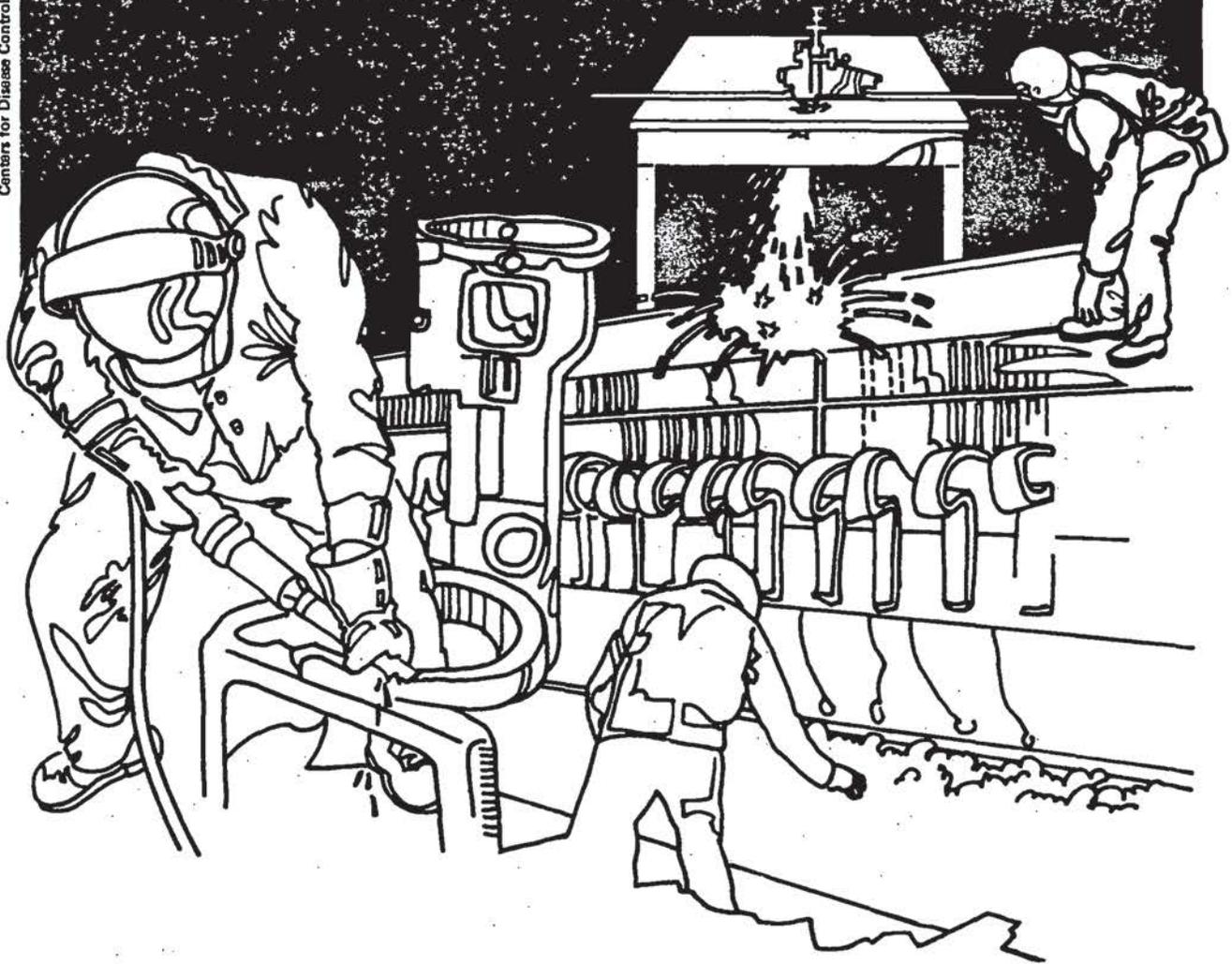


NIOSH



Health Hazard Evaluation Report

HETA 82-116-1319
MODINE MANUFACTURING
McHENRY, ILLINOIS

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.

Mention of company names or products does not constitute endorsement by the National Institute for Occupational Safety and Health.

HETA 82-116-1319
MAY 1983
MODINE MANUFACTURING
McHENRY, ILLINOIS

NIOSH INVESTIGATORS:
Daniel Almaguer, I.H.
Richard Kramkowski, P.E.

I. SUMMARY

On February 1, 1982, the National Institute for Occupational Safety and Health (NIOSH) received a request to evaluate employee exposures to chromic acid at a condenser dipping operation at Modine Manufacturing, McHenry, Illinois. The requestor was concerned with potential health hazards associated with the dipping operation.

