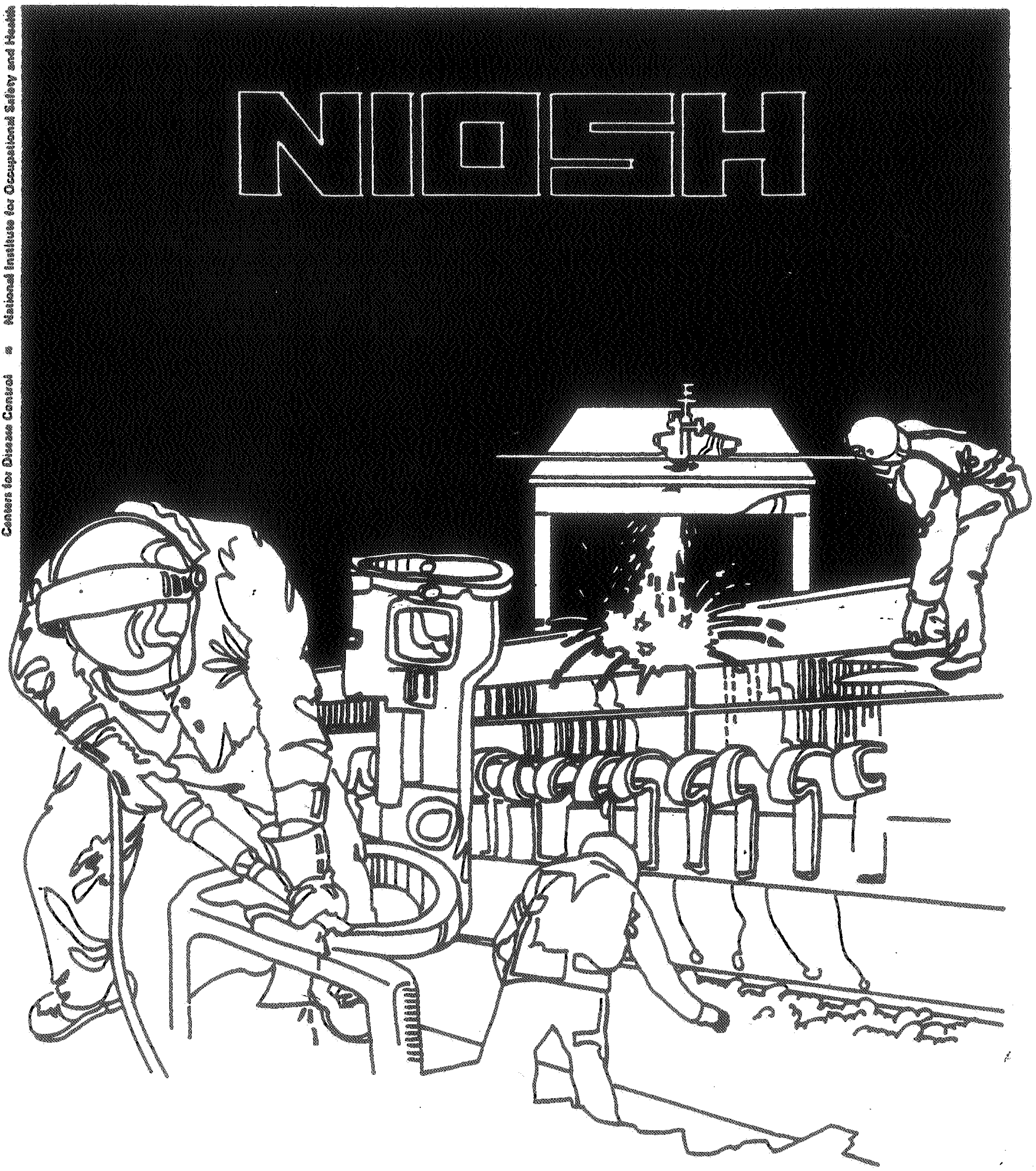
U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES • Public Health Service
Centers for Disease Control • National Institute for Occupational Safety and Health



Health Hazard Evaluation Report

HETA 85-083-1705
SUMMIT FINISHING COMPANY, INC.
MOORESVILLE, INDIANA

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.

HETA 85-083-1705
JUNE 1986
SUMMIT FINISHING COMPANY, INC.
MOORESVILLE, INDIANA

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I. SUMMARY

On November 26, 1984, the National Institute for Occupational Safety and Health (NIOSH) was requested to evaluate employee exposures to chemicals used in electroplating operations at Summit Finishing Company, Inc., Mooresville, Indiana.

In January 1985, NIOSH investigators conducted an initial survey visit to the facility during which confidential employee questionnaires were administered. An environmental survey was conducted in June 1985, during which personal and area air samples were collected for inorganic acids, cyanides, trace metals, formaldehyde and perchloroethylene.

Of the 20 employees who completed the questionnaires, 17 reported episodes of acute upper respiratory irritation when working in the vicinity of the plating tanks, with 12 reporting instances of nosebleeds.

