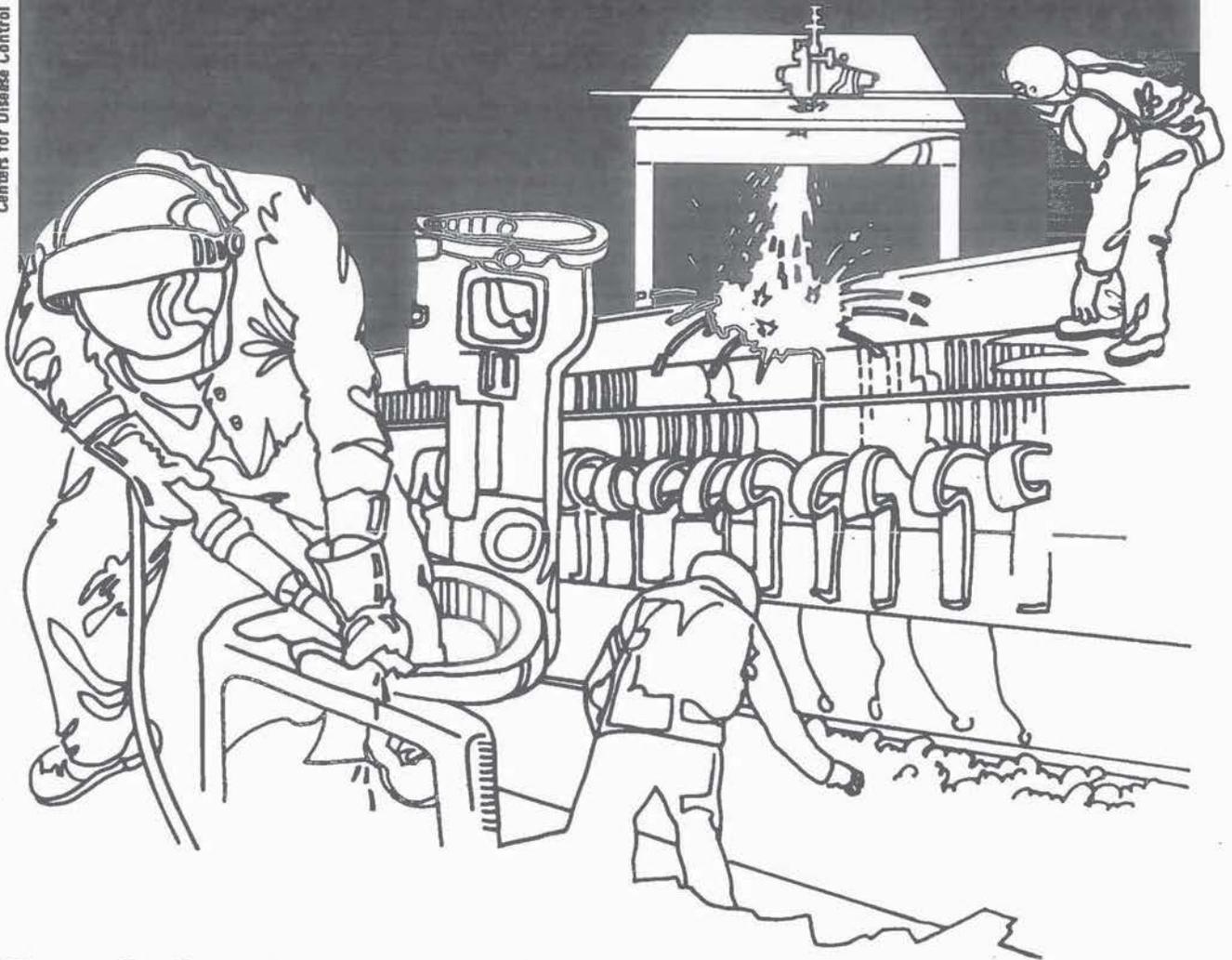


# NIOSH



## Health Hazard Evaluation Report

HHE 80-195-811  
ELCO CORPORATION  
CONNECTOR DIVISION  
HUNTINGDON, PENNSYLVANIA

## 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. 699(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.

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

HE 80-195-811  
FEBRUARY 1981  
ELCO CORPORATION  
CONNECTOR DIVISION  
HUNTINGDON, PENNSYLVANIA

NIOSH INVESTIGATORS:  
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## I. SUMMARY

On July 2, 1980, NIOSH received a request regarding radiation exposure from a group of employees at ELCO Corporation. The employees complained of burning eyes, red skin, nausea, and lumps on the scalp. They felt that radiation (ultraviolet (UV) or radio frequency (RF)) from RF dielectric heater/sealers used to produce terminal contact strips were causing those symptoms.