In March 1982, NIOSH investigators conducted an initial survey during which a bulk sample of the dip solution was collected. In May 1982, environmental samples were collected to assess employee exposures to chromium(VI) [Cr(VI)] and zinc chromates, local exhaust ventilation measurements were taken, and confidential questionnaires were administered to seven employees who were currently working or had recently worked at the dipping operation.

Personal breathing-zone air samples showed a time-weighted average (TWA) concentration for Cr(VI) of 0.7 micrograms per cubic meter ($\mu\text{g}/\text{m}^3$) of air (NIOSH recommended standard - $1 \mu\text{g}/\text{m}^3$) for the dip tank operator, and no detectable levels for the buffer or an area sample taken about 15 feet from the dip tank. Zinc chromates were not detected in two personal breathing-zone air samples.

Wipe samples indicated Cr(VI) contamination spread throughout the dipping and buffing operations and was determined to occur via direct handling of plastic caps used to cap the treads of the condensers during the dipping operation, the handling of objects by the dip tank operator, and the handling of the condenser units by the buffer.

Results of the medical questionnaires revealed one reported case of dermatitis in the buffer, various other reported signs of mucous membrane irritation among other employees, and complaints of nausea and lightheadedness.

The low levels of Cr(VI) detected at the dip tank operation indicate that the ventilation system was operating effectively. Ventilation measurements showed an average velocity of 140 feet per minute (fpm) at the face of the exhaust hood of the dip tank operation.

On the basis of the data collected in this study, NIOSH has concluded that a health hazard did not exist at this plant due to exposure to airborne Cr(VI) or zinc chromates at the time of the survey. However, a potential hazard did exist due to poor work practices in the handling of the dip solution. Recommendations for controlling the spread of Cr(VI) are included in the body of this report.

KEYWORDS: SIC 3479 (Coating, Engraving, and Allied Services, Not Elsewhere Classified), coating, rust preventive, chromium (VI), chromic acid, dermatitis.

II. INTRODUCTION

On February 1, 1982, an authorized representative of employees submitted a Health Hazard Evaluation request regarding the health consequences faced by employees exposed to a condenser dipping operation at the Modine Manufacturing Company, McHenry, Illinois. The request centered around potential employee exposures to chromic acid mist at a condenser dipping operation which had been installed in early January 1982. Workers reported being able to smell an odor and a feeling of illness associated with the chrome dipping operation.

NIOSH investigators responded to the request by conducting an initial survey of the plant on March 26, 1982. An opening conference was held followed by a walk-through survey of the plant, and a bulk sample of the dip solution was collected for qualitative analysis. On May 20, 1982, NIOSH investigators returned to the plant to conduct environmental sampling for chromium (VI) [Cr(VI)] and zinc chromates, and to administer confidential employee questionnaires.

III. BACKGROUND

A. Plant Production and Work Force

Modine Manufacturing has been involved in the production of aluminum condensers, evaporators, and auto coolers since 1962. The plant has a production rate of approximately 40,000 units per month.

The plant was operating two shifts per day at the time of the initial survey and provided employment for 115 production workers, 10 maintenance workers, and 32 administrative personnel. Employees work an 8-hour shift, 5 days per week.

B. Process Description and Employee Duties

Radiator condensers which are assembled in other areas of the plant are brought to the dip tank. Alodine NR3 is mixed with water in the proportions of 40% Alodine and 60% water and placed in the dip tank. Condensers are manually placed on a pivoting rack by the dip tank operator and lowered into the dip tank solution for approximately 15 to 20 seconds. Excess solution is then blown off the condenser using a low flow air hose, flexible plastic caps are removed from the treads of the condenser, and the condensers are placed onto conveyor racks which lead to an oven for drying. Flexible plastic caps removed from the condensers were placed in a box, taken to the buffing operation, and reused.

Condensers exiting from the oven are removed from the racks by the buffer, who then buffs the treads with a pneumatic wire brush, places the recycled flexible plastic caps back on the treads, and then places the units on pallets for movement to other areas of the plant.

C. Engineering, Administrative, and Personal Protective Controls

The dip tank operator is required to wear eye protection, face shield, rubber gloves, a rubber apron, rubberized sleeves extending above the elbows, and rubber boots. The buffer was required to wear safety glasses and rubber gloves.

The dip tank operation is run only during the second shift and for only approximately 2 - 3 hours per shift, about once every week or two. The back side of the dip tank was ventilated approximately one month after operation was begun.

