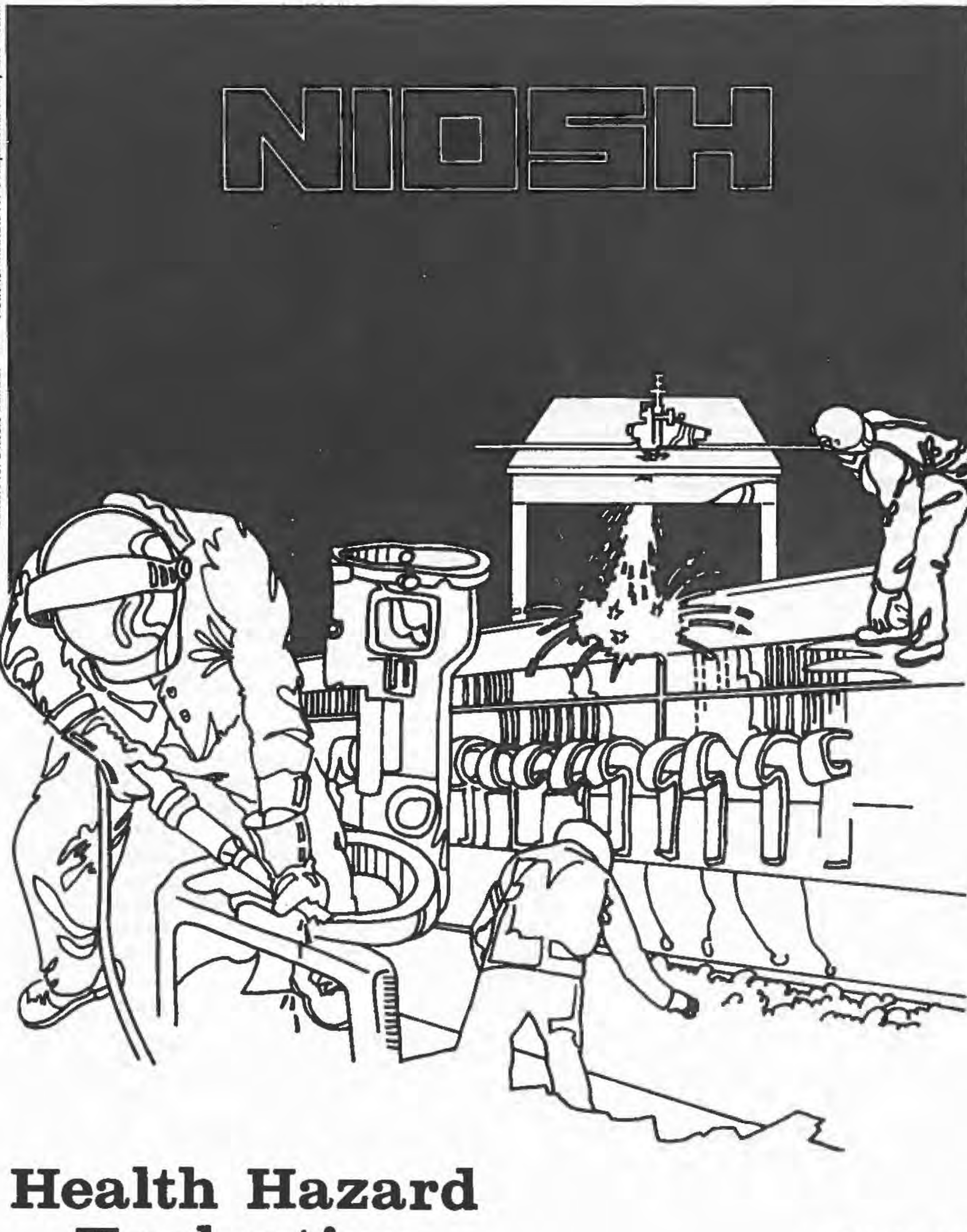
U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES ■ Public Health Service
Centers for Disease Control ■ National Institute for Occupational Safety and Health



Health Hazard Evaluation Report

HETA 81-263-1178
COPPERWELD STEEL COMPANY
WARREN, OHIO

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 81-263-1178
JANUARY 1984-REVISED
COPPERWELD STEEL COMPANY
WARREN OHIO

NIOSH INVESTIGATORS:
Jay C. Klemme, MD, MPH
Steven A. Lee, I.H.