On September 25, 1980, an initial walk-through survey was conducted by NIOSH personnel during which observations of the operations, RF radiation measurements and non-directed medical questionnaires were administered to the RF dielectric heater machine operators. Personal air samples to determine worker exposure to hydrogen chloride and ozone gases were collected on November 5-6, 1980.

RF radiation measurements were made on September 25, 1980, with the aluminum RF shielding door up (reduced RF shielding) and down (maximum RF shielding). The operator of the RF sealer sits directly in front of this door. Measurements of electric and magnetic field strengths were made at the following positions for each operator: eyes, neck, chest, waist, gonads, knees, ankles and hands. None of the RF measurements exceeded the applicable OSHA standard ( $40,000 \text{ V}^2/\text{m}^2$  and  $0.25 \text{ A}^2/\text{m}^2$ ) for exposure of personnel to RF radiation. In fact, only at one location was an up-scale reading observed ( $0.1 \text{ A}^2/\text{m}^2$  at ankles). The remaining electric field strengths were all less than  $1 \text{ V}^2/\text{m}^2$  and all the magnetic field strengths were less than  $0.1 \text{ A}^2/\text{m}^2$ . The frequency range of the RF emissions (in MHz) was measured to assist in interpretation of the RF electric and magnetic field strength measurements.

Non-directed medical questionnaires were administered to five employees (3 operators, 1 set-up, and 1 maintenance). The health problems elicited were: 1 eye irritation, 2 skin reddening and irritation, 1 sore throat, 1 heart problem.

Four each, environmental air samples were collected for hydrogen chloride and ozone. Analysis of the samples showed air concentrations of hydrogen chloride were below the lower limit of detection (LLD) (5 micrograms ( $\mu\text{g}$ ) per cubic meter of air sampled). Employee exposures to ozone ranged from 5  $\mu\text{g}$  (LLD) to 60  $\mu\text{g}$  per cubic meter of air sampled.

On the basis of the data obtained during this investigation, NIOSH determined that a health hazard due to overexposure to RF radiation, hydrogen chloride or ozone did not exist. There may have been a health problem from infrared (IR), ultraviolet (UV) radiation and visible light due to the eye and skin complaints. This was rectified by installing a No. 8 darkened plastic shield. Recommendations, along with a discussion, are incorporated into this report.

KEYWORDS: SIC 3678 (Connectors, for Electronic Applications), RF, UV, IR, visible light, hydrogen chloride, ozone, eye irritation, skin reddening and irritation, sore throat, heart problem.

## II. INTRODUCTION

Under the Occupational Safety and Health Act of 1970, NIOSH investigates the adverse health effects caused by conditions in the workplace. On July 2, 1980, a request was submitted by the employees of Elco Corporation, Huntingdon, Pennsylvania, expressing concern that radiation (ultraviolet (UV) or radiofrequency (RF)) from dielectric heater/sealers which was causing a burning of the eyes, red skin, nausea and lumps on the scalp.

## III. BACKGROUND

On September 25, 1980, an initial walk-through survey was conducted by NIOSH personnel during which observations of the operations, RF radiation measurements and non-directed medical questionnaires were administered to the RF dielectric heater machine operators. Personal air samples to determine worker exposure to hydrogen chloride and ozone gases were collected on November 5-6, 1980.

Elco Corporation at this site produced electrical connectors. The area of concern was the RF dielectric heater/sealer machines. Three units are located in a copper-screened area, called the "cage". The screen was installed to prevent any stray radiation entering other areas of the plant.

Metallic contacts made elsewhere are hand screened to remove foreign objects and put into a vibration feeder. These contacts are dropped into a fixture. A piece of PVC plastic approximately 12"x3/8"x1/8" is placed on the fixture and placed into the dielectric heater/sealer machine. A perforated aluminum door is closed and the machine then goes through a cycle of (a) softening the plastic, (b) pressing in (embedding) the contacts and (c) releasing the connector strip. The perforations in the door are necessary so that the operator may see a small fluorescent bulb which is activated when the machine is in operation.

