HETA 95-0296-2547
AUTOMOTIVE CONTROLS CORPORATION
INDEPENDENCE, KANSAS

ANN M. KRAKE, M.S.
VERONICA HERRERA-MORENO, M.D.

PREFACE

The Hazard Evaluations and Technical Assistance Branch of NIOSH conducts field investigations of possible health hazards in the workplace. These investigations are conducted under the authority of Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6) which authorizes the Secretary of Health and Human Services, following a written request from any employer or authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

The Hazard Evaluations and Technical Assistance Branch also provides, upon request, medical, nursing, and industrial hygiene technical and consultative assistance (TA) to federal, state, and local agencies; labor; industry; and other groups or individuals to control occupational health hazards and to prevent related trauma and disease.

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NIOSH INVESTIGATORS:
ANN M. KRAKE, M.S.
VERONICA HERRERA-MORENO, M.D.

SUMMARY

On August 9-11, 1995, National Institute for Occupational Safety and Health **(NIOSH)** representatives conducted a health hazard evaluation **(HHE)** at the Automotive Controls Corporation **(ACC)** in Independence, Kansas, in response to a confidential request submitted by employees in the Hybrid Department. The request concerned potential employee exposure to solvents, including 1,1,1-trichloroethane **(1,1,1-TCE)** and dioxane, used to wash parts. Reported health problems included weakness, shakiness, blurred vision and eye irritation, inability to think or talk, depression, and respiratory and thyroid problems. Personal breathing zone **(PBZ)**, area, and process air sampling was conducted for 1,1,1-TCE and dioxane, and a qualitative ventilation assessment was made. In addition, confidential medical interviews were conducted with Hybrid Department and health unit employees, the Occupational Safety and Health Administration **(OSHA)** Log and Summary of Occupational Injuries and Illnesses (Form 200) was evaluated, and work practices and operations were observed.

Full-shift PBZ exposures for 1,1,1-TCE ranged from 69 to 198 parts per million **(ppm)**; all were below the OSHA and American Conference of Governmental Industrial Hygienists **(ACGIH)** exposure limit of 350 ppm. PBZ exposures for dioxane ranged from 1.5 to 13.3 ppm; all 21 samples exceeded the NIOSH Recommended Exposure Limit **(REL)** ceiling of 1 ppm. Short-term PBZ exposures during tray washing at the end of the shift were 422 ppm (1,1,1-TCE) and 11.8 ppm (dioxane), exceeding the NIOSH REL for dioxane and for 1,1,1-TCE, which is 350 ppm (15-minute ceiling). Full-shift area concentrations ranged from 92 to 1,517 ppm for 1,1,1-TCE and from 2.5 to 51 ppm for dioxane and were highest for both compounds inside the storage room at the wash sink and at each degreasing tank at approximate worker breathing zone level.

A review of the OSHA Form 200 did not show any trends of injury or illness among Hybrid Department employees. However, medical interviews with 44 of the 60 employees in the Hybrid Department, revealed that there were a variety of symptoms experienced by workers that were reportedly work-related, including headaches (57%), eye irritation (39%), neurological symptoms [dizziness, fatigue, or poor concentration] (34%), and throat irritation (18%).

All employee exposures to dioxane were a health hazard, and some exposures to 1,1,1-TCE were hazardous. Some workers' symptoms, such as dizziness, headaches, and mucous membrane irritation, were consistent with the solvent exposures measured. Solvent concentrations in the Hybrid Department should be reduced. Recommendations for preventing hazardous exposures are provided.

KEYWORDS: SIC 3694 (Ignition apparatus for internal combustion engines - manufacturing), 1,1,1-trichloroethane, dioxane, vapor degreasing tanks, headaches, eye irritation, throat irritation, neurological symptoms.

INTRODUCTION

On June 14, 1995, the National Institute for Occupational Safety and Health **(NIOSH)** received a confidential employee request for a health hazard evaluation **(HHE)** at the Automotive Controls Corporation **(ACC)** in Independence, Kansas. The request concerned potential employee exposure to solvents, including dioxane and 1,1,1-trichloroethane **(1,1,1-TCE)**, used to wash parts in the Hybrid Department. Reported health problems included weakness, shakiness, blurred vision and eye irritation, inability to think or talk, depression, and respiratory and thyroid problems.