I. SUMMARY

On April 6, 1981 the National Institute for Occupational Safety and Health (NIOSH) received a request from employees at Copperweld Steel Company to perform a health hazard evaluation of reducing gas (RX gas) generating equipment in the heat treating area of the finishing unit. Their concern was based on the reported development of chronic dizziness, tremor, memory loss, and weakness among workers who had been hospitalized in February following accidental exposure to RX gas, whose primary constituents were hydrogen, nitrogen, and carbon monoxide (CO).

On May 13-15, 1981 an in-plant survey was performed which consisted of an opening conference at which labor and management were represented; a walk-through survey of the RX gas generating area of the heat treating unit; and interviews with employees from the heat treating area, company officials and union representatives. Information was obtained from hospital records and from physicians who had provided care to 3 affected workers. Industrial hygiene data and other background information were obtained from the Occupational Safety and Health Administration (OSHA) officers who had undertaken an earlier investigation of the reported incident.

The 3 workers who had been hospitalized in February 1981 were found to have evidence of persistent neurological impairment, including symptoms or findings relating to memory, concentration, mood, coordination, and intellectual function that are consistent with known long-term neurological effects of carbon monoxide poisoning. Environmental evaluation of the RX gas generating equipment when in usual operation revealed no levels of CO above 5 parts per million. A "positive lock-out system" that was installed after the February 1981 incident should assure that workers will not be exposed to CO during generator maintenance while other RX gas generators are operating.

On the basis of the medical and environmental findings, NIOSH determined that Copperweld workers are not ordinarily exposed to hazardous levels of carbon monoxide (CO) from the system of 4 interconnected reducing gas (RX gas) generators. However, prior to the installation of a "positive lock-out system," workers performing generator maintenance on a disabled generator were potentially at risk of exposure to hazardous levels of CO from other RX gas generators. Additional recommendations to prevent accidental exposure to harmful levels of CO are presented.

KEYWORDS: SIC 3312 (blast furnaces (including coke ovens), steel works, and rolling mills), carbon monoxide, reducing gas, carboxyhemoglobin, neurological effects, lock-out mechanism.

II. INTRODUCTION

On April 6, 1981 the National Institute for Occupational Safety and Health (NIOSH) received a request from employees at Copperweld Steel Company to perform a health hazard evaluation of reducing gas (RX gas) generating equipment in the heat treating area of the finishing unit. Their concern was based on the reported development of dizziness, tremor, memory loss, and weakness among workers who had been hospitalized in February following accidental heavy exposure to RX gas, whose primary constituents were hydrogen (H_2), nitrogen (N_2), and carbon monoxide (CO).

On May 13-15, 1981 an in-plant survey was performed which consisted of an opening conference at which labor and management were represented; a walk-through survey of the RX gas generating area of the heat treating unit; and interviews with employees from the heat treating area, company officials and union representatives. Information was obtained from hospital records and from physicians who had been involved in providing care to the affected workers. Industrial hygiene data and other background information were sought and obtained from the Occupational Safety and Health Administration (OSHA) officers who had undertaken an earlier investigation of the reported incident. An interim report was issued by NIOSH in June 1981.

III. BACKGROUND

A. Setting

Copperweld Steel Company, Warren, Ohio, is a wholely owned subsidiary of Copperweld Corporation that is located in a facility that was started in 1939. It is a producer of specialty steel products such as hot-rolled, cold-rolled, thermal treated, and free-machining steels. The plant employs approximately 2500 workers, who are represented by the United Steel Workers of America or by one of three other unions. There are approximately 100 workers in the heat finishing area.

The area where the incident occurred contains two heat treating furnaces to which RX gas is supplied by four "RX atmosphere gas generators." The purpose of the generators is to supply a non-decarburizing and non-oxidizing atmosphere during heat treatment of the steel in the furnaces. The gas is generated by cracking a controlled mixture of air and methane such that practically all of the oxygen (O_2) in the air combines with the hydrocarbon fuel to form H_2 and CO. The final product is supposed to consist of about 20% CO, 40% H_2, and 40% N_2. Each unit generates up to 100 cubic feet per minute (cfm) of gas.

Prior to 1979, two of the RX gas generators were connected to each treating furnace. In 1979, the RX gas generators were interconnected so that either furnace could be supplied with gas from two generators even if one of the generators was out of service. It appeared that a failure to properly control this system of interconnections resulted in exposure of employees to room air that had been contaminated with RX gas that had flowed back through an open valve to a partially disassembled generator unit.

After the February 1981 incident, the company installed a "positive lock-out" system for the RX gas generators so that maintenance cannot be conducted on a downed generator without first securely locking the valve closed that connects the unit to the other gas generators. This positive lockout system should prevent a recurrence of this mode of employee exposure to RX gas during generator maintenance procedures.