IV. EVALUATION DESIGN AND METHODS

During the initial survey of March 1982, bulk samples of the chromic acid solution used at the dipping operation were taken for qualitative analysis of trace metals and subsequently revealed the presence of zinc.

The environmental evaluation conducted May 20, 1982, consisted of ventilation measurements, personal breathing-zone sampling for Cr(VI) and zinc chromates (reported as zinc), and area sampling for Cr(VI). Cr(VI) spot tests were conducted on workers' hands and several surfaces for the detection of Cr(VI).

A. Sampling for chromic acid mist [specifically Cr(VI) and zinc chromates] was conducted using polyvinyl chloride filters connected via tygon tubing to personal sampling pumps calibrated at a flow of 1.5 liters per minute. Personal exposures were obtained by placing the filter cassette in the workers' breathing zones and area samples were obtained by locating the sampling train at a water test station located approximately 15 feet from the dip tank.

B. The Cr(VI) spot test is a qualitative colorimetric test for the presence of the Cr(VI) ion. This test was conducted on work surfaces and employees' hands. The test is a modification of the analytical method for Cr(VI) (P&CAM 169) and involved moistening a filter paper smear tab with distilled water, thoroughly wiping the surface of interest, placing a drop of 1 N H₂SO₄ and one drop of diphenylcarbazide on the filter paper, and noting any color change. A reddish-violet color change is indicative of the presence of the Cr(VI) ion. Possible interferences for the diphenylcarbazide method include many of the heavy metals including iron, copper, nickel, and vanadium.

C. Measurements of the local exhaust ventilation present at the dip tank were obtained using an air velocity meter. These measurements showed an average velocity of 140 feet per minute (fpm) at the face of the exhaust hood of the dip tank operation. Other ventilation measurements showed a velocity of 60 fpm flowing past the workers' breathing zones toward the hood, and 100 fpm at tank height level.

D. Medical questionnaires were administered to employees who were currently working in the area or who had worked with the operation since its beginning in early January.

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 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 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 (OSHA) occupational health standards. Often, the NIOSH recommendation 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 solely 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 legally required to meet only 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. Chromium Compounds

There are two recommended standards for Cr(VI). One for carcinogenic Cr(VI) which pertains to occupations and workplaces where there is exposure to Cr(VI) materials associated with an increased incidence of lung cancer. NIOSH recommends that the permissible exposure limit for carcinogenic Cr(VI) compounds be reduced to 1 ug/m^3 and that these compounds be regulated as occupational carcinogens. Certain other forms of Cr(VI) are currently believed to be non-carcinogenic: They are the monochromates and bichromates (dichromates of hydrogen, lithium, sodium, potassium, rubidium, cesium, and ammonium, and Cr(VI) oxide (chromium acid anhydride). NIOSH recommends that the permissible exposure limit for non-carcinogenic chromium be reduced to 25 ug/m^3 Cr(VI) averaged over a work shift of up to 10 hours per day, 40 hours per week, with a ceiling level of 50 ug/m^3 Cr(VI) averaged over a 15-minute period.¹

Chromic acid and its salts have a corrosive action on the skin and mucous membranes. The lesions are confined to the exposed parts, affecting chiefly the skin of the hands and forearms and the mucous membranes of the nasal septum. The characteristic lesion is a deep, penetrating ulcer which, for the most part, does not tend to suppurate, and which is slow in healing.²

Small ulcers, about the size of a match head or end of a lead pencil, may be found chiefly around the base of the nails, on the knuckles, and/or dorsum of the hands and forearms. These ulcers tend to be clean, and progress slowly. They are frequently painless, even though quite deep. They heal slowly, and leave scars. On the mucous membrane of the nasal septum, the ulcers are usually accompanied by purulent discharge and crusting. If exposure continues, perforation of the nasal septum may result, but produces no deformity of the nose. Chromate salts have been associated with cancer of the lungs.²

Chromium(VI) materials have been implicated as responsible for such effects as skin ulceration, ulcerated nasal mucosae, perforated nasal septa, rhinitis, nosebleed, perforated eardrums, kidney damage, pulmonary congestion and edema, epigastric pain, erosion and discoloration of the teeth, and dermatitis. In addition, they have been associated with an increased incidence of lung cancer.²

In one study, NIOSH reported high incidences of nasal mucosal irritation and septal perforation where the greatest concentration of airborne chromium was $9.1 \text{ micrograms per cubic meter (ug/m}^3\text{)}$. However, in this workplace, there was strong evidence that direct transfer of Cr(VI) from work to nasal surfaces occurred frequently.^{3,4}