Of the 450 employees at this plant, only five are exposed to RF radiation.

## IV. EVALUATION DESIGN AND METHODS

### (a) RF Radiation

A Hewlett-Packard Model 5303B/5300B, serial #1520A02450/1452A0228, Frequency Counter/Measuring System mainframe and an Singer Model 90799-2 antenna loop with an upper limit of 525 MHz were available to identify the frequency of any detectable RF radiation found emanating from an RF dielectric heater.

RF measurements were performed with a Narda Model 8619 (S/N 05066) meter and two probes. The Model 8644 probe (S/N 01008), calibrated April 24, 1980, is used to measure the electric field strength in volts squared per meter squared ( $V^2/m^2$ ) and the Model 8635 (S/N 02001) probe, calibrated September 4, 1980, is used to measure the magnetic field strength in amperes squared per meter

squared ( $A^2/m^2$ ). The minimum detectable limit for the electric field is 2000  $V^2/m^2$  and 0.1  $A^2/m^2$  for the magnetic field. The overall accuracy for the Model 8644 probe is + 1.5 dB - 3.5 dB (+ 41% - 55%) and for the Model 8635 probe is + 3.0 dB (+ 100% - 50%). The Model 8644 probe is usable in the frequency range of 10-3000 MHz and the Model 8635 probe between 10-300 MHz.

RF electric field measurements were also performed with a Holaday Model HI-3001 (S/N 26004) and two probes. The Model HI-3001 green probe (S/N 014) and the red probe (S/N 015) were calibrated on September 14, 1980, and were used to measure the electric field strength in volts squared per meter squared ( $V^2/m^2$ ). The minimum detectable limit for the green probe was 5  $V^2/m^2$  and  $5 \times 10^3$   $V^2/m^2$  for the red probe. The maximum detectable field strength for the green probe was  $10^4$   $V^2/m^2$  and  $10^7$   $V^2/m^2$  for the red probe. The overall accuracy of the green and red probes was + 2.0 dB (+ 59% - 37%). Both the green and red probes have a frequency range of 0.5 MHz to 1000 MHz.

(b) Hydrogen Chloride - Ozone

During this evaluation, flashing and PVC plastic decomposition were noted. For this reason, environmental air sampling was conducted for hydrogen chloride and ozone gases.

Airborne samples for hydrogen chloride collected on silica gel tubes (with the above indicated laboratory numbers) were analyzed for hydrogen chloride by ion chromatography. NIOSH Method P&CAM 310<sup>2</sup> was used to prepare and analyze the samples.

To effect separation of the chloride peak from neighboring interfering signals, pump flow rate was decreased to 25% (115 mL/hour) and an additional 3 x 250 mm analytical column specified in the method. A retention time for chloride of 6.6 minutes was observed under these conditions.

The limit of detection (LOD) for hydrogen chloride was 5 micrograms ( $\mu g$ ) per sample.

Airborne samples for ozone were collected in a midget impinger containing 10 ml of 1 percent potassium iodide in 1 N sodium hydroxide. These samples were subsequently analyzed by NIOSH Method P&CAM S-8<sup>2</sup>.

The LOD for ozone was 5  $\mu g$  per sample.

V. EVALUATION CRITERIA

Radiation

The Occupational Safety and Health Administration radiation protection standard for occupational exposure to RF and microwave radiation (29 CFR 1910.97)<sup>3</sup> applies to the frequencies 10 - 100,000 MHz. It establishes as a limit for occupational exposures a maximum power density of 10 mW/cm<sup>2</sup>, as averaged over any possible 6-minute period. In the far field, a power density of 10mW/cm<sup>2</sup> is equivalent to a mean squared electric field strength of 40,000 volts<sup>2</sup>/meter<sup>2</sup> or a mean squared magnetic field strength of 0.25 amperes<sup>2</sup>/meter<sup>2</sup>. OSHA is presently enforcing both of these mean squared field strengths averaged over any 0.1-hour period, as exposure limits for RF energy, under its occupational standard for nonionizing radiation (29 CFR 1910.97).