The results of personal samples collected for inorganic acids revealed the presence of sulfuric acid in only one of eight samples at a time-weighted average (TWA) concentration of 0.17 milligrams sulfuric acid per cubic meter of air (mg/M^3). This value is below the NIOSH recommended exposure limit (REL) and the Occupational Safety and Health Administration's (OSHA) Permissible Exposure Limit (PEL) of 1 mg/M^3 on a TWA basis. Concentrations of nitric and phosphoric acid in these samples were found to be below the limit of detection of 4 micrograms (ug)/sample. Concentrations of hydrogen cyanide in ten general area air samples ranged from 0.08 to 1.33 mg/M^3, with a mean of 0.50 mg/M^3 (NIOSH REL 5 mg/M^3 as a 10-minute ceiling; OSHA PEL 11 mg/M^3, 8-hour TWA). No particulate cyanide was detected above media background levels (8.8 ug/filter) in these samples. Personal samples collected for trace metals were below their respective evaluation criteria, with TWA concentrations of 0.009 and 0.013 mg/M^3 of copper in two samples (OSHA PEL 1 mg/M^3), and a TWA concentration of 0.002 mg/M^3 of lead in one sample (OSHA PEL 0.05 mg/M^3). Concentrations of formaldehyde were below the limit of detection of 2 ug/sample in two area samples. TWA concentrations of 82.1 and 84.2 parts of perchloroethylene per million parts of air (ppm) were detected in two long-term personal samples, both of which exceeded the NIOSH REL of 50 ppm perchloroethylene, but were below the OSHA standard of 100 ppm, as a TWA. Concentrations of perchloroethylene in three short-term personal samples were 82.4, 119.9, and 184.8 ppm, two of which exceeded the NIOSH recommended ceiling of 100 ppm, but were below the OSHA ceiling of 200 ppm.

On the basis of the data collected during this survey, it has been determined that a potential health hazard existed from airborne exposures to perchloroethylene. In addition, a significant number of employees reported episodes of mucous membrane irritation which was attributed to exposures to substances used in the electroplating processes. Recommendations for engineering controls, personal protective equipment and work practices, designed to reduce employee exposures, are contained in Section VIII of this report.

KEY WORDS: SIC 3471, Electroplating, Metal Cleaning, Perchloroethylene, Metals, Cyanide, Inorganic Acids, Irritation, Nosebleeds.

II. INTRODUCTION

On November 26, 1984, NIOSH received a request from an authorized representative of the United Steelworkers of America - District 30, for a health hazard evaluation at the Summit Finishing Company, Inc., Mooresville, Indiana. The requestor was concerned with employee exposures to chemicals used in the electroplating operations.

On January 23, 1985, NIOSH investigators conducted an initial survey at the facility. An opening conference was held with representatives of plant management and the local union during which background information was obtained which related to the basis for the request and the nature of plant operations. Following this meeting, a walk-through survey was conducted in the production area of the plant. Confidential interviews were administered to 18 employees working on the plant's first shift, and the names and addresses of 13 employees working on the second and third shifts were obtained so that medical questionnaires could be sent to them by mail.

Following this survey, preliminary recommendations regarding the design of local exhaust ventilation systems were provided to the company by letter on February 4, 1985. Since the company was in the process of modifying the existing local exhaust ventilation system, tentative plans were made for a NIOSH environmental survey to coincide with the completion of these modifications in order to assess their effectiveness. However, due to delays in implementing these changes, it was decided to conduct an environmental survey on June 19 and 20, 1985, prior to the completion of these modifications. The results of the environmental survey, along with pertinent recommendations, were transmitted to the company and the requestor by letter on November 4, 1985.

III. BACKGROUND

A. Plant History and Workforce

Summit Finishing Company, Inc., Mooresville, Indiana, provides precision electroplating and steel protection for the automotive, electronics, and housing industries. The company has been at its present location since 1973; however, the building it presently occupies was reported to have been used for electroplating by previous occupants. At the time of the survey, there were 67 company employees, with approximately 26 of these involved directly in the production operations. The company operates three work shifts per day, with the majority of the workforce employed on the first shift.

B. General Discussion of Electroplating Operations

1. Metal Pretreatment

Prior to electroplating, a thorough cleaning of the surface of the workpiece or metal stock is required in order to ensure the proper adherence of the plating metal to the base metal. Commonly used pretreatment processes include solvent, acid, and alkaline cleaning.

The process of solvent cleaning or vapor degreasing utilizes an organic solvent to remove grease, lubricants, and soluble soils. Acid solutions are used to remove layers of metal oxides, with the process of removing thick layers of oxide being referred to as pickling, and the process of removing thin oxide layers referred to as bright dipping. Alkaline solutions are also used to remove oils and solid soils from workpiece surfaces by way of their detergent action. Certain alkaline cleaners (electrolytic types) can also be agitated by gas bubbles to enhance their effectiveness. Tanks or baths containing the pretreatment solutions are located at the beginning of each plating line, with the particular arrangement and types of substances used based on the particular needs of the metal to be plated. A water rinse tank is usually located between each of these tanks.[1]

2. Electroplating

Electroplating is an electrochemical process by which a metallic layer is deposited on a base metal through the action of an electrical current. Although different methods of electroplating exist, the process usually involves the use of an anode (composed of the metal to be plated), a cathode (composed of the part to be plated), and an electrolytic solution (usually containing metallic salts of the metal to be plated and acids, alkaline materials and other additives to impart stability or functional properties to the solution, e.g. brighteners). The application of an electrical current, usually from a low voltage DC power supply, causes a migration of the metal ions from the electrolyte solution to the cathode where they are deposited on the base metal. Metal from the anode then dissolves into the solution to replace the metal ions as they are depleted from the electrolyte.[1,2]

Although practically any metal can be used to coat or plate another metal, the following general discussion is provided for the major plating processes encountered in this survey.