During August 9-11, 1995, a team of NIOSH investigators conducted a site visit at ACC that included an opening conference, a walk-through inspection of the facility, confidential medical interviews, and air sampling for solvents used in the Hybrid Department.

BACKGROUND

ACC began manufacturing voltage regulators in 1964 and has since expanded to include the production of electronic ignition systems for automobile and marine engines. ACC currently employs just over 1,000 people.

The Hybrid Department is divided into three areas that produce ignitions, regulators, and the distributor-less ignition system, or DIS. There are 60 employees in the Hybrid Department, including 51 on first shift and 9 who work second shift.

The HHE request primarily concerned the use of three vapor degreasing tanks in the department that are filled with a mixture of 1,1,1-TCE and dioxane, called Chlorothene® SM Solvent. The tanks are used throughout the shift for cleaning trays of parts. Employees using the tanks and others in the department began experiencing weakness, shakiness, blurred vision, depression, and respiratory and eye irritation, approximately two years ago. Several employees also noted thyroid dysfunction and cancer, which they attributed to workplace solvent exposure. Employees expressed additional concerns about exposures during the end-of-shift tray-washing, which takes place inside a storage room (approximately 50 square feet in size) each afternoon. Trays are washed in a sink filled with Chlorothene® for approximately 15 minutes, with the room's door usually closed to reduce migration of solvent fumes to the rest of the department.

During the NIOSH site visit, employees in the Hybrid Department who worked with chemicals either in addition to or other than Chlorothene® expressed their concerns regarding potential exposures to an experimental solder paste, aluminum oxide powder, and adhesives. NIOSH investigators interviewed these employees and observed the operations, and employee concerns and recommendations for addressing these concerns are included in this report.

EVALUATION CRITERIA

General Guidelines

To evaluate occupational exposures to potentially toxic agents, NIOSH investigators use NIOSH Criteria Documents and recommended exposure limits **(RELs)**,[1] the American Conference of Governmental Industrial Hygienists' **(ACGIH)** Threshold Limit Values **(TLVs)**,[2] and the Occupational Safety and Health Administration **(OSHA)** permissible exposure limits **(PELs)**.[3] These criteria are designed to provide exposure levels to which most workers may be exposed over a working lifetime without experiencing significant adverse health effects. However, because of variations in individual susceptibility, a small percentage of workers may experience occupational illness even if exposures are maintained below these limits. The evaluation criteria do not take into account individual hypersensitivity, pre-existing medical conditions, or possible interactions with other workplace agents, medications being taken by the worker, or other environmental conditions.

The evaluation criteria for chemical substances are usually based on personal breathing zone **(PBZ)** exposures to the airborne substance over an entire 8- to 10-hour workday, expressed as a time-weighted average **(TWA)**. Personal exposures are usually expressed in units of parts per million **(ppm)**, milligrams per cubic meter **(mg/m^3)**, or micrograms per cubic meter **($\mu g/m^3$)**. To supplement the 8-hr TWA where there are recognized adverse health effects from short-term exposures, some substances have a short-term exposure limit **(STEL)** for 15-minute peak periods, or a ceiling limit (**C**), which is not to be exceeded at any time. Additionally, some chemicals have a "skin" notation to indicate that the substance may be absorbed through direct contact of the material with the skin and mucous membranes.

NIOSH RELs and ACGIH TLVs are based primarily on concerns related to the prevention of occupational disease. The OSHA PELs are legal standards in the U.S. In developing PELs, OSHA is required to consider the economic and technologic feasibility of controlling exposures in various industries, public notice and comment, and judicial review, in addition to prevention of occupational diseases and injury. NIOSH investigators recommend that exposures be reduced below the most protective of these criteria.

The OSHA PELs, as found in Tables Z-1 through Z-3 of the OSHA General Industry Air Contaminants Standard (29 CFR 1910.1000), that were effective on July 1, 1993, and which are currently enforced by OSHA are listed here unless otherwise noted. In 1992 a federal appeals court vacated the more protective PELs set by OSHA in 1989 for 212 substances, moving them back to PELs established in 1991 (*AFL-CIO v. OSHA*, 965 F.2d 962 [11th Cir., 1992]). The court also vacated new PELs for 164 substances not previously regulated.