In April, 1981, investigators from the OSHA, using an Ecolyzer[R] Model 2800, took air measurements for CO in the Heat Treating Department near the RX gas generators. No levels above 5 ppm were detected during normal operation of the units, which indicated that the system was well enclosed.

B. Description of Episode

The reported incident occurred on RX gas unit East Number 4, which was shutdown on February 19, 1981 for repair of a defect in the water jacket of the catalytic column. On February 22, while other RX gas generator units were operating normally, two workers undertook to fill the catalytic column with cubes of the catalytic agent. One employee stood in a stooped position atop the RX gas generator unit and emptied buckets of catalytic agent into the column. A second employee would fill the buckets with catalytic material, climb the ladder, and hand the bucket of material to the employee on top. The employee on top of the unit during this period reported that he had noted a slight breeze on the side of his face but had perceived no odor or dust.

About 20 minutes after the beginning of this process, while trying to pick up loose pieces of catalyst that were scattered atop the column, the worker on top of the gas generator unit sensed that he was losing his balance and knelt to avoid falling from the furnace top. He described perceiving that the chunks of material on top of the generator were moving away from his hand as he tried to reach for them. The employee on the ladder observed the flailing hand movements and other uncoordinated movements of the employee on top of the gas generator, realized that this first employee was losing consciousness, grabbed hold of him to prevent him from falling, and called to passing workers for help. One of the nearby workers climbed up the back of the gas generating unit itself, saw that the first person was unconscious atop the unit and the second was losing consciousness on the ladder, and grabbed hold of the person on the ladder to prevent him from falling backwards. Other workers brought ladders to the area and carried down the first two workers. The third worker climbed back down to the floor but immediately developed a sense of loss of balance and collapsed to the floor. Two workers were taken to the in-plant medical facility, where each had pale clammy skin, shallow breathing, and appeared to be unconscious. Care was supervised by the nurse on duty. Each of these two workers received 3-5 mechanically assisted breaths and then was able to maintain adequate spontaneous breathing of O_2. The third worker reportedly received O_2 at the site of the incident. The three workers were initially treated at the scene by plant personnel trained in emergency medical care and then taken by ambulances to three different hospitals in the community.

Each of the three individuals was evaluated in a hospital emergency room and was then admitted for a period of observation. CO was mentioned as a constituent of the gas exposure in only one of the three hospital records. Arterial blood gas measurements made for each individual at the time of emergency room assessment showed elevated O_2 saturation, elevated partial pressure of O_2, and borderline to moderate alkalosis. No blood tests specific for CO were performed.

Two of the three individuals were noted to have had speech difficulties during their hospitalizations. In-depth neurological evaluations during hospitalization are not documented in the records of any of the three individuals. Each of the three individuals was discharged from hospital care on the third day after hospitalization.

IV. EVALUATION CRITERIA

Carbon Monoxide

CO is a colorless, odorless, tasteless, non-irritating gas that is produced by incomplete combustion, such as in internal combustion engines, heaters and furnaces with inadequate air supply or venting, improperly adjusted diesel engines, and cigarette smoke. It has commercial use as an O_2 scavenging agent in applications where hot or molten metal must be protected from oxidation. In the past, CO was a component of some commercial cooking and lighting gas, but this use has been discontinued because of the health risks posed by CO. The poisonous effects of CO result from O_2 deprivation of body tissues. CO breathed into the lungs combines with hemoglobin (Hb), the O_2 carrier in the blood, to form carboxyhemoglobin (COHb), which is unable to carry O_2 properly. CO also can interfere with the function of other chemical systems in the body and is under investigation as a possible cause of atherosclerosis.[1,2]

Except in individuals with underlying heart disease who may not tolerate even slight compromise of oxygenation of the heart, the central nervous system is the part of the body that is most vulnerable to oxygen deprivation. Symptoms that may be apparent at COHb levels of 15-25% include headache, nausea, muscular weakness, palpitations, impaired fine manual dexterity, dizziness, and confusion.[1,3] Higher concentrations of COHb can cause dimming of vision and impaired intellect that can progress to collapse, unconcsiousness, coma, and death if elevated levels of COHb are not reduced.[1,3] Severe neurologic and psychiatric complications of acute CO poisoning can develop hours or days after apparent full recovery from initial symptoms.[1,4] The types and severity of symptoms may vary markedly among comparably exposed individuals. Persistent symptoms can include difficulties with vision, hearing, speech, comprehension, memory, concentration, arithmetic calculations, recognition of words or faces, spatial orientation, putting on clothing, coordination, tremor, and control of temper. Recovery can continue for up to 2 years but may not be complete.

