromatography according to NIOSH Method 2505⁴ with the following modifications: a) a fused silica capillary coated column was used; b) oven conditions and carrier gas flowrate were modified to achieve separation of the compounds; and c) media standards were used. The analytical LOD was 3 μg per sample, which is equivalent to a MDC of 0.04 ppm, assuming a sample volume of 18.7 liters. The LOQ was 9.1 μg per sample, which is equivalent to a MQC of 0.12 ppm, assuming a sample volume of 18.7 liters.

p-Toluenesulfonic Acid

Area air samples for p-toluenesulfonic acid were collected using two different sampling techniques: 13-mm glass fiber filters and impingers containing isopropanol. Five area air samples were collected on glass fiber filters using a flowrate of 1 lpm and three area air samples were collected in impingers at a

flowrate of 1 lpm. One bulk sample of liquid formulation was also submitted for analysis.

The glass fiber filters were treated with a 2:98 isopropanol:water solution in an ultrasonic bath to bring the *p*-toluenesulfonic acid into solution. The impinger samples were heated and the isopropanol allowed to evaporate using nitrogen. The residues were dissolved in an isopropanol:water solution. These sample solutions and the bulk sample were analyzed using high performance liquid chromatography with ultraviolet detection. The analytical LOD was 0.08 µg per sample, which is equivalent to a MDC of 0.03 µg/m³, assuming a sample volume of 271 liters. The LOQ was 0.27 µg per sample, which is equivalent to a MQC of 1.0 µg/m³, assuming a sample volume of 271 liters.

Volatile Organic Compounds

To detect decomposition products, four thermal desorption tube samples were collected for qualitative analysis of volatile organic compounds using personal sampling pumps calibrated at 0.2 lpm. The thermal desorption tubes were analyzed using gas chromatography/mass spectrometry (GC/MS). All samples were dry purged with helium to remove excess water.

Carbon Monoxide

Crane operators' exposures to carbon monoxide were measured using Draeger® passive diffusion tubes which utilize a colorimetric method (carbon monoxide reacts with palladium salts, resulting in a color change or stain). The diffusion tubes were fastened to the employee's collar in the breathing zone for the duration of the workshift. The length of the resulting stain was determined and the time-weighted average calculated. The MDC for an 8-hour sample was 6.25 ppm.

EVALUATION CRITERIA

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 Limits (RELs),⁵ (2) the American Conference of Governmental Industrial Hygienists' (ACGIH®) Threshold Limit Values (TLVs®),⁶ and (3) the U.S. Department of Labor, OSHA Permissible Exposure Limits (PELs).⁷ 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.

Respirable Silica (Quartz)

Crystalline silica (quartz) is associated with silicosis, a fibrotic disease of the lung caused by the deposition of fine particles of crystalline silica in the lungs. Symptoms usually develop insidiously, with cough, shortness of breath, chest pain, weakness, wheezing, and non-specific chest illnesses. There are three forms of silicosis: (1) chronic silicosis, which usually occurs after at least 10 years of exposure to silica at relatively low concentrations, (2) accelerated silicosis which results from exposure to high concentrations of respirable silica and develops 5 to 10 years after the initial exposure, and (3) acute silicosis which occurs when exposure concentrations are very high and can cause symptoms to develop within a few weeks to 4 to 5 years after the initial exposure.⁸ The NIOSH REL for respirable quartz is $50 \mu\text{g}/\text{m}^3$ as a TWA for up to 10 hours per day during a 40-hour work week.⁵ This REL is intended to prevent silicosis. However,

evidence indicates that crystalline silica is a potential occupational carcinogen and NIOSH is currently reviewing the data on carcinogenicity.⁸ The International Agency for Research on Cancer (IARC) has recently reclassified crystalline silica as carcinogenic to humans (Group 1) based on epidemiological studies.⁹ Several of these studies, but not all, showed elevated lung cancer risks that could not be explained by confounding factors including cigarette smoking, arsenic exposure, radon inhalation, or other exposures.

OSHA requires that the 1971 PEL for respirable silica⁷ be dependent upon the percent silica in the sample, and that the respirable silica exposure for an 8-hour TWA not exceed the value obtained from the formula:

$$\frac{10 \text{ mg}/\text{m}^3}{\% \text{SiO}_2 + 2}$$

The vacated 1989 OSHA PEL for respirable silica was $100 \mu\text{g}/\text{m}^3$ as a time-weighted average. The ACGIH® TLV® for respirable quartz is $100 \mu\text{g}/\text{m}^3$, as an 8-hour TWA.⁶

Elements

A list of selected elements along with a brief summary of their primary health effects and the evaluation criteria for occupational exposures to these contaminants are presented in Table 1.

Table 1
Health Effects and Criteria Limit Summary for Selected Elements

Element	Primary Health Effects ^{10,11,12,13,17}	OSHA PEL (mg/m ³) ⁷	NIOSH REL (mg/m ³) ⁵	ACGIH® TLV® (mg/m ³) ⁶
Aluminum (Al)	Metallic aluminum dust is considered a relatively benign "inert dust".	15	10	10
Barium (Ba)	Soluble barium compounds can cause eye, skin, and mucous membrane irritation.	0.5	0.5	0.5
Chromium (Cr)	Chromium (Cr) exists in a variety of chemical forms and toxicity varies among the different forms. Elemental chromium is relatively non-toxic, but other chromium compounds may cause skin irritation, sensitization, and allergic dermatitis. In the hexavalent form (Cr(VI)), Cr compounds are corrosive and possibly carcinogenic.	1.0	0.5	0.5
Iron (Fe)	Inhalation of iron oxide dust may cause a benign pneumoconiosis called siderosis.	10	5	5
Magnesium (Mg)	Magnesium oxide can cause eye and nasal irritation. Exposure has been associated with the development of metal fume fever.	15 (vacated 10)	None	10
Manganese (Mn)	Manganese fume exposure has been associated with chemical pneumonitis and central nervous system effects.	5 (ceiling)	1	0.2
Nickel (Ni)	Metallic nickel compounds cause sensitization dermatitis. NIOSH considers nickel a potential carcinogen, as nickel refining has been associated with an increased risk of nasal and lung cancer.	1	0.015 Carcinogen	1 (0.5 – proposed)
Phosphorus (P)	Phosphorus exposure can cause irritation of the eyes and respiratory tract. Direct contact with the skin can result in burns.	1	1	0.1
Titanium (Ti)	Titanium dioxide exposure can result in mild pulmonary tract irritation. It has been associated with lung tumors in animals.	15 (vacated 10)	Carcinogen	10
Zinc (Zn)	Zinc oxide has been associated with shortness of breath, minor lung function changes, and metal fume fever.	15 (vacated 5)	5	10

Resorcinol

Resorcinol is used in a variety of operations and products including resins for tires, dyes, cosmetics, skin creams, laminates, adhesives, and as a cross-linking agent for neoprene. Acute exposure to resorcinol can cause eye, skin, and mucous membrane irritation.¹⁴ Dermal exposures have resulted in symptoms of dermatitis, hyperemia, pruritus, restlessness, methemoglobinemia, convulsions, tachycardia, dyspnea, and death.^{14,17} The NIOSH REL and ACGIH® TLV® for resorcinol are both 10 ppm, as TWAs.^{5,6} OSHA does not currently have a PEL for resorcinol; the vacated 1989 OSHA PEL was 10 ppm.⁷

