U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES ■ Public Health Service
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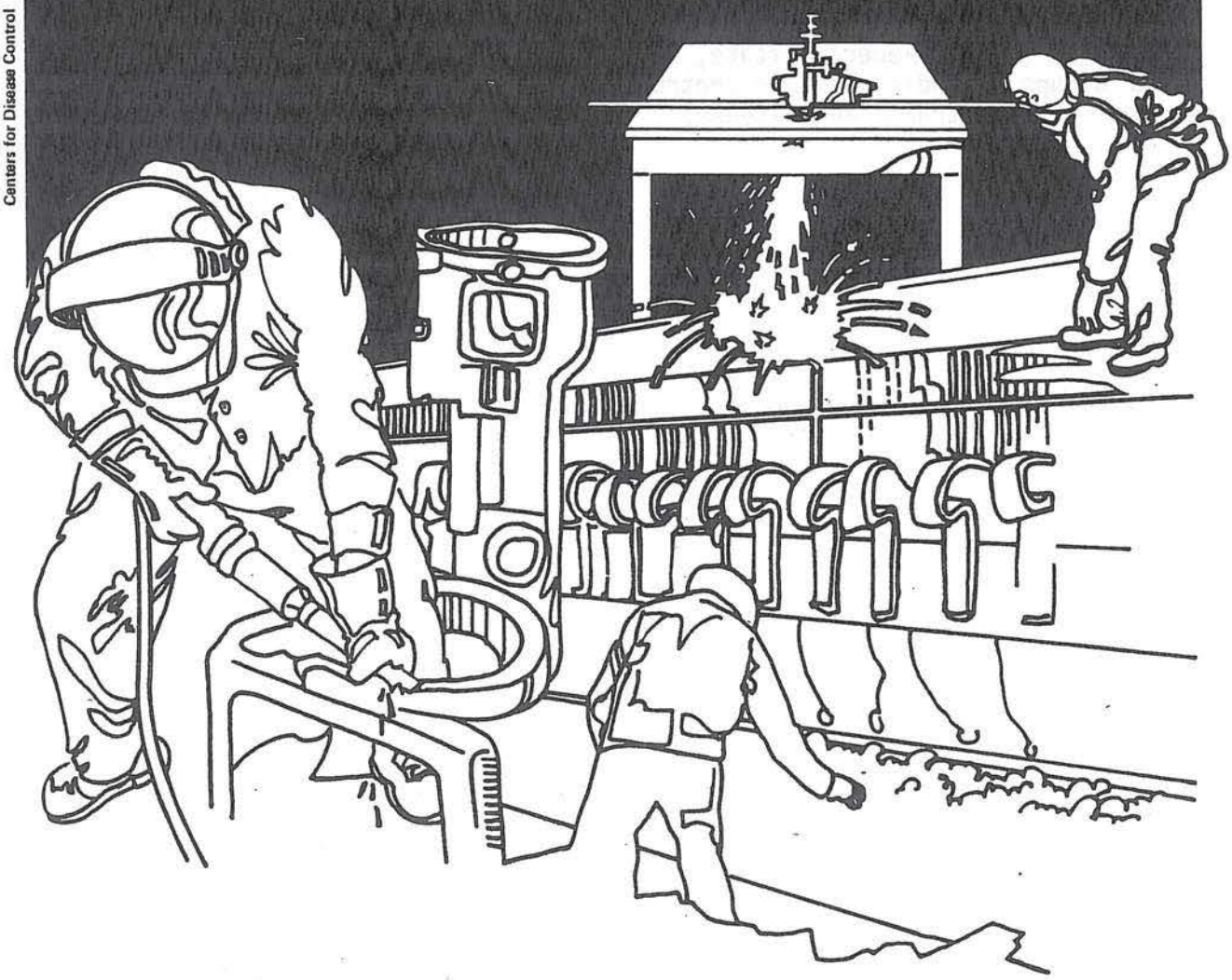
NIOSH



