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SUMMARY

In June 1992, the National Institute for Occupational Safety and Health (NIOSH) received a confidential employee request to conduct a health hazard evaluation at Indian Industries in Evansville, Indiana. The request concerned exposures to BZ-123, an organic solvent which contains toluene, xylene, and methyl ethyl ketone (MEK). Worker complaints of dry and peeling skin, nausea, vomiting, and night sweats were reported in the request.

A medical and industrial hygiene survey was conducted on September 9-10, 1993. The medical evaluation included employee interviews and a review of medical records. The industrial hygiene evaluation included a walk-through inspection, collection of hand wipe samples, and air monitoring to evaluate workers' exposures to toluene, xylene, styrene, MEK, and 2-butoxyethanol.

Confidential employee interviews were performed with 17 workers. The most commonly reported symptoms were skin dryness and irritation, headaches, dizziness, nausea, and eye irritation. Most workers interviewed reported skin and mucous membrane irritation or neurological symptoms consistent with exposures to organic solvents, but the specific illnesses described in the relevant medical records were not consistent with the recognized toxicological effects to exposures to toluene, xylene, or MEK.

Personal-breathing-zone concentrations of toluene collected on the paint line operators during clean-up ranged from 9.1 to 429.4 parts per million (ppm) for up to a 45-minute sampling period. One worker's exposure was 8.5 times the American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Value (TLV®) of 50 ppm, a level which exceeds the ACGIH recommendation that excursions in worker exposure levels should not exceed five times the time-weighted average (TWA) exposure limit. Furthermore, the short-term exposure of this worker exceeded the NIOSH short-term exposure limit (STEL) of 150 ppm for toluene and the equivalent exposure criterion for solvent mixtures. Air sampling indicated that the concentrations were below the Occupational Safety and Health Administration Permissible Exposure Limits. The 8-hour TWAs for the solvent exposures to workers in the molding, silk screening, and paint line areas were below the pertinent occupational health exposure criteria. However, the measured concentrations for styrene approached the NIOSH action level of 25 ppm. Employee hand wipe samples found low levels of cadmium, chromium, lead, nickel, and zinc, suggesting inadequate use of appropriate personal protective equipment and the potential for ingestion of these metals.

NIOSH investigators concluded that employees were exposed to potentially hazardous concentrations of organic solvents. In an effort to reduce workers' exposures, recommendations such as improved local exhaust ventilation, implementation of an effective respiratory protection program, and utilization of appropriate personal protective equipment are provided in the Conclusions and Recommendations section of this report.

Keywords: SIC 3949 (Sporting and Athletic Goods, Not Elsewhere Classified), silk screening, BZ-123, toluene, xylene, styrene, methyl ethyl ketone, 2-butoxyethanol, elements, metals.

INTRODUCTION

On June 8, 1992, the National Institute for Occupational Safety and Health (NIOSH) received a confidential employee request to conduct a health hazard evaluation at Indian Industries in Evansville, Indiana. The request stated concerns regarding potential exposures to BZ-123, a solvent which contains toluene, xylene, and methyl ethyl ketone (MEK). Worker complaints of dry and peeling skin, nausea, vomiting, and night sweats were reported. A site visit, which included a medical and industrial hygiene survey, was conducted on September 9-10, 1992. An interim report, distributed to Indian Industries in January 1993, described the evaluation methods and techniques, and summarized the medical and environmental data.

BACKGROUND AND FACILITY DESCRIPTION

Indian Industries, established in 1927, is a manufacturer of sporting goods equipment, including basketball backboards and poles, table tennis tables, pool tables, and fitness and archery equipment. Currently, Indian Industries employs approximately 400 workers over three shifts. Of these, 300 are production workers. Production is seasonal and the work force typically decreases after December to 250 employees. Approximately 50% of the work force is female.

Indian Industries' production facility is housed in a renovated one-story building, originally used as a car assembly plant. The 155,000 square feet of production area includes molding, assembly, silk screening, painting, and packing operations.

Based on the information provided in the request and in the opening conference, the investigation focused on the molding areas for basketball backboards and table tennis tops, silk screening operations, and the table tennis paint line. The majority of exposures to BZ-123 occur in these departments. A general process description is presented below.

Molding areas

Basketball backboards and table tennis tops are made from a polyester sheet molding compound (SMC), which contains fiberglass impregnated with a styrene monomer. The SMC is placed into a 1000-pound press which is heated to approximately 300° Fahrenheit. The SMC is heat activated and becomes hard once heated. The newly formed backboard or table tennis top is then transferred to the appropriate department. At the end of each shift, BZ-123 is used to clean the press. Latex gloves are worn during the clean-up operation. No local exhaust ventilation is used in the department.