Furfuryl Alcohol

Furfuryl alcohol is used in flavorings, as a wetting agent, in foundry cores, sealants, cements, and polymers, and as a solvent in dyes and resins.¹⁴ It is an eye, nose, and throat irritant.¹⁵ Short-term exposure to furfuryl alcohol can cause central nervous system depression. Chronic exposure to furfuryl alcohol can cause headache, eye irritation, and dermatitis. Skin contact with furfuryl alcohol can cause minor irritation. The NIOSH REL for furfuryl alcohol is 10 ppm, as a 10-hour TWA, with a skin notation.⁵ The OSHA PEL for resorcinol is 50 ppm; the vacated 1989 OSHA PEL was 10 ppm.⁷ The ACGIH® TLV® for furfuryl alcohol is 10 ppm, as an 8-hour TWA, with a skin notation.⁶

p-Toluenesulfonic Acid

p-Toluenesulfonic acid is used to manufacture drugs, dyes, and other chemicals, and is used as a catalyst in coatings, paint, polymers, and textile production.¹⁶ It is irritating to the skin, eyes, and mucous membranes. Direct skin contact can cause severe skin burns. There are currently no occupational health evaluation criteria for p-toluenesulfonic acid.

Carbon Monoxide

Carbon monoxide (CO) is a colorless, odorless, tasteless gas which can be a product of the incomplete combustion of organic compounds. CO combines with hemoglobin and interferes with the oxygen carrying capacity of blood. Symptoms include headache, drowsiness, dizziness, nausea, vomiting, collapse, cardiovascular disease, myocardial ischemia, and death.^{17,18} The NIOSH REL for carbon monoxide is 35 ppm for an 8-hour TWA.⁵ NIOSH also recommends a ceiling limit of 200 ppm which should not be exceeded at any time during the workday. The current OSHA PEL for carbon monoxide is 50 ppm for an 8-hour TWA and the vacated PEL was 35 ppm.⁷ The ACGIH® TLV® for carbon monoxide is 25 ppm as an 8-hour TWA.⁶

RESULTS/DISCUSSION

Respirable Silica (Quartz)

The results of the seven PBZ and eight area air samples for respirable silica are presented in Table 2. The seven PBZ sample concentrations ranged from 0.13 to 0.72 mg/m³, as TWAs. All seven personal exposures exceeded the NIOSH REL of 0.05 mg/m³ for respirable silica and the ACGIH® TLV® of 0.1 mg/m³ for respirable silica. One PBZ sample concentration (0.41 mg/m³) collected for the sand reclamation operator exceeded the respective OSHA PEL for respirable silica (quartz). The plane machine operators, grinders, and chippers wore PAPR respirators equipped with helmets and HEPA filters. NIOSH has given these respirators an assigned protection factor (APF) of 25. Therefore, if the respirators are properly fitted to the employees and used in conjunction with a respiratory protection program, exposures would be expected to be below the occupational exposure limits.

The area air sample concentrations ranged from a trace amount to 0.185 mg/m³, as TWAs. The highest area concentrations were found for the chipping shed crane operator's cab (0.14 mg/m³), the Bobcat® operation during shake-out and sand reclamation

(0.19 mg/m³), and the shake-out crane operator's cab (0.13 mg/m³).

Cristobalite was not detected in any of the area air samples at a LOD of 0.020 mg, which is equivalent to a MDC of 0.024 mg/m³, assuming a sample volume of 833 liters.

Elements

The seven PBZ and six area air sample concentrations for elements are shown in Table 3. Four of the seven PBZ concentrations exceeded the OSHA PEL of 10 mg/m³ for iron and five of the seven sample concentrations exceeded the NIOSH REL and ACGIH® TLV® of 5 mg/m³ for iron. The five samples collected for the chippers had exposures ranging from 5.53 to 37.12 mg/m³. Manganese concentrations for four chippers (range: 1.65 to 2.83 mg/m³) exceeded the NIOSH REL of 1 mg/m³ for manganese and five manganese concentrations for the chippers (range: 0.708 to 2.83 mg/m³) exceeded the ACGIH® TLV® of 0.2 mg/m³ for manganese. The air concentrations of aluminum (none detected to 0.862 mg/m³), barium (none detected to 0.005 mg/m³), chromium (none detected to 0.046 mg/m³), magnesium (trace to 1.07 mg/m³), nickel (none detected to 0.033 mg/m³), phosphorus (none detected to 0.015 mg/m³), titanium (none detected to 0.215 mg/m³), and zinc (none detected to 0.004 mg/m³) were below their respective occupational health criteria. The results for calcium and sodium are reported but there are no occupational evaluation criteria for those elements. The chippers wore PAPR respirators equipped with helmets and HEPA filters. NIOSH has given these respirators an assigned protection factor (APF) of 25. Therefore, if the respirators are properly fitted to the employees and used in conjunction with a respiratory protection program, exposures would be expected to be below the occupational exposure limits.

Resorcinol

The two PBZ and three area air sample concentrations for resorcinol are displayed in Table 4. The concentrations for the five air samples were below the

NIOSH REL and the ACGIH® TLV® of 10 ppm for resorcinol. The two PBZ samples for the molding machine operator and machine helper were both 0.75 ppm. During part of the monitored shift, the auger on the sand machine was replaced (this happens routinely about every two weeks) and, therefore, the amount of time the sand machine was used for production was reduced. The three area sample concentrations for resorcinol ranged from 0.04 to 0.19 ppm. The bulk sample of material used in the no-bake molding process contained 1390 µg/ml of resorcinol.

Furfuryl Alcohol

The results of the three PBZ and two area air samples for furfuryl alcohol are presented in Table 5. All sample concentrations were below the OSHA PEL of 50 ppm for furfuryl alcohol and the NIOSH REL/ACGIH® TLV® of 10 ppm for furfuryl alcohol. The PBZ concentrations ranged from a trace level for a pitman to 1.83 ppm for a machine operator. The two area sample air levels were 0.16 ppm in the Crane #3 cab and 1.33 ppm at the machine operator's workstation.

p-Toluenesulfonic Acid

The results of the eight area air samples for p-toluenesulfonic acid are listed in Table 6. The sample concentrations ranged from 29 µg/m³ next to the molding machine to 124 µg/m³ on the end of the molding machine. The impinger and glass filter sample results were very similar. The bulk sample of liquid formulation used in the no-bake molding process contained 78.3% p-toluenesulfonic acid by weight. There are currently no occupational health criteria for p-toluenesulfonic acid.

Volatile Organic Compounds

The major components identified on the thermal desorption tube samples were furfuryl alcohol, toluene, furfural, methanol, 2-methylfuran, and isopropanol. Numerous other furan-based compounds and alkyl benzoates were also detected.

These compounds are likely from the no-bake molding process. Copies of the chromatograms are included in Appendix A.