In another study listed in the NIOSH Criteria Document on Chromium(VI) where airborne concentrations of 3 ug/m^3 or less were reported, the lack of proper work practices, ventilation, and protective equipment was probably primarily responsible for the signs and symptoms of Cr(VI) poisoning. The fact that 24 of the patients had cutaneous ulcers or

scars of ulcers indicates that sloppy conditions existed in most workplaces studied. It was not stated in the article what the total population at risk was in the plating shops, making an evaluation of the overall prevalence of signs and symptoms of Cr(VI) poisoning difficult.²

The Criteria Document on exposure to chromic acid concluded that, in the presence of good work practices, the environmental limit of 50 ug Cr(VI) oxide [26 ug Cr(VI)/m³] as a time-weighted average and 100 ug Cr(VI) oxide [52 ug Cr(VI)/m³] as a 15-minute ceiling would be sufficient to protect against irritation and ulceration of nasal mucosae, perforation of nasal septa, and other harmful effects.⁵

Newhouse⁶ found dermatitis in automobile assemblers from handling bolts, nuts, screws, and washers treated with a chromate dip used as an antirust agent. This would be similar to the employee (Buffer) handling condensers following the drying process.

B. Zinc Oxide Dust

The current OSHA standard for zinc oxide fumé is 5 milligrams per cubic meter (mg/m³) of air averaged over an 8-hour work shift.¹ In its Criteria Document for zinc oxide, NIOSH recommended retention of the 5 mg/m³ limit as a workplace environmental standard, and that the same value be used for zinc oxide dust.⁷

Poor hygiene practices when using this substance may lead to the development of dermatitis. Inhalation of the fumes or dust particles of small size may cause metal fume fever; a syndrome usually lasting 24-48 hours which causes a feeling of general malaise, weakness, fever, and chills.⁸

VI. RESULTS AND CONCLUSION

Personal samples collected near the breathing zone of the dip tank operator showed TWA concentrations of 0.7 ug/m³ Cr(VI) (8-hour TWA - 0.066 ug/m³) and levels of zinc below that of the blank submitted for analysis. If the zinc present had been in the form of zinc chromate (ZnCrO₄) or zinc dichromate (ZnCr₂O₇), the molar ratios would have been approximately [1 mole Cr: 1.25 moles Zn] and [1 mole Zn: 1.6 mole Cr(VI)], respectively. Additionally, an area sample collected at a water test station located approximately 15 feet from the chrome dipping operation showed no detectable concentrations of Cr(VI). The amount of Cr(VI) present in the samples collected at the dipping operation were below the 8-hour TWA for both the carcinogenic and non-carcinogenic forms of Cr(VI); therefore, a hazard did not exist at this plant due to airborne Cr(VI).

Similarly, personal samples collected near the breathing zone of the buffer showed no detectable Cr(VI) and a TWA concentration of 0.65 mg/m³ zinc (8-hour TWA - 0.10 mg/m³). Again, the molar ratios do

not indicate the presence of zinc in the form of zinc chromate. Based on the data collected, it must be concluded that the zinc present at the buffing operation was in the form of zinc oxide dust, not zinc chromate.

Results of Cr(VI) spots tests showed that surfaces in the immediate area surrounding the dip tank were contaminated with Cr(VI). Contamination was determined to have probably occurred via work practices. The handling of objects by the dip tank operator with contaminated gloves could result in contamination of these objects. The recycling of the flexible plastic caps, which had become contaminated as a result of being immersed in the dip tank solution, likely resulted in contamination of that area and may have accounted for the rash which the buffer had complained of.

Results of the medical questionnaires revealed one complaint of dermatitis in the worker conducting the buffing operation, and various signs of mucous membrane irritation of the upper respiratory tract along with complaints of nausea and lightheadedness among other employees who had worked at the dipping operation.

VII. RECOMMENDATIONS

1. At the time of the environmental survey, the dip tank solution was very low and the dip tank operator was required to place his glove into the solution and splash the solution over the uncovered portion of the condenser in order to cover the condenser completely. It is therefore recommended that the dip tank solution be maintained at a level high enough to avoid this practice and the subsequent spread of the solution to other parts of the dip tank area.
2. Flexible plastic caps being used during the dipping operation should be washed with soap and water and rinsed before being sent to the buffing operation to prevent the spread of Cr(VI) to the buffing operation.
3. Protective clothing should be decontaminated with a soap and water solution and rinsed with water before being used again.
4. Good personal hygiene and work practices should be observed by all employees. Washing of hands before smoking, eating, and drinking will help to reduce possible contamination.
5. Smoking, eating, and drinking should be prohibited at work stations and should be allowed only during breaks and within the designated lunch and break areas.
6. Food, drinks, and cigarettes should not be kept at work locations or near the production area.

