NIOSH HEALTH HAZARD EVALUATION REPORT:

HETA #2000–0124–2875
Tenneco Automotive
Milan, Ohio

June 2002

DEPARTMENT OF HEALTH AND HUMAN SERVICES
Centers for Disease Control and Prevention
National Institute for Occupational Safety and Health

PREFACE

The Hazard Evaluations and Technical Assistance Branch (HETAB) of the National Institute for Occupational Safety and Health (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 (OSHA) 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.

HETAB 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 NIOSH.

ACKNOWLEDGMENTS AND AVAILABILITY OF REPORT

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Highlights of the NIOSH Health Hazard Evaluation

Evaluation of Nitrosamines in Rubber Mixing and Curing Processes in an Automobile Parts Manufacturing Facility

On January 21, 2000, the National Institute for Occupational Safety and Health (NIOSH) received a request for a health hazard evaluation (HHE) at the Tenneco Automotive (TA) facility in Milan, Ohio, by an authorized representative of the United Auto Workers Union (Local 2352). The request expressed concern about inadequate ventilation and possible nitrosamine generation from the rubber mixing and curing processes in the facility. Development of cancer among employees due to occupational exposure to nitrosamines was the foremost health concern of the HHE requestor.

What NIOSH Did

- We collected air samples for nitrosamines, total dust, respirable dust, total hydrocarbons, and volatile organic compounds.
- We talked to employees about their jobs, the facility, and health problems they feel may be associated with working at TA.
- We looked at the various ventilation systems in the facility.
- We observed employees and their jobs in all areas of the facility.

What NIOSH Found

- No nitrosamines were found in any of the air samples collected.
- Low concentrations were found of total dust, respirable dust, and total hydrocarbons in the air samples collected.
- Not enough supply air was coming into the facility.
- NIOSH did not receive requested medical records after repeated attempts to obtain them. Therefore no assessment of health conditions could be conducted.

What Tenneco Automotive Managers Can Do

- Add more supply air into the facility.
- Make sure the ventilation systems are balanced and are not turned off/on by unqualified persons.
- Improve communication between management, union, and employees. The union and employees should be made aware of the problems within the building and decisions made by management to address those problems.

What the Tenneco Automotive Employees Can Do

- Keep supply ventilation on in the facility.
- Press Room employees should stand clear of the presses when they are opened.
- Make sure appropriate housekeeping and employee hygiene practices are performed in the facility.

CDC Workplace Safety and Health

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HETA Report #2000-0124-2875

National Institute for Occupational Safety and Health NIOSH

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SUMMARY

On January 21, 2000, the National Institute for Occupational Safety and Health (NIOSH) received a request for a health hazard evaluation (HHE) at the Tenneco Automotive (TA) facility in Milan, Ohio, by an authorized representative of the United Auto Workers Union (Local 2352). The request expressed concern about inadequate ventilation and possible nitrosamine generation from the rubber mixing and curing processes in the facility. The request indicated a variety of health symptoms experienced by TA employees including respiratory and sinus infections, nose bleeds, and loss of voice, as well as a cancer concern in relation to nitrosamine exposure. However, discussions with the requestor revealed that cancer in relation to nitrosamine exposure was the primary health concern. In response to this request, NIOSH investigators conducted an initial site visit on May 10, 2000, and a follow–up investigation on April 5, 2001.

On May 10, 2000, NIOSH investigators collected eight general area (GA) air samples for volatile organic compounds (VOCs). Based upon the initial findings, the NIOSH investigators determined that a follow–up visit was necessary to better characterize workers' exposures to nitrosamines as well as total and respirable particulates and total hydrocarbons. On April 5, 2001, NIOSH investigators collected a total of 32 personal breathing zone (PBZ) and 7 GA air samples for nitrosamines, 1 PBZ and 13 GA air samples for total particulate, 1 PBZ and 13 GA air samples for respirable particulate, 26 GA air samples for total hydrocarbons, and 8 GA air samples for VOCs during the first shift. Nitrosamine air samples were analyzed for N–nitrosodimethylamine (NDMA), N–nitrosodiethylamine (NDEA), N–nitrosodipropylamine (NDPA), N–nitrosodibutylamine (NDBA), N–nitrosopiperidine (NPIP), N–nitrosopyrrolidine (NPYR), and N–nitrosomorpholine (NMOR).

During the initial and follow–up surveys, the VOC air samples found over 100 different components with o–chlorotoluene and diphenylamine as typically the strongest peaks identified. None of the seven individual nitrosamines analyzed for were detected in the air samples. All air samples collected for total particulate, respirable particulate, and total hydrocarbons were below relevant evaluation criteria.

During the course of this evaluation, NIOSH never received any information from identified management or labor representatives concerning health problems (specifically, cancer,) among current or former employees of TA. In the absence of this information, no evaluation of the occupational cancer risks among TA employees could be made.

Based on the lack of information provided to them, NIOSH investigators are unable to conclude that a health hazard related to nitrosamine exposure existed at the Tenneco Automotive facility. However, at the time this investigation was conducted, air concentrations of nitrosamines and other compounds were all below relevant evaluation criteria. The ventilation survey and observation of work practices conducted by NIOSH did result in suggested improvements in this facility. These suggestions are presented in the Recommendations section of this report.