# Health Hazard Evaluation Report

HHE 80-084-927
GENERAL ELECTRIC COMPANY
LYNN, MASSACHUSETTS

## 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.

HHE 80-084-927
July 1981
General Electric Company
Lynn, Massachusetts

NIOSH INVESTIGATORS:
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## I. SUMMARY

During March, 1980, the National Institute for Occupational Safety and Health (NIOSH) received a request from the International Union of Electrical Workers (IUE), Local #201 for a health hazard evaluation of the "copper job" at General Electric Company, Lynn, Massachusetts. The request indicated that 29 employees working at the copper job were being exposed to substances that were causing green skin discoloration, itching, nose bleeds and respiratory problems. Two substances identified by the requestor as being present at the site were copper and silver.

On April 2, 22-24, 1980, NIOSH conducted an environmental evaluation of the four operations related to the copper job: milling, brazing, annealing, and sanding (filing). Twenty air samples were collected over all three shifts. Copper levels in air ranged from 0.010 mg/$M^3$ during the milling operation, to 0.683 mg/$M^3$ during sanding. The current federal occupational exposure standard for copper dusts is 1.0 mg/$M^3$.

Medical evaluations were conducted in July and December, 1980, which included dermatologic examination, occupational and symptom history; blood tests for copper levels, liver enzymes and complete blood counts; and urinary copper levels. Twenty-six (93%) of the workers gave a history of green skin discoloration, and (72%) reported itching particularly during the summer. Of the 14 workers examined, 13 had greenish discoloration of the hands and fingernails, and 7 had more widespread skin discoloration. There was no evidence of excess systemic absorption of copper or of hematological or liver function abnormalities related to excessive copper absorption.

As a result of this investigation, NIOSH has determined that a health hazard existed in that exposure to copper has resulted in dermatologic toxicity as experienced by workers in this plant which consists of skin discoloration and itching. Recommendations are made in the body of this report to further reduce employee exposure to copper to levels below which symptoms of dermatologic disease occur.

KEYWORDS: SIC 3621, Copper, Green Skin, Dermatitis

## II. INTRODUCTION/BACKGROUND

In March, 1980 NIOSH received a request from an authorized representative of employees (International Union of Electrical Workers, Local #201) for a Health Hazard Evaluation of the "copper job" at the General Electric Company, Lynn, Massachusetts. In the "copper job", copper strips are formed into rectangular components for use in turbine generators. The specific jobs which are involved in this process include milling, annealing, brazing, sanding and filing, and inspection of the final product. The brazing operation also includes grinding, which is the major source of airborne contamination. The process has been intact at the plant for approximately 45 years and no basic modifications have occurred in the essentials of the process during that time. Improved ventilation was provided to the brazing operation approximately 20 years ago. Personal protective equipment has been provided and consists of cloth gloves and dust respirators which are supplied by the company. Barrier creams have been provided to workers in response to the medical complaints of skin irritation and itching. Workers wear their own clothing to and from work; no work clothing is provided by the company.

Medical complaints from workers included reports of greenish pigmentation of the skin, itching of the skin in exposed areas, greenish discoloration of clothing, greenish discoloration of the hair, general feeling of fatigue, failure of cuts to heal properly, abnormal sense of taste, nosebleeds, altered sexual function, and upper respiratory tract congestion.

NIOSH issued an interim report in May of 1980.

## III. EVALUATION DESIGN AND METHODS

### A. Environmental

Information was gathered from OSHA case files concerning previous inspections of the "copper job". A literature review was included in the 1977 OSHA file. An updated literature search was requested.

NIOSH industrial hygienists conducted a walkthrough of the requested area on April 2, 1980.

During the period from April 22-24, 1980, environmental sampling was conducted on all three shifts to characterize the airborne levels of copper and silver. Samples were collected on AA filters using MSA Model G pumps at a flow rate of 1.5 liters per minute (lpm). Analysis was performed by wet ashing the filters with nitric and perchloric acids to insure their complete oxidation. The ashed samples were diluted to a final volume of 10 ml and aspirated into an atomic absorption spectrophotometer.