Copper Plating - Two types of baths are generally used in copper plating, cyanide and acid-types. These baths are further categorized according to concentration, with a "strike" bath usually being a more dilute cyanide solution containing materials such as copper cyanide complex, sodium or potassium cyanide, sodium hydroxide, and sodium carbonate. Strike baths are generally operated at a lower temperature than the stronger or more concentrated cyanide-type or acid-type baths. Acid copper baths usually contain copper sulfate and sulfuric acid.[1]

Silver Plating - Cyanide-type solutions are generally the only solutions used for silver plating. Like copper, silver is usually plated in successive layers, utilizing a low concentration strike solution which may contain potassium silver cyanide, potassium copper cyanide, and potassium carbonate. The material to be plated is then passed through solutions of successively stronger concentrations to apply thicker layers of silver plate.[1]

Tin and Tin Alloy Plating - Solutions used to plate tin and tin alloys include sulfate and fluoborate-type baths. The composition of sulfate-type baths often includes both stannous sulfate and sulfuric acid. Fluoborate-type baths generally include stannous fluoborate and fluoboric acid. When tin or tin alloys are applied to nonferrous metals, a copper undercoat is often required.[1]

C. Description of Plant Operations

The major types of plating operations carried out at Summit Finishing Company were silver, copper, tin, and tin-lead. However, in addition to these, a number of other processes were carried out on a limited basis. A complete listing of the various metal pretreatment and electroplating processes which were in place at the time of the environmental survey, along with their specific locations, are provided in Table 1. Some of these operations, including the chromic acid dip tank and two tanks containing nickel solutions, were not in use at the time of the survey.

Electroplating operations at the facility are carried out at nine separate plating lines. Line numbers one through five are continuous plating lines which are used to plate "continuous" stock, such as large rolls of strip, stampings, or wire. The major job function of the employees working on these lines is to maintain the flow of materials going into and out of the line. Employees are generally located at the "head end" of the lines to load the stock, and at the "tail end" of the lines to check the finished product and ensure the proper winding of the material back onto spools. The employees also periodically enter the tank area of the line in order to check the operating conditions of the tanks and maintain the solutions. On occasion, individual lines are "rebuilt" to accommodate new products and plating solutions, a process which often requires the employees to work in the proximity of operational plating lines.

The remaining plating lines (six through nine) are rack and barrel type which are used for plating individual or batches of parts. Employees working at these lines are responsible for moving the hangers or racks containing the parts through a series of tanks containing the pretreatment and plating solutions. The nature of these operations brings the operators into close proximity to the plating tanks.

One additional production-related operation being conducted in the rear of the plating area was a metal post-treatment process referred to as "reflow". This operation involved one employee, the reflow operator, who placed batches of plated parts into a container of heated oil. Following this, the parts were dipped into a tank of perchloroethylene to remove the residual oil.

The majority of the metal pretreatment and electroplating tanks were supplied with local exhaust ventilation, which was in the process of being modified at the time of the survey. Many of the tanks were also equipped with covers which could be opened or closed as necessary. Personal protective equipment utilized by the employees included safety shoes, safety glasses and cloth work gloves; with goggles, face shields, aprons, rubber gloves, and boots reportedly available for specific activities. In addition, both disposable dust and combination cartridge type respirators were also reported to be made available to the employees.

IV. MATERIALS AND METHODS

During the initial survey of January 23, 1985, information was collected regarding general plant operations, the specific types of electroplating processes being conducted, the substances used, and the types of exposure controls which were in place. The company's 1984 "Log and Summary of Occupational Injuries and Illness" (OSHA Form No. 200) was reviewed for the presence of work-related health problems. In addition, confidential interviews were conducted with all of the 18 production employees working on the plant's first shift. A questionnaire was used in order to obtain information regarding the employees' work history and the presence of any general or work related health problems. Copies of this questionnaire were also mailed to the 13 employees working on the 2nd and 3rd shifts.

On June 19 & 20, 1985, an environmental survey was conducted during which personal samples (obtained near the employee's breathing zone) and general area samples (obtained in the immediate vicinity of the plating tanks) were collected to assess the airborne concentrations of the various contaminants. The selection of substances to be included in the sampling protocol was based on a consideration of several factors; including; the types of contaminants which could be released from the various plating processes (refer to Table 1), the potential toxicity of these materials, the results of the employee interviews, and general observations of the presence and effectiveness of existing local exhaust ventilation. The types of contaminants selected for evaluation in this survey, along with a brief discussion of the specific rationale for their inclusion in the sampling protocol, are provided below.

1) Acid mists - Airborne exposures to acid mists were evaluated due to the extensive use of acids in the various pretreatment and electroplating solutions, and the number of workers attributing symptoms of acute irritation to exposure to these substances. Since a number of different acids were present in the various metal pretreatment and plating baths, a sampling methodology was used which allowed for the analysis of multiple acid components on each sample.

2) Cyanides - Due to their high acute toxicity and widespread use in electroplating operations, samples were collected for airborne cyanides. These included both cyanide salt mists and hydrogen cyanide, both of which can be generated from electroplating processes.

3) Metals - Since a significant portion of the mist generated above electroplating baths generally consists of metal salts composed of the plating metal and the anionic constituent of the bath,[2] the airborne concentrations of these substances were evaluated. The sampling methodology which was used allowed for the analysis of multiple metals on each sample.

4) Organic Solvents - Visual observations made during the walk-through survey indicated a lack of local exhaust ventilation at the degreasing tank used by the reflow operator. Samples were, therefore, collected for perchloroethylene, the solvent used at this operation.

5) Miscellaneous - Due to concern with the potential carcinogenicity of formaldehyde, samples were collected to determine the airborne concentrations of this substance which was present as an additive in some of the tin/lead plating baths.

A complete listing of the sampling media, flow rates, analytical procedures and their limits of detection is provided in Table 2. Specific information regarding the locations and durations of sample collection is provided in Tables 3 through 7.

