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I. SUMMARY

On November 15, 1988, the National Institute for Occupational Safety and Health (NIOSH) received a request from the International Association of Machinists and Aerospace Workers to conduct a Health Hazard Evaluation at MDT/Castle, Rochester New York. Potential exposures which were identified in the request included chromium, nickel, and other stainless steel welding products.

NIOSH investigators conducted an initial site visit and walk-through inspection on January 18, 1989. Environmental monitoring was performed on February 14-15, 1989. On August 18, 1989, a follow-up medical evaluation was conducted.

Eighteen (18) personal, and four (4) general area samples were collected to characterize employee exposure to welding fumes. Personal samples were collected from the welders' shirt collar, outside of the welding helmet. Airborne total chromium concentrations ranged from 0.9 to 201.6 micrograms per cubic meter (ug/M^3), and chromium was detected on all 22 air samples. Laboratory analysis did not differentiate between trivalent and hexavalent chrome, and these data should not be compared to any chrome VI criteria. Airborne nickel concentrations ranged from 2.8 to 647.8 ug/M^3, with 18 of the 22 sample results exceeding the NIOSH Recommended Exposure Limit (REL) of 15 ug/M^3. None exceeded the OSHA Permissible Exposure Limit (PEL) of 1000 ug/M^3.

Three of 22 sample results (2 personal and 1 area) exceeded the OSHA PEL of 100 ug/M^3 for copper fume, ranging from none detected (ND) to 446.5 ug/M^3. Exposure to other metals were below applicable environmental criteria.

The average urine chromium level was 2.7 micrograms per liter (ug/L), with a median of 1.7 ug/L. The range was less than 1 ug/L (the limit of detection) to 11.2 ug/L. Adjusting for creatinine, the average urine chromium level was 1.6 ug/L, with a median of 1.3 ug/L and a range of less than 1 ug/L to 4.7 ug/L. All samples were below the upper limit of the population reference range of 15 ug/L, and well below a suggested end-of-work-week reference value of 30 ug/L for occupational exposure.

The average urine nickel level was 14.2 ug/L, with a median of 10.8 ug/L, ranging from less tha 5 ug/L (limit of detection) to 45 ug/L. Adjusting for creatinine, the mean urine nickel level was 8.6 ug/L with a median of 7.0 ug/L and a range of less than 5 ug/L to 26.4 ug/L. Twelve welders (55%) were above the population reference range of less than 10 ug/L.

There was a significant correlation between the urine nickel and chromium levels (correlation coefficient = 0.44; (y=8.21 + 2.09x; p=0.36). After adjusting for creatinine, the correlation coefficient was 0.56 (y=4.73 + 2.4x, p=0.007).

Based on the results of the environmental and medical evaluations, the NIOSH investigators believe that a potential health hazard exists in the welding department from excessive employee exposure to airborne nickel and copper. Recommendations are made in Section VIII of this report to improve ventilation and require the use of personal protective equipment during welding operations.

KEYWORDS: SIC 3443 (Metal Fabrication), nickel, chromium, copper, metal fume fever, stainless steel, sterilizers, medical monitoring, welding.

II. INTRODUCTION

On November 15, 1988, the National Institute for Occupational Safety and Health (NIOSH) received a request from an authorized employee representative of the International Association of Machinists and Aerospace Workers to conduct a Health Hazard Evaluation at MDT/Castle in Rochester, New York. The request stated that employees in the Welding Department were experiencing nausea, headaches, gastrointestinal illness, chest pain, shortness of breath, and pain in their extremities. Potential exposures identified in the request included chromium, nickel, and other stainless steel welding products.

NIOSH investigators conducted an initial site visit and walk-through inspection on January 18, 1989. Copies of previous industrial hygiene survey results were obtained for review. These reports included: January 20, 1983 report by the Hartford Insurance Company; report of the June 25, 1986 survey by NATLSCO (National Loss Control Co.); State Of New York, Department of Labor, Division of Safety and Health 7(c)(1) OSHA consultation inspections of January 22, 1987, July 23, 1987, July 30, 1987, November 5, 1987, and April 12, 1988. Based on these reviews, a NIOSH environmental sampling protocol was established to focus on the welding operations. Environmental monitoring was performed on February 14-15, 1989. Results of the environmental monitoring were forwarded to the company and union officials on July 13, 1989. An interim report of environmental results was sent to company and union officials in August, 1989. On August 18, 1989, a follow-up medical evaluation was conducted. Medical results were sent to the individual medical study participants on September 28, 1989, with an explanation of the test values.