Ventilation checks were made qualitatively using 30 sec. smoke candles and a velometer. Photographs were taken of the facility and process.

B. Medical

Currently employed workers were interviewed by a team of occupational physicians from the Harvard School of Public Health. Physical examinations were performed on a portion of these workers by a dermatologist to assess the dermatologic effects of exposure. Additional laboratory studies were performed including liver function tests, routine hematologic studies, serum iron determinations, iron binding capacity determination, and plasma and urine copper measurements. Routine analyses of these samples were performed in a commercial laboratory. A special laboratory (ESA Laboratories, Bedford, Ma.) was used for the copper determinations.

Statistical procedures used include simple tabulations as well as simple linear regression analysis.

The individual results of tests performed were reported directly to the individuals affected with a description of the medical significance of their individual test results.

## IV. EVALUATION CRITERIA

COPPER:

Copper is a relatively non-toxic metal[1]. Most reports of copper toxicity have consisted of gastrointestinal symptoms following ingestion of copper contaminated foods or beverages. In some of these cases, abnormal liver function tests and mild, transient jaundice have been seen following ingestion of large amounts of copper. Other systemic effects include episodes of hemolysis in persons chronically exposed to copper which may result in acute hemolytic crisis. Rare cases of renal failure have been seen in patients ingesting large amounts of copper. Chronic exposure in industrial settings has not been associated with such reports. Skin discoloration and dermatitis in persons exposed to copper is a recognized problem.

The current federal standard for occupational exposure to copper, as put forth by the Occupational Safety and Health Administration (OSHA), is subdivided into two categories: Copper Fume; 0.1 $mg/M^3$, and Copper Dusts and Mists; 1.0 $mg/M^3$.

SILVER:

The primary health effect produced by exposure to silver is argyria (permanent discoloration of the skin). This condition manifests itself as a dark, slate grey color, usually observed on a workmans face, forehead, neck, hands and forearms.

Silver dust is also deposited in the lungs and may be regarded as a form ao pneumoconiosis, although it carries no hazard of fibrosis.

The current federal standard for occupational exposure to silver is 0.01 mg/$M^3$.

The American Conference of Governmental Industrial Hygienists (ACGIH) has recommended an 8 hour Time Weighted Average (TWA) exposure limit for silver of 0.1 mg/$M^3$.

## V. RESULTS AND DISCUSSION

### A. Environmental

The following table is a summary of the environmental sampling data. The levels of silver were below the OSHA standard in all samples. The copper levels contain both dust and fume and no distinction could be made as to the quantity of each phase in the samples. However, the majority of the copper present would be in the dust form, as every operation except annealing produces dust.

| Job Title | Shift | Sample Vol. (LITERS) | Results (mg/$M^3$) Copper | Silver |
|---|---|---|---|---|
| Sand and File | 2nd | 606 | 0.132 | 0.002 |
| Brazing | 2nd | 600 | 0.400 | 0.010 |
| Sand and File | 2nd | 600 | 0.683 | 0.003 |
| Milling | 2nd | 604. | 0.017 | 0.001 |
| Milling | 2nd | 591 | 0.054 | 0.001 |
| Braze(Utility) | 2nd | 410 | 0.156 | 0.002 |
| Sand and File | 2nd | 546 | 0.531 | 0.004 |
| Sand and File | 2nd | 544. | 0.220 | 0.001 |
| Sand and File | 2nd | 543 | 0.589 | 0.002 |
| Brazing | 3rd | 535. | 0.019 | 0.001 |
| Milling | 3rd | 514. | 0.010 | 0.001 |
| Brazing | 3rd | 552 | 0.167 | 0.009 |
| Milling | 3rd | 562. | 0.023 | 0.001 |
| Sand and File | 3rd | 555 | 0.595 | 0.001 |
| Brazing | 1st | 423 | 0.061 | 0.002 |
| Brazing | 1st | 627 | 0.132 | 0.008 |
| Milling | 1st | 630 | 0.013 | 0.001 |
| Brazing | 1st | 624 | 0.240 | 0.006 |
| Annealing | 1st | 618 | 0.018 | 0.001 |
| Work Bench Area | 1st | 562. | 0.012 | 0.001 |

For this evaluation all copper results were compared to the dust standard. This was done because the relative contribution of fume from brazing was considered minimal.