In addition to the collection of environmental samples, smoke tubes were used to qualitatively assess the effectiveness of the local exhaust ventilation system at the metal pretreatment and electroplating tanks.

V. EVALUATION CRITERIA

As a guide to the evaluation of the hazards 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 preexisting 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 becomes available.

The primary sources of environmental evaluation criteria for the workplace are: 1) NIOSH Criteria Documents and recommendations, 2) the American Conference of Governmental Industrial Hygienists' (ACGIH) Threshold Limit Values (TLV's), and 3) the U.S. Department of Labor/Occupational Safety and Health Administration (OSHA) occupational health standards. Often, the NIOSH recommendations and ACGIH TLV's are lower than the corresponding OSHA standards. Both NIOSH recommendations and ACGIH TLV's usually are based on more recent information than are the OSHA standards. The OSHA standards also may be required to take into account the feasibility of controlling exposures in various industries where the agents are used; the NIOSH-recommended standards, by contrast, are based primarily on concerns relating to the prevention of occupational disease. In evaluating the exposure levels and the recommendations for reducing these levels found in this report, it should be noted that industry is required by the Occupational Safety and Health Act of 1970 (29 USC 651, et seq.) to meet those levels specified by an OSHA standard.

A time-weighted average (TWA) exposure refers to the average airborne concentration of a substance during a normal 8 to 10-hour workday. Some substances have recommended short-term exposure limits or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from high, short-term exposures.

A summary of the evaluation criteria and the major health effects of the substances evaluated in this survey is presented in Table 8.

VI. RESULTS

A. Employee Interviews

A total of 20 employee questionnaires were evaluated, which included the 18 employees who were interviewed during the initial survey visit, and two employees responding to questionnaires mailed to them. Of the 20 employees, 17 reported episodes of acute upper respiratory irritation when working in the vicinity of the plating tanks, including twelve reporting instances of nosebleeds. Symptoms were most often attributed to exposure to inorganic acids (particularly the bright dip) and the various copper plating solutions. Review of the company's OSHA Form No. 200 revealed 24 entries for 1984, including one instance where an employee was "overcome by fumes", and instances of splashes of solutions onto employee's skin or eyes.

B. Environmental Survey

The results of the air samples collected for inorganic acids are presented in Table 3. All samples were analyzed for sulfuric, nitric, and phosphoric acid. Sulfuric acid was detected in only one of eight personal samples at a TWA concentration of 0.17 mg/M^3, and in one of four area samples at a TWA concentration of 0.13 mg/M^3. Nitric acid was not detected in the personal samples, but was detected in three of four area samples at TWA concentrations of 0.10, 0.62, and 0.71 mg/M^3. Phosphoric acid was not detected in any of the personal or area samples. All sample results were well below their respective environmental criteria (refer to Table 8).

The results of the air samples collected for cyanides are presented in Table 4. No particulate cyanide was detected above the media background levels (8.8 ug/filter) in any of the ten area samples collected in the vicinity of the plating tanks. Hydrogen cyanide was detected in all ten samples at TWA concentrations ranging from 0.08 to 1.33 mg/M^3, with a mean of 0.50 mg/M^3; however these values were below the evaluation criteria (Table 8).

The results of the air samples collected for trace metals are presented in Table 5. Copper was detected at TWA concentrations of 0.009 and 0.013 mg/M^3 in the two personal samples, and at TWA concentrations ranging from 0.005 to 0.079 mg/M^3 in six area samples. These concentrations were well below the environmental criteria (Table 8). Lead was detected in one of the two personal samples at a TWA concentration of 0.002 mg/M^3, and in three of six area samples at TWA concentrations of 0.005, 0.013, and 0.020 mg/M^3. These concentrations are below the environmental criteria for lead (Table 8). Other trace metals which were identified in the samples included chromium (0.013 mg/M^3) and nickel (0.041 mg/M^3) each detected in one area sample. Due to a concern with the potential carcinogenicity of nickel and certain forms of hexavalent chromium, NIOSH recommends reducing exposures to these substances as low as feasible. However, it should be noted that these sample results reflect general area concentrations where personnel would not be routinely present.

Table 6 presents the results of the area samples collected for formaldehyde. No formaldehyde was detected in either of the two samples collected in the areas where this substance was present.

Table 7 shows the results of the personal samples collected for perchloroethylene at the reflow operation. TWA concentrations of 82.1 and 84.2 parts of perchloroethylene per million parts of air (ppm) were detected in long-term samples collected on two consecutive days. Both of these values are above the NIOSH REL of 50 ppm perchloroethylene for up to a 10-hour TWA, but are below the OSHA standard of 100 ppm for an 8-hour TWA. Concentrations of perchloroethylene in three short-term personal samples were 82.4, 119.9, and 184.8 ppm. Two of these three samples exceeded the NIOSH recommended exposure limit of 100 ppm for a ten minute sampling period, but these values were all below the OSHA standard of 200 ppm as a ceiling concentration.

C. Work Practices, Personal Protection and Engineering Controls

During the survey visits, various instances of poor work practices were noted. One employee was observed eating while working on the plating lines, and another employee indicated he occasionally smoked while working on the line. Other examples of poor work practices included the failure to regularly close plating tank hoods when solutions were not being checked or adjusted. In addition, employees were observed to be performing tasks without using the proper personal protective equipment. These included the frequent use of cloth gloves in instances where contact with the tank solutions was probable, and the failure to use a splash shield or rubber apron during a task where a large container of an acid solution was being added to a metal pretreatment tank.

Deficiencies in the design of the local exhaust ventilation system were also noted during the surveys. Some examples of these included:

- Frequent use of 90' branch entries.

- Branch entries at angles opposed to the direction of air flow.