Carbon Monoxide

The results for the three PBZ air samples are given in Table 7. The PBZ concentrations ranged from 14 to 37 ppm. One CO sample collected on the pour/ladle crane operator (37 ppm) exceeded the NIOSH REL of 35 ppm and the ACGIH® TLV® of 25 ppm for carbon monoxide. One possible source of the carbon monoxide is the decomposition of the no-bake binders used in the molding process.

Observations

Employees were smoking, eating, and drinking in the general work area despite the provision of a separate breakroom. Visible clouds of dust escaped when one of the sand hoppers in the molding department was being filled. Some employees expressed concern over the potential of the power cord for the PAPR respirators getting caught in the planing machines. There are currently no regulations that address that issue. When a PAPR respirator is certified, the cord is checked to make sure it is long enough not to interfere with head movement or fit. Some chipping and grinding operations require employees to sit in or partially enter the casting which may increase employees' exposures to the generated dust. The walk-ways in the plant were cluttered with castings, molds, sand, and other debris, making it difficult to walk between departments and get to the exits.

OSHA 200 Logs Review/Health Issues

Review of the OSHA 200 logs for 1995 to November 1996 did not show any work-related illnesses, but did reveal mostly traumatic injuries, such as strains, sprains, burns, and eye injuries. Informal discussions with employees did not reveal any major health issues that were thought to be related to exposures in the work environment.

CONCLUSIONS

The foundry industry has been identified as a complex process with numerous associated health hazards.¹⁹ Little information is available about the long-term health effects of emissions from molds composed of synthetic chemical molding materials. Mortality studies have indicated that a two- to three-fold excess risk of lung cancer has been identified for molders, pourers, and cleaning room operators when compared to a reference population.²⁰ Smoking history was not available for these studies. The industrial hygiene sampling data indicate that respirable silica (quartz), carbon monoxide, iron, and manganese exposures in this facility constitute a potential health hazard to workers. These environmental monitoring results reflect workplace conditions on the days of the survey. Employees did not report any health problems during informal conversations with NIOSH investigators. During the walk-through survey, some potential safety and health hazards were identified, such as the use of compressed air to clean loose sand from castings, and cluttered walk-ways.

RECOMMENDATIONS

The following recommendations are offered to reduce employee exposures' to respirable silica (quartz), carbon monoxide, iron, and magnesium, and to help correct safety and health issues that were identified at this facility. NIOSH and OSHA recommend that a hierarchy of controls be used to control employee exposures. Engineering controls should be used first, followed by administrative controls such as work practices, and as a final solution, personal protective equipment such as respiratory protection.

(1) To reduce respirable silica exposures, high velocity, low volume (HVLV) tool hoods with noise mufflers could be used for the hand grinders.²¹ Exposure to dust from chipping and grinding in the interior of large castings could be controlled by the use of a flexible exhaust duct which could be inserted into the interior of the casting.

(2) To reduce exposures to respirable silica and noise during casting cleaning, the compressed air hoses should be eliminated and replaced with a central vacuum system. As an interim measure, the existing air lines should be regulated to reduce air to less than 30 pounds per square inch (psi) and equipped with regulators.²² An industrial vacuum should be used on a regular basis to collect loose sand/dust on the floor.

(3) To avoid ingestion of contaminants such as metals and organic compounds, employees should not be allowed to eat, drink, or smoke in the production area.

(4) To improve general ventilation and comfort, a make-up air system should be installed to supply fresh air. The air exhausted from the building should be replaced with tempered air from an uncontaminated source. This air could be directed to operator work areas to provide a cleaner environment. The use of man-cooling fans is not recommended since they interfere with the performance of local exhaust ventilation hoods.

(5) The walk-ways throughout the plant should be kept clear of debris and other obstacles which make walking between departments difficult, and could prevent employees from easily exiting the building.

(6) To prevent the power cord on the PAPR respirators from slipping, a clip could be used to fasten the cord to the back of the employee.

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Table 2
Respirable Silica (Quartz) Air Sampling Results
Centre Foundry & Machine Co.
Wheeling, West Virginia
HETA 97-0004
November 20-21, 1996

Job Title/Location	Sampling Time	Sample Volume (liters)	Respirable Dust Concentration (TWA-mg/m ³)*	Respirable Silica Concentration (TWA-mg/m ³)	Respirable Silica (Quartz) OSHA PEL (TWA-mg/m ³)
Personal					
Planing Machine Operator	7:20 a.m. - 2:39 p.m.	746.3	1.51	0.13	0.92
Chipper	7:47 a.m. - 1:37 p.m.	595	0.76	0.13	0.83
Chipper	7:50 a.m. - 1:41 p.m.	596.7	4.16	0.23	1.31
Grinder	9:13 a.m. - 2:33 p.m.	544	9.19	0.72	1.02
Grinder	7:25 a.m. - 2:49 p.m.	754.8	7.5	0.38	1.4
Planing Machine Operator	7:15 a.m. - 2:33 p.m.	744.6	0.83	0.13	0.57
Sand Reclaim Operator	4:03 p.m. - 9:45 p.m.	581.4	1.81	0.41	0.4
NIOSH REL (10-hr TWA)				0.050 (Ca)**	
ACGIH® TLV®				0.100	
Minimum Detectable Concentration (MDC)		833		0.012	
Minimum Quantifiable Concentration (MQC)		833		0.036	

* = TWA (time-weighted average) mg/m³ = milligrams per cubic meter ** = Ca (suspected human carcinogen)

Table 2
Respirable Silica (Quartz) Air Sampling Results (continued)

Centre Foundry & Machine Co.

Wheeling, West Virginia

HETA 97-0004

November 20-21, 1996

Job Title/Location	Sampling Time	Sample Volume (liters)	Respirable Dust Conc. (TWA-mg/m ³)*	Respirable Silica Concentration (TWA-mg/m ³)	Respirable Silica (Quartz) OSHA PEL (TWA-mg/m ³)
Area					
Next To Planing Machine	7:45 a.m. - 2:27 p.m.	683.4	0.56	0.08	0.6
Next to Chipper's Work Area	8:15 a.m. - 2:32 p.m.	640.9	0.70	0.09	0.68
Machine Operator's Station	8:09 a.m. - 2:18 p.m.	627.3	0.64	0.21	0.31
Sand Machine	8:10 a.m. - 2:21 p.m.	630.7	0.76	0.27	0.27
Ladle Crane Operator's Cab	7:26 a.m. - 2:40 p.m.	737.8	0.04	Trace	—
Chipping Shed Crane Oper's Cab	7:52 a.m. - 2:42 p.m.	697	0.49	0.14	0.32
Bobcat	3:28 p.m. - 9:50 p.m.	649.4	0.71	0.19	0.36
Shake-out Crane Operator Cab	1:45 p.m. - 9:55 p.m.	833	0.36	0.13	0.26
NIOSH REL (10-hr TWA)				0.050 (Ca)**	
ACGIH® TLV®				0.100	
Minimum Detectable Concentration (MDC)**		833		0.012	
Minimum Quantifiable Concentration (MQC)**		833		0.036	

* = TWA (time-weighted average) mg/m³ = milligrams per cubic meter ** = Ca (suspected human carcinogen)