Excess amount of RF energy absorbed by workers may produce adverse thermal effects resulting from heating of deep body tissue. These thermal effects may include potentially damaging alterations in cells caused by localized increases in tissue temperature. Scientists involved in this work have generally agreed that exposures of humans to levels of RF energy at or above a far-field power density of  $10\text{mW}/\text{cm}^2$  can cause net increases in tissue or body temperatures, and that exposures at or above these values should be avoided. In the far field, a power density of  $10\text{mW}/\text{cm}^2$  is equivalent to a mean squared electric field strength of  $40,000\text{ volts}^2/\text{meter}^2$  or a mean squared magnetic field strength of  $0.25\text{ amperes}^2/\text{meter}^2$ . Because the body's surface heat sensors, located in the skin, are not activated when RF energy is absorbed deep within body tissues, RF sealer workers may be unaware that they are absorbing RF energy.

Absorption of RF energy may also result in "nonthermal" effects on cells or tissue, which may occur without a measurable increase in tissue or body temperature. "Non-thermal" effects are reported to occur from exposure to RF energy at field strengths lower than those necessary to cause thermal effects. While scientists are not in complete agreement regarding the significance of reports of "nonthermal" effects observed in laboratory animals, NIOSH believes there is sufficient documentation of such effects to cause concern.

For radiation frequencies similar to those commonly used with RF sealers and heaters, reported observations at relatively low energy levels in laboratory rats or rabbits included changes in: electroencephalographic (EEG) recordings of electrical activity of the brain, conditioned reflex behavior, chemical composition of the blood, the endocrine (hormonal) system, and the immunologic (infection defense) system. For the frequencies at which these observations have been made the rates of energy absorption in man are much greater than in laboratory animals. Therefore, the biological effects observed in the laboratory animals may occur in humans at exposure levels even lower than those reported for the animals.

Other adverse health effects on the eye, heart rate, and the central nervous system have been observed in laboratory animals exposed to electromagnetic energy at higher frequencies in the microwave region of the electromagnetic spectrum. The extent to which these latter effects may also be caused by absorption of energy at the lower frequencies employed by RF sealers is not known.

There is no convincing evidence to indicate that RF energy can cause cancer in humans. Reports have described chromosomal abnormalities in animal and human cells cultured in the laboratory after exposure to RF energy.<sup>4</sup> However, the relevance of such studies to humans is not known and must be determined through additional research.

There have been reports which suggest an association between RF exposure and reproductive damage in animals and humans. These reports, primarily from Eastern Europe and the Soviet Union, list a variety of reproductive and developmental effects resulting from occupational exposures of workers and experimental exposures of laboratory animals to electromagnetic energy at frequencies in the RF and microwave ranges. Reported effects from exposure of women to fields of relatively high intensity RF and microwave energy have included changes in menstrual pattern, increased incidence of miscarriage, and decreased lactation in nursing mothers.

Retarded fetal development and increased congenital anomalies have been noted among exposed offspring.<sup>4</sup> Laboratory studies have shown that exposure of pregnant rats to RF energy (at levels believed to have been relatively high) resulted in numerous fetal malformations including abnormalities of the central nervous system, eye deformities, cleft palate, and deformation of the tail.

There is a report of changes in spermatogenesis (production of male germ cells in the testicles) among workmen exposed to nonionizing electromagnetic energy. Reproductive effects in male experimental animals, including testicular damage, debilitated or stillborn offspring and changes in spermatogenesis, have been reported to be related to exposure to electromagnetic energy at microwave frequencies. Similar studies have not been reported for the lower frequencies of RF sealers and heaters.

NIOSH surveys indicate that a large majority of the workers using RF sealing and heating equipment are women of child-bearing age. NIOSH is beginning an epidemiologic study of potential reproductive effects among operators of RF sealers, and is conducting laboratory research to study the possibility that teratogenic effects (malformations) in animals may result from exposure to RF radiation.

Substance*	OSHA <sup>3</sup>
Hydrogen Chloride	7000 (C)**
Ozone	200

\* Denotes micrograms of contaminant per cubic meter of air sampled.

\*\* The concentration that should not be exceeded even instantaneously.

#### Hydrogen Chloride<sup>5</sup>

##### Local--

Hydrochloric acid and high concentrations of hydrogen chloride gas are highly corrosive to eyes, skin, and mucous membranes. The acid may produce burns, ulceration, and scarring on skin and mucous membranes, and it may produce dermatitis on repeated exposure. Eye contact may result in reduced vision or blindness. Dental discoloration and erosion of exposed incisors occur on prolonged exposure to low concentrations. Ingestion may produce fatal effects from esophageal or gastric necrosis.

##### Systemic--

The irritant effect of vapors on the respiratory tract may produce laryngitis, glottal edema, bronchitis, pulmonary edema, and death.