The NIOSH recommended time-weighted average (TWA) exposure limit is 35 parts per million (ppm) over a 10 hour work shift. The reccommended ceiling limit is 200 ppm. With such exposure, accumulation of CO proceeds gradually over several hours. The resulting concentration of COHb in the blood should not exceed 5% of total Hb. This level of COHb is considered to be tolerable for healthy individuals, although several studies indicate subtle reversible neurological changes at levels below 5%.[5] Inhalation of a higher concentration of CO in the air produces a more rapid increase in COHb and a higher peak level. At very high concentrations of CO, life threatening levels of COHb can develop in minutes.

Diagnosis of CO poisoning requires specific testing for COHb, because the usual test of blood O_2 content may show a normal value, even in a severely affected individual. Medical treatment is based on decreasing the level of COHb so that body tissues again receive adequate O_2. When breathing normal air, the level of COHb decreases by one half in approximately $4^1/2$-5 hours.[3] Administration of pure O_2 accelerates the elimination of CO. In severe cases of CO poisoning, hyperbaric (high pressure) O_2 therapy can reverse the CO effects rapidly to prevent death or reduce neurological damage.[1] In the presence of neurologic signs or impairment of mentation, Kindwall[1] indicates that the victim should be referred to a facility having hyperbaric O_2 facilities regardless of his/her COHb level.

V. RESULTS

In May, 1981, the medical officer interviewed the three affected workers. Table A lists symptoms that were reported by at least two of the affected workers to have continued beyond the time of discharge from the hospital. Most of the symptoms listed were still being experienced at the time of the NIOSH investigation, although a few had resolved partially or completely by that time.

Table A

Symptoms experienced since hospital discharge by two or more of the affected employees

Shortness of breath with exertion
Muscular weakness with exertion

Lightheadedness when standing up from sitting position
Sense of insufficient balance/sense of possibly falling

Poor coordination and timing
Trembling/shivering/sense of internal shaking (worse under stress)

Difficulty of word assembly into sentences
Losing track of wording while speaking
Poor recall of words or names
Episodes of misspelling own signature

Confusion
Forgetfulness/need lists for everyday activities
"One track mind"
Must think about how to do activities that had been automatic
Poor concentration

"Keyed up"/irritable/readily lose temper

Errors of cognition during activity

Falling asleep in chair or at table (when relaxing, not during activity)

The medical officer detected the following signs in one or more of the individuals during conversation with the three affected employees and cursory neurological examination of two employees: abnormality of heel-to-toe gait, abnormality of rapid alternating movement, briskness of deep tendon reflexes, errors of word choice and sentence assembly, and slowness and inaccuracy of serial seven subtractions.

The Copperweld plant physician, when interviewed by the NIOSH medical officer in regard to the February incident, reported that he had not known that RX gas contained CO and had not obtained information on the composition of RX gas from company officials. The Copperweld nurse on duty at the time of the incident reported that she had notified all 3 hospitals that arriving patients might have been exposed to CO.

There were no warning signs or labels in the heat treating area that would indicate high levels of CO in the gas generating equipment and ductwork. Employees in the area and plant safety personnel reportedly were not aware that CO was present in RX gas or that RX gas could cause serious injury and death.

VI. DISCUSSION

Atmospheres containing 1500 ppm (0.15%) of CO are immediately dangerous to life or health.[6] RX gas at the Copperweld Steel Company contains approximately 200,000 ppm (20%) of CO. Dilution of relatively small quantities of RX gas by the general room air of the plant would prevent the average CO concentration in the plant from rising rapidly, but the CO concentration near the leak could be extremely dangerous. The apparent incomplete appreciation of this CO hazard by Copperweld management, medical personnel, and hourly employees; the absence of any labeling or posting of CO hazards near the CO generating equipment; and the absence of CO detection monitors to warn of CO contamination in the air created a setting in which a serious CO accident could occur.

Questions were raised about the possibility that the effects noted were not caused by CO. However, the patterns of symptoms and medical findings were compatible with CO poisoning. The RX gas generator was presumed to be producing the intended gas mixture, which contained 20% CO, since plant personnel reported no problems with the steel treated on the day of the incident. Hydrogen and nitrogen, the other main constituents of RX gas, do not pose specific health risks except for the obvious explosive potential of hydrogen. Asphyxiation by nitrogen or hydrogen is implausible, since an increasing concentration of RX gas would cause death from CO poisoning long before mechanical displacement of room air would significantly reduce O_2 concentration in the area.