III. BACKGROUND

MDT/Castle manufactures stainless steel sterilizer units primarily for the medical community. Sterilizers range in size from 8-inch table-top models to 60-inch, single door powerclaves. Approximately 350 workers are employed at this facility, of which 37 are welders. The Welding Department operates 2 shifts, with 23 welders on the day shift (7:00 am - 3:30 pm) and 14 on the night shift (3:30 pm to midnight).

The majority of welding operations employ arc welding: metal-inert gas (MIG), tungsten-inert gas (TIG), shielded stick welding, and automatic robot welding (also MIG). Helium, argon, and carbon dioxide are used as shielding gases. Most of the base material is nickel-clad steel, and many of the filler metals contain nickel and chromium. Two of the most commonly used electrodes are Inconel-92 and Monel-60 (both trade names). Inconel-92 contains 71% nickel, 17% chromium, 6% iron, 3% titanium and 2% manganese. Monel-60 contains 65% nickel, 0.1% chromium, 27% copper, 4% manganese and 3% titanium.

In January, 1983, a supplied-air respiratory protection system was installed by the company for use when welding inside tanks. This system was prompted by environmental monitoring results which indicated a potential for excessive ozone exposures during welding of the interior seams of the sterilizers. The respirator air supply is drawn from compressors which also supply plant air. However, the respirator air is first passed through a filtering system and has an in-line carbon monoxide (CO) monitor. There have been frequent complaints from employees about the quality of the air supplied to the respirators, which has led to their intermittent usage. In addition, workers reported that there have been several alarms from the CO monitor, which were not investigated at the time. The breathing air was the subject of the July 23, 1987, consultation inspection by personnel from the State of New York. The breathing air was determined "acceptable" (no CO or hydrocarbons detected), but the State inspector measured excessive dryness of the supplied air (1-2% relative humidity).

All welders are included in the plant's respiratory protection program and have received training in the use and limitations of the respirators. In addition to the supplied air respirators, welders routinely wear 3M, Premium Welding Fume Respirators, Model 9925. These are disposable models which appear to have gained acceptance among employees. Welders are also included in the plant's hazard communication and hearing conservation programs.

Each welding station is totally confined behind colored protective screens. These orange and blue screens protect passersby and other workers from eye flash.

Both general and local exhaust ventilation are used in the welding department. General ventilation exhausts air through the ceiling to the outside. A flexible duct, attached to a mechanical exhaust fan is located near the plasma cutting machine. In addition, portable, recirculating exhaust systems are available in the welding area for use when welding in hard-to-reach areas. These portable systems filter the air before recirculating the exhaust. The blue haze that characterizes many large welding shops was not evident at this plant, indicating the effectiveness of the ventilation system. In addition, the welding area appeared clean and orderly.

IV. EVALUATION DESIGN AND METHODS

A. Environmental

Air samples for welding fumes were collected on mixed cellulose ester filters. Personal samples were collected by placing the filter cassettes near the breathing-zone of the workers. The filters were located outside of the welders helmet. Therefore, the data do not take into account the amount of protection believed to be afforded by the helmet. The filter media were connected via Tygon™ tubing to battery-operated sampling pumps at calibrated air flows ranging from 1.5 to 2 liters per minute (LPM). The filters were analyzed using inductively coupled argon plasma-atomic emission spectroscopy (ICP-AES) according to NIOSH Method No. 7300,[1] a technique that permits for the simultaneous analysis of

28 metals of toxicological importance. A list of these elements and their corresponding analytical limits of detection is presented in Table 1. CrVI analysis was not specifically requested because the majority of the welding operations (i.e., MIG and TIG) would not be expected to produce this contaminant.[2]

Sampling for carbon monoxide in respirator breathing air and around the abrasive blasting booth was accomplished using Draeger™ length-of-stain indicator tubes and a 100 cc bellows pump.