- Abrupt duct expansions.

- Lack of tapering of long ducts with multiple branches.
- Damaged, deteriorated, or missing seals at duct joints.
- Open ended branch ducts and disconnected ductwork.

It should be noted that the company was in the process of modifying sections of the local exhaust ventilation which may have been responsible for some of the conditions which were observed.

Observations of airflow patterns in the immediate vicinity of the plating tanks, which were made using smoke tubes, indicated the majority of the ventilation systems on the tanks to be operating effectively. However, the effective functioning of these systems appeared to be occasionally disturbed by transient air currents within the building. This was particularly true in instances where tank covers had been left open. Furthermore, the presence of irritating emissions periodically emanating from the tanks, which were experienced by the investigators during this testing, served as a further indication of periodic lapses in the efficiency of these systems.

During the initial survey, a canopy type exhaust hood was observed above a stripping tank located in a room adjacent to the plating operations. The location of this hood in relation to the tank, was such that it would have drawn the contaminants across the workers breathing zone during tank loading and unloading. Preliminary recommendations for improving the design of the local exhaust ventilation on this operation were made following the initial survey visit, and the unit was no longer in use at the time of the environmental survey.

VII. DISCUSSION AND CONCLUSIONS

As evidenced by the results of the environmental survey, while airborne concentrations of perchloroethylene did not exceed OSHA standards, they did exceed the NIOSH REL on both a ceiling and TWA basis. This result is not surprising in light of the lack of ventilation at this operation. The installation of a properly designed local exhaust ventilation system at the degreasing tank should effectively reduce this employee's exposure.

The results of the environmental samples collected for cyanides, inorganic acids, metals, and formaldehyde were all found to be below their respective evaluation criteria at the time of the survey. Despite this finding, there were a significant number of employees working at the plating lines who reported episodic symptomatology indicative of acute mucous membrane irritation. It is possible that these symptoms can be explained by several different factors. One key area which may greatly influence employee exposures is work practices. Poor work practices, such as the failure to regularly close tank covers, can greatly increase the potential for brief exposure to elevated concentrations of the various bath constituents. One recent study showed that tanks which were covered showed the lowest average tank-area contaminant concentrations, and that emissions at one electroplating operation were reduced 20-fold when a cover was placed on a tank.[1]

Other factors which may be responsible for the reported symptomatology may be instances where the local exhaust ventilation is rendered ineffective due to transient air currents within the building or during the activities such as the necessary opening of tank covers to monitor conditions or add solutions. Employee exposures during these instances could be minimized by increasing the air exhausted at the individual tanks. As previously indicated, many design deficiencies in the local exhaust ventilation system were identified during the survey. While these deficiencies in-and-of themselves do not preclude the effective functioning of the local exhaust ventilation at the individual tanks, they can contribute to excessive losses and imbalances that may result in a reduction in the overall system efficiency. It is probable that the correction of some of the major design deficiencies would provide for better system balance and increased capture velocities that would further minimize the employee exposures in these situations.

Therefore, despite the finding of contaminant concentrations below the evaluation criteria, it would be prudent to provide ongoing attention to maintaining and improving the local exhaust ventilation system. Not only would this be likely to reduce episodes of acute respiratory irritation among employees, but it also would be beneficial in other ways. Examples of this would be the additional degree of protection that would be afforded in the event of changes in operating conditions (i.e., increased bath temperatures or current densities) or process components which might result in either an increase in the concentrations or toxicity of the emissions. In addition, an efficient exhaust ventilation system would help to minimize the hazard which might occur from the accidental mixing of incompatible chemicals (i.e., acids and cyanide salts) which would release a highly toxic reaction product. Furthermore, a properly designed and maintained local exhaust system will operate more efficiently, and thus reflect a cost savings over a poorly designed system.

Based on the observations made during the survey visits, the use of personal protective equipment is another area which should receive increased attention. Particular emphasis should be given to selecting the appropriate personal protective equipment for each task. In instances where the employee's hands may come into direct or indirect contact with the plating solutions, the proper type of glove should be utilized to provide a suitable degree of impermeability to the particular solution. The use of non-coated cloth gloves in these instances, would provide little in the way of protection from skin contact, and may actually increase the time of skin contact if they become wet. Since many of the chemicals used in plating operations are capable of causing severe burns or irritation upon direct contact with the skin or eyes, each task must be carefully evaluated for this potential hazard, with the appropriate personnel protective equipment selected based on the potential for contact with any portion of the body. Proper training and supervision is also necessary to ensure that the proper personal protective equipment is selected and worn by the employees during these tasks. It should be noted that personal protective equipment is not intended to serve as a substitute for proper planning, work practices, engineering and administrative controls, and personal hygiene.

VIII. RECOMMENDATIONS

The following recommendations are provided in order to minimize the potential health hazards from occupational exposure to the chemicals used in the electroplating processes. It is recognized that some of these modifications, which were underway at the time of the survey, may have already been implemented.