VII. RECOMMENDATIONS

Important measures should be implemented that would protect employees in situations where loss of containment of CO gas might occur. The following procedures for education, labeling, posting, monitoring, and emergency planning were included in the interim report and are repeated here.

1. All employees must be aware of the presence of systems containing CO throughout the plant and should be made aware that it is a colorless, odorless, non-irritating gas that can cause serious injury or death.

2. CO generating systems, ductwork, and other containers of CO should carry a label or sign stating:

CARBON MONOXIDE
(CO)

DANGER
COLORLESS, ODORLESS GAS

May be fatal if inhaled
High concentrations in the air may be explosive

Seek immediate medical attention
if you experience any of the below symptoms:
1. Severe Headache
2. Dizziness
3. Nausea or vomiting

First aid: Remove victim immediately to an uncontaminated atmosphere. Call a physician immediately. If breathing has stopped, give artificial respiration. Administer oxygen.

Labels and signs should be readily recognizable by forklift or heavy equipment operators who may travel near CO generating systems and duct work.

3. Company and union officials should encourage all workers to quickly report any damage to equipment that might result in CO leaks. CO generating systems should also be monitored regularly for leaks using CO measuring instruments.

4. NIOSH recommends that exposure to CO be limited to a 10-minute ceiling level of 200 ppm to avoid exceeding a COHb blood concentration of 5%. NIOSH has also recommended that automatic visual and audible alarms be set to activate at 500 ppm in areas where large amounts of CO are generated, stored, or used. This warning is designed to assure a timely, orderly evacuation of the area by all potentially exposed workers. However, the 500 ppm recommendation would only be appropriate if the work area is constantly monitored for CO concentration by direct-reading instruments. Otherwise, it would be possible for workers to be exposed to CO at levels greater than 200 ppm for more than 10 minutes. Therefore, if the alarm system is going to be used by itself, without being frequently monitored by qualified individuals, NIOSH recommends that the alarm be set to activate at 200 ppm.

5. All personnel in areas of potential accidental exposure to CO should be trained on standard escape, rescue, and first aid procedures.

6. Company personnel who might be contacted as sources of information during an emergency must be able to accurately identify the gas constituents and must be aware of the potential severity of CO poisoning.

X. REFERENCES

1 Kindwall EP. Carbon monoxide and cyanide poisoning. Hyperbaric oxygen therapy (Davis JC, Hunt TK, eds). Bathesda, Maryland: Undersea Medical Society, Inc., 1977 (177-190).

2 Wald N, Howard S,Smith PG, Kjeldsen K. Association between atherosclerotic diseases and carboxyhaemoglobin levels in tobacco smokers. Brit Med J 1:761-765 (1973).

3 Ginsberg MD. Carbon monixide. Experimental and Clinical Neurotoxicology (Spencer PS, Schamuberg HH, eds). Baltimore: Williams & Wilkins, 1980 (374-394).

4 Garland H, Pearce J. Neurological complications of carbon monoxide poisoning. Quarterly J Med 36(144):445-455 (1967).

5 Carbon monoxide. NIOSH/OSHA occupational health guidelines for chemical hazards (Mackison FW, Stricoff RS, Partridge LJ, eds). DHHS(NIOSH) Publication no.81-123 (1981).

6. National Institute for Occupational Safety and Health. NIOSH/OSHA pocket guide to chemical hazards. Cincinnati, OH: National Institute for Occupational Safety and Health, 1980. (DHHS (NIOSH) publication no. 78-210).

XI. AUTHORSHIP AND ACKNOWLEDGEMENTS

Evaluation conducted and report prepared by:	Jay C. Klemme, M.D., M.P.H. Medical Officer Medical Section
	Steven A. Lee Industrial Hygienist Industrial Hygiene Section
Originating Office:	Hazard Evaluations and Technical Assistance Branch Division of Surveillance, Hazard Evaluations, and Field Studies
Report Typed By:	Stephanie Harris Clerk-Typist Medical Section

XII. 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. Copperweld Steel Company, Warren, Ohio.
2. United Steelworkers of America, Local 2243, Warren, Ohio.
3. OSHA, Region V.
5. NIOSH, 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.

DEPARTMENT OF HEALTH AND HUMAN SERVICES
PUBLIC HEALTH SERVICE
CENTERS FOR DISEASE CONTROL
NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH
ROBERT A. TAFT LABORATORIES
4676 COLUMBIA PARKWAY, CINCINNATI, OHIO 45226

OFFICIAL BUSINESS
PENALTY FOR PRIVATE USE. $300

Third Class Mail

POSTAGE AND FEES PAID
U.S. DEPARTMENT OF HHS
HHS 396