B. Medical

The initial medical evaluation conducted on January 18, 1989, consisted of a review of the OSHA 200 logs for 1986 through 1988, a walk-through inspection of the medical facilities, and private interviews with 18 employees. On August 18, 1989, a follow-up medical evaluation was conducted, consisting of a work practices and symptom questionnaire survey of 22 welders and an end-of-work-week post-shift urine sample which was analyzed for determination of chromium and nickel.

V. EVALUATION CRITERIA

A. Environmental 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 of workers may experience adverse health effects because of individual susceptibility, a pre-existing medical condition and/or by 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 considered for this study were: 1) NIOSH criteria documents and recommendations (RELs), 2) the American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values (TLVs), and 3) the U.S. Department of Labor (OSHA) federal occupational health standards (PELs). Often, the NIOSH recommendations and ACGIH TLVs are lower than the corresponding OSHA standards. Both NIOSH REL's and ACGIH TLVs 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 exposure limits, 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 legally 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 8-10 hour workday. Some substances have recommended short-term exposure limits (STEL) or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from high, short-term exposures.

Table 2 presents a list of metals detected on the breathing zone samples, along with their applicable occupational exposure criteria.

Information on possible health effects of excessive exposure to welding fumes and selected metals that may be found in welding fumes is provided below:

1. <u>Total Welding Fumes, not otherwise classified</u>[2,3]

The health effects associated with exposure to welding fumes are dependant on the toxicity of individual component metals. This classification applies to welding environments where concentrations of toxic metals (e.g.; chromium, cadmium, zinc) are not in excess of their respective exposure criteria. Usually in these situations, the major component of the fume is iron oxide or aluminum oxide, depending on whether the base metal is carbon (mild) steel or aluminum. Oxides of these metals are considered nuisance particulates and have a PEL of 5 mg/M^2. Welding is sometimes associated with metal fume fever.

In April, 1988, NIOSH published "Criteria for a Recommended Standard: Welding, Brazing, and Thermal Cutting"[2]. In this document, NIOSH recommends "as a prudent public health measure" that worker exposures to all chemical and physical agents associated with welding be reduced to the lowest concentrations technically feasible using current state-of-the-art engineering and good work practice controls. Exposure limits for individual chemical or physical agents are to be considered upper boundaries of exposure.

2. Chromium[3,5,6]

The known health hazards from excessive exposure to chromium welding fumes are dermatitis; ulceration and perforation of the nasal septum; irritation of the mucous membranes of the eyes, nose, and throat; and chronic asthmatic bronchitis. Chromium compounds can act as allergens in some workers and may cause dermatitis in exposed skin. Chromium exists in one of three valence states: 2+, 3+, and 6+. Chromium compounds in the 3+ state are of a low order of toxicity. In the 6+ state, chromium compounds are irritants and corrosive. NIOSH considers the this hexavalent form to be carcinogenic. Workers in the chromate-producing industry have been reported to have an increased risk of lung cancer.

3. Iron Oxide Fume[3,5]

Inhalation of iron oxide fume or dust causes an apparently "benign" pneumoconiosis termed siderosis. Iron oxide alone does not cause fibrosis in the lungs of animals, and the same probably applies to humans. Exposures of 6 to 10 years are usually considered necessary before changes recognizable by x-ray can occur; the retained dust gives x-ray shadows that may be indistinguishable from fibrotic pneumoconiosis.

4. Nickel[7,8]

Metallic nickel and certain soluble nickel compounds, as dust or fume, can cause sensitization resulting in dermatitis and/or asthma. Nickel fume in high concentrations is a respiratory irritant. Nickel is carcinogenic in animals, and several epidemiologic studies have shown an increased incidence of cancer of the paranasal sinuses and lungs among workers in nickel refineries and factories. Suspicion of carcinogenicity has been focused primarily on respirable particles of nickel, nickel subsulfide, nickel oxide, and on nickel carbonyl vapor.