Table 3
Air Sampling Results For Elements
Centre Foundry & Machine Co.
Wheeling, West Virginia
HETA 97-0004
November 20-21, 1996

Job Title/ Location	Sampling Time	Sample Volume (liters)	Concentration (TWA - mg/m ³)												
			Al	Ba	Ca	Cr	Fe	Mg	Mn	Na	Ni	P	Ti	Zn	
Personal															
Chipper	7:36 a.m. - 1:39 p.m.	726	0.372	0.001	0.112	0.010	10.19	0.634	2.48	0.048	0.009	0.008	0.088	0.003	
Chipper	7:34 a.m. - 2:45 p.m.	862	0.151	0.001	0.082	0.003	37.12	0.325	0.708	0.023	0.003	Trace	0.004	0.002	
Furnace Oper.	8:07 a.m. - 2:23 p.m.	752	0.013	0.0002	0.043	—	0.24	0.15	0.029	0.040	—	—	0.002	0.003	
Chipper	7:21 a.m. - 2:42 p.m.	882	0.862	0.003	0.136	0.014	12.47	1.04	2.83	0.124	0.011	0.013	0.215	0.004	
Chipper	7:30 a.m. - 2:35 p.m.	850	1.14	0.005	0.176	0.046	12.94	1.07	1.76	0.435	0.033	0.015	0.153	0.004	
Chipper	7:27 a.m. - 2:36 p.m.	858	0.329	0.002	0.079	0.005	5.53	0.871	1.65	0.032	0.009	0.007	0.066	0.003	
Ladleman	8:17 a.m. - 2:18 p.m.	722	0.019	Trace	0.033	—	0.093	0.024	0.004	0.024	—	—	—	Trace	
OSHA PEL			15	0.5	—	1	10	15	5	—	1	0.1	15	15	
NIOSH REL			10	0.5	—	0.5	5	—	1	—	0.015	0.1	Ca	5	
ACGIH® TLV®			10	0.5	—	0.5	5	10	0.2	—	1 (0.5)^	0.1	10	10	
MDC		700	0.0001	0.0001	0.004	0.0007	0.001	0.0007	0.00001	0.003	0.0007	0.003	0.0003	0.0007	
MQC		700	0.0004	0.0002	0.011	0.002	0.004	0.002	0.00005	0.010	0.001	0.006	0.0006	0.002	

^ = Listed under Notice of Intended Changes for 1996.

Table 3 (continued)
 Air Sampling Results For Elements Centre Foundry & Machine Co. Wheeling, West Virginia
 HETA 97-0004
 November 20-21, 1996

Job Title/ Location	Sampling Time	Sample Volume (liters)	Concentration (TWA - mg/m ³)												
			Al	Ba	Ca	Cr	Fe	Mg	Mn	Na	Ni	P	Ti	Zn	
Area															
West Side of North Pit	8:29 a.m. - 2:23 p.m.	700	—	—	—	—	0.012	0.002	0.001	0.011	—	—	—	Trace	
West Side of North Pit	8:25 a.m. - 2:16 p.m.	702	—	—	—	0.026	Trace	0.001	0.011	—	—	—	—	—	
Pour/Ladle Crane Cab	7:26 a.m. - 2:40 p.m.	868	0.004	Trace	Trace	0.051	0.031	0.006	0.013	—	—	—	0.0005	Trace	
Chipping Crane Cab	7:52 a.m. - 2:42 p.m.	820	0.091	0.004	0.003	0.001	0.939	0.095	0.195	0.029	Trace	—	0.017	0.003	
Area - Bobcat	8:29 a.m. - 2:23 p.m.	764	0.042	0.0006	0.037	—	0.196	0.076	0.004	0.014	—	—	0.003	Trace	
Area - Crane Operator	8:29 a.m. - 2:23 p.m.	980	0.013	0.0007	0.015	—	0.080	0.143	0.003	0.011	—	—	0.001	Trace	
OSHA PEL			15	0.5	—	1	10	15	5	—	1	0.1	15	15	
NIOSH REL			10	0.5	—	0.5	5	—	1	—	0.015	0.1	Ca	5	
ACGIH® TLV®			10	0.5	—	0.5	5	10	0.2	—	1 (0.5)^	0.1	10	10	
MDC		700	0.0001	0.0001	0.004	0.0007	0.001	0.0007	0.00001	0.003	0.0007	0.003	0.0003	0.0007	
MQC		700	0.0004	0.0002	0.011	0.002	0.004	0.002	0.00005	0.010	0.001	0.006	0.0006	0.002	

^ = Listed under Notice of Intended Changes for 1996.

Table 4
Resorcinol Air Sampling Results
Centre Foundry & Machine Co.
Wheeling, West Virginia
HETA 97-0004
November 21, 1996

Job Description/Area	Sample Time	Sample Volume (liters)	Concentration (ppm)*
Personal			
Machine Helper	6:32 a.m. – 3:13 p.m.	26.05	0.75
Machine Operator	6:37 a.m. – 3:09 p.m.	25.6	0.75
Area			
West Side of South Pit	6:49 a.m. – 2:00 p.m.	21.55	0.19
Machine Operator's Workstation	6:35 a.m. – 2:27 p.m.	94.4	0.04
Crane Cab #3	8:05 a.m. – 2:56 p.m.	82.2	0.05
OSHA PEL (8-hr TWA)			None#
NIOSH REL (10-hr TWA)			10
ACGIH® TLV®			10
Minimum Detectable Concentration (MDC)		94.4	0.007
Minimum Quantifiable Concentration (MQC)		94.4	0.028

* = ppm (parts per million)

= Vacated 1989 OSHA PEL is 10 ppm

Table 5
Furfuryl Alcohol Air Sampling Results
Centre Foundry & Machine Co.
Wheeling, West Virginia
HETA 97-0004
November 21, 1996

Job Description/Area	Sample Time	Sample Volume (liters)	Concentration (ppm)*
Personal			
Machine Helper	6:30 a.m. – 3:13 p.m.	26.15	1.59
Pitman	6:50 a.m. – 2:31 p.m.	23.05	Trace (0.04)#
Machine Operator	8:55 a.m. – 3:09 p.m.	18.7	1.83
Area			
Machine Operator Station	6:30 a.m. – 3:13 p.m.	94	1.33
Crane #3	6:30 a.m. – 3:13 p.m.	82.2	0.16
OSHA PEL (8-hr TWA)			50##
NIOSH REL (10-hr TWA)			10
ACGIH® TLV®			10
Minimum Detectable Concentration (MDC)		18.7	0.04
Minimum Quantifiable Concentration (MQC)		18.7	0.12

* = ppm (parts per million)

= Between MDC and MQC

= Vacated 1989 OSHA PEL is 10 ppm

Table 6
p-Toluenesulfonic Acid Area Air Sampling Results
Centre Foundry & Machine Co.
Wheeling, West Virginia
HETA 97-0004
November 21, 1996