Keywords: 3069 (Fabricated Rubber Products [Not Elsewhere Classified]), rubber, injection–molding, press operator, mixing crew, nitrosamines, total particulate, respirable particulate, hydrocarbons, respiratory infection, sinus infection, nose bleeds, loss of voice, cancer

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INTRODUCTION

On January 21, 2000, the National Institute for Occupational Safety and Health (NIOSH) received a request for a health hazard evaluation (HHE) at the Tenneco Automotive (TA) facility in Milan, Ohio, by an authorized representative of the United Auto Workers Union (Local 2352). The request expressed concern about inadequate ventilation and possible nitrosamine generation from the rubber mixing and curing processes in the facility. The request indicated a variety of health symptoms experienced by TA employees including respiratory and sinus infections, nose bleeds, and loss of voice, as well as a cancer concern in relation to nitrosamine exposure. However, discussions with the requestor revealed that cancer in relation to nitrosamine exposure was the primary health concern. In response to this request, NIOSH investigators conducted an initial site visit on May 10, 2000, and a follow–up investigation on April 5, 2001.

On May 10, 2000, the initial site visit began with an opening conference and facility tour. The initial environmental evaluation consisted of general area (GA) air sampling for volatile organic compounds (VOCs) during the first shift, to evaluate potential environmental contaminants. On October 17, 2000, the NIOSH medical officer held a meeting with TA management, union, and corporate legal representatives to discuss the importance of collecting information concerning the types of exposures encountered by TA employees and any reported health effects. On April 5, 2001, NIOSH investigators conducted a follow–up investigation which consisted of personal breathing zone (PBZ) and GA air sampling for nitrosamines, total and respirable particulates, total hydrocarbons, and VOCs during the first shift.

BACKGROUND

The original Milan, Ohio, plant was built in 1946 and was 4800 square feet (ft^2) in size. Between 1949 and 1977, several additions expanded the plant to a total of 231,500 ft^2, approximately 11 acres. This facility produces free rubber molded parts, rubber to metal mold bonded bushings, Teflon® lined mold bonded bushings, and rubber compounds. Various rubber compounds are used, including styrene–butadiene, neoprene, bromobutyl, natural, and natural synthetic (same properties as natural rubber, but man–made), but 97% of the rubber used is natural rubber (standard Indonesian rubber [SIR]).

The Milan plant consists of three lines of natural and synthetic compounding and mixing, 19 injection–molding presses, 66 transfer–molding presses, and two lines of adhesive application. There are approximately 100 different formulations of rubber routinely used. The plant also has 200–300 non–routine, past or present molds that can be used. The finishing operations include swages for a variety of parts, buffers for removing flash from parts, manual cutters and slitters for bar mold parts, hoppers for inspection of parts not meeting quality standards, a liquid nitrogen tumbler to deflash rubber parts, and washer lines to rinse/wash/rinse/dry rubber parts.

The plant currently has 50 salaried employees which include 12 engineers, 8 production supervisors, 3 production control personnel, and 2 skilled trades supervisors. There are 276 hourly employees who are represented by the United Auto Workers Union (UAW) Local 2352. The hourly employees average approximately 46 years in age with an average seniority of approximately 15 years.

METHODS

Initial Site Visit

Environmental

On May 10, 2000, the initial site–visit began with an opening conference and facility tour. The initial environmental evaluation consisted of GA air sampling for VOCs during the first shift to evaluate potential environmental contaminants.

Volatile Organic Compounds

Eight GA air samples for VOCs were collected and qualitatively analyzed in accordance with NIOSH Method 2549.[1] Sample collection was performed through stainless steel thermal desorption tubes containing three beds of sorbent material (1st section contains Carbopack Y, 2nd section contains Carbopack B, and 3rd section contains Carboxen 1003) at a nominal airflow rate of 0.05 liters per minute (lpm). The tubes were conditioned by heating at 375°C for 2 hours. The tubes were then dry purged with helium for 30 minutes at 100 cubic centimeters per minute (cc/min) to remove water. After the samples were prepared for analysis, they were desorbed in a Perkin–Elmer ATD 400 automatic thermal desorption system at 300°C for 10 minutes. A 30 meter DB–1 fused silica capillary column was used for the analyses.

Follow–up Site Visit

Based upon the initial findings (VOCs present and areas perceived to be of interest to conduct sampling in the work environment), the NIOSH investigators determined that a follow–up visit was essential to better characterize worker exposures to various areas of the facility. The NIOSH investigators decided to focus attention on exposures to nitrosamines, total and respirable particulate, and total hydrocarbons.

Environmental

Volatile Organic Compounds

Eight GA air samples for VOCs were collected in the Press room, Injection–molding, and Cold–feed extrusion areas. VOCs were collected through stainless steel thermal desorption tubes containing three beds of sorbent material (1st section contains Carbopack Y, 2nd section contains Carbopack B, and 3rd section contains Carboxen 1003) at a nominal airflow rate of 0.05 lpm, and qualitatively analyzed with a Perkin–Elmer™ ATD 400 automatic thermal desorption system in accordance with NIOSH Method 2549.[1]

Nitrosamines

Thirty–nine PBZ and GA air samples were collected throughout the Press, Injection–molding, Cold–feed extrusion, Mixer, and Mill areas during first shift. Nitrosamines were collected on Thermosorb™/N air samplers at a calibrated flow rate of 1.0 lpm in accordance with a modified version of NIOSH Method 2522 in which high resolution mass spectrometry was employed as an analytical finish rather than a thermal energy analyzer.[1] The samples were analyzed for the following nitrosamines: N–nitrosodimethylamine (NDMA), N–nitrosodiethylamine (NDEA), N–nitrosodipropylamine (NDPA), N–nitrosodibutylamine (NDBA), N–nitrosopiperidine (NPIP), N–nitrosopyrrolidine (NPYR), and N–nitrosomorpholine (NMOR). Table 3 presents the analytical limits of detection (LOD), the minimum detectable concentrations (MDC), the limits of quantitation (LOQ), and the minimum quantifiable concentrations (MQC). The MDCs and MQCs assume a sample volume of 500 liters.