5. Copper[9,10,11]

Pure copper fume is associated with metal fume fever. This condition is relatively rare due to the high vaporization point of copper (2350°C) but may nevertheless occur during the welding process. Metal fume fever is an acute illness characterized by fever and influenza-like symptoms, but is noninfectious in origin. It is characterized by fever, chills, sweating, weakness, headache, myalgias, and cough, often coming several hours after the causative exposure and resolving without treatment, within 24-36 hours.

In addition, copper poisoning may lead to a number of toxic effects, including metallic taste, excessive salivation, nausea, vomiting, and epigastric burning, among others. Chronic copper poisoning causes hemochromatosis; Wilson's disease is a hereditary disorder that may be aggravated by, but has not been ascribed to, industrial exposure to copper.

B. Effects of Arc Welding on Respiratory Symptoms and Lung Function

Previous studies[13,14,15] have noted a variety of acute and chronic health problems associated with arc welding, which have not clearly been attributable to any single metal fume or gas exposure, but which may be related to the combined effects of different exposures created by arc welding. Some metal fumes and gases generated by welding are respiratory irritants, and symptoms of eye, nose, and throat irritation, as well as cough and phlegm production, have been reported by welders in association with their work shift.[12] Welders have been reported to have an increased prevalence of chronic bronchitis.

Some studies have also shown welders to have declines in pulmonary function compared to non-welders, including lower total lung capacity (TLC),[16] lower forced vital capacity (FVC) and forced expiratory volume in one second (FEV1).[13,16] However, it has not been possible to attribute changes in pulmonary function to specific exposures, and not all studies have found lower pulmonary function in welders.[15] In addition, it is not known whether changes in lung function associated with welding can, in the absence of smoking or other exposures, lead to clinically significant abnormalities in lung function. Exposures encountered by welders vary with the type of welding process, the material welded, and the use of local ventilation and personal protective equipment. Therefore, it is not possible to make reliable generalizations about health effects of welding in all workplaces. Differences in exposures may explain why various studies of welders have not produced consistent results.

VI. RESULTS AND DISCUSSION

A. Environmental

Qualitative and quantitative analytical results for metals are presented in Table 2. These results show the presence of aluminum, barium, calcium, chromium, copper, iron, magnesium, manganese, nickel and zinc. The range of airborne concentration for each of these metals are presented, along with their corresponding evaluation criteria.

Individual air sampling results for the various types of welding are presented in Table 4. Environmental concentrations are provided for chromium, nickel, zinc, copper, iron, magnesium, manganese, and aluminum, which were present in significant amounts. The results reported for chromium should be considered as the total chromium concentration; i.e., the samples were not specifically analyzed for chromium VI. It has been reported in the literature that MIG and TIG welding and plasma cutting produce very low chromium VI content, whereas "stick" welding produces a relatively higher proportion of chromium VI (as high as 70% of the total chromium content).[2] One explanation for this is that chromium VI is quickly reduced to chromium III in the presence of reducing agents in the welding plume, such as aluminum.

Total chromium concentrations ranged from 0.9 to 201.6 micrograms per cubic meter (ug/M^3). Nickel concentrations ranged from 2.8 to 647.8 ug/M^3, with 18 of the 22 samples exceeding the NIOSH REL of 15 ug/M^3. None exceeded the OSHA PEL of 1000 ug/M^3.

Three of 22 sample results exceeded the OSHA PEL of 100 ug/M^3 for copper fume, and concentrations ranged from ND to 446.5 ug/M^3. All other detected metals did not exceed any environmental criteria.

The exposure levels reported represent the concentration of contaminants outside of the welders helmet, which means employee's exposures were actually less than the reported values.

B. Medical

There were two occupational diseases reported in the OSHA 200 logs. Both were from 1988; 1986 and 1987 logs reported only injuries. These two 1988 illness reports included: (1) a possible occupational liver problem in one employee and (2) chest pain with urticaria in another employee while he was welding inside a sterilizer body.

The medical facilities consist of a dispensary, staffed during the day by a registered nurse. A physician is available for three days per week for one hour each day. During the evening shift, and for emergencies, employees are referred to an emergency room at a local hospital. There is no formal medical monitoring program, other than that required to achieve compliance with the OSHA recordkeeping requirements.