Silk screening operations

Silk screening is a form of printing. An emulsion is used to block the ink from penetrating through the screen onto the equipment. A photonegative image of the art work is made, and the emulsion is removed (washed out) from the areas to be printed. The ink is added to the screen and the image is transferred onto the equipment.

Prior to silk screening, most of the sporting goods equipment is cleaned with isopropyl alcohol and placed within the press. The image printed onto the equipment is either air dried or ultraviolet (UV) cured. All of the silk screen operations are performed manually, except for the basketball backboard process. There is no local exhaust ventilation used in any of the silk screen areas.

At the end of the shift, or whenever the color scheme is changed, the silk screen press is cleaned with BZ-123. The screen is saturated with the chemical and wiped with paper cloths. Latex gloves are worn during this clean-up operation.

Table tennis paint line

In the table tennis paint line, the table is placed onto an automatic conveyor system which moves the equipment through a series of processes. First, the table is sanded and brushed, and an UV-cured filler containing a styrene monomer is applied to "fill" any pits in the table. The table then proceeds through an UV oven. The table is sanded and brushed again, and then painted. The paint line has local exhaust ventilation to capture and remove any process emissions.

Once a day, the paint line undergoes a clean-up operation using BZ-123; this typically takes 30 to 45 minutes. Latex gloves are worn during this activity.

EVALUATION PROCEDURES

In order to evaluate reported health problems and potential occupational hazards, medical and industrial hygiene evaluations were performed. The medical evaluation included a series of interviews with selected employees and a review of the relevant medical records. The environmental assessment included a walk-through of the plant to evaluate work practices and overall industrial hygiene and safety conditions, hand wipe sampling, and an air monitoring survey.

Medical evaluation

Two medical officers interviewed 17 of the approximately 300 production workers. Labor and management representatives selected employees who were experiencing possible work-related health problems or who had worked in the silk screening or spray painting areas. During the interview, the medical officers asked if the interviewee knew of any other employees who might be experiencing work-related health problems; workers identified in this manner were also interviewed. From the interviews, information was gathered about workplace conditions, work practices, and frequency of medical symptoms possibly related to chemical exposures.

The Occupational Safety and Health Administration (OSHA) 200 Injury and Illness logs for 1990 through 1992 and pertinent medical records were reviewed.

Environmental methods

The environmental evaluation focused primarily on air monitoring, but also included the collection of wipe samples, and walk-through evaluations of environmental and safety conditions. Environmental monitoring included evaluation of exposures to toluene, xylene, styrene, MEK, and 2-butoxyethanol, along with an assessment of wipe samples for elements.

Air monitoring

Toluene, xylene, and styrene

Personal breathing zone and area air samples for toluene, xylene, and styrene were collected on activated charcoal according to the NIOSH Method 1501[1] with modifications. Eight-hour time-weighted average (TWA) samples were connected via Tygon® tubing to Gillian Lo Flow Sampler® battery-operated personal sampling pumps. Air was sampled through the tubes at a nominal flow rate of 0.1 liters per minute (ℓ/min). Short-term samples were collected using the Gillian Hi Flow Sampler® battery-operated personal sampling pumps at a flow rate of 1 ℓ/min. After sampling, the charcoal tubes were removed and analytes desorbed with 1 milliliter (ml) of carbon disulfide containing 1 microliter per ml of benzene as an internal standard. The samples were analyzed using gas chromatography-flame ionization detection (GC-FID). The analytical limit of detection (LOD) for NIOSH Method 1501 is 0.01 milligram (mg) per analyte.

Methyl ethyl ketone

Personal and area samples for MEK were collected on Orbo-90 tubes by a modified NIOSH Method 2500.[1] Samples were collected at a flow rate of 0.1 and 1 ℓ/min for 8-hour TWA and short-term sampling, respectively. After sampling, the analyte was desorbed using carbon disulfide containing benzene and analyzed by GC-FID. The NIOSH Method 2500 for MEK has a LOD of 0.01 mg/sample.

2-butoxyethanol (EGBE)

Airborne concentrations of 2-butoxyethanol (ethylene glycol monobutyl ether or EGBE) were collected on activated charcoal tubes followed by desorption in methylene chloride containing toluene and methanol and analyzed by GC-FID, as described in NIOSH Method 1403[1] with modifications. Personal and area samples were collected on activated charcoal using a battery-operated sampling pump at 0.1 ℓ/min for 8-hour TWA samples and at 1 ℓ/min for short-term samples. The LOD for NIOSH Method 1403 is 0.01 mg/sample.

All of the Gillian Lo Flow Sampler® and Gillian Hi Flow Sampler® pumps were calibrated prior to and after sampling using the Gillian Gilibrator® and the Kurz Pocket Flow Calibrator™ mass flowmeter, respectively. Both the Kurz Pocket Flow Calibrator™ mass flowmeter and the Gillian Gilibrator® were calibrated against a primary standard. For subsequent calculations of sample volumes, the mean pre- and post flow rates were used. A minimum of 10% of the sampled charcoal and Orbo-90 tubes were prepared and submitted as field blanks with the sample sets.