Total Particulate

Fourteen GA air samples were collected for total particulate in the Press room and mixing areas. Total particulate air samples were collected on a tared 37–millimeter (mm) diameter, 5–µm poly vinyl chloride (PVC) filter, at a calibrated flow rate of 2.0 lpm. The filter was gravimetrically analyzed in accordance with NIOSH Method 0500[1] with modifications. The analytical LOD for the total particulate filters was 0.02 milligrams (mg), which is equivalent to a MDC of 0.02 milligrams per cubic meter of air (mg/m^3), assuming a sample volume of 1000 liters.

Respirable Particulate

Fourteen GA air samples were collected for respirable particulate in the Press room and mixing areas. Respirable particulate air samples were collected with tared 37–mm diameter, 5–µm PVC filters in line with a 10–mm cyclone at a calibrated flow rate of 1.7 lpm. The filters were gravimetrically analyzed in accordance with NIOSH Method 0600[1] with modifications. The analytical LOD for the respirable particulate filters was 0.02 mg, which is equivalent to a MDC of 0.02 mg/m^3, assuming a sample volume of 1000 liters.

Total Hydrocarbons

Twenty–six GA air samples were collected for total hydrocarbons in the Press room, Injection–molding, and Cold–feed extrusions areas. Total hydrocarbons were collected on a solid sorbent tube containing coconut shell charcoal (100 mg/50 mg), at a calibrated flow rate of 0.05 lpm, and analyzed by gas chromatography in accordance with NIOSH Method 1550.[1] "Total hydrocarbons" is the sum of all peaks in the chromatogram minus the solvent peak. "Total hydrocarbons" was quantitated against an n–decane standard. The analytical LOD was 0.002 mg/sample, which is equivalent to a MDC of 0.08 mg/m^3, assuming a sample volume of 25 liters. The LOQ was 0.007 mg/sample, which is equivalent to a MQC of 0.28 mg/m^3, assuming a sample volume of 25 liters.

Temperature and Relative Humidity

Temperature and relative humidity (RH) measurements were collected in the Press room, Injection–molding area, 1st floor mixing area, 2nd floor at Banbury #1, 2nd floor K–7, 3rd floor mixing, and outside. Temperature and RH measurements were made using a Velocicalc® Plus Model 8360 Air Velocity Meter (TSI Incorporated, Saint Paul, Minnesota). This portable, battery–operated instrument monitors temperature at a range from 14°F to 140°F and RH at a range of 20% to 95%.

Facility Ventilation Assessment

Ventilation blueprints of all floors were reviewed during the survey. Any changes to these blueprints were noted. Subsequently, a visual inspection of the various ventilation systems in the facility was conducted.

Other Activities

Informal discussions with employees were conducted during the evaluation. Employees were encouraged to share their opinions about topics such as the condition of the TA facility, the ventilation systems in various areas of the facility, and any health problems that may be attributable to the building's air quality or to specific activities performed in the facility.

Medical

In August 2000, a NIOSH medical officer spoke by telephone with the HHE requestor. During that conversation, occupational cancer was identified as the primary health concern that initiated submission of the HHE. At that time, a request was made by the NIOSH medical officer for a list of the names and job descriptions of all TA workers diagnosed with cancer. Subsequently, the medical officer held telephone conversations with the plant Environmental Health and Safety Engineer and the Corporate Director of Environmental Health and Safety requesting similar information.

On October 17, 2000, a meeting was held at TA in Milan, Ohio. In attendance at the meeting was the NIOSH medical officer, the HHE requestor (and other members of the union leadership), plant managers and engineers, Corporate Director of Environmental Health and Safety, and Corporate Legal Counsel. At the meeting, the NIOSH medical officer explained the importance of collecting information concerning the types of exposures encountered by TA employees and any reported health effects. It was explained that this information was necessary to determine whether the reported health effects were due to workplace exposures or conditions.

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 increases 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),[2] (2) the American Conference of Governmental Industrial Hygienists' (ACGIH®) Threshold Limit Values (TLVs®),[3] and (3) the U.S. Department of Labor, Occupational Safety and Health Administration (OSHA) Permissible Exposure Limits (PELs).[4] Employers are encouraged to follow the OSHA limits, the NIOSH RELs, the ACGIH TLVs, or whichever are the more protective criterion.

OSHA requires an employer to furnish employees a place of employment that is free from recognized hazards that are causing or are likely to cause death or serious physical harm [Occupational Safety and Health Act of 1970, Public Law 91–596, sec. 5(a)(1)]. Thus, employers should understand that not all hazardous chemicals have specific OSHA exposure limits such as PELs and short–term exposure limits (STELs). An employer is still required by OSHA to protect their employees from hazards, even in the absence of a specific OSHA PEL.

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

Nitrosamines

Nitrosamines are compounds characterized by the –N–N=O functional group. They result from the combination of primary, secondary, or tertiary amines with nitrite. These reactions can occur in the laboratory; in various food, household, or industrial products; in industrial processes; and in vivo. Because of the variety of amines and reaction conditions possible, there are hundreds of nitrosamines; and because of the large number of exposure sources, including formation in vivo, there is a complicated matrix of total nitrosamine exposure. Occupational exogenous exposures have been observed in rubber industries, leather tanning industries, metal working industries, chemical industries, mining, pesticide production, detergent production, and fish factories.