Private medical interviews were conducted with 18 employees, 14 of the 23 day shift welders, 2 of the day shift heavy fabricators, and 2 of the 14 evening welders. Symptoms reported during these interviews are summarized below.

Symptom	No. reporting	Percent (N=18)
Headache	7	39
Upper respiratory irritation	6	33
Chest pain or heaviness	5	28
Shortness of breath	4	22
Abdominal pain or nausea	3	17
Fatigue or malaise	3	17
Arthralgias or myalgias	2	11
No symptoms	7	39

In addition, two employees noticed symptoms of shortness of breath, nausea, and chest heaviness while using the air-supplied respirator in the Fall of 1988.

Employees reported they often did not use the air-supplied respirator because of inconvenience, nasal and throat dryness, and concern for their safety. The following table summarizes this finding.

Use of Respirator	No. reporting	Percent (N=13)
All the time (inside and out)	1	8
Always inside	3	23
Occasionally inside	6	46
Never inside	3	23

Five of the 18 interviewed employees did not work inside sterilizer bodies and are not included.

Employees who occasionally used the air-supplied respirator inside tanks often said that their decision to use it rather than a fume mask depended on the length of time they planned to spend inside the tank. One employee stated that he could not tolerate the dryness of the supplied air.

In summary, during the initial medical evaluation, sporadic and inconsistent use of the air-supplied respirator, as well as the fume mask, was reported by many of the welders. Symptoms possibly related to exposure to welding fumes were reported by approximately 61% of the welders interviewed.

The follow-up industrial hygiene evaluation demonstrated exposure above the NIOSH REL in some welders for nickel and possibly chromium, and above the OSHA PEL for copper. These samples were obtained outside the welding helmet, however. Therefore, a follow-up medical evaluation to better define whether the welding conditions actually produced an overexposure to any of these metals was performed. Two biologic indicators of exposure (urine nickel and chromium levels) and a symptom questionnaire were used to assess potential overexposure.

The follow-up evaluation was conducted at the end of the first and second shifts on Friday, August 18, 1989. The end-of-work-week sample was chosen because of its documented usefulness in evaluating cumulative exposures to chromium without interfering with assessment of nickel exposures[20] and because it provided a useful time frame for questions directed at determining exposures and work practices.

Twenty-two welders completed the questionnaire and submitted a urine sample. The questionnaire obtained demographic information (age and sex), work history information for the past week (total hours welding, total hours welding stainless steel, nickelclad steel, and aluminum, and welding inside a vessel), smoking and work practice information (use of the supplied air respirator and fume mask inside and outside of vessels), and symptoms associated with welding. The spot end-of-work-week urine sample was analyzed for chromium, nickel, and creatinine.

All welders were men. The average age was 35 years. Twelve (55%) were smokers. The average total hours welding in the past week was 27, with a range of 0 (in two) to 46. Only 10 employees welded stainless steel, and only 2 employees welded aluminum.

There was no relationship between the type of welding, the total hours welding, or the location of the welding (e.g., welding inside a vessel) during the week prior to the evaluation, and the urine nickel or chromium levels. There was also no association between smoking status and urine nickel or chromium.

The relationship between hours welding and urine nickel and chromium levels was complicated by the variable use of the available respiratory protection. Of the 12 welders doing inside welding, three (25%) never used the air-supplied respirator, four (33%) used it intermittently, and five (42%) used it all the time. (Due to the confined space conditions of inside welding, those welders not using the air-supplied respirator should be considered at risk for asphyxiation.)

Of the three welders doing inside welding who never used the supplied air respirator, one used the fume mask. Twelve welders (55%) used the fume mask with some welding; three (25%) used it only while welding inside.

The results of the symptom survey is presented in Table 3. All of these symptoms were associated by the participants with welding. Nasal stuffiness was the most common current symptom, followed by fatigue, cough, difficulty breathing, eye and throat irritation, muscle aches, and shortness of breath. Headache was the most common overall symptom, followed by eye irritation, fatigue, sneezing, stuffy nose, and cough. Thus, upper respiratory irritative symptoms predominated.