Wipe samples

Hand wipe samples for elements were collected using commercial pre-moistened Wash 'n Dri® wipes to determine the potential for exposure to metals through ingestion which may occur either by direct hand-to-mouth contact or indirectly from hand-to-mouth contact through clothing, cigarettes, or food which has been contaminated by these compounds. Workers thoroughly wiped the front and back of their hands with a towelette five times during the day (prior to work, prior to break, after break, prior to lunch, and at the end of the shift) and then placed it in a new sealable plastic bag.

The wipes were removed from their plastic bags, digested in nitric and perchloric acid, heated, and quantitatively transferred to 50 milliliter (ml) volumetric flasks. The solutions were analyzed for elements by inductively coupled plasma, atomic emission spectrometry (ICP-AES), according to NIOSH Method 7300.[1]

EVALUATION CRITERIA

General guidelines

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

In addition, some hazardous substances may act in combination with other workplace exposures, the general environment, or with medications or personal habits of the worker to produce health effects even if the occupational exposures are controlled at the level set by the evaluation criterion. These combined effects are often not 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 source of environmental evaluation criteria for the workplace are: 1) NIOSH Criteria Documents and 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, OSHA Permissible Exposure Limits (PELs).[4] The OSHA standards may be required to take into account the feasibility of controlling exposures in various industries where the agents are used; the NIOSH RELs, by contrast, are based primarily on concerns relating to the prevention of occupational disease. It should be noted that industry is legally required to meet those levels specified by an OSHA standard.

A 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 (STELs) or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from high short-term exposures.

Toluene

Toluene is a colorless, aromatic organic liquid. It is a solvent typically found in paints, coatings, gasoline, and other petroleum solvents, and is used as a raw material in the synthesis of organic chemicals, dyes, detergents, and pharmaceuticals.

Inhalation and skin absorption are the major routes of exposure. Toluene can cause acute irritation of the eyes, respiratory tract, and skin. Since it is a defatting solvent, repeated or prolonged skin contact will remove the natural lipids from the skin and cause drying, fissuring, and dermatitis.[5]

The main effects associated with exposure to toluene are central nervous system (CNS) depression and neurotoxicity. Studies have shown that subjects exposed to 100 parts per million (ppm) of toluene complained of eye and nose irritation, and in some cases, headache, dizziness, and a feeling of intoxication.[6-7] No symptoms were noted below 100 ppm in these studies. However, concentrations above 200 ppm can cause dizziness, drowsiness, headache, nausea, vomiting, and unconsciousness. There are a number of reports of neurological damage due to deliberate sniffing of toluene-based glues, resulting in motor (muscle) weakness, intention tremor, ataxia (staggering), and cerebral atrophy. Recovery is complete; however, permanent impairment may occur after prolonged glue-sniffing. Exposure to extremely high concentrations of toluene may cause mental confusion, loss of coordination and consciousness.[8-9]

The OSHA PEL for toluene is 200 ppm, whereas the NIOSH REL is 100 ppm for an 8-hour TWA.[4,10] NIOSH has also set a recommended STEL of 150 ppm for a 15-minute sampling period.[2] More recently, ACGIH has lowered their exposure criteria to 50 ppm for an 8-hour TWA. This value was based on prevention of transient headaches, irritation, and reductions in cognitive responses reported in humans at levels greater than or equal to 40 ppm.[11] Also, the ACGIH TLV® carries a skin notation, indicating that cutaneous exposure contributes to the overall absorbed inhalation dose and potential systemic effects.[3]

Xylene

Xylene is a colorless liquid with an odor threshold of 1 ppm. Xylene is also used in paints, coatings, gasoline, and other petroleum solvents, and is used as a raw material in the synthesis of organic chemicals, dyes, detergents, and pharmaceuticals.

Its vapor has irritant effects on the skin and mucous membranes, including the eyes and respiratory tract. Irritants alter the chemistry of the skin. This alteration may cause itching, redness, inflammation, and

discomfort. Repeated or prolonged skin contact may cause erythema, drying, and defatting of the skin. At high concentrations, repeated exposure to xylene may cause reversible damage to the eyes.[7]

Acute exposures may cause dizziness, staggering, drowsiness, and unconsciousness. Previous studies have shown that concentrations from 60 to 350 ppm may cause giddiness, anorexia, and vomiting. At high concentrations, exposure to xylene has narcotic effects on the CNS, and minor reversible effects on the liver and kidneys.[7,12]

The current OSHA PEL, NIOSH REL, and ACGIH TLV® for xylene are 100 ppm over an 8-hour TWA.[2-4] The NIOSH and ACGIH have published STELs for xylene of 150 ppm over 15 minutes.[2,3]