Most nitrosamines are suspected to be human carcinogens, but direct causal associations have not yet been proven. Cancer is believed to be a multistage process, beginning with (1) *exposure* to a carcinogen or procarcinogen and followed by (2) *initiation* of a cell to a genetically altered cell by damage to the DNA; (3) *promotion* of the altered cell to a preneoplastic lesion; (4) *conversion* of the preneoplastic lesion to a malignant tumor through a genetic change; and finally (5) *progression* of the tumor to clinical cancer. Exposure to a carcinogen must result in a genetic change in order to cause cellular initiation; likewise, there must also be a genetic change for a preneoplastic lesion to convert into a malignant tumor.[5] These genetic changes can occur by spontaneous mutation, and they can also occur by DNA adduct formation from exposure to carcinogens that are initiators or promoters, or both.

These genetic changes must occur in certain chromosomal locations in order to cause the next step in carcinogenicity. Mutations in some of these chromosomal locations have been identified, such as activation of proto–oncogenes or inactivation of tumor suppressor genes, but these and other processes are still being researched.[5]

There are many factors that prevent every exposure to a carcinogen from resulting in clinical cancer. Genetic predisposition (inheritance of certain genetic mutations, variations in activity of metabolizing enzymes and DNA repair enzymes, variations in immunity and immune cell enzymes) plays an important role in the development or lack of development of cancers. Variations in lifestyle and overall health may also play a part as these factors influence immune function and intracellular repair processes.

Exogenous or endogenous nitrosamines are hypothesized to cause cancer by being metabolized into reactive intermediates that then covalently bind to macromolecules, including DNA. If the adducts to the DNA result in a genetic mutation during the replication process, and if that mutation occurs in certain areas of the genome, the cell can undergo the second and third stages of carcinogenesis (initiation and promotion). If a second genetic mutation occurs in the right place, conversion to a malignant tumor can result.

Although a causal association between nitrosamine exposure and human cancer has not yet been firmly established, there is circumstantial evidence that nitrosamines cause cancer in humans. In 1956, Magee and Barnes demonstrated the carcinogenic potential of NDMA in rats.[6] Since then, nitrosamines have been studied extensively in laboratory animals. Approximately 90% of the 300 tested nitrosamines have shown carcinogenic effects in bioassays and laboratory animals. Animals that have been studied include mammals, birds, fish, and amphibia. Of the approximately 40 animal species tested, none has been resistant. The tumor sites depend on the specific nitrosamine, the species tested, and the route of administration. Nitrosamine effects have been demonstrated in the bladder, bronchi, central nervous system, earduct, esophagus, eyelid, duodenum, forestomach, glandular stomach, hematopoietic system, intestine, jaw, kidney, larynx, nasal cavity, oral cavity, ovary, liver, mammary glands, pancreas, pelvis, peripheral nervous system, pharynx, respiratory tract, skin, testes, trachea, uterus, and vagina.[7] Dose–response studies with rats have shown "no effect levels" corresponding to dietary concentrations of 1 part per million (ppm) NDMA, 1 ppm NDEA, and 1 ppm NPYR.[7] These N–nitrosamines and others appear to be very potent carcinogens.

The biochemical, pathological, and experimental data provides little evidence that humans might be resistant to the carcinogenic potential of nitrosamines.[8] Human tissues from the trachea, bronchus (lung), esophagus, colon, pancreatic duct, bladder, and buccal mucosa have been shown to metabolize nitrosamines into DNA–binding compounds.[8] Human liver tissue appears to metabolize nitrosamines with a similar activity as rodent liver tissue, and rodents have similar acute symptoms of liver necrosis and cirrhosis that have been observed in humans exposed to nitrosamines.[8] A few human DNA adduct studies have revealed higher levels of nitrosamine–related DNA adducts in cancer cases than in controls.[9,10] Studies in experimental animals have shown similar DNA adduct formation to those detected in the human studies.[11,12,13]

Only one nitrosamine, NDMA, is regulated in the United States. Both OSHA and NIOSH classify NDMA as an occupational carcinogen, recommending that its exposure be reduced to the lowest feasible concentration. There are no established numerical exposure limits in this country.

Germany has strict regulations for occupational exposures to nitrosamines. In general industry, the total exposure to all nitrosamines present may not exceed 1 $\mu g/m^3$. In special cases, such as the tire storage warehouses, exposures to all nitrosamines present may not exceed 2.5 $\mu g/m^3$. In addition to these regulations, eight nitrosamines are regulated individually: NDMA, NMOR, NPIP, phenyl–ethylnitrosamine, phenyl–methylnitrosamine, NDBA, di–iso–propylnitrosamine, and NDEA.

Total Hydrocarbons

Total hydrocarbon results cannot be compared to any relevant evaluation criteria because none exist. However, OSHA, NIOSH, and ACGIH have evaluation criteria for Stoddard solvent (a refined petroleum solvent). The 8–hour TWAs for Stoddard solvent are as follows: the OSHA PEL is 2900 mg/m^3, the NIOSH REL is 350 mg/m^3 with a 15–minute ceiling of 1800 mg/m^3, and the ACGIH TLV is 525 mg/m^3.