Job Description/Area	Sample Time	Sample Volume (liters)	Concentration ($\mu\text{g}/\text{m}^3$)*
Impinger			
Area Next to Molding Machine	8:10 a.m. – 2:14 p.m.	364	65
Area Next to Molding Machine	8:07 a.m. – 2:13 p.m.	366	55
Area Between Molding Machine and Mold Filling Area	8:14 a.m. – 2:15 p.m.	363	37
Glass Fiber Filters			
End of Molding Machine	10:40 a.m. – 3:11 p.m.	271	124
Area Next to Molding Machine	10:34 a.m. – 2:16 p.m.	282	29
Area Next to Molding Machine	8:14 a.m. – 2:15 p.m.	361	36
Area Next to Molding Machine	8:07 a.m. – 2:13 p.m.	366	59
Machine Operator Work Station	8:10 a.m. – 2:14 p.m.	364	42
Minimum Detectable Concentration (MDC)		271	0.3
Minimum Quantifiable Concentration (MQC)		271	1.0

* = $\mu\text{g}/\text{m}^3$ (micrograms per cubic meter)

Table 7
Carbon Monoxide Air Sampling Results
Centre Foundry & Machine Co.
Wheeling, West Virginia
HETA 97-0004
November 20-21, 1996

Job Description/Area	Sample Time	Concentration (TWA-ppm)*
Personal		
Chipping Shed Crane Operator (non-smoker)	7:52 a.m. – 2:42 p.m.	14
Pour/Ladle Crane Operator (smoker)	7:26 a.m. – 2:40 p.m.	14
Pour/Ladle Crane Operator	1:55 p.m. – 9:45 p.m.	37
OSHA PEL (8-hr TWA)**		50
NIOSH REL (10-hr TWA)		35
ACGIH® TLV®		25
Minimum Detectable Concentration (MDC)		6.25

* TWA = time-weighted average

** Vacated 1989 OSHA PEL 35 ppm

ppm = parts per million

Appendix A

SEQ 8567
THERMAL DESORPTION TUBES
PEAK IDENTIFICATION

- 1) Air/CO₂¹
- 2) Formaldehyde²
- 3) Propane
- 4) Methanol
- 5) Butane
- 6) Ethanol
- 7) Acetone
- 8) Isopropanol
- 9) Pentane
- 10) Methyl ethyl ketone (MEK)
- 11) 2-Methylfuran³
- 12) Hexane
- 13) Tetrahydrofuran³ (THF)
- 14) Benzene
- 15) p-Dioxane
- 16A) 2,5-Dimethylfuran³
- 16) Toluene
- 17) Hexanal¹
- 18) Furfural³
- 19) Hexamethylcyclotrisiloxane¹
- 20) 2-Furanmethanol (furfuryl alcohol)
- 21) 4-Cyclopentene-1,3-dione
- 22) Xylene/ethyl benzene isomers
- 23) 2-Acetylfuran³
- 24) Methyleneethyl benzene
- 25) Phenol
- 25A) 1-Methyl-2-pyrrolidinone
- 26) Aliphatic aldehydes, C₇-C₁₀¹
- 27) Limonene
- 28) 2,2'-methylenebisfuran³
- 29) Methyl benzoate
- 30) Aliphatic hydrocarbons
- 31) Methyl methylbenzoate
- 32) 2,2' [oxybis(methylene)]bisfuran³
- 33) 4-Formyl methyl benzoate
- 34) Dimethylphthalate⁴
- 35) Diethylphthalate⁴
- 36) Propanoic acid alkyl ester⁴
- 37) Isopropyl myristate⁴

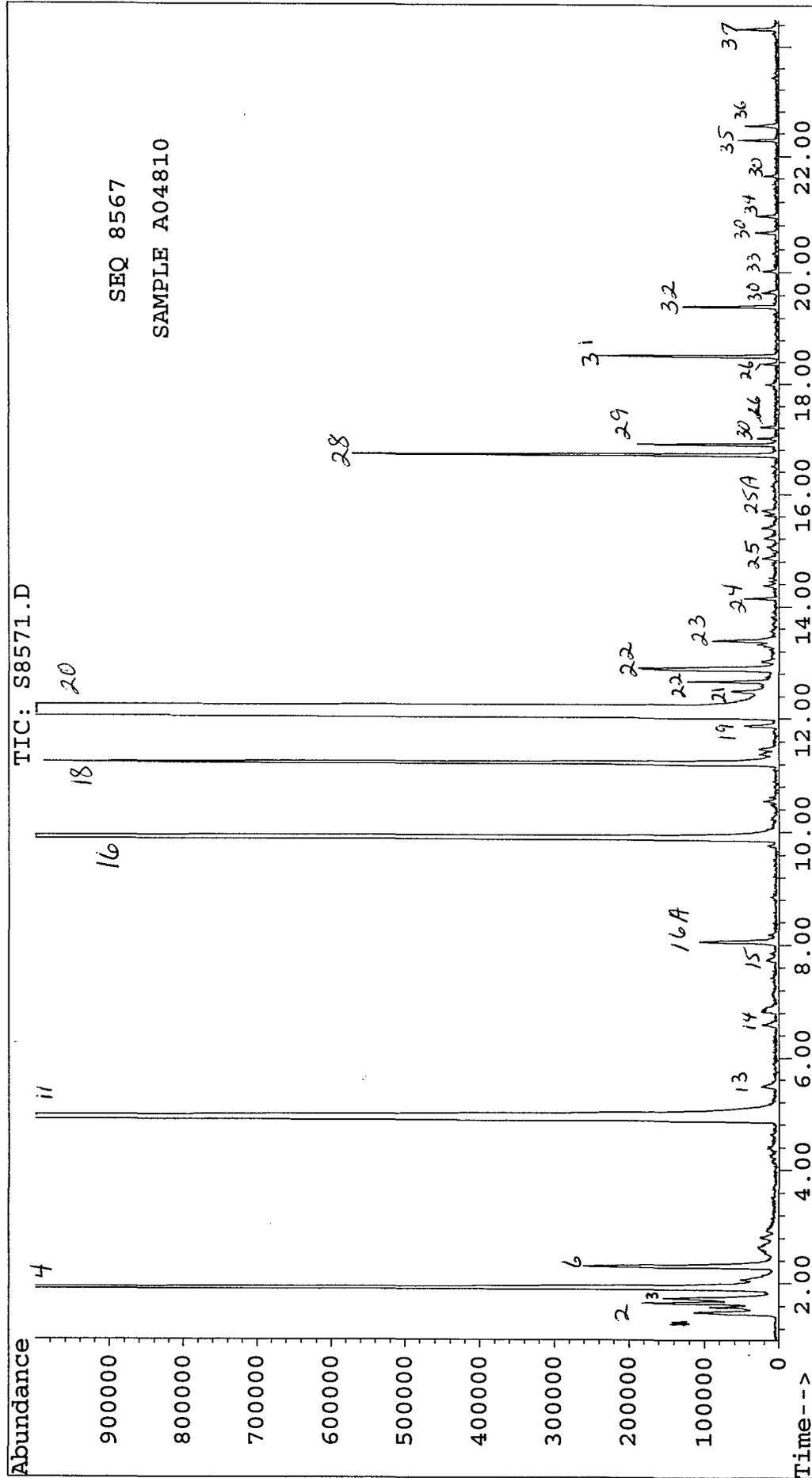
¹Also present on some field and/or media blanks.