Styrene

The major routes of occupational exposure to styrene are inhalation and skin absorption. Styrene vapor is an eye and respiratory tract irritant. The major target organ for workers exposed to styrene is the CNS. Acute exposures may cause headache, fatigue, nausea, difficulty in concentrating, and a feeling of intoxication. Decrements in balance, coordination, manual dexterity, and reaction time have also been associated with styrene exposures.[5,13] Workers exposed to concentrations averaging 50 ppm have demonstrated acute effects on neuropsychological tests of verbal learning skills and other abilities.[14] Liquid styrene is a skin irritant and repeated or prolonged exposure can cause dermatitis.[5] Human studies on the reproductive effects among workers exposed to styrene are limited and reveal conflicting and inconsistent reports of adverse effects.[2,15,16] Currently, styrene is not considered to be a potential occupational carcinogen.[2,3]

The OSHA PEL is 100 ppm for an 8-hour TWA.[4] The NIOSH REL and ACGIH TLV® for styrene are 50 ppm for an 8-hour TWA.[2, 3] In addition to this limit, NIOSH has established an action level of 25 ppm. Due to daily variability of exposures, a worker's TWA exposure that is below the NIOSH REL of 50 ppm on one day does not necessarily indicate that exposures on other days would also be below the REL. NIOSH believes that if a worker's TWA exposure is at or above the 25 ppm action level, then there is sufficient probability that, on other days, exposures could exceed the NIOSH REL of 50 ppm.[11] The NIOSH and ACGIH STELs for this substance are 100 ppm for a 15-minute sampling period, whereas OSHA has set a ceiling limit of 200 ppm.

Methyl ethyl ketone (MEK)

MEK is an irritant to the eyes, mucous membranes, and skin. At high concentrations, it produces CNS depression in animals, and a severe exposure would presumably have a similar effect in humans.[5] NIOSH, OSHA, and ACGIH have all set the 8-hour exposure limit for MEK at 200 ppm.[2-4] The NIOSH and ACGIH STELs for MEK are 300 ppm.[2, 3]

2-butoxyethanol (EGBE)

2-butoxyethanol (ethylene glycol monobutyl ether, or EGBE) is a colorless liquid with a mild ether odor; the odor threshold is 0.10 ppm. Exposures to EGBE may cause health problems associated with the CNS, blood and hematopoietic (blood cell-forming) system, and the kidneys. However, there is no evidence at this time to indicate that EGBE causes adverse reproductive or developmental effects.[5,17]

The NIOSH REL is 5 ppm for up to 10 hours per day, 40 hours per week. NIOSH has also set an action level at 2.5 ppm.[2] The OSHA PEL is 50 ppm, whereas the ACGIH TLV® is 25 ppm.[3-4] All three organizations have designated EGBE with a skin notation, indicating that exposure by the cutaneous route contributes to the overall exposure.[2-4]

Equivalent exposure criterion for mixtures

Concurrent exposure to two or more hazardous substances which act upon the same target organ system should be considered as additive exposures. In the absence of contrary information, the combined effect, rather than that of each individually, should be given primary consideration when evaluating worker exposure to substances with similar physiologic effects.

To evaluate the additive effect, the exposure level of each substance is computed as a fraction of the evaluation criterion for that substance. If the sum of the fractions exceeds unity (1), the worker is considered to be overexposed to that mixture of substances.[3,4]

When evaluating exposure to chemical mixtures, it is important to note that synergistic action or potentiation may occur with some combinations of atmospheric contaminants. A synergistic effect is where the combined effect of two or more chemicals is much greater than the sum of the effect from separate exposure to the chemicals. Potentiation is the case where a chemical agent by itself does not have a toxic effect on an organ system, but when present with exposure to another chemical agent, it makes that agent much more toxic.[18] Applying the equivalent exposure evaluation criterion to synergistic or potentiating substances may underestimate the true affect on the workers' health as a result of exposure to such chemical mixtures.

The effects of toluene, xylene, styrene, MEK, and 2-butoxyethanol were considered additive. Exposure to organic solvents such as these is an example of when to apply the equivalent exposure criteria for additive effects from chemical mixtures due to the ability of these substances to produce narcosis and other symptoms related to CNS depression.

RESULTS AND DISCUSSION

Medical evaluation

The NIOSH medical investigators interviewed 17 employees working in the production areas. The most common symptoms were skin dryness and irritation, headaches, dizziness, nausea, and eye irritation. Nearly all of the workers interviewed felt that the symptoms were associated with exposures to BZ-123, MEK, and/or fiberglass. Some workers also felt that there were inadequate ventilation, inappropriate protective gloves, and a lack of training regarding safety issues and chemical exposures.

A review of the OSHA 200 logs revealed that foreign body injuries to the eye were second only to musculoskeletal traumas in reported injuries.