RESULTS

Initial Site Visit

Environmental

Volatile Organic Compounds

Eight thermal tube area air samples were collected. One thermal tube was placed in each of the following areas: Press #421, Press #511, Banbury #2 (above mill), K–7 (by pelletizer), Injection–molding machine #605, Injection–molding machine #699, Press #126, and Press #111. In addition to the eight area air samples, another thermal tube was collected and used to assess the possible interference from water, and two thermal tubes were used as a field blanks. Table 1 indicates the major peaks and their associated collection area. Appendix A gives the peak number and its associated compound as well as the chromatograms for each sample collected. Compounds present varied among samples. Several amines and other nitrogen compounds such as isothiocyanates and amides were identified. Several samples contained o–chlorotoluene and diphenylamine as the larger components. Over 100 individual components were detected. Other compounds present in some samples included t–butyl amine, methyl isoamyl ketone (MIAK), ethylene glycol, methyl isobutyl ketone (MIBK), various C_9–C_{15} branched alkanes, toluene, methyl ethyl ketone (MEK), butyl cellosolve, limonene, carbon disulfide, morpholine, cyclohexylamine, cyclohexanone, benzothiazole, perchloroethylene, phthalamide, and nonyl phenol isomers.

Follow–up Site Visit

Environmental

Area 8–hour TWA results are based on the compiled exposure results in that specific area for the entire task period and are intended to be representations of potential exposure.

Volatile Organic Compounds

Eight thermal tube area air samples were collected. One thermal tube was placed in each of the following areas: outside at the front of the building; cold–feed operator's station; Press #111; near Press #451; Banbury #1 mezzanine; and Injection–molding machines 699, 692, and 694. In addition to the eight area air samples, another thermal tube was collected and used to assess the possible interference from water, and one thermal tube was used as a field blank. Table 2 indicates the major peaks and their associated collection area. Appendix B gives the peak number and its associated compound as well as the chromatograms for each sample collected. Compounds present varied among samples. Several amines and other nitrogen compounds such as isothiocyanates and amides were identified. Over 100 individual components were detected. Major compounds detected on some samples were diphenylamine, chlorotoluene, benzothiozole, toluene, morpholine, phthalic anhydride, limonene, xylene, and C_9H_{12} alkyl benzenes. Other compounds present in some samples included t–butyl amine, carbon disulfide, MIAK, MIBK, MEK, butyl cellosolve, cyclohexylamine, cyclohexanone, perchloroethylene, phthalimide, and various nitrogen containing compounds such as alkyl amines. One sample (near Press #451) indicated the presence of nitrosomorpholine.

Nitrosamines

None of the air samples collected during the day shift on April 5, 2001, contained detectable concentrations of the seven individual nitrosamines analyzed for. All air samples were collected as close to a full 8–hour shift as possible. The GA and PBZ air sample locations for nitrosamines are presented in Table 4.

Total Particulate

The GA and PBZ air sampling results for total particulate collected during the day shift on April 5, 2001, are presented in Table 5. The total particulate concentrations ranged from 0.04 mg/m^3 to 1.71 mg/m^3. The highest total particulate concentration (1.71 mg/m^3) was collected as a PBZ sample on the Compounder in the Mixing area. The sampling results indicated that there were no 8–hour TWA concentrations exceeding the ACGIH TLV or the OSHA PEL.

Respirable Particulate

The GA and PBZ air sampling results for respirable particulate collected during the day shift on April 5, 2001, are presented in Table 6. The respirable particulate concentrations ranged from a non–detectable concentration to 0.36 mg/m^3. The highest respirable particulate concentration (0.36 mg/m^3) was collected in the GA of the injection–molding machine #694. The sampling results indicated that there were no 8–hour TWA concentrations exceeding the ACGIH TLV or the OSHA PEL.

Total Hydrocarbons

Hydrocarbons were detected in the initial site–visit thermal tube air samples and were sampled and analyzed for in the follow–up site visit to quantitatively determine the concentration in various areas of the Milan plant. The GA air sampling results for total hydrocarbons collected during the day shift on April 5, 2001, are presented in Tables 7 and 8. The total hydrocarbon concentrations ranged from non–detectable concentrations to 3.14 mg/m^3. The highest total hydrocarbon concentration (3.14 mg/m^3) was collected in the GA of the Pelletizer. Total hydrocarbons does not have any relevant occupational exposure evaluation criteria. However, the levels found are much lower than relevant Stoddard solvent evaluation criteria.

Temperature and Relative Humidity

Temperature and RH levels were measured three times during the work day (once in the morning and twice in the afternoon) in locations previously discussed and are presented in Table 9. Temperature and RH levels inside the facility ranged from 65.8°F to 77.5°F, and 18.2% to 26.3%, respectively. The temperature and RH levels measured outside the building ranged from 50.5°F to 63.6°F, and 22.3% to 26.5%, respectively.

Facility Ventilation Assessment

Various ventilation systems were in place in the facility, including ceiling exhaust fans, stand–up fans, and local exhaust ventilation (LEV). Some of these systems were not in operation at the time of the site–visit. The compounder in the mixing department has a movable exterior slot hood which slides along the additive bin. When the larger access door is open, the slot hood is not in the correct position for maximum ventilation. The bag in which the additives are placed does not have any LEV in place.

Other Activities

Informal discussion with employees revealed a concern about the lack of supply air in the facility. Employees also described health symptoms consistent with those outlined in the HHE request.