Methyl Chloroform (1,1,1-Trichloroethane)[4]

1,1,1-TCE is a clear, non-flammable liquid used as a solvent and cleaning agent. Skin absorption can occur, but is not considered a primary exposure route. 1,1,1-TCE is an anesthetic (central nervous system depressant), and like many organic solvents will defat the skin, causing dryness, redness, and scaling of exposed areas. This solvent is poorly metabolized once in the body and is excreted unchanged in the expired air. Deaths due to anesthesia and cardiac sensitization have been observed in industrial exposures involving poorly ventilated or confined areas. In some studies involving human exposures, anesthetic effects, including lightheadedness, incoordination, and impaired equilibrium, were observed at concentrations approaching 500 ppm. In a long-term study of workers exposed to 1,1,1-TCE (at concentrations which in some situations exceeded 200 ppm), no adverse health effects related to exposure were observed. 1,1,1-TCE has not been proven to have carcinogenic or mutagenic effects.

Dioxane [5]

Dioxane is a flammable liquid used as both a solvent and a stabilizer in chlorinated solvents. Primary routes of exposure include skin absorption and inhalation. It is an irritant to the eyes and mucous membranes, and on prolonged heavy exposure it is toxic to the liver and the kidneys. The International Agency for Research on Cancer **(IARC)** has determined that there is sufficient evidence of carcinogenicity to animals and inadequate evidence for humans.

NIOSH has determined that dioxane is an animal (liver, kidney, and nasal) carcinogen and therefore a potential human carcinogen, and has established an REL of 1 ppm.[6] OSHA's current PEL, which is 100 ppm, does not take into consideration the potential carcinogenicity of dioxane. The ACGIH TLV for dioxane is currently 25 ppm, but changes are proposed which include the addition of a skin designation and an A3 carcinogen designation.[7] (ACGIH uses a qualitative ratings system for potential carcinogens, including A5—not suspected as a human carcinogen; A4—not classifiable as a human carcinogen; A3—animal carcinogen; A2—suspected human carcinogen; and A1—confirmed human carcinogen.)

ACC is in the process of testing a prototype degreaser which would replace their current vapor degreasing tanks and solvent mixture, reportedly within a year. The prototype is a fully enclosed and automated system, which uses a cyclohexane and isopropyl alcohol mixture instead of the Chlorothene® solvent.

EVALUATION METHODS

Environmental

Air samples were collected and analyzed for 1,1,1-TCE and dioxane, which make up the highest percentage of ingredients, 96.5% and 2.5%, respectively, in the chemical listed on the HHE request, Chlorothene® SM Solvent. All personal and area air sampling was conducted using Gilian® Model LFS 113 DC battery-operated low-flow sampling pumps, operating at a calibrated flow rate of 20 cubic centimeters per minute **(cc/min)**, attached with flexible tubing to solid sorbent charcoal tubes (SKC® 100/50 milligram). The samples were analyzed by gas chromatography according to NIOSH Methods 1003 (halogenated hydrocarbons)[8] and 1602 (dioxane).[9] Each sorbent tube was desorbed in 1 milliliter of carbon disulfide, and analysis of each compound was conducted on a gas chromatograph with a flame ionization detector.

Workers representative of each job category and/or work station throughout the Hybrid Department were sampled; these included 18 assemblers, 1 stock handler, 1 repair operator, and 1 group leader. Nine area samples were collected by placing the sampling pumps throughout the department, including near the vapor degreasing tanks. Three process samples were obtained by placing the charcoal tubes inside the vapor degreasing tanks. A PBZ 20-minute sample was collected as one employee, an assembler, washed trays in the Chlorothene® mixture inside the storage room, with the door open, towards the end of the work shift.

Medical

The medical portion of this HHE included a review of OSHA Log and Summary of Injuries and Illnesses (Form 200) for 1990-1994, interviews with the employees from both shifts, and an interview with the plant medical staff. Voluntary, confidential interviews were conducted with 44 of the 60 employees (73%) in the Hybrid Department. Information obtained from the interviewed employees included work history, medical history, symptoms experienced, and employees' perception of the workplace conditions. The NIOSH medical officer also interviewed the head nurse of the plant medical department regarding Hybrid Department employee medical problems.