Selected medical records were reviewed to verify worker-reported medical diagnoses and to analyze possible health effects related to exposures to BZ-123. The illnesses described in the medical records were not consistent with the recognized toxicological effects to exposures to the chemicals in BZ-123.

Environmental evaluation

Clean-up Operation: Personal air monitoring

On September 9, 1992, personal exposure monitoring of the second shift paint line clean-up procedures was performed and the results are presented in Tables 1-3. The clean-up consisted of filling the coating trays with BZ-123, allowing the roller to soak in the solvent for a short period of time, followed by wiping the coating tray, roller, and affiliated parts to remove the residual coating solution and excess BZ-123. Respirators were not worn during this procedure.

Table 1 shows the actual exposure concentrations of toluene, xylene, styrene, and MEK during the clean-up operation. Four personal exposure samples were collected (sample times ranged from 29 to 45 minutes). Measured toluene concentrations ranged from 9.1 to 429.4 ppm. *The ACGIH recommends that under NO circumstances should excursions in worker exposure levels exceed five times the TWA exposure limit.*[3] The worker who cleans the filler pan had an exposure level to toluene which was 8.5 times the ACGIH TLV® of 50 ppm for an 8-hour TWA during the clean-up procedure. Xylene was measured at a concentration ranging from 1.98 to 70.5 ppm. Styrene concentrations ranged from less than the minimum detectable concentration of 0.8 to 66.7 ppm. Airborne exposure concentrations of MEK ranged from 5.2 to 111.1 ppm. In order to compare these values to the OSHA PELs, NIOSH RELs, and ACGIH TLVs®, the 8-hour TWAs were calculated. With the exception of the clean-up operation, the paintline operators performed the same job tasks as the table tennis paint line control operator which was monitored on September 10. Therefore, the same exposure as the table tennis paintline control operator (refer to Table 5 for this exposure data) was used for the period of time which was not sampled. The results of the adjusted 8-hour TWA concentrations are presented in Table 2. All of the TWAs decrease to a level below the OSHA PELs, NIOSH RELs, and ACGIH TLVs®. However, the equivalent exposure criterion of the paint line operator cleaning the filler pan was exceeded.

Table 3 contains the results of short-term sampling for the paint line clean-up procedure. Two short-term samples were collected for a 10-minute sampling period. The 15-minute STELs were calculated assuming a similar exposure for the five minutes which were not sampled since these workers performed the same job tasks for 36 and 45 minutes. The toluene concentrations were 54.8 ppm and 174.9 ppm. The latter sample, collected in the breathing zone of the operator cleaning the filler pan, exceeds the NIOSH STEL of 150 ppm for toluene. The results from the xylene, styrene, and MEK samples were all below the STELs of 150 ppm, 150 ppm, and 300 ppm, respectively.

Area air sampling

Table 4 presents the results from area samples collected on September 10, 1992. All four area samples for toluene, xylene, styrene, MEK, and EGBE were below the respective criteria limits. Since all of these solvents are volatile organic compounds and affect the CNS in a similar manner, a combined exposure value was calculated. The equivalent exposure values are also presented in Table 4 and range from 0.04 to 0.10. If the equivalent exposure value exceeds 1.0 (unity), the solvent mixture exposure is considered to exceed the recommended limit. On this sampling day, the equivalent exposure criteria were not exceeded.

Personal air monitoring

The results for the personal air monitoring collected for toluene, xylene, styrene, MEK, and EGBE are shown in Table 5. Fourteen personal breathing zone samples were collected on workers in the molding, silk screening, and paint line areas. In regards to the short duration samples, the 8-hour TWAs were calculated, assuming similar exposure for the time period which was not sampled since similar job tasks were performed throughout the entire shift. All the concentrations for toluene, xylene, MEK, and EGBE were below the OSHA PELs, NIOSH RELs, and ACGIH TLVs®. Airborne levels of styrene ranged from 0.64 to a maximum concentration equal to 20.9 ppm, which was measured in the breathing zone of one molding operator. Although the measured concentrations for styrene were below the OSHA PEL,

NIOSH REL, and ACGIH TLV®, it is important to note that the concentrations approached the NIOSH action level of 25 ppm. Due to daily variability, NIOSH believes that if a worker's TWA exposure is at or above the 25 ppm action level, then there is sufficient probability that, on other days, exposures to styrene could exceed the NIOSH REL of 50 ppm.[11] Again, since all of the solvents can cause at least some of the same effects, the equivalent exposure values were calculated and found to range from 0.05 to 0.40. The results of personal equivalent exposures did not exceed unity.