1) Local exhaust ventilation should be installed at the perchloroethylene tank used for the reflow operation. In addition, the existing ventilation system for the plating lines should be evaluated for major deficiencies which could adversely effect the performance of the overall system. The installation of new local exhaust ventilation, as well as the modification of existing systems, should take into consideration standardized design practices such as those provided in the American Conference of Governmental Industrial Hygienists "Industrial Ventilation", the American National Standards Institute "Practices for Ventilation and Operation of Open-Surface Tanks", and the Occupational Safety and Health Administration "General Industry Standards".[3,4,5]

2) Local exhaust ventilation systems should be periodically evaluated for their effectiveness. This should include the use of smoke tubes or other suitable methods in order to qualitatively evaluate the airflow characteristics at the individual tanks; including the effects of room air currents and other external sources of air disturbance on the the ventilation system's performance. In addition, a quantitative evaluation of system performance should be made following any major changes or revisions in the systems to ensure that minimum recommended exhaust rates are achieved.[3]

3) In instances where engineering controls are not feasible and respirator use is necessary (i.e., maintenance work, tank cleaning, or other infrequent short periods of exposure) employees should be provided with a properly selected and fitted respirator. A respiratory protection program should be put into place which meets the requirements provided in the OSHA "General Industry Standards", 29 CFR 1910.134.[5]

4) Face shields, chemical goggles, splash aprons, arm coverings, gloves, and boots should be made readily available to the employees. Individual job tasks should be carefully evaluated, with the selection of the appropriate type(s) of protective equipment based on the potential for skin or eye contact with the various solutions. The employees should also receive periodic training as well adequate supervision to ensure the proper use of this equipment.

5) Employees should be encouraged to utilize work practices which minimize the risk of exposure at all times. This includes practices such as closing plating tank covers whenever possible. All tanks and storage containers should be clearly and accurately labelled to allow for easy identification of their contents, and should be immediately relabelled to reflect any changes in the solutions. Strict attention should also be given to instructing employees as to the proper

methods of storage and use of reactive chemicals. The "Electroplating Engineering Handbook" provides a discussion of the special precautions that need to be taken when reactive chemicals such as cyanides are being used.[6]

6) Proper personal hygiene procedures should be stressed for all personnel working on the electroplating lines. Hands should be regularly washed, particularly after contact with any of the solutions. Any skin problems (i.e., dermatitis) should be promptly reported to management so that proper corrective actions can be taken. Regular housekeeping should be emphasized in the plating tank area, as well as the employee lunch room. Eating, drinking, or smoking should not be allowed in the vicinity of the plating lines.

IX. REFERENCES

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XI. DISTRIBUTION AND AVAILABILITY OF DETERMINATION REPORT

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A. Requestor
B. Summit Finishing Company
C. U. S. Department of Labor, OSHA - Region V
D. NIOSH Regional Offices/Divisions

For the purposes of informing the affected employees, copies of the report should be posted in a prominent place accessible to the employees, for a period of 30 calendar days.

TABLE 1

Locations and Potential Emissions of
Metal Pretreatment and Electroplating Processes

Summit Finishing Company, Inc.
Mooresville, Indiana
June 19-20, 1985

Type of Process	Location by Plating Line Number(s)	Component(s) of Bath Which May Be Released to Atmosphere*
METAL PRETREATMENT		
Metal Cleaning		
Alkaline Cleaning	1 - 9	Alkaline Sodium Salts
Degreasing	1, 2	Perchloroethylene
Acid Dipping		
Bright Dip	2, 5	Sulfuric, Phosphoric, Nitric Acid
Sulfuric Acid	1, 3, 4	Sulfuric Acid
Hydrochloric Acid	6 - 9	Hydrochloric Acid
ELECTROPLATING		
Strike Solutions		
Copper	5,8	Cyanide Salts
Silver	4, 6, 9	Cyanide Salts
Woods Nickel	9	Nickel Chloride, Hydrochloric Acid
Fluoborate Plating		
Lead-Tin Alloy	5, 6, 7	Lead Fluoborate-Fluoboric Acid
Cyanide Plating		
Copper	2, 4, 6 - 9	Cyanide Salts, Sodium Hydroxide
Indium	9	Cyanide Salts, Sodium Hydroxide
Silver	4, 6, 9	None
Acid Plating		
Chromium	8	Chromic Acid
Copper	1, 3	Copper Sulfate, Sulfuric Acid
Nickel	6	Nickel Sulfamate
Tin	1 - 3, 6	None
Alkaline Plating		
Tin	7	Sodium Stanate

*Source: American Conference of Governmental Industrial Hygienists, Industrial Ventilation, A Manual of Recommended Practice, Sixteenth Edition. Lansing, Michigan. American Conference of Governmental Industrial Hygienists, 1980.

TABLE 2

Sampling and Analysis Methodology

Summit Finishing Company, Inc.
Mooresville, Indiana
June 19 - 20, 1985

Substance	Collection Media	Flowrate (LPM)	Analysis	Detection Limit (ug/sample)	NIOSH Reference Method
INORGANIC ACIDS	Silica Gel Tubes	0.2	Ion Chromatography	4.0	7903

TABLE 3

Results of Environmental Samples Collected for Inorganic Acids
Summit Finishing Company, Inc.
Mooresville, Indiana

Sample Date (1985)	Sample Type	Job Title or Location/ Line Number	Sample Duration (minutes)	Sample Volume (Liters)	TWA Concentration/ Contaminant* (mg/M3)
6/19	Personal	Plater/Line 1	450	82.1	0.17/H_2SO_4†
6/19	Personal	Plater/Line 2	436	80.7	< LOD
6/19	Personal	Set-up/Line 5	428	85.2	< LOD
6/19	Personal	Plater/Line 8	406	73.8	< LOD
6/19	Area	Opposite Copper sulfate tank/Line 1	283	53.1	< LOD
6/19	Area	Over Bright Dip tank/Line 2	383	76.6	0.71/HNO_3
6/20	Personal	Plater/Line 2	301	56.1	< LOD
6/20	Personal	Group Leader	301	56.2	< LOD
6/20	Personal	Plater/Line 1	298	55.2	< LOD
6/20	Personal	Plater/Line 8	299	61.0	< LOD
6/20	Area	Above Bright Dip tank/Line 2	293	53.1	0.13/H_2SO_4† 0.62/HNO_3
6/20	Area	Over Tin Sulfate tank/Line 2	287	59.3	0.10/HNO_3

Abbreviations and Key

TWA - Time-weighted average concentration (all sample results are expressed as a TWA for the duration of sample collection).
mg/M^3 - milligrams of contaminant per cubic meters of air
H_2SO_4 - Sulfuric Acid
HNO_3 - Nitric Acid
< LOD - Less than the limit of detection of 4 micrograms per sample for sulfate, phosphate, and nitrate.
* - All samples were analyzed for sulfuric, phosphoric, and nitric acids.
† - Some breakthrough may have occurred on these samples due to high contaminant percentages present on the back-up sections of the sorbent tubes.