Of the four welders who noticed fevers or chills from welding, 2 (50%) also became nauseated or vomited, 3 (75%) noticed joint pain and cough, and all 4 noted muscle aches, fatigue, headache, and difficulty breathing. Several symptoms were associated with fevers and chills during welding: difficulty breathing ($p=0.001$), headache ($p=0.04$), nausea and vomiting ($p=0.06$), and muscle aches ($p=0.08$). This symptom complex is suggestive of metal fume fever.

The average urine nickel level was 14.2 micrograms per liter (ug/L), with a median value of 10.8 ug/L. The range was less than 5 ug/L (the limit of detection) to 45.1 ug/L. Twelve welders (54.5%) were above the population reference range of less than 10 ug/L. Adjusting for creatinine, the mean urine nickel level was 8.6 ug/L with a median of 7.0 ug/L and a range of less than 5 ug/L to 26.4 ug/L. It should be noted that there is currently no generally recognized standard for urine nickel levels.

The average urine chromium level was 2.7 ug/L, with a median of 1.7 ug/L. The range was less than 1 ug/L (the limit of detection) to 11.2 ug/L. Adjusting for creatinine, the average urine chromium level was 1.6 ug/L, with a median of 1.3 ug/L and a range of less than 1 ug/L to 4.7 ug/L. All concentrations were below the upper limit of the population reference range of 15 ug/L, and well below a suggested end-of-work-week reference value of 30 ug/L for occupational exposure.[20]

There was a significant correlation between the raw urine nickel and chromium data (correlation coefficient = 0.44; y=8.21+2.09x; p=0.36). After adjusting for creatinine, the correlation coefficient was 0.56 (y=4.73 + 2.4x; p=0.007).

VII. CONCLUSIONS

1. Based on the results of the environmental and medical investigation, a potential health hazard exists in the welding department from employee exposure to nickel above the NIOSH REL. In addition, three employees were exposed to copper at concentrations exceeding the OSHA standard. These measured exposure levels, however, do not take into account the protection afforded by the use of respirators. The medical evaluation supported the conclusion that there was an overexposure to nickel among the welders. Respiratory protection was found to be used intermittently or not at all by the majority of welders. The urine nickel levels in 55% of the welders tested were above the population reference range, as was the average urine nickel level, despite the fact that more than 90% of the nickel compounds present in stainless steel welding fumes are insoluble, and therefore poorly absorbed and less likely to appear in the urine.[20]

2. Environmental measurements suggest a potential for significant exposure to chromium during stainless steel welding. The medical evaluation supported this finding. Although the urine chromium levels were all within the population reference range, there was a significant correlation between them and the urine nickel levels. This implies that a common exposure was responsible for the variation found in both. In addition, chromium VI occurs in both soluble and insoluble forms, the latter being poorly absorbed and therefore less likely to appear in the urine. Thus, the urinary levels may under-represent the actual exposure.

3. Some symptoms reported by welders are consistent with the irritant effects of exposure to welding fumes in general. In addition, four welders had symptoms consistent with metal fume fever, a finding consistent with the high exposure to copper fume.

4. The inconsistent use of the air-supplied respirators seems to be due to employee concern over the quality of the breathing air and the excessive dryness of the breathing air. These perceptions result in the respirators not being used routinely, thus placing the welders at risk from both acute and chronic illnesses.

VIII. RECOMMENDATIONS

1. Use of the existing local exhaust ventilation (LEV) systems to remove metal fumes at their source should be required.

2. Those workers welding for prolonged periods of time in one location should use a fan in conjunction with the LEV to prevent fumes from entering their breathing zone. The fan should be placed appropriately so as not to defeat the LEV system.

3. The present respirator program should be thoroughly reviewed and updated to ensure that it is in compliance with all the requirements of the OSHA respirator standards (29 CFR 1910.134), including medical screening.

4. The use of the air-supplied respirators must be enforced when welding inside the sterilizer bodies. One way to ensure their use would be to provide a separate system for breathing air (separate from general plant air). The problems encountered in the past with regard to the quality of the breathing air has led to a reluctance on the part of the welders to use the respirators.