Short-term air monitoring

Short-term sampling was also performed in the breathing zone of the silk screen operators during the clean-up operations at the end of shift. Three personal samples were collected on the archery and basketball silk screen operators. The sampling times ranged from four to ten minutes, depending on the length of time to perform the task. The measured concentrations ranged from 62.1 to 101.8 ppm for toluene, 3.34 to 7.48 ppm for xylene, and 26.7 to 40.0 ppm for MEK, and are presented in Table 6. In order to compare these exposures to the STELs, the concentrations were adjusted to a 15-minute sampling time. Since the clean-up procedure lasted a maximum of ten minutes, a zero exposure was assumed for the time period which was not sampled. All exposures were below the NIOSH and ACGIH STELs for their respective criteria.

Hand wipes samples

Hand wipe samples were collected on six workers. Low levels of cadmium, chromium, lead, nickel, and zinc were identified in the samples. Although samples were collected five times during the day, no trend was observed in the data. These results indicate inadequate use of appropriate personal protective equipment and the potential for ingestion of these metals.

CONCLUSIONS AND RECOMMENDATIONS

The health hazard evaluation was initiated as a result of concerns regarding potential exposures to BZ-123, a solvent which contains toluene, xylene, and MEK. The major concerns reported were dry and peeling skin, headaches, nausea, and eye irritation.

Air sampling results indicate that an inhalation health hazard exists during the clean-up operations of the paint line. The worker who cleans the filler pan was exposed to toluene above the NIOSH STEL of 150 ppm, and to solvent mixtures above equivalent exposure criterion for solvents. Also, the same employee exposure had an excursion level which was 8.5 times the ACGIH TLV®. The ACGIH recommends that no excursion level exceed five times the TLV®. Although the silk screening operators were not overexposed to solvents during the survey, there is a potential for overexposure based on the variability in time in the clean-up process and the increase in exposure with respect to time. Irritant and neurologic symptoms were consistent with the effects of the organic solvents used in the operations evaluated.

The employee exposures should be reduced by improved industrial hygiene. In particular, exposures can be reduced by installing engineering controls, improving worker training, and providing and enforcing the use of appropriate protective clothing. Specific recommendations regarding general safety and chemical exposures are presented below.

1. Ideally, local exhaust ventilation should be upgraded to reduce the solvent exposures on the paint line. A firm specializing in engineering controls should be consulted to design/upgrade the ventilation system. The installation/upgrade of this system should use standardized design practices such as those provided in the ACGIH's *Industrial Ventilation, 20th Edition, A Manual of Recommended Practice.*[19] In the interim, respiratory protection should be provided to all of the workers on the paint line during the clean-up procedure. Indian Industries must meet the minimum requirements set forth by the U.S. Department of Labor, OSHA in the respiratory protection standard (29 CFR 1910.134), which includes written standard operating

procedures, medical surveillance, fit-testing, worker training, and all other aspects of the program.[4]

2. Local exhaust ventilation should be installed to reduce the solvent exposures to the silk screen operators during the clean-up operations. In some instances, fixed local exhaust is not feasible and a movable hood with a flexible duct may be used.

3. The efficacy of engineering controls should be tested by conducting industrial hygiene monitoring on the workers in the silk screen and paint line areas. This monitoring should document a reduction of the chemical exposures to levels below the NIOSH RELs, OSHA PELs, and ACGIH TLVs®.

4. BZ-123 and other solvents used throughout Indian Industries contain flammable liquids which are regulated by OSHA, primarily under 29 CFR 1910.106. During the investigation, it was observed that the flammable solvents were transferred into unapproved containers, and solvent-drenched rags were stored in inappropriate containers. Indian Industries should provide flammable storage containers for flammable solvents and rags soaked with solvents.

5. Appropriate personal protective gloves should be used during the silk screen and paint line clean-up operations. According to Forsberg and Mansdorf's *Quick Selection Guide to Chemical Protective Clothing*, natural rubber gloves should not be used for toluene, styrene, xylene, MEK, or 2-butoxyethanol. Polyvinyl chloride (PVC), Teflon™, or Viton™ gloves are recommended when handling toluene, styrene, and xylene. For MEK, butyl rubber or Viton™ gloves are recommended. Butyl rubber or Viton™ gloves should be used when handling 2-butoxyethanol.[20] Indian Industries should have a variety of glove sizes to ensure proper fit for all workers. As part of the hazard communication program, the employees should also be trained on the specific type of gloves which should be worn for specific chemical hazards.

6. The work practice of washing hands with chemicals, such as isopropanol and MEK, should be discontinued immediately. Skin contact with solvents such as toluene, xylene, and MEK can cause dermatitis. In addition, absorption of these solvents through the skin may also occur, potentially causing systemic effects.

7. Worker training and other aspects of a hazard communication should be improved. Indian Industries is required to meet all provisions of the hazard communication standard (29 CFR 1910.1200) as set forth by OSHA.[4] Workers should be familiar with the location of the material safety data sheets, the hazards associated with the chemicals used, and appropriate protective measures which should be taken when using the chemicals.