TABLE 4

Results of Area Samples Collected for Hydrogen Cyanide
Summit Finishing Company, Inc.
Mooresville, Indiana

Sample Date (1985)	Sample Location/ Line Number	Sample Duration (minutes)	Sample Volume (Liters)	TWA Concentration Hydrogen Cyanide* (mg/M3)
6/19	Opposite copper cyanide tank/Line 6	180	180	0.11
6/19	Opposite copper cyanide tank/Line 7	180	180	0.28
6/19	Behind silver cyanide tank/Line 4	180	180	0.47
6/19	In front of copper cyanide tank/Line 2	180	180	0.44
6/19	In back of copper cyanide tank/Line 4	185	185	1.30
6/20	Directly over copper cyanide sump tank/Line 2	180	180	0.42
6/20	Directly over copper cyanide tank/Line 8	180	180	0.14
6/20	Over copper cyanide tank/Line 8	180	180	0.08
6/20	Behind copper cyanide strike tank/Line 5	180	180	1.33
6/20	To rear of silver cyanide tank/Line 6	180	180	0.44

Abbreviations and Key

TWA - Time-weighted average concentration (all sample results are expressed as a TWA for the duration of sample collection).

mg/M^3 - milligrams of contaminant per cubic meter of air

* - Sample results reflect hydrogen cyanide ion concentration present in the bubbler solution used in sample collection. No particulate cyanide was detected above background levels on the cellulose ester membrane filters which preceded the bubblers.

TABLE 5

Results of Environmental Samples Collected for Trace Metals
Summit Finishing Company, Inc.
Mooresville, Indiana

Sample Date (1985)	Sample Type	Job Title or Location/ Line Number	Sample Duration (minutes)	Sample Volume (Liters)	TWA Concentration/ Contaminant* (mg/M3)
6/19	Personal	Plater/Line 6	404	606	0.009/Copper
6/19	Personal	Plater/Line 6	406	609	0.013/Copper 0.002/Lead
6/19	Area	Over tin sulfate tank/Line 2	373	560	0.079/Copper
6/19	Area	Over lead-tin tank/Line 6	361	542	0.018/Copper
6/19	Area	Opposite lead-tin tank/Line 7	361	542	0.013/Copper
6/20	Area	Behind lead-tin tank/Line 5 (end of line)	248	372	0.005/Copper 0.020/Lead
6/20	Area	Behind lead-tin tank/Line 5 (mid-line)	250	375	0.013/Chromium 0.009/Copper 0.013/Lead 0.041/Nickel
6/20	Area	Behind copper sulfate tank /Line 2	244	366	0.040/Copper 0.005/Lead

Abbreviations and Key

TWA - Time-weighted average concentration (all sample results are expressed as a TWA for the duration of sample collection).

mg/M^3 - milligrams of contaminant per cubic meters of air

* Each sample was analyzed for 31 trace metals. Unless otherwise indicated, the results were less than the limit of detection of 1 microgram/filter for each element, or were detected at concentrations which were not significant when compared to their respective evaluation criteria.

TABLE 6

Results of Area Samples Collected for Formaldehyde
Summit Finishing Company, Inc.
Mooresville, Indiana

Sample Date (1985)	Sample Location/ Line Number	Sample Duration (minutes)	Sample Volume (Liters)	TWA Concentration Formaldehyde (ppm)
6/19	Directly overhead/ Between Lines 6 & 8	348	28	< LOD
6/19	Opposite Line 7	349	29	< LOD

< LOD - Less than the analytical limit of detection of 2 micrograms per sample

TABLE 7

Results of Personal Samples Collected for Perchloroethylene
Summit Finishing Company, Inc.
Mooresville, Indiana

Sample Date (1985)	Job Duty	Sample Duration (minutes)	Sample Volume (Liters)	TWA Concentration Perchloroethylene (ppm)
6/19	Reflow Operator	418	17.0	82.1
6/19	Reflow Operator	67	13.2	82.4*
6/19	Reflow Operator	39	7.6	119.9*
6/20	Reflow Operator	288	11.7	84.2
6/20	Reflow Operator	22	3.5	184.8*

Abbreviations and Key

TWA - Time-weighted average concentration (all sample results are expressed as a TWA for the duration of sample collection).

ppm - parts of contaminant per million parts of air

* - Denotes a short-term sample collected for comparison to ceiling criteria. All other samples collected were for comparison to 8 or 10-hr TWA's.