Medical

Despite repeated requests and the on–site meeting with union and management representatives, no information about health problems among employees at this facility was ever received by NIOSH. Additional follow–up telephone calls to union and management representatives requesting assistance in identifying current or former workers diagnosed with cancer were equally unsuccessful. Neither union nor management provided any information concerning the health effects that current or former employees may have experienced. Therefore, medical assessment looking at possible associations with work exposures and health effects could not be performed, and the primary health concern initially identified during this HHE (i.e., occupational cancer) was not evaluated. Without any documentation that health problems actually existed among workers, it was determined that further medical evaluation by NIOSH would not be helpful.

DISCUSSION

Although the thermal tube results indicated the presence of amine compounds (morpholine, diphenylamine, others) and one sample with a small NMOR peak, no volatile nitrosamines were detected on the GA and PBZ air samples collected during the follow–up visit.

The total and respirable particulate and total hydrocarbon concentrations were low and suggest limited potential for overexposure. However, GA air samples do not give a true representation of personal exposures, merely an indication of potential exposures. The highest total and respirable particulate concentrations were on the Compounder in the Mixing area, which would be expected since this area involves the mixing of dry ingredients for a specific formulation.

In advance of the NIOSH sampling period, doors in the Press room were opened to the outside during third shift, which according to employees was not typical for that area. It is plausible that the incoming fresh air may have affected the concentrations of compounds sampled in that area. However, the concentrations found were so low that it is unlikely that they would have exceeded relevant evaluation criteria had the doors been closed. Press room employees were observed to be in direct proximity to press fumes when presses were opened. PBZ air samples did not show any overexposures, however employees should stand clear of the fume cloud when presses are first opened.

The TA facility relies heavily on dilution ventilation for control of contaminants that may be released during the production process. The ventilation survey indicated that the facility is under considerable negative pressure mostly due to ceiling exhaust fans located throughout the building. This considerable negative pressure can reduce the overall efficiency of the system and also result in system stress due to increased static pressures induced on the fans.

CONCLUSIONS

The results from the PBZ and GA air samples collected for nitrosamines did not indicate their presence in the facility. Although, the PBZ and GA air samples collected for total particulate, respirable particulate, and hydrocarbons did result in detectable concentrations in some facility areas, all air sample concentrations for these compounds were below relevant evaluation criteria.

Although this request was prompted by a perceived increase of cancer cases among TA employees, an analysis of an association between occupational exposures and disease was hampered by a lack of available medical information. Neither union nor management provided any information concerning the health effects that current or former employees may have experienced. Therefore, no medical assessment looking at possible associations with work exposures and health effects could be performed.

RECOMMENDATIONS

The following recommendations are based on the findings of this investigation.

1. Although all PBZ air samples collected were below relevant evaluation criteria, Press room employees should stand clear of the generated fumes after presses are opened.

2. Supply air should be increased in the facility to reduce the amount of excess negative pressure.

In addition, this will assist in dilution of any generated contaminants.

3. Communication between management, union, and employees should be improved. The union and other employees should be made aware of any future problems within the building and decisions made by management to address those problems.

4. Appropriate housekeeping and employee hygiene should be standard practice at TA. A regular cleaning schedule for all areas of the facility will help keep particulate and other contaminants to a minimum. Good hygiene practices, such as hand–washing before eating, drinking, or smoking, will reduce the possibility of exposures by routes other than inhalation, such as ingestion by hand–to–mouth contact.

5. TA should have a plant medical contact for employees. This contact can then communicate with plant management for any follow–up.

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HETA 2000–0124–2875, Tenneco Automotive, Milan, Ohio.
Table 1. Results of Initial Site Visit on May 10, 2000, GA Air Sampling for Volatile Organic Compounds.

Location	Part #	Compound #	Sample #	Press Type	Major compounds
Press #421	680810	216420	AO 4424	Conventional	Methyl isobutyl ketone (MIBK) Toluene o–Chlorotoluene Diphenylamine
Press #511	616270	216854	AO 3700	Conventional	Diphenylamine
Banbury #2 – above mill	N/A	265230 206010 205019 205023 237401	AO 3798	N/A	MIBK Branched C_9–C_{12} aliphatic HCs
K–7 by pelletizer	N/A	216770 216812 217642 118508	AO 4163	N/A	Ethylene glycol Branched C_9–C_{12} aliphatic HCs Tetramethyldicyne–diol (?) Diphenylamine
Press #605	86121–0	215546	AO 5008	Injection–molding	Methyl isoamyl ketone (MIAK) o–Chlorotoluene Cyclohexyl isothiocyanate Diphenylamine
Press #699	85409–1	217538	AO 3679	Injection–molding	t–Butyl amine MIAK o–Chlorotoluene Phthalamide Diphenylamine
Press #126	681570	217414	AO 3393	Conventional	Very small peaks
Press #111	616340	901858	A 41085	Conventional	MIBK Toluene o–Chlorotoluene Limonene

HCs = hydrocarbons
N/A = not applicable

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Table 2. Results of Follow–up Site Visit on April 5, 2001, GA Air Sampling for Volatile Organic Compounds.