RESULTS

Environmental

The results for PBZ air sampling are shown in Table 1. Full-shift PBZ exposures ranged from 69 to 198 ppm for 1,1,1-TCE, and from 1.5 to 13.3 ppm for dioxane. All full-shift 1,1,1-TCE exposures were below the OSHA and ACGIH exposure limit; however, three personal exposures were greater than 50% of the limit. The exposures for dioxane were also below the OSHA criterion, but all of them exceeded the NIOSH REL (ceiling) of 1 ppm. During tray washing in

the storage room, short-term PBZ exposures to 1,1,1-TCE (422 ppm) and dioxane (11.8 ppm) exceeded the NIOSH REL for each compound and approached the ACGIH STEL of 450 ppm for 1,1,1-TCE.

Area and process sample results are shown in Table 2. Full-shift area concentrations ranged from 92 to 1,517 ppm for 1,1,1-TCE and from 2.5 to 51 ppm for dioxane and were highest inside the storage room at the wash sink for both compounds. Concentrations were next highest for samples taken at each degreasing tank at approximate worker breathing zone levels and ranged from 234 to 405 ppm for 1,1,1-TCE and from 6.1 to 8.7 ppm for dioxane. Area and process samples cannot always be interpreted using occupational exposure criteria, but substantial area concentrations were measured at the northwest ultrasonic degreaser (405 ppm 1,1,1-TCE and 7.6 ppm dioxane) and the junction coat degreaser (375 ppm 1,1,1-TCE and 8.7 ppm dioxane). The degreasing tanks currently in place are equipped with an interior cooling system which re-condenses the heated solvent vapors, creating a vapor barrier which prevents the escape of vapors from the tank. Each tank is also equipped with local exhaust ventilation **(LEV)**, a slot 1-2" in height that runs the length of the back of the tank and is designed to capture the stray solvent vapors created when trays of parts are lifted out of the tank ("solvent dragout") by the employee. The LEV associated with each of the tanks did not appear to be effectively operating during the NIOSH visit, as solvent vapors from these tanks could be seen escaping into the environment, even while no trays were being lifted in or out. According to the tank manufacturers, the LEV is supposed to operate right at 100 cubic feet per minute **(cfm)** per square surface foot **(ft^2)** of the degreaser opening. Because the tank surface openings are approximately 2½ ft^2, the LEV should be operating at about 250 cfm. However, the northeast and northwest tanks appeared to be operating below that level, and the junction coat degreaser LEV, according to management, was operating above it at 655 cfm. According to the manufacturer, operating the LEV for each tank above 100 cfm per ft^2 of surface opening would create less rather than more protection by causing a disruption of the vapor barrier inside the tank, allowing solvent vapors to leak into the surrounding environment.

All three of the degreasing tanks are equipped with lids, which were not observed to be used during the NIOSH site visit. According to the tank manufacturers, this is correct usage of the tanks, as the lids should only be in place when the tanks are not in use. This is because removal of the lids may cause solvent dragout.

Employees using the tanks relied on a single wooden step to enable them to reach into the tanks. The height of the step put most of the workers' breathing zones where the trays of parts are removed (with solvent still evaporating) from the tank. Also, most of the employees were quickly removing the trays directly from the tank, without leaving them to dry first. When questioned about this practice, most employees reported that with a quota to fill, they could not

afford to let the parts dry completely prior to removing the trays, and instead let them air-dry as they returned to their work station. According to the tank manufacturers, the trays are supposed to be lifted into the freeboard area to drain prior to being lifted out of the tank, and once dried, they should be lifted out at a rate no greater than 10 feet per second.

At the end of the shift, one employee usually washes all the screens and trays in a sink filled with Chlorothene® inside the storage room. The sink is equipped with an LEV duct, but the duct is located only on the left side of the sink and faces towards the room instead of the sink, where the work is being completed. The storage room itself has no general exhaust ventilation, but is equipped with a supply air duct. Employees reported that because co-workers complained of the smell during this task, the employee washing the trays was often required to close the door.