²Formaldehyde may be present as an impurity and/or decomposition product in methanol.

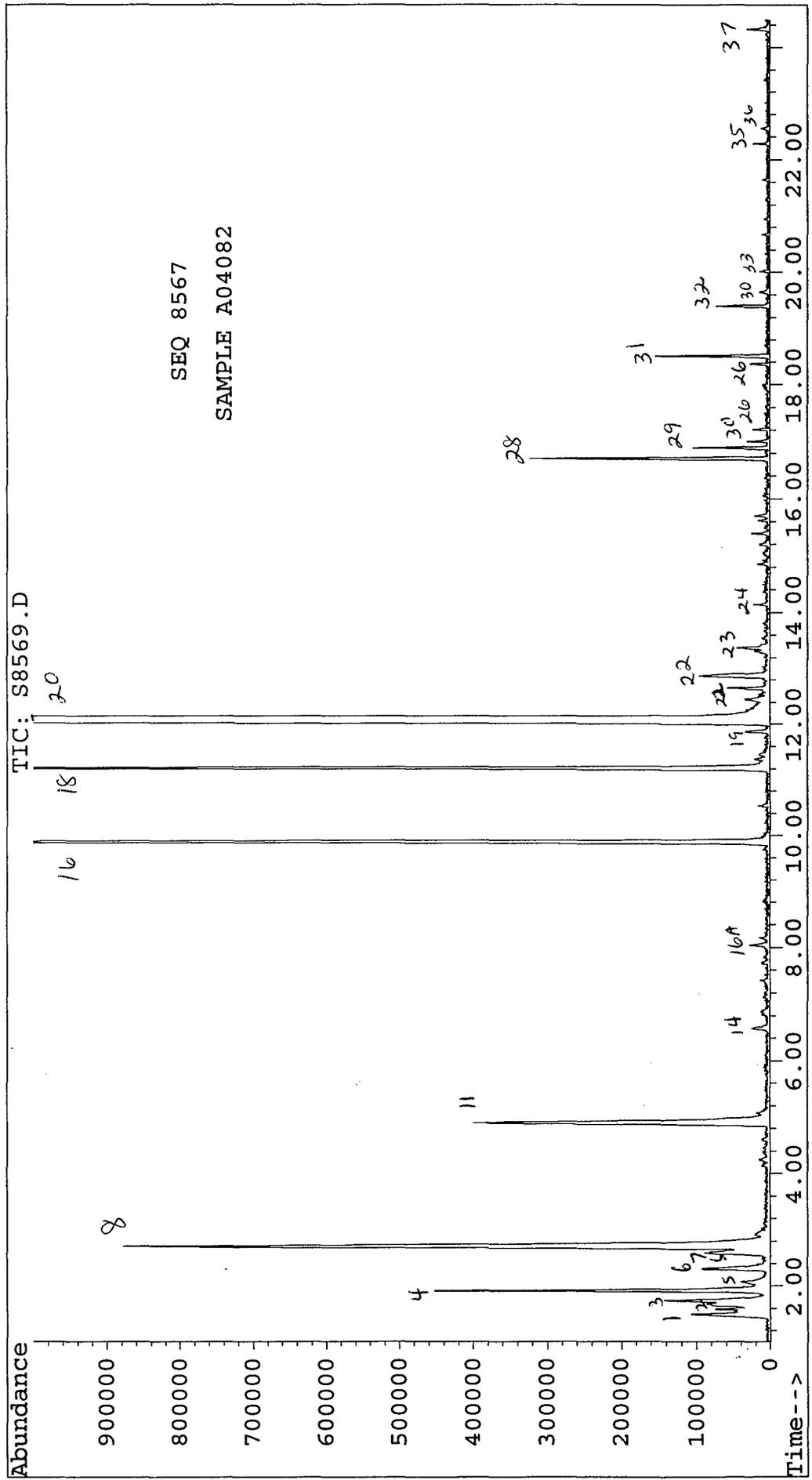
³Furfural and various furan compounds may be impurities and/or decomposition products from the furfuryl alcohol.

⁴Sometimes present as a system contaminant.

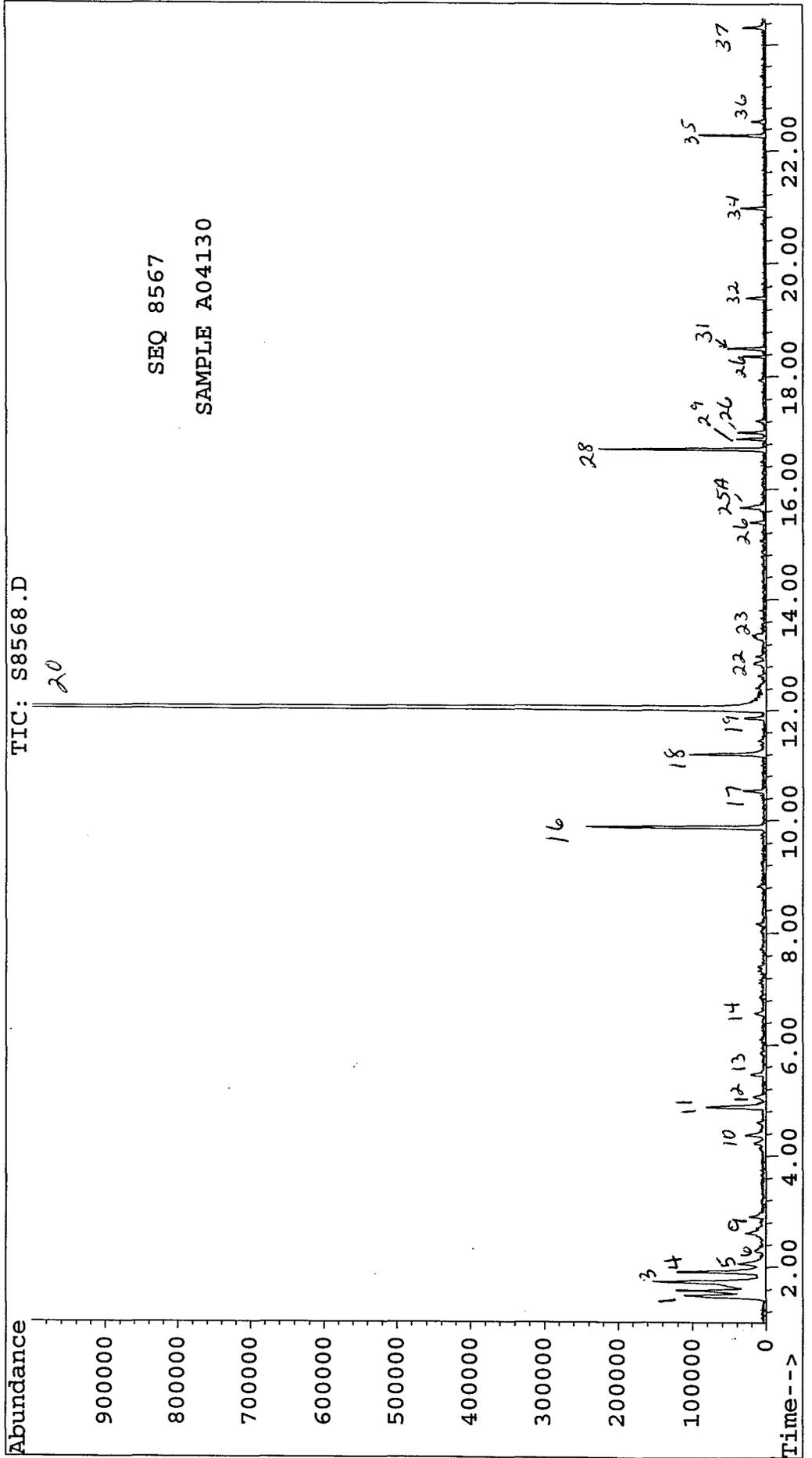
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Operator : AAG
Acquired : 25 Nov 96 12:50 pm using AcqMethod ATD
Instrument : 5970 - In
Sample Name: SAMPLE A04810 PURGED
Misc Info : 30 M DB-1 SC20-300 TP35-300
Vial Number: 5