Location	Part #	Sample #	Major compounds
Outside	N/A	AO 3929	Small amount of various compounds
Cold–feed operators station	N/A	A39808	Methyl isobutyl ketone (MIBK) C_9H_{12} alkyl benzenes Diphenylamine
Press #111	61634–0	AO 4286	t–butyl amine C_9H_{12} alkyl benzenes Diphenylamine
Near Press # 451	61485–0	AO 5000	t–butyl amine o–Chlorotoluene Limonene Benzothiozole Diphenylamine
Banbury #1 mezzanine	N/A	A40989	Acetic acid possibly Acetylcyclohexene C_9H_{12} alkyl benzenes Phthalic anhydride
Injection–molding machine #699	Unknown	AO 5013	Toluene o–Chlorotoluene Benzothiozole Diphenylamine
Injection–molding machine #692	66955–3	AO 3534	o–Chlorotoluene Diphenylamine
Injection–molding machine #694	85587–0	AO 5005	o–Chlorotoluene Chlorotoluene isomer Cyclohexame isothiocyanate* Trimethyldihydroquinone Diphenylamine

N/A = not applicable
* = May be the product of heating in the thermal desorber. A known reaction is to have an amine + CS_2 (carbon disulfide) + heat yield the corresponding isothiocyanate.

HETA 2000–0124–2875, Tenneco Automotive, Milan, Ohio.
Table 3. Follow–up Site Visit on April 5, 2001, Nitrosamine LODs, LOQs, MDCs, and MQCs.

Nitrosamine	LOD	MDC		LOQ	MQC
N–nitrosodimethylamine (NDMA)	65	1.3x10^{-4}		200	4x10^{-4}
N–nitrosodiethylamine (NDEA)	56	1.12x10^{-4}		170	3.4x10^{-4}
N–nitrosodipropylamine (NDPA)	37	7.4x10^{-5}		110	2.2x10^{-4}
N–nitrosodibutylamine (NDBA)	110	2.2x10^{-4}		330	6.6x10^{-4}
N–nitrosopiperidine (NPIP)	140	2.8x10^{-4}		430	8.6x10^{-4}
N–nitrosopyrrolidine (NPYR)	65	1.3x10^{-4}		200	4x10^{-4}
N–nitrosomorpholine (NMOR)	47	9.4x10^{-5}		140	2.8x10^{-4}

LOD = limit of detection (nanograms per sample [ng/sample])
LOQ = limit of quantitation (ng/sample)
MDC = minimum detectable concentration (micrograms per cubic meter of air [µg/m^3])
MQC = minimum quantifiable concentration (µg/m^3)

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Table 4. Follow–up Site Visit on April 5, 2001, Nitrosamine PBZ and GA Air Sampling Job/Locations.

Job/Location (type of sample)	
PBZ – Press #111	PBZ – Injection–molding machine #617
PBZ – Press #120	PBZ – Injection–molding machine #618
PBZ – Press #127	PBZ – Cold–feed Extrusion worker
PBZ – Press #145	PBZ – Banbury #1 worker
PBZ – Press #230–232	PBZ – Banbury #1 worker
PBZ – Press #240–242	PBZ – Cold–feed Extrusion worker
PBZ – Press #211–213	PBZ – K–7 Serviceman
PBZ – Press #450–454	GA – K–7 Mill Roller
PBZ – Press #431, 440	GA – K–7 Mill Distall CPU
PBZ – Press #421	PBZ – K–7 Operator (2nd floor)
PBZ – Press #511–516	PBZ – Banbury #2 Operator (2nd floor)
PBZ – Press #310–313	PBZ – Banbury #2 Operator (2nd floor)
PBZ – Injection–molding machine #694	PBZ – Banbury #1 Operator (2nd floor)
PBZ – Injection–molding machine #692 (on machine #699 for approximately 1 hour)	PBZ – K–7 Serviceman (3rd floor)
PBZ – Injection–molding machine #602–619	GA – Shake Conveyer
PBZ – Injection–molding machine #604	GA – Banbury #1 mezzanine
PBZ – Ferrule machine worker	GA – Lunchroom
PBZ – Injection–molding machine #605	GA – Picnic Table by Press Room
PBZ – Injection–molding machine #698	GA – Outside – on fence at front of building
PBZ – Injection–molding machine #616	

PBZ = personal breathing zone
GA = general area sample

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Table 5. Results of Follow–up Site Visit on April 5, 2001, PBZ and GA Air Sampling for Total Particulate.

Job/Location (type of sample)	Time (military)	Volume (liters)	8–hour TWA Concentration (mg/m^3)
GA – Press #111	0612 – 1344	901	0.12
GA – Press #126	0617 – 1059	563	0.30
GA – Press #240	0623 – 1350	896	0.15
GA – Press #143	Pumps and Samples Lost		
GA – Press #230/231	0632 – 1352	882	0.19
GA – Press #211	0634 – 1353	880	0.19
GA – Press #451/452	0637 – 1349	869	0.14
GA – Press #440	0641 – 1351	861	0.14
GA – Injection–molding machine #694	0705 – 1406	845	0.51
GA – Injection–molding machine #692	0712 – 1405	826	0.19
PBZ – Compounder, mixing room	0751 – 1436	818	1.71
GA – Banbury #1	0753 – 1450	837	0.63
GA – K–7	0805 – 1451	815	0.23
GA – K–7 mezzanine	0758 – 1444	814	0.28
GA – Outside – on fence at front of building	0815 – 1510	837	0.04
Minimum Detectable Concentration (MDC)	0.02		
Total Particulate Evaluation Criteria	OSHA PEL – 15 mg/m^3 ACGIH TLV – 10 mg/m^3		

PBZ = personal breathing zone
GA = general area sample
mg/m^3 = milligrams per cubic meter of air
ND = non detectable concentration

HETA 2000–0124–2875, Tenneco Automotive, Milan, Ohio.
Table 6. Results of Follow–up Site Visit on April 5, 2001, PBZ and GA Air Sampling for Respirable Particulate.