Medical

Of the 44 employees interviewed, 43 were female. The average age was 43 years, with a range of 22 to 69 years. The average years worked at ACC was 12 years, with a range of 1 to 24 years, and the average years worked in the Hybrid Department was 9 years, with a range of 1 to 22 years. Review of the OSHA Form 200 did not show any noteworthy patterns or trends of injury or illness for employees of the Hybrid Department. Employee interviews revealed that there were a variety of symptoms that employees attributed to their work environment (work-related). The main symptom experienced by 25 workers (57%) was headache. Of the 25 employees reporting headaches, 13 experienced work-related headaches at least weekly. Other work-related symptoms included eye irritation (39%), neurological complaints [dizziness, fatigue, and/or poor concentration] (34%), and throat irritation (18%).

In addition, 7 workers in the Hybrid Department (15%) had been diagnosed with thyroid disorders and were concerned about the relationship of these disorders with exposure to chemicals in the workplace. Neither 1,1,1-TCE nor dioxane are known to be associated with thyroid disorders; occupational exposures that are associated with thyroid disorders include iodine, polyhalogenated biphenyls, organochlorine pesticides, lithium and thyroidal irradiation.[10] Also, recent research indicates that up to 17% of the general female population has a thyroid disorder,[11, 12] which indicates that women working in the Hybrid Department are experiencing a lower prevelance of thyroid disorders when compared to the general population.

Most of the employees (65%) were concerned about being exposed to 1,1,1-TCE from the degreasing tanks; however, they stated that the safety conditions have improved in the last five years.

Twenty-three employees (52%) reported communication problems between employees and management, especially within the past two years. Other issues raised include inconsistencies with rule-making and perceptions of management favoritism towards certain workers.

Other Exposure Concerns

In response to employee requests during the NIOSH site visit, we looked at three additional chemical exposure concerns in the Hybrid Department that were not included on the HHE request. No air sampling was conducted, but employees were interviewed and work practices were observed. Employees on the heat sink line (manual build) complained of headaches, nausea, and dizziness while using a test-solder paste which contains tin, lead, silver, rosin, a-terpineol, and organic thixatrope (a gel that becomes fluid when shaken) mixture. According to the manufacturer's MSDS, inhalation or ingestion of the solder paste may cause nausea, vomiting, headaches, joint and muscle pain, dermatitis, and eye irritation. Employees reported that they didn't begin to experience these symptoms until they began using the new (test) solder paste a few months ago. Most of the work stations were equipped with LEV, however, visible fumes were apparent in the employees' breathing zones. Employees mentioned that their immediate work environment and health symptoms usually improve after the LEV is cleaned, but they reported that cleaning was very infrequent.

Several employees reported that when working with epoxy resin adhesives, they develop a rash on exposed skin surfaces. The main ingredient in the resins, Conapoxy® AD-3 Black Adhesive and AD-10 Resin, is diglycidyl ether bisphenol-A **(DGEBA)** resin, (40-70%), which, according to several studies, can cause severe irritation of the eyes, respiratory tract, and skin, as well as allergic contact dermatitis (sensitization), from even a single accidental occupational exposure.[13] According to the NIOSH Registry of Toxic Effects of Chemical Substances **(RTECS)** criteria, DGBEA is also a tumorigenic and carcinogenic agent.

Employees operating the trimmers, which use 25 micron aluminum oxide powder, are reportedly experiencing respiratory irritation from the powdered residual, which they claim gets on their lips and into their noses. Use of the powder for welding and grinding may produce respirable dust or fumes, less than 10 microns in size.

DISCUSSION AND CONCLUSIONS

The PBZ air sampling results showed that all dioxane exposures and several 1,1,1-TCE exposures were a health hazard. PBZ exposures during tray-washing activities in the storage room exceeded the NIOSH REL for both chemicals and approached the ACGIH STEL for 1,1,1-TCE and therefore were a health hazard: It is likely that concentrations are even higher inside the room when the door is closed. Some of the symptoms experienced by the Hybrid Department employees, such as headaches, eye and throat irritation, and neurological symptoms, could be caused by occupational exposures to 1,1,1-TCE and dioxane. Exposures such as those found by the NIOSH investigators indicate the need for progressive action on the part of management in order to understand the reasons for the levels and to begin reducing them. The

exposures and air concentrations detected during the NIOSH visit could be related to inefficient LEV associated with each of the degreasing tanks. Also, several work practices and the work quota could have contributed to the results, including tank access (via the single step) and removal of the trays from the tank without first allowing them to dry.