A qualitative check of the ventilation system, which is provided for the brazing operation, and consists of: local exhaust at the point of operation; dust collection; and air recirculation; was conducted using a 30 second smoke candle. The smoke from the candle was collected efficiently at the point of generation, but was not contained by the bag filters. Thus, the fume generated during the brazing operation is likely to be recirculated throughout the room.

B. Medical

Two visits were made to the plant to interview and test workers in July and December 1980. Twenty-eight of twenty-nine eligible workers were interviewed and twenty-two individuals had blood and/or urine tests performed. Dermatologic examinations were performed on fourteen individuals.

Ninety-three percent of interviewed workers gave a history of having had green skin at some time during their employment at the plant (Table 1). The prevalence of dermatologic abnormalities did not vary between work areas. The next most common complaint was of skin itching which was reported by 72 percent of workers. Most workers noted that the itching was most prominent during the summer and seemed to be made worse by perspiration. Other systemic symptoms of feeling rundown, difficulty with healing cuts, impaired taste or smell, and other symptoms (Table 1) were reported by approximately 20-30 percent of workers.

Plasma copper levels ranged from 66 ug/100 ml. to 126 ug/100 ml., all levels being below the upper level of normal for adults (130 ug/100 ml.). Urine copper determinations were obtained on 11 individuals and ranged from 16-105 ug/liter (Normal adult range 40-70 ug/liter). Only one value, 105 ug/liter, exceeded the upper limit of normal.

PHYSICAL EXAMINATION

Thirteen of fourteen individuals examined had greenish discoloration of the hands and fingernails. Seven (50%) had greenish discoloration of the soles and seven had greenish discoloration of the face, scalp, or neck. Four had green hair. Five had folliculitis. One had greenish discoloration in the axilla, and one person had signs of excoriation of the arms, probably due to scratching.

BLOOD DETERMINATIONS

No significant abnormalities were seen on the routine hematologic studies. Alkaline phosphatase levels were normal in all persons tested. Total bilirubin levels were normal in all except one individual who had a result of 1.5 mg/100 ml. Serum iron and iron binding capacity determinations were essentially normal.

Modest elevations of levels of lactic dehydrogenase, serum glutamic oxalacetic transaminase (SGOT) and serum glutamic pyruvic transaminase (SGPT) were seen. To further assess the significance of these abnormalities of liver function, workers were stratified by alcohol consumption history and by job exposure categorization to assess the relationship of liver function to occupational exposures. There was no clear relationship between liver function test results and levels of consumption of alcohol (Table 2). In evaluating the relationship between occupational exposure to copper and liver function tests, simple linear regression techniques were used to determine if the relationship existed between serum copper level and the concentration of liver enzymes in serum. Results of liver function tests were not correlated with plasma copper levels (Table 3).

Blood and urine copper levels were evaluated with respect to duration of employment and job category. No relationship was seen between duration of work and the concentration of copper in plasma (Table 4). Slightly higher urine copper levels were seen in workers who were employed for more than six months but the small numbers of subjects tested makes the drawing of any conclusion from this data very difficult. Furthermore, as mentioned previously, urine copper levels were normal in all but one individual tested.

The highest job-specific average copper level was seen in brazing workers (Table 5), however this is attributable to the fact that the highest single level of 105 ug/liter occurred in one of these workers and therefore the mean represents an unstable estimate in view of the small number of subjects in this category. No differences were seen between jobs with regard to plasma copper levels.