Job/Location (type of sample)	Time (military)	Volume (liters)	8–hour TWA Concentration (mg/m^3)
GA – Press #111	0612 – 1344	786	0.10
GA – Press #126	0617 – 1346	823	0.26
GA – Press #240	0623 – 1350	789	0.10
GA – Press #143	Pumps and Samples Lost		
GA – Press #230/231	0632 – 1352	743	0.15
GA – Press #211	0634 – 1353	765	0.18
GA – Press #451/452	0637 – 1349	756	0.13
GA – Press #440	0641 – 1351	757	0.08
GA – Injection–molding machine #694	0705 – 1406	727	0.36
GA – Injection–molding machine #692	0712 – 1405	724	0.13
PBZ – Compounder, mixing room	0751 – 1436	693	0.17
GA – Banbury #1	0753 – 1450	735	0.10
GA – K–7	0805 – 1451	698	0.08
GA – K–7 mezzanine	0758 – 1444	706	0.12
GA – Outside – on fence at front of building	0815 – 1510	708	ND
Minimum Detectable Concentration (MDC)	0.02		
Respirable Particulate Evaluation Criteria	OSHA PEL – 5 mg/m^3 ACGIH TLV – 3 mg/m^3		

PBZ = personal breathing zone
GA = general area sample
mg/m^3 = milligrams per cubic meter of air
ND = non detectable concentration

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Table 7. Results of Follow–up Site Visit on April 5, 2001, GA Air Sampling for Total Hydrocarbons.

Location	**Time (military)**	**Volume (liters)**	**8–hour TWA Concentration (mg/m^3)**
GA – Press #126	0618 – 1347	22.5	0.37
GA – Press #111	0619 – 1344	22.4	Trace
GA – Press #240	0623 – 1350	22.4	0.43
GA – Press #143	Pumps and Samples Lost		
GA – Press #230/231	0632 – 1352	22.0	Trace
GA – Press #211	0635 – 1353	22.0	ND
GA – Press #451/452	0637 – 1350	21.9	0.40
GA – Press #440	0641 – 1351	21.6	Trace
GA – Press #421	0647 – 1356	21.5	ND
GA – Press #510	0651 – 1357	21.3	ND
GA – Press #310	0655 – 1358	21.2	Trace
GA – Injection–molding machine #694	0705 – 1406	21.3	0.99
GA – Injection–molding machine #692	0712 – 1405	20.7	Trace
GA – Injection–molding machine #604	0716 – 1410	20.8	Trace
Minimum Detectable Concentration (MDC)	0.08		
Minimum Quantifiable Concentration (MQC)	0.28		

GA = general area sample
mg/m^3 = milligrams per cubic meter of air
ND = non detectable concentration
Trace = concentration between the MDC and the MQC

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Table 8. Results of Follow–up Site Visit on April 5, 2001, GA Air Sampling for Total Hydrocarbons.

Location	**Time (military)**	**Volume (liters)**	**8–hour TWA Concentration (mg/m^3)**
GA – Ferrue machine	0719 – 1411	20.9	0.38
GA – Injection–molding machine #605	0722 – 1410	20.4	Trace
GA – Injection–molding machine #619	0728 – 1412	20.3	Trace
GA – Injection–molding machine #616	0730 – 1429	21.2	0.52
GA – Injection–molding machine #617	0732 – 1412	20.1	Trace
GA – Injection–molding machine #618	0734 – 1429	20.8	Trace
GA – K–7 Mill Distall CPU	0754 – 1436	20.2	ND
GA – K–7 Mill Roller	0755 – 1436	20.2	ND
GA – By Pelletizer	0817 – 1443	19.4	3.14
GA – Banbury #1 mezzanine	0820 – 1443	19.2	ND
GA – Lunchroom	0827 – 1457	19.5	Trace
GA – Picnic Table by Press Room	0830 – 1400	16.5	0.91
GA – Outside – on fence at front of building	0815 – 1510	20.8	ND
Minimum Detectable Concentration (MDC)	0.08		
Minimum Quantifiable Concentration (MQC)	0.28		

GA = general area sample
mg/m^3 = milligrams per cubic meter of air
ND = non detectable concentration
Trace = concentration between the MDC and the MQC

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Table 9. Results of Follow–up Site Visit on April 5, 2001, Measurements for Temperature and Relative Humidity.

Location	Time (military)	Temperature (°F)	Relative Humidity (%)
Press Room	0852	67.4	23.3
	1210	75.1	20.3
	1500	74.1	20.9
Injection–molding Room	0856	65.8	23.2
	1216	72.9	18.7
	1502	74.3	20.8
1st Floor Mixing	0859	68.6	26.3
	1221	73.5	19.6
	1440	73.4	21.2
2nd Floor Banbury #1	0902	68.5	21.9
	1224	74.1	19.0
	1446	73.9	20.5
2nd Floor K–7	0903	69.8	21.3
	1225	77.2	18.2
	1447	77.5	20.9
3rd Floor Mixing	0907	72.8	20.0
	1230	74.7	18.7
	1453	72.8	20.7
Outside – E of front	0912	50.5	26.5
	1237	63.6	22.8
	1504	60.1	22.3

Appendix A

Initial Site Visit on May 10, 2000

Thermal Desorption Tubes – Peak Identification

Chromatograms

Appendix B

Follow–up Site Visit on April 5, 2001

Thermal Desorption Tubes – Peak Identification

Chromatograms

DEPARTMENT OF HEALTH AND HUMAN SERVICES
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