#### Ozone<sup>5</sup>

##### Local--

Ozone is irritating to the eyes and all mucous membranes. In human exposures, the respiratory signs and symptoms in order of increasing ozone concentrations are: dryness of upper respiratory passages; irritation of mucous membranes of nose and throat; choking, coughing, and severe fatigue; bronchial irritation, substernal soreness, and cough. Pulmonary edema may occur, sometimes several hours after exposure has ceased. In severe cases, the pulmonary edema may be fatal.

Animal experiments demonstrate that ozone causes inflammation and congestion of respiratory tract and, in acute exposure, pulmonary edema, hemorrhage, and death.

Chronic exposure of laboratory animals resulted in chronic bronchitis, bronchiolitis, emphysematous and fibrotic changes in pulmonary parenchyma.

Systemic--

Symptoms and signs of subacute exposure include headache, malaise, shortness of breath, drowsiness, reduced ability to concentrate, slowing of heart and respiration rate, visual changes, and decreased desaturation of oxyhemoglobin in capillaries. Animal experiments with chronic exposure showed aging effects and acceleration of lung tumorigenesis in lung-tumor susceptible mice.

Animal experiments further demonstrated that tolerance to acute pulmonary effects of ozone is developed and that this provided cross tolerance to other edemagenic agents. Antagonism and synergism with other chemicals also occur.

Ozone also has radiomimetic characteristics, probably related to its free-radical structure. Experimentally produced chromosomal aberrations have been observed.

## VI. RESULTS AND DISCUSSION

RF radiation measurements were made with the aluminum RF shielding door up (reduced RF shielding) and down (maximum RF shielding). The operator of the RF sealer sits directly in front of this door. Measurements of electric and magnetic field strengths were made at the following positions for each operator: eyes, neck, chest, waist, gonads, knees, ankles and hands. None of the RF measurements exceeded the applicable OSHA standard ( $40,000 \text{ V}^2/\text{m}^2$  and  $0.25 \text{ A}^2/\text{m}^2$ ) for exposure of personnel to RF radiation (see Table I). In fact, only at one location was an up-scale reading observed ( $0.1 \text{ A}^2/\text{m}^2$  at ankles). The remaining electric field strengths were all less than  $1 \text{ V}^2/\text{m}^2$  and all the magnetic field strengths were less than  $0.1 \text{ A}^2/\text{m}^2$ . The frequency range of the RF emissions (in MHz) was measured to assist in interpretation of the RF electric and magnetic field strength measurements.

OSHA had previously surveyed the RF dielectric heater/sealers at Elco Corporation (May 21, 1980) and found the RF radiation emitted to be below the applicable OSHA Standard.

The environmental air samples collected for hydrogen chloride and ozone were below their respective permissible levels (see Table II).

During the walk-through visit of September 25, 1980, a flashing was noted when the plastic strips were inserted into the RF dielectric heater/sealer machine. This did not occur on every strip. During the discussion, it was brought out that the PVC strips are made of reprocessed plastic. While conducting the non-directed interviews, there were complaints of eye and skin irritation. One employee was out of work for two weeks with skin irritation on the arms, neck and face. Redness on the face was evident during the interview. During this time it was recommended that a No. 8 or 9 shield such as worn by welders be attached to the doors. A No. 8 plastic shield was attached to the doors on the three machines. During a telephone conversation later, an employee remarked that the eyes were less irritated when working a full day.

It is the opinion of the NIOSH personnel that having to work in the cage causes psychological problems to the employees, viz the feeling is that, "They are protecting the other employees, but do not care about us." During the two visits, it was discussed with management that shielding the individual machines and eliminating the cage would abate this problem.

NIOSH and OSHA are concerned about potential health hazards to workers exposed to RF energy emitted from RF sealers and heaters. The present Federal standard was derived using data principally from experiments with animals at microwave frequencies, not at the lower radiofrequencies. The standard was intended to prevent thermal effects.

The extent to which biological effects attributed to the absorption of RF energy by animals reflect an occupational hazard to workers is not fully known. There are uncertainties in extrapolating experimental results from animals to humans and to frequencies other than those used in the experiments. These problems have been compounded by the difficulty in properly measuring near-field RF energy exposures, which has been only recently resolved. NIOSH recommends that future research projects dealing with RF energy meet requirements for: 1) better exposure dosimetry and quantification of biological results, 2) use of adequate experimental controls, and 3) uniform reporting of experimental parameters and results.