8. Eye trauma from foreign bodies and splashes is preventable. Indian Industries requires the use of safety glasses with side shields in all production areas; however, chemical splash goggles should be required whenever chemicals are being transferred from one container to another or when there is a potential for a chemical splash.

9. The use of compressed air to blow fiberglass off of the equipment, along with dry sweeping, should be discontinued since these practices produce inhalation and eye injury hazards. A vacuum system, preferably equipped with a high efficiency particulate air (HEPA) filter, should be used.

10. Safety equipment, including eye wash stations and safety showers, should be installed and readily accessible as set forth by the OSHA standard 29 CFR 1910.151.[4]

11. Although a noise survey was not conducted as part of this health hazard evaluation, a number of deficiencies were noted regarding the requirements of the OSHA noise standard (29 CFR

1910.95).[4] Periodic noise surveys, which include both sound level measurements and noise dosimetry, should be performed to measure the noise levels. Signs must be posted to identify the areas where hearing protection is required. Indian Industries should require the use of hearing protection devices in areas which exceed a noise level of 85 decibels on an A-weighted scale. Workers should be trained on the effects of noise and encouraged to reduce both occupational and recreational noise to prevent noise-induced hearing loss.

12. Ingestion resulting from hand-to-mouth contact with contaminated food, cigarettes, and other objects is another route of worker exposure to toxic substances. Workers should be prohibited from consuming food, drink, or tobacco products in the production area. Also, after leaving the production area, workers should wash their hands prior to eating, drinking, or smoking.

13. NIOSH recommends that the use of tobacco products be curtailed in situations where employees may be exposed to chemical substances which may interact with tobacco products and *where non-smoking workers may be exposed to side-stream cigarette smoke*. The best method for controlling worker exposure to tobacco smoke is to eliminate smoking from the workplace. Until this is achieved, smoking should be restricted to areas outside of the plant or to a designated area such as a smoking room which has additional dedicated ventilation. The air from this smoking area should be exhausted directly to the outside and not recirculated within the building.[21]

14. Indian Industries has tested materials throughout the production area to determine if asbestos is present and performs periodic monitoring to measure the airborne concentration of asbestos as described by the U.S. Environmental Protection Agency (EPA) operations and maintenance program for asbestos.[22] However, NIOSH investigators observed friable asbestos which showed extensive physical and water damage. Indian Industries should encapsulate, enclose, repair or remove the damaged, friable asbestos material to prevent any occupational exposures.

15. The UV lamps used in the silk screening departments should be shielded to prevent any possible occupational exposures to UV radiation.

16. In order to address general health and safety issues a safety committee, including both employer and employee representatives, should be established.

AUTHORSHIP AND ACKNOWLEDGEMENTS

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DISTRIBUTION AND AVAILABILITY OF REPORT

Copies of this report have been sent to:

1. Confidential requestors
2. Indian Industries
3. International Union of Electronics, Electrical, Salary, Machine, and Furniture Workers, Local 848
4. OSHA Region V

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

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Table 1

Results of Air Sampling During Paintline Clean-Up Procedures
Indian Industries
Evansville, Indiana

September 9, 1992

Job Category/Location	Sample Time (minutes)	Concentration (parts per million)			
		Toluene	Xylene	Styrene	MEK
Paintline Operator/ Undercoater & Precision Pan	36	60.2	5.9	< 0.8	45.4
Paintline Operator/ Undercoater Pan - Outside Paint Room	29	51.3	6.6	< 0.8	25.3
Paintline Operator/ Filler Pan	40	9.1	2.0	0.6	5.2
Paintline Operator/ Filler Pan	45	429.4	70.5	66.7	111.1
Minimum Detectable Concentration (MDC)		0.9	0.8	0.8	1.2
Minimum Quantifiable Concentration (MQC)		3.0	2.6	2.6	3.8

Table 2

8-Hr TWA Results During Paintline Clean-Up Procedures
Indian Industries
Evansville, Indiana

September 9, 1992

Job Category/Location	TWA (parts per million)				Equivalent Exposure Values
	Toluene	Xylene	Styrene	MEK	
Paintline Operator/ Undercoater & Precision Pan	7.4	2.1	0.9	4.4	0.2
Paintline Operator/ Undercoater	6.0	2.1	0.9	2.5	0.2
Paintline Operator/ Filler Pan -- Outside Paint Room	3.6	1.8	0.9	1.4	0.1
Paintline Operator/ Filler Pan	43.0	8.3	7.1	11.4	1.2
MDC	0.9	0.8	0.8	1.2	
MQC	3.0	2.6	2.6	3.8	
Exposure Limit					
NIOSH REL	100	100	50	200	1.0
OSHA PEL	200	100	100	200	1.0
ACGIH TLV®	50	100	50	200	1.0