Table 8
Evaluation Criteria and Health Effects Summary

SUBSTANCE	EVALUATION CRITERIA[1,2]			PRIMARY HEALTH EFFECTS
	NIOSH	OSHA	ACGIH	
Cyanides (as CN)	5 mg/M^3 (10-min)	5 mg/M^3 (skin)	5 mg/m^3 (skin)	HCN when inhaled or cyanide salts when ingested can cause immediate collapse. High concentrations of cyanides can cause death due to chemical asphyxia. Lower concentrations can cause dizziness, headaches, weakness, confusion, nausea, and vomiting. Other effects are slow gasping respiration and eye and skin irritation. HCN gas has a bitter almond odor and can cause nose and upper respiratory tract irritation.[1,3]
Hydrogen Cyanide (HCN)	5 mg/M^3 (10-min)	11 mg/M^3	10 mg/M^3 (C)(skin)	
Hydrogen Chloride (Hydrochloric acid or HCL)	NA	7 mg/M^3 (C)	7 mg/M^3 (C)	High concentrations are very corrosive to eyes, skin, and mucous membranes. HCL can cause burn ulcers and scarring of skin mucous membranes can cause dermatitis with repeated exposure. Inhalation can result in burning, choking, coughing, laryngitis, bronchitis, pulmonary edema, and death. Long-term exposure may cause erosion of the teeth.[1]
Nitric Acid	5 mg/M^3	5 mg/M^3	5 mg/M^3 10 mg/M^3 (15-min)	Causes eye, mucous membrane and skin irritation; delayed pulmonary edema; pneumonitis; bronchitis, and dental erosion. Its extremely corrosive nature can produce burns and ulcers of the skin, eye, and mucous membranes.[1]
Sulfuric acid	1 mg/M^3	1 mg/M^3	1 mg/M^3	Concentrated sulfuric acid can cause rapid damage to mucous membranes, is exceedingly dangerous to the eyes, and can burn and char the skin and mouth. Diluted sulfuric acid is irritating to the eyes, nose, throat, and skin and may cause scarring of the skin and blindness. Inhaled sulfuric acid can cause irritation of the eyes, nose, and throat, etching of dental enamel and edema of the lungs and throat.[1,3]

Table 8 (continued)
Evaluation Criteria and Health Effects Summary

SUBSTANCE	EVALUATION CRITERIA[1,2]			PRIMARY HEALTH EFFECTS
	NIOSH	OSHA	ACGIH	
Tetrachloroethylene (perchloroethylene or "perc")	50 ppm 100 ppm (15-min)	100 ppm 200 ppm (5-min) 300 ppm (P)	50 ppm 200 ppm (15-min)	Can cause dermatitis, headaches, fatigue, dizziness, nausea, drowsiness, and anesthetic death. It causes depression of the central nervous system, and also eye, nose, and throat irritation. Long-term exposure to tetrachloroethylene may cause skin irritation and damage the liver and kidneys.[1,3]
Copper salts (as CU) (Including copper sulfate and cuprous chloride dust or mist)	NA	1 mg/M^3	1 mg/M^3	Copper salts act as skin irritants, causing itching, erythema, and dermatitis. Can also cause upper respiratory tract irritation, a metallic taste in the mouth, and nausea, and congestion of the nasal mucous membranes. Copper salts can also produce salivation, nausea, vomiting, gastric pain, hemorrhagic gastritis and diarrhea if introduced into the gastrointestinal tract.[3]
Nickel	LFL	1 mg/M^3	1 mg/M^3 (metal) 0.1 mg/M^3 (soluble)	Skin sensitization is the most commonly seen toxic reaction to nickel and its compounds. Nickel is also an irritant to the eyes and mucous membranes of the respiratory tract. Due to concern about the potential carcinogenicity of nickel compounds, NIOSH recommends that occupational exposure to nickel be reduced to the lowest feasible level.[3,4]
Chromium (Cr) and its compounds	†	†	†	In some workers, chromium compounds act as allergens, causing dermatitis and pulmonary sensitization. In the hexavalent state Cr(VI), these compounds are irritating and corrosive to the skin and mucous membranes. Certain forms of hexavalent chromium have been found to cause respiratory cancer.[3,5]

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† - NIOSH: LFL for carcinogenic Cr(VI); 0.025 mg/M^3 non-carcinogenic Cr(VI) and 0.050 mg/M^3 (15-min).
OSHA: 0.1 mg/M^3 chromic acid & chromates, 1 mg/M^3 metal, insoluble salts, 0.5 mg/M^3 soluble salts.
ACGIH: 0.5 mg/M^3 for metal, Cr(II), Cr (III); 0.05 mg/M^3 for Cr (VI) soluble and insoluble.

Table 8 (continued)
Evaluation Criteria and Health Effects Summary

SUBSTANCE	EVALUATION CRITERIA[1,2]			PRIMARY HEALTH EFFECTS
	NIOSH	OSHA	ACGIH	
Inorganic Lead	<0.1 mg/M^3	0.05 mg/M^3	0.15 mg/M^3	Can cause fatigue, loss of sleep, headache, abdominal pain and decreased appetite. Inhalation or ingestion may damage the kidneys, nervous system, and bone marrow. Long-term exposure is associated with infertility and fetal damage in pregnant women.
Formaldehyde	LFL	3 ppm	1 ppm 2 ppm (15 min)	Vapors can cause irritation of the eyes & upper respiratory tract. Contact with the liquid can cause both primary irritation and sensitization dermatitis. Has been shown to cause cancer in animals and NIOSH considers it to be a potential humam carcinogen.

All evaluation criteria expressed as 8-hour (OSHA, ACGIH) or 10-hour (NIOSH) time-weighted averages (TWA's) unless a shorter duration of exposure is specified below the criteria. Those criteria followed by a "C" or "P", should not be exceeded at any time during the workshift.
Skin - indicates a potential for contribution to the overall exposure through skin absorption.
LFL - Due to a potential for carcinogenicity, exposures should be reduced to the lowest feasible limit.
mg/M^3 - milligrams of contaminant per million parts of air
ppm - parts of contaminant per million parts of air

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