While scientists are not in complete agreement on the interpretation of available data on biological effects, NIOSH believes there is sufficient evidence of such effects to cause concern about human exposures. NIOSH and OSHA recommend that precautionary measures be instituted to protect workers from unwarranted exposure to RF energy.

Existing national health standards for RF energy have been based on evidence of the thermal effects which result from the body's absorption of RF energy and the subsequent heating of deep body tissue. However, in recent years since the development of existing national standards, concern has increased over reported "nonthermal" effects, which may occur at exposure levels lower than those causing measurable thermal effects and therefore the following recommendations are made even though the measurements did not exceed present standards.

## VII. RECOMMENDATIONS

### Engineering

(a) Consider shielding the individual machines rather than having a cage.

(b) The distance between the worker and the source of RF energy emission should be maximized. Examples of means to accomplish this include the use of automatic feeding devices, rotating tables, and remote materials handling.

(c) The RF sealing and heating equipment should be electronically tuned to minimize the stray power emitted.

(d) Whenever possible, equipment should be switched off when not being used. Maintenance and adjustment of the equipment should be performed only while the equipment is not in operation.

(e) After the performance of maintenance or repair, all machine parts, including cabinetry, should be reinstalled so that the equipment is intact and its configuration is unchanged.

VIII. AUTHORSHIP AND ACKNOWLEDGEMENTS

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Acknowledgements

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IX. DISTRIBUTION AND AVAILABILITY

Copies of this Determination Report are currently available upon request from NIOSH, Division of Technical Services, Information Resources and Dissemination Section, 4676 Columbia Parkway, Cincinnati, Ohio 45226. After 90 days, the report will be available through the National Technical Information Service (NTIS), Springfield, Virginia. 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. Elco Corporation, Huntingdon, PA
2. Employee Representative
3. NIOSH, Region III
4. OSHA, Region III

For the purpose of informing the 5 employees of the results of the Elco Corporation survey, the employer shall promptly "post" for a period of 30-calendar-days the Determination Report in a prominent place(s) near where employees work.

X. REFERENCES

1. NIOSH Manual of Analytical Methods, Volume 5, NIOSH Publication #79-141, 1979.
2. NIOSH Manual of Analytical Methods, Volume 2, NIOSH Publication #77-157B, 1977
3. U.S. Department of Labor, Occupational Safety and Health Administration, Federal Register, Vol. 39, No. 125, June 27, 1974 (Revised No. 7, 1978).
4. NIOSH Current Intelligence Bulletin No. 33, NIOSH Publication #80-107, 1979.
5. Occupational Diseases: A Guide to Their Recognition, USPHS, CDC, NIOSH, Publication #77-181, Revised June 1977.

Table I

Elco Corporation  
 Huntingdon, Pennsylvania

Summary of RF Measurement Data  
 September 25, 1980

<u>Manufacturer</u>	<u>Model No.</u>	<u>Units Measured</u>	<u>(V<sup>2</sup>/m<sup>2</sup>)</u>	<u>(A<sup>2</sup>/m<sup>2</sup>)</u>
Progress Electronics	HFGKG	1	<1	0.1
Progress Electronics	HFGKG	1	<1	<0.1
Progress Electronics	HFGKG	1	<1	<0.1

TABLE II  
ELCO CORPORATION  
HUNTINGDON, PENNSYLVANIA

Results of Personal Air Samples for Hydrogen Chloride and Ozone at RF Heater/Sealer

Hydrogen Chloride\*

<u>Date</u>	<u>Sample No.</u>	<u>Sample Period</u>	<u>Airborne Concentration</u>
Nov. 5	1	7:20-11:45	← LOD**
	2	11:45-15:20	← LOD
	3	15:20-20:45	← LOD
Nov. 6	4	7:15-14:45	← LOD

Ozone\*

Nov. 5	1	7:20-11:45	60
	2	11:45-15:20	28
	3	15:20-20:45	← LOD
Nov. 6	4	7:15-14:45	← LOD

\* Denotes microgram of contaminant per cubic meter of air sampled.

\*\*Denotes less than limit of detection - 5 micrograms per sample

Evaluation Criteria

<u>Substance</u>	<u>OSHA</u>
Hydrogen Chloride	7000 (C)
Ozone	200