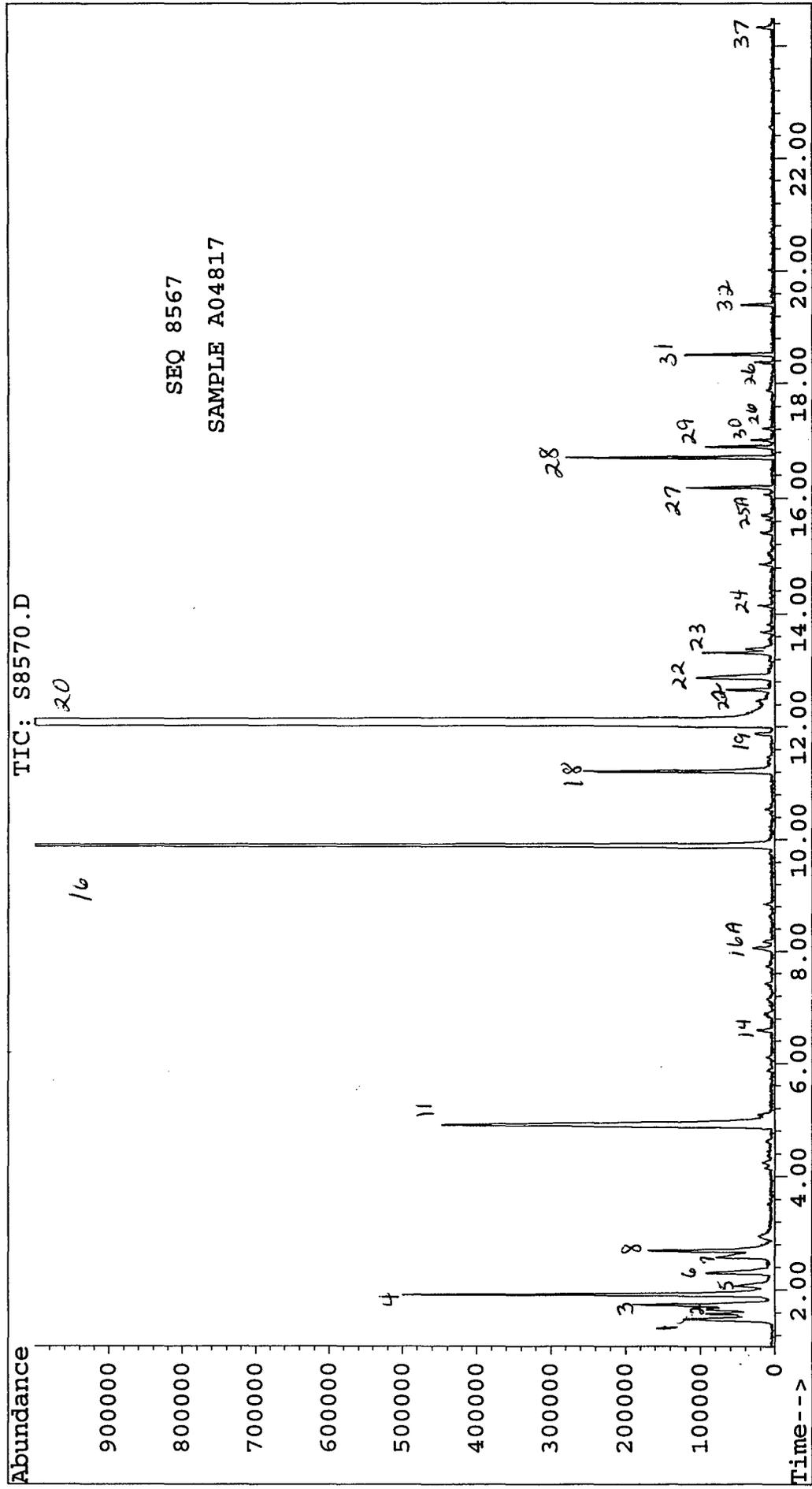
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 Acquired : 25 Nov 96 11:13 am using AcqMethod ATD
 Instrument : 5970 - In
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 Misc Info : 30 M DB-1 SC20-300 TP35-300
 Vial Number: 3