## VI. CONCLUSION

Employee exposures to both silver and copper were below established environmental criteria for the metals.

However, these investigations show clear evidence of discoloration of the skin and of dermatologic symptoms related to exposure to copper among workers employed in the "Copper Job" at the General Electric Company in Lynn, Massachusetts. The prevalence of disease was virtually 100 percent in production workers who were exposed to copper fume in their job (brazing). The symptoms appeared to be worse during hot periods and to be exacerbated by perspiration. Dermatologic examination showed that discoloration was most prominent on the hands and face. No other significant dermatologic conditions were identified in this group to account for their symptoms of pruritis.

There was no evidence in this group that significant systemic absorption of copper developed as a result of their exposure to copper in these jobs. Undoubtedly, small amounts of copper may

have been absorbed as a result of inhalation of copper fume, but the contribution of this occupational exposure to total body copper stores was minimal as reflected by plasma and urine copper determinations. Despite the reports of systemic symptoms among 20-30 percent of interviewed workers, no relationship was seen between the reports of these symptoms and measurements of copper in plasma or urine which would support the hypothesis that these symptoms were related to copper exposure. Tests of hematologic function and hepatic function showed no evidence of copper toxicity.

We were unable to explain the slightly increased prevalence of abnormalities on three liver function tests (LDH, SGOT, and SGPT), by assessing reported histories of alcohol consumption as well as by evaluating the possibilities of occupational exposures that have contributed to these abnormalities. We do not feel that there is any evidence that workplace exposures are responsible for these minor abnormalities.

It is determined that exposure to copper has resulted in dermatologic toxicity (skin discoloration and itching), as experienced by workers in this plant.

## VII. RECOMMENDATIONS

1. Consideration should be given to control measures which will reduce environmental copper exposure to levels below which symptoms of dermatologic disease occur. Possibly a more efficient collection system which will filter fumes as well as dusts.

2. Since environmental levels now are far below the permissible exposure limits (PEL), attention should also be given to work practices or work conditions which could be modified to further reduce exposure or reduce symptoms.

3. No further medical monitoring is indicated in view of the essentially normal results of biological testing performed in this investigation.

4. It is recommended that barrier creams no longer be used by workers exposed to copper since they appear to increase the amount of perspiration during hot weather thereby exacerbating the symptoms of pruritis.

## VIII. REFERENCES

1. Cohen, S.R., "A Review of the Health Hazards from Copper Exposure", J. Occup. Med., 16:621-624, 1974.

2. "Occupational Safety and Health Standards for General Industry" (29CFR 1910) US Dept. of Labor, OSHA, January, 1978.

3. "Threshold Limit Values for Chemical Substances and Physical Agents in the Workroom Environment", American Conference of Governmental Industrial Hygienists, 1980.

## IX. AUTHORSHIP AND ACKNOWLEDGEMENTS

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## X. DISTRIBUTION AND AVAILABILITY OF DETERMINATION REPORT

For the purposes of informing the "affected employees", The General Electric Company must post this report for at least 30 days in a prominent place(s) near where employees work.

Copies of this Determination Report are currently available, upon request, from NIOSH, Division of Technical Services, Information and Dissemination Section, 4676 Columbia Parkway, Cincinnati, Ohio 45226. After ninety (90) days, the report will be available through the National Technical Information Service (NTIS), Springfield, Virginia 22161. Information regarding its availability through NTIS can be obtained from NIOSH, Publications Office at the Cincinnati, Ohio address.