5. Welders should use the fume mask at all times while welding outside a vessel.

6. Environmental monitoring for Chromium VI should be conducted if stick welding operations are routinely used.

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XI. DISTRIBUTION AND AVAILABILITY OF REPORT

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

1. MDT/Castle Company, Inc.
2. International Association of Machinists and Aerospace Workers
3. OSHA, Region II

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 1
Elements Analyzed by ICP-AES and their Corresponding
Analytical Limits of Detection

MDT/Castle
Rochester, New York
HETA 89-040

Element	Analytical Limit of Detection (micrograms per sample)
Aluminum	10
Arsenic	5
Beryllium	1
Calcium	1
Cadmium	10
Cobalt	1
Chromium	1
Copper	1
Iron	1
Lithium	5
Magnesium	1
Manganese	1
Molybdenum	1
Nickel	1
Lead	2
Phosphorus	10
Platinum	10
Selenium	10
Silver	2
Sodium	50
Tin	10
Tellurium	10
Titanium	10
Thallium	10
Tungsten	20
Vanadium	1
Yttrium	1
Zinc	1
Zirconium	10

Note: 1000 micrograms = 1 milligram

Table 2
Metals Detected on Breathing Zone Samples

MDT/Castle
Rochester, New York
HETA 89-040

Substance (Metal)	Range (ug/M^3)	Number of samples detected on	NIOSH REL	ACGIH TLV (in ug/M^3)	OSHA PEL
Aluminum	ND - 690	14/22	----	5000	5000
Chromium	0.9 - 201	22/22	**	500	1000
Copper	ND - 446	21/22	----	200	100
Iron	6.6 - 2009	22/22	----	5000	10000
Magnesium	ND - 46	21/22	----	10000	15000
Manganese	1.9 - 355	22/22	----	1000	C-5000
Nickel	2.8 - 648	22/22	15	1000	1000
Zinc	ND - 87	20/22	5000	5000	5000

C - an employee's exposure shall at no time exceed the ceiling value

**The NIOSH RELs for chromium compounds distinguishes chromium VI compounds which are carcinogenic (REL 1 ug/M^3) and chromium VI compounds which are non-carcinogenic (REL 25 ug/M^3). These RELs are not applicable for total chromium, which was measured in this study.

Table 3
MDT/Castle - Symptom Survey
HETA 89-040

SYMPTOM PRESENT	PRESENT CURRENTLY #(%)	SOMETIMES PRESENT #(%)	NEVER #(%)
Stuffy nose	6 (27.3%)	7 (31.8%)	9 (40.9%)
Fatigue/tired	5 (22.7%)	9 (40.9%)	8 (36.4%)
Cough	4 (18.2%)	7 (31.8%)	11 (50.0%)
Joint pain	4 (18.2%)	6 (27.3%)	12 (54.5%)
Diff. breath.	3 (13.6%)	3 (13.6%)	16 (72.7%)
Throat irrit.	3 (13.6%)	7 (31.8%)	12 (54.5%)
Muscle aches	3 (13.6%)	8 (36.4%)	11 (50.0%)
Eye irritat.	3 (13.6%)	12 (54.5%)	7 (31.8%)
Dizziness	2 (9.1%)	4 (18.2%)	16 (72.7%)
Headache	1 (4.5%)	14 (63.6%)	7 (31.8%)
Sneezing	1 (4.5%)	13 (59.1%)	8 (36.3%)
Post nasal	1 (4.5%)	8 (36.4%)	13 (59.1%)
Runny nose	1 (4.5%)	8 (36.4%)	13 (59.1%)
Skin rash	1 (4.5%)	3 (13.6%)	18 (81.8%)
Bronchitis	0 (0%)	1 (4.5%)	21 (95.5%)
Hoarseness	0 (0%)	6 (27.3%)	16 (72.7%)
Wheezing	0 (0%)	3 (13.6%)	19 (86.4%)
Numb/tingle	0 (0%)	3 (13.6%)	19 (86.4%)
Fevers/chills	0 (0%)	4 (18.2%)	18 (81.8%)
Nausea/vomit	1 (4.5%)	3 (13.6%)	18 (81/8%)
Swollen face	0 (0%)	2 (9.1%)	20 (90.9%)