RECOMMENDATIONS

The following recommendations are provided to help prevent hazardous exposures to solvents and other chemicals in the Hybrid Department:

1. ACC should continue with the testing and use of the automated vapor degreaser prototype, which is a completely enclosed tank, and uses chemicals potentially less harmful to employees than 1,1,1-TCE and dioxane.

2. To reduce exposures to 1,1,1-TCE and dioxane in the Hybrid Department, the LEV systems associated with the three vapor degreasing tanks and the wash sink in the storage room should be evaluated and adjusted, according to the manufacturer's specifications, to provide more effective capture of the Chlorothene® vapors. Based on observation, LEV on the heat sink line should be adjusted to more efficiently capture the solder paste fumes. The systems should also be regularly cleaned and maintained for optimum performance.

3. During tray-washing activities, the door to the storage room should remain open. General ventilation should also be provided to the storage room; fresh air should be supplied and exhausted directly outdoors, without being recirculated into the rest of the department. The heating, ventilation, and air conditioning **(HVAC)** system should be regularly cleaned and maintained, as well.

4. Employees should follow the manufacturer's directions for operation of the degreasing tanks by allowing the trays to drain and dry completely in the freeboard area prior to their removal. The trays should be removed from the tanks at no greater than 10 feet per second, and if possible, held at arm's length to avoid breathing any escaping solvent vapors.

5. ACC management should consider either reducing or abolishing the work quota in the Hybrid Department in order to create a work environment more conducive to safe and healthy work practices.

6. For employees who have direct contact with solvents, the following glove materials are recommended for use with both 1,1,1-TCE and dioxane: Polyvinyl alcohol **(PVAL)** gloves have shown resistance to chemical permeation for greater than 8 hours of continuous use, although dioxane will cause some degradation of the material due to chemical absorption in that time. Both Teflon® **(PTFE)** and polyethylene/ethylene vinyl alcohol **(PE/EVAL)** have shown resistance to chemical permeation for over 4 hours of continuous use, with no dioxane degradation.[14]

7. The solder paste and adhesives currently being used should be substituted for suitable non-toxic versions. If this is not possible, employees working with the adhesives (DGBEA) should wear the following protective gear: Long-sleeve work shirts, aprons, safety glasses, and either PVAL or PE/EVAL gloves - only these types of gloves have shown resistance to chemical permeation for greater than 4 hours of continuous use. No other types are recommended because of permeation and/or degradation in under an hour.[15] For solder paste users, the manufacturer recommends that safety glasses and "impervious rubber gloves" be worn when using the solder pastes. No permeation data could be located for the solvent ingredient in the solder paste, alpha-terpineol, for the purpose of selecting chemical protective clothing. However, there are permeation data for cyclohexanol, phenol, and creosol(s), which have chemical similarities to alpha-terpineol. Permeation data from these three similar chemicals show that butyl rubber, which has shown resistance to chemical permeation for over 8 hours of continuous use, is the most effective elastomeric polymer of those polymers studied.[16]

8. It is very important for every employee in the Hybrid Department to remove their overcoat and wash their face and hands with soap and water prior to eating, drinking, or smoking, because otherwise many of the chemicals they work with may be hazardous if ingested.

9. Employee complaints regarding the trimmer should be evaluated, and exposures to total and respirable dust and aluminum oxide should be determined.

10. ACC should continue to utilize joint labor/management safety and health teams to improve communication between employees and management regarding working conditions. These teams could be used to direct future investigations to those areas or processes where employee health complaints or illnesses are reported.