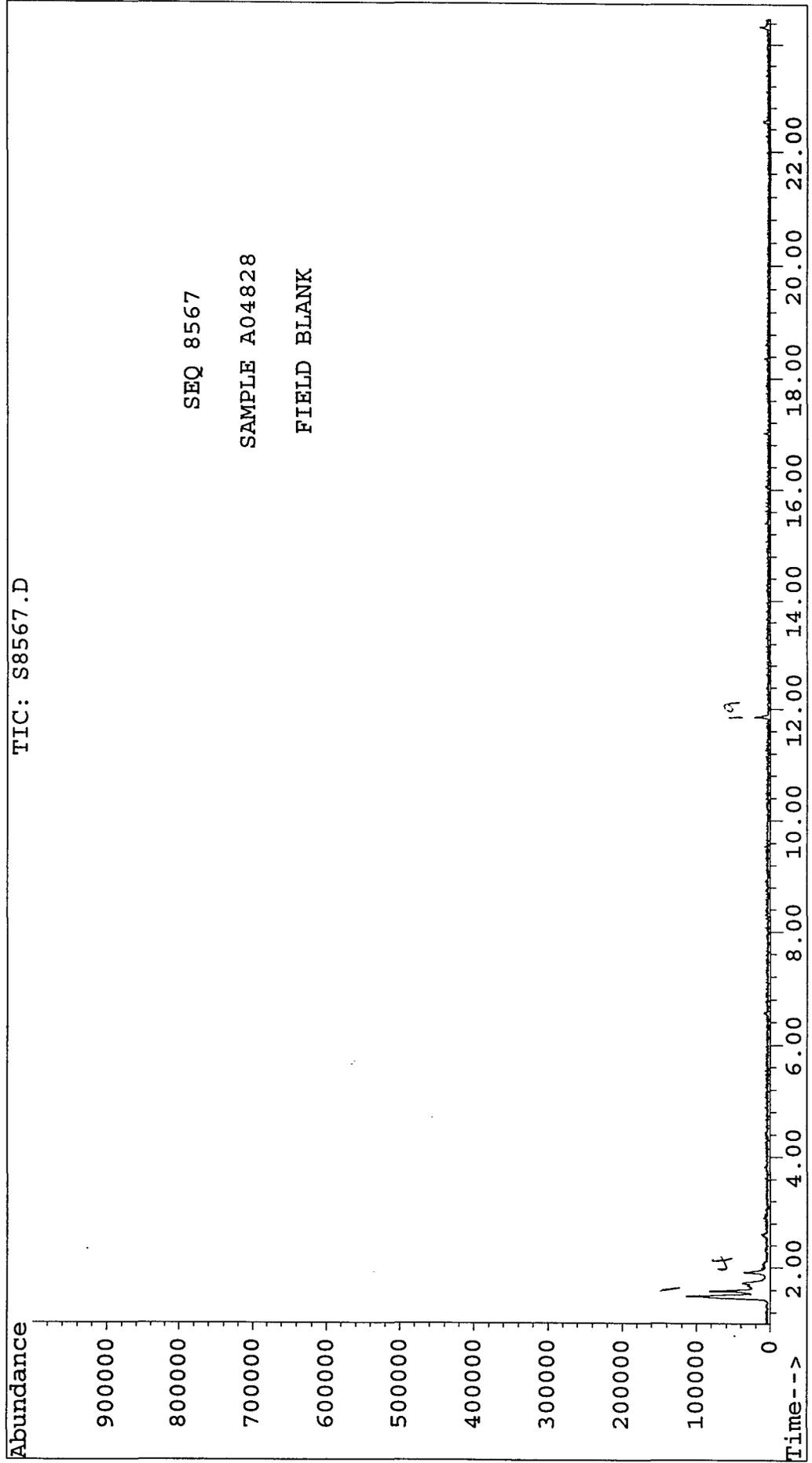
File : C:\HPCHEM\1\DATA\S8567\S8568.D
Operator : AAG
Acquired : 25 Nov 96 10:24 am using AcqMethod ATD
Instrument : 5970 - In
Sample Name: SAMPLE A04130 PURGED
Misc Info : 30 M DB-1 SC20-300 TP35-300
Vial Number: 2



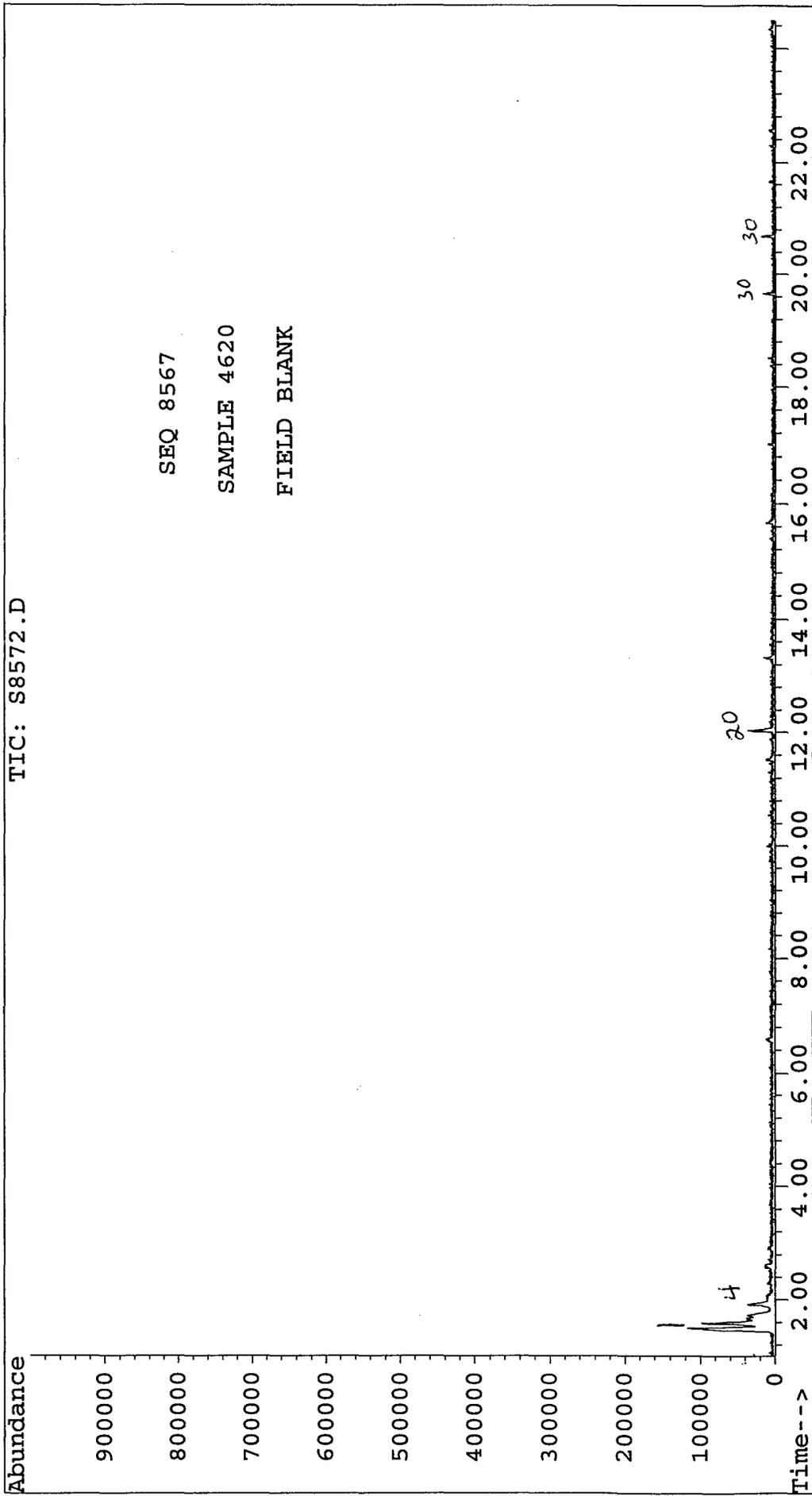
File : C:\HPCHEM\1\DATA\S8567\S8570.D
Operator : AAG
Acquired : 25 Nov 96 12:01 pm using AcqMethod ATD
Instrument : 5970 - In
Sample Name: SAMPLE A04817 PURGED
Misc Info : 30 M DB-1 SC20-300 TP35-300
Vial Number: 4



File : C:\HPCHEM\1\DATA\S8567\S8567.D
Operator : AAG
Acquired : 25 Nov 96 9:35 am using AcqMethod ATD
Instrument : 5970 - In
Sample Name: SAMPLE A04828 FIELD BLANK PURGED
Misc Info : 30 M DB-1 SC20-300 TP35-300
Vial Number: 1



File : C:\HPCHEM\1\DATA\S8567\S8572.D
Operator : AAG
Acquired : 25 Nov 96 1:39 pm using AcqMethod ATD
Instrument : 5970 - In
Sample Name: SAMPLE A04620 FIELD BLANK PURGED
Misc Info : 30 M DB-1 SC20-300 TP35-300
Vial Number: 6





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