Copies of this report have been sent to:

General Electric Company
1000 Western Avenue
Lynn, Massachusetts, 01907

International Union of Electrical Workers
Local #201
90 Exchange Street
Lynn, Massachusetts 01901

U.S. PHS- Region 1
JFK Federal Building
Boston, Massachusetts 02203

NIOSH- Region 1

U.S. Department of Labor-OSHA, Region 1

TABLE 1: PREVALENCE OF SYMPTOMS BY JOB CATEGORY

| | N* | SYMPTOMS (%Reporting) Green Skin | Itch | Run Down | Slow To Heal | Reduced Taste/Smell | Nose-Bleeds | Frequent Colds | Reduced Sex Interest | Chest Congestion | Skin Rash |
|---|---|---|---|---|---|---|---|---|---|---|---|
| All jobs Combined | 28 | 93% | 71% | 29% | 56% | 39% | 25% | 25% | 7% | 25% | 29% |
| Milling | 5 | 100% | 80% | 20% | 20% | 20% | 20% | 20% | 0% | 20% | 40% |
| Annealing | 1 | 100% | 100% | 0% | 100% | 100% | 100% | 0% | 0% | 0% | 0% |
| Brazing | 9 | 100% | 100% | 33% | 33% | 33% | 22% | 33% | 0% | 22% | 44% |
| Sand & File | 16 | 94% | 69% | 31% | 38% | 44% | 31% | 25% | 13% | 25% | 19% |
| Inspector | 3 | 66% | 0% | 0% | 33% | 33% | 0% | 0% | 0% | 33% | 0% |

*Included are individuals performing a job at least 10% of the time. Therefore, some individuals appear in two job categories.

TABLE 2
Mean Liver Function Test Results
by Level of Alcohol Consumption

| ALCOHOL CONSUMPTION HISTORY | N | LDH | SGPT | SGOT |
|---|---|---|---|---|
| None | 2 | 256 | 44 | 19 |
| Less than one drink per week | 3 | 221 | 31 | 31 |
| One to several drinks per week | 8 | 224 | 42 | 25 |
| More than seven drinks per week | 3 | 204 | 39 | 26 |

TABLE 3
Linear Regression of Plasma Copper
Versus Miltiple Outcome Measure

| Test | N | $r^2$ | a | b |
|---|---|---|---|---|
| SGOT | 21 | 0.03 | 9.34 | 0.19 |
| SGPT | 21 | 0.02 | 11.67 | 0.36 |
| LDH | 20 | 0.06 | 181.36 | 0.50 |
| Alkaline Phosphate | 21 | 0.06 | 54.44 | 0.21 |
| Total Bilirubin | 21 | 0.17 | 1.36 | -0.01 |
| WBC | 21 | 0.08 | 3.85 | 0.04 |
| Urine Copper | 10 | 0.26 | 118.20 | -0.78 |

TABLE 4
Copper Levels in Blood and Urine
by Duration of Exposure

| Duration of Exposure | N | Mean Plasma Copper* | N | Mean Urine Copper** |
|---|---|---|---|---|
| 0 - 3 months | 4 | 103.5 | 1 | 18.0 |
| 3.1 - 6 months | 5 | 101.8 | 1 | 18.0 |
| 6.1 - 12 months | 4 | 117.75 | 3 | 38.33 |
| 12 months or more | 8 | 108.25 | 6 | 33.17 |

* Units expressed in micrograms per 100 milliliter (µg/100ml)
**Units expressed in micrograms per liter (µg/l)

TABLE 5
Copper levels by Job Category

| Job Category | Urine Copper Level (ug/l)** | | | Plasma Copper* | | |
|---|---|---|---|---|---|---|
| | N | Mean | S.D. | N | Mean | S.D. |
| 1. Milling | 1 | 19 | - | 2 | 115.0 | 2.83 |
| 2. Annealing | 1 | 16 | - | 1 | 117.0 | - |
| 3. Brazing | 2 | 63.5 | 58.69 | 6 | 105.0 | 20.70 |
| 4. Sand and File | 7 | 25.57 | 19.62 | 13 | 103.69 | 12.55 |
| 5. Inspector | 2 | 22.0 | 5.66 | 2 | 123.0 | 0 |

* Units expressed in micrograms per 100 milliliter (µg/100ml)
**Units expressed in micrograms per liter (µg/l)