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AUTHORSHIP AND ACKNOWLEDGEMENTS

Report Prepared By:

Ann M. Krake, M.S.
Industrial Hygienist
Industrial Hygiene Section

Veronica Herrera-Moreno, M.D.
Medical Officer
Medical Section

Field Assistance:

Deborah B. Friedman, B.A.
Industrial Hygienist

Michael MacDonald, D.O.
Medical Officer

Boris D. Lushniak, M.D., M.P.H.
Medical Officer

Originating Office:

Hazard Evaluations and Technical Assistance Branch
Division of Surveillance, Hazard Evaluations and Field Studies

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1. Confidential requestors
2. Safety Department Supervisor, ACC
3. OSHA Region VII

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

TABLE 1
HETA 95-0296-2547
Personal Breathing Zone Sampling Results
Automotive Controls Corporation
August 10, 1995

Assemblers	Sampling Time (minutes)	1,1,1-Trichloroethane TWA (ppm)	Dioxane TWA (ppm)
Build-up assembler	454	91	2.7
Die bonder	433	192	4.8
Gluer/staker	427	110	3.6
Gluer/solderer	431	81	6.1
Gluer	367	78	2.0
Gold ball bonder	446	142	4.4
Heat sink line	450	198	5.9
Heavy-wide bonding	452	118	3.1
HEI gluer	444	101	2.7
Junction coat cleaner	436	160	4.8
Parallel gap welder	446	89	2.4
Seal guard, test	415	82	2.1
Soldering, line 4	460	100	2.5
Relief worker	184	69	1.5
Substrate build-up	429	153	3.6
Substrate gluer	449	132	13.3
Test operator	447	82	2.2
Trim (ignition), test	458	116	3.0
MISCELLANEOUS			
Material handler	489	178	4.3
Repair operator	441	135	3.5
Group leader	435	110	2.9
Tray washing (STEL)	20	422	11.8
NIOSH REL - TWA		350 C	1C[†], Ca
OSHA PEL - TWA		350*	100[‡], Sk
ACGIH TLV - TWA		350[§]	(25)
Minimum detectable concentration (MDC)		0.02	0.03
Minimum quantifiable concentration (MQC)		0.07	0.1

C = ceiling limit for a 15-minute period. C[†] = ceiling limit for a 30-minute period.
Sk = skin designation. [§] = STEL/ceiling limit is 450 ppm.
Ca = potential for cancer; liver and kidney effects; liver, lung, and nasal cavity tumors in animals.
* = the vacated 1989 OSHA Standard also lists a 15-minute STEL of 450 ppm.
[‡] = denotes the enforceable PEL; the vacated OSHA 1989 Standard limit is 25 ppm.
( ) = denotes intended value change to include a skin and an animal carcinogen designation.

TABLE 2
HETA 95-0296-2547
Process and Area Sampling Results
Automotive Controls Corporation
August 10, 1995

Hybrid Department Area Samples	1,1,1-Trichloroethane TWA (ppm)		Dioxane TWA (ppm)	
Junction coat degreaser	375		7.6	
Vapor degreaser (northwest)	234		6.1	
Vapor degreaser (northeast)	405		8.7	
Pick/Place table top (near manual build)	185		4.5	
Heat sink area table top	207		5.2	
Wash sink in storage room	1,517		51	
Outside storage room on freezer top	121		3.3	
West side of Hybrid near ovens	92		2.5	
East side, just south of vapor degreasers on table	170		4.4	
Hybrid Department Process Samples				
Junction Coat Tank	2,143		259	
Ultrasonic Tank (northwest)	2,370		182	
Ultrasonic Tank (northeast)	2,218		170	
NIOSH REL - TWA	350 C		1C[†], Ca	
OSHA PEL - TWA	350*		100[‡], Sk	
ACGIH TLV - TWA	350[§]		(25)	
	Process	**Area**	**Process**	**Area**
Minimum detectable concentration (MDC)	0.03	0.02	0.05	0.03
Minimum quantifiable concentration (MQC)	0.12	0.07	0.16	0.1

C = ceiling limit for a 15-minute period.
C[†] = ceiling limit for a 30-minute period.
Ca = potential for cancer; liver and kidney effects; liver, lung, and nasal cavity tumors in animals.
* = the vacated 1989 OSHA Standard also lists a 15-minute STEL of 450 ppm.
[‡] = denotes the enforceable PEL; the vacated OSHA 1989 Standard limit is 25 ppm.
Sk = skin designation.
[§] = STEL/ceiling limit is 450 ppm.
( ) = denotes intended value change to include a skin and an animal carcinogen designation.