VIII. REFERENCES

1. National Institute for Occupational Safety and Health. NIOSH/OSHA occupational health guidelines for chemical hazards. Cincinnati, Ohio: National Institute for Occupational Safety and Health, 1981. (DHHS (NIOSH) publication no. 81-123).
2. National Institute for Occupational Safety and Health. Criteria for a recommended standard: occupational exposure to chromium VI. Cincinnati, Ohio: National Institute for Occupational Safety and Health, 1976. (DHEW publication no. (NIOSH) 76-129).
3. Cohen SR, Davis DM, Kramkowski RS. Clinical manifestations of chromic acid toxicity--nasal lesion in electroplate workers. *Cutis* 1974 13:558-68.
4. National Institute for Occupational Safety and Health. Health hazard evaluation report no. HETA 72-118-104. Cincinnati, Ohio: National Institute for Occupational Safety and Health, 1973.
5. National Institute for Occupational Safety and Health. Criteria for a recommended standard: occupational exposure to chromic acid. Cincinnati, Ohio: National Institute for Occupational Safety and Health, 1973. (DHEW publication no. (NIOSH) 73-11021).
6. Newhouse ML. A cause of chromate dermatitis among assemblers in an automobile factory. *J Ind Med* 1963;20:199-203.
7. National Institute for Occupational Safety and Health. Criteria for a recommended standard: occupational exposure to zinc oxide. Cincinnati, Ohio: National Institute for Occupational Safety and Health, 1976. (DHEW publication no. (NIOSH) 76-104).
8. National Institute for Occupational Safety and Health. Occupational diseases: a guide to their recognition. Revised ed. Cincinnati, Ohio: National Institute for Occupational Safety and Health, 1977. (DHEW (NIOSH) publication no. 77-181).

IX. AUTHORSHIP AND ACKNOWLEDGEMENTS

Report Prepared by: Daniel Almaguer
Industrial Hygienist
NIOSH - Region V
Chicago, Illinois

Environmental Assistance: Richard S. Kramkowski
Regional Consultant for OSH
NIOSH - Region V
Chicago, Illinois

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

Laboratory Analysis: Measurement Support Branch
NIOSH - Cincinnati, Ohio

X. DISTRIBUTION AND AVAILABILITY OF REPORT

Copies of this report are currently available upon request from NIOSH, Division of Standards Development and Technology Transfer, 4676 Columbia Parkway, Cincinnati, Ohio 45226. After 90 days, the report will be available through the National Technical Information Service (NTIS), 5285 Port Royal, Springfield, Virginia 22161. Information regarding its availability through NTIS can be obtained from NIOSH Publications Office at the Cincinnati address. Copies of this report have been sent to:

1. International Association of Machinists, District 140.
2. Modine Manufacturing Company
3. NIOSH, Region V
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.

TABLE I

Breathing-Zone and General Area Air Concentrations of Chromium (VI)

Modine Manufacturing Company
McHenry, Illinois

May 20, 1982

Job Classification/Location	Sampling Time (Minutes)	Cr(VI) TWA Conc. (sample duration)	Cr(VI) Conc. (8-hr. TWA)
Dip Tank Operator	45 min.	0.7 ug/m ³	0.066 ug/m ³
Area (15 ft. from dip tank)	93 min.	-ND-	-ND-
Buffer	80 min.	-ND-	-ND-
Blank	-0- min.	-ND-	-ND-

Abbreviations: ug/m³ = micrograms per cubic meter of air
N.D. = Not Detected - the limit of detection for Chromium (VI) was 0.3 micrograms chromium (VI) per filter

TABLE II

Breathing-Zone and General Area Air Concentrations of Zinc

Modine Manufacturing Company
McHenry, Illinois

May 20, 1982

Job Classification	Sampling Time (minutes)	Zinc TWA Conc. (sample duration)	Zinc Conc. (8-hour TWA)
Buffer	80 min.	0.65 mg/m ³	0.10mg/m ³
Dip Tank Operator	38 min.	*	*
Blank	-0- min.	**	**

Abbreviations: mg/m³ = milligrams per cubic meter of air
N.D. = Not Detected - the limit of detection for Zinc was 1 micrograms Zinc

* - Below level of blank submitted for analysis

** - Blank submitted for analysis equaled 4 micrograms Zinc