Table 3

Results of Short-Term Sampling During
Paintline Clean-Up Procedures
Indian Industries
Evansville, Indiana

September 9, 1992

Job Category/Location	Concentration parts per million (ppm)			
	Toluene	**Xylene**	**Styrene**	**MEK**
Paintline Operator/ Filler Pan	174.9	31.7	30.0	83.3*
Paintline Operator/ Undercoater & Precision Pan	54.8	5.7	(0.5)	28.3
MDC	0.4	0.3	0.3	0.5
MQC	1.2	1.0	1.1	1.5
Exposure Limit				
NIOSH STEL	150	150	100	300
OSHA	--	--	200[c]	---
ACGIH STEL	--	150	100	300

* = Breakthrough
( ) = Value between MDC and MQC
c = ceiling limit

Table 4

Results of Area Air Sampling
Indian Industries
Evansville, Indiana

September 10, 1992

Location	Sample Time (minutes)	8-hr TWA (parts per million)					Equivalent Exposure Values
		Toluene	Xylene	Styrene	MEK	EGBE	
Basketball Silk Screen	333	1.3	(0.2)	3.3	---	< 0.1	0.1
Archery Silk Screen	387	0.8	(0.2)	1.3	8.4	< 0.1	0.1
Archery Spray Paint Booth	376	0.3	(0.1)	1.7	0.5	---	0.04
Outside	437	< 0.1	< 0.1	< 0.1	---	< 0.1	
MDC		0.1	0.1	0.1	0.1	0.1	
MQC		0.2	0.2	0.2	0.3	0.2	
Exposure Limit							
NIOSH REL		100	100	50	200	5	1.0
OSHA PEL		200	100	100	200	50	1.0
ACGIH TLV®		50	100	50	200	25	1.0

--- Analysis not requested

Table 5

Results of Personal Air Monitoring
Indian Industries
Evansville, Indiana

September 10, 1992

Job Category	Sample Time (minutes)	8-hr TWA (parts per million)					Equivalent Exposure Values
		Toluene	Xylene	Styrene	MEK	EGBE	
Fitness Silk Screen Operator	480	1.7	0.3	1.3	--	<0.1	0.1
Archery Silk Screen Operator/Spray Paint Finisher	474	5.0	0.6	1.2	--	<0.1	0.1
Archery Spray Paint Finisher	472	1.0	0.2	1.4	--	<0.1	0.05
Basketball Line Packer	493	0.8	(0.1)	2.4	--	<0.1	0.1
Basketball Silk Screen Operator	494	5.3	0.5	2.7	--	<0.1	0.2
Basketball Silk Screen Operator	492	2.3	0.3	2.4	--	<0.1	0.1
Basketball Line Backboard Cleaner	494	2.5	0.4	2.9	--	<0.1	0.1
Yard Games Silk Screen Operator	472	2.1	0.2	0.6	--	<0.1	0.05
Table Tennis Assembler	475	5.5	1.0	1.0	--	<0.1	0.1
Table Tennis Paintline Feeder/Rover	273	5.6	3.7	1.1	--	--	0.2
Table Tennis Paintline Control Operator	434	3.1	1.8	1.0	1.1	--	0.1
Basketball Backboard Press Operator	442	0.6	(0.1)	20.9	--	--	0.4
Basketball Backboard Press Operator	442	0.3	(0.1)	3.7	--	--	0.1
Basketball Backboard Press Operator	443	3.6	0.3	17.7	--	--	0.4
MDC		0.1	0.1	0.1	0.1	0.1	
MQC		0.2	0.2	0.2	0.3	0.2	
Exposure Limit							
NIOSH REL		100	100	50	200	5	1.0
OSHA PEL		200	100	100	200	50	1.0
ACGIH TLV®		50	100	50	200	25	1.0

( ) Value between MDC and MQC
--- Analysis not requested

Table 6

Results of Short-Term Sampling During Silk Screen Clean-Up Procedures Indian Industries Evansville, Indiana

September 10, 1992

Job Category	Sample Time (minutes)	Concentration (parts per million)					
		Toluene		Xylene		MEK	
		Actual*	Adjusted**	Actual	Adjusted	Actual	Adjusted
Archery Silk Screen Operator/Spray Finisher	4	62.7	16.7	3.3	0.9	--	--
Basketball Silk Screen Operator	10	101.8	67.9	7.5	5.0	40.0	26.7
Basketball Silk Screen Operator	7	67.1	31.3	4.5	2.1	26.7	12.5
MDC		0.3		0.2		0.3	
MQC		0.9		0.8		1.0	
Exposure Limit							
NIOSH STEL		150		150		300	
ACGIH STEL		---		150		300	

* Actual = exposures were calculated using actual sampling time.
** Adjusted = 15-minute exposures were calculated assuming a zero exposure for the time period which was not sampled.