U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
CENTER FOR DISEASE CONTROL
NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH
CINCINNATI, OHIO 45226

HEALTH HAZARD EVALUATION DETERMINATION REPORT
HE 80-97-713

HEWLETT-PACKARD COMPANY
LOVELAND, COLORADO

JULY 1980

I. SUMMARY

On June 3, 1980, the National Institute for Occupational Safety and Health (NIOSH) conducted a health hazard evaluation at the request of the Hewlett-Packard Company in Loveland, Colorado to determine the intensity of the electromagnetic fields emitted by various radio frequency (RF) plasma systems (SIC 3825).

Although these systems are enclosed, some RF radiation was emitted through cracks and RF transparent materials such as glass. A comprehensive RF survey was performed and field strengths were recorded for sites producing detectable levels of radiation. For the three systems surveyed, electric field strength measurements ranged from 27.6 to 551 volts/meter (V/m); magnetic field strengths ranged from 0.33 to 2.4 amperes/meter (A/m). However, all measurable field strengths were determined to be nondetectable at 1-5 inches from point of emission. Current OSHA standards based upon "thermal effects" of RF radiation limit exposures to 10 milliwatts/square centimeter, equivalent in the far field to 200 V/m - E field and 0.5 A/m - H field.

On the basis of these measurements, NIOSH determined that the operators of those systems surveyed would not be exposed to RF radiation in excess of the current OSHA standard. Recommendations are presented in Section VII on page 5.

II. INTRODUCTION

Under the Occupational Safety and Health Act of 1970*, NIOSH investigates the potential health effects of agents found in the work place. On March 10, 1980, Hewlett-Packard Company requested NIOSH to conduct such an investigation of their RF plasma systems. The NIOSH survey team met with company representatives for an opening and closing conference and performed RF measurements at various RF plasma systems on June 3, 1980.

III. BACKGROUND

The Hewlett-Packard Company produces electronic test instruments at the facility surveyed. Some electronic parts used in the manufacturing of these instruments must have very thin metallic coatings such as gold deposited on selected surfaces. Also, many parts may require selected surfaces to be etched. One process utilized by Hewlett-Packard to achieve the appropriate surface is the RF plasma system.

Basically, the RF plasma system acts as a large vacuum tube. The system consists of an RF generator with controls, vacuum pump with controls, and a vacuum chamber. Inside the vacuum chamber are placed the parts to be coated or etched. Then the vacuum chamber is evacuated and refilled (but not to atmospheric pressure) with an inert gas such as argon. Once the chamber is filled with the inert gas, but still under negative pressure, the RF generator is activated. The inert gas is ionized by the RF electromagnetic fields. These ions then strike the electrically charged plate or parts causing a release of metal ions (plasma). Of course, if the part is the target, it is etched. These released metal ions are collected on a ground state plate. If the part is the ground state plate, it will receive a thin metallic coating.

Two types of RF plasma systems were surveyed, the plasma etcher and the plasma sputtering system. The sputtering system deposits a thin metallic coating on the parts. Both of these systems are enclosed although some RF radiation is emitted through cracks or RF transparent materials such as glass. The operator position and the operational time will vary depending on the type of system, work load, and schedule.

IV. EVALUATION DESIGN AND METHODS

The NIOSH survey team measured the intensity of the electric and magnetic fields emitted from several RF plasma systems. The field intensities were corrected for frequency; however, the measurements were not corrected for the

*Public Law 91-596, Occupational Safety and Health Act of 1970, 29 December 1970.

work cycle. Therefore, the measurements represent the maximum possible exposure to the operator in the measured field. The correction for the work cycle would effectively time-weight the exposure over an 8-hour day.

The electromagnetic fields were measured with a Narda Broad-Band Isotropic Radiation Monitor, Model 25540 with an electric field probe, Model 8644 and a magnetic field probe, Model 8635. Each system was surveyed by slowly scanning every accessible surface of the system as close as possible. When RF radiation was detected, the probe was slowly removed until radiation was no longer detectable. This distance was also recorded. Frequency determinations were made with a Hewlett-Packard Model 5303B/5300B with a Singer #90799 Loop.

V. EVALUATION CRITERIA

The absorption of excessive RF energy by humans may cause adverse thermal effects due to heating of deep body tissue. The current OSHA standard[1] which limits exposures to below 10 milliwatts per square centimeter (mW/cm^2) averaged over any 0.1-hour period was promulgated to protect against thermal effects. In the far field, a power density of 10 mW/cm^2 is equivalent to an electric field strength of 200 volts/meter (V/m) and a magnetic field strength of 0.5 amperes/meter (A/m).

Absorption of RF energy may also result in "nonthermal" effects within the human body, which may occur without a measurable increase in tissue or body temperature. These reported "nonthermal" effects in animals at relatively low energy levels (below 10 mW/cm^2) include microscopic ocular changes,[2,3] alterations in neuroendocrine function,[4,5] alterations in the central nervous system,[6,7] behavorial changes,[8,9] changes in the immunologic system,[10] embryotoxic effects,[6,11] and reproductive effects.[12,13] Since NIOSH is concerned about these potential "nonthermal" effects, a criteria document on RF radiation has been drafted. The tentatively proposed NIOSH recommended standard is 61.4 V/m for the electric field and 0.164 A/m for the magnetic field in the 10-400 MHZ range. In the far field, these levels would be equivalent to 1 mW/cm^2.

VI. RESULTS AND DISCUSSION

RF measurements were made by slowly scanning every accessible surface of each system as closely as possible. When RF radiation was detected, the level and location were recorded. The probe was then slowly removed from the surface until the RF radiation was no longer detectable. This distance was also recorded. The data has been corrected for frequency, but not for the work cycle of the operator. Results are presented in the following table.

TABLE OF RESULTS

System	Location*	E-Field At Surface (V/m)	H-Field At Surface (A/m)	Distance At Nondetectable Levels (inches)
SEPE				
@ 500 W	Site A	N.D.**	0.99	1-2
13.56 MHZ	Site B	27.6	0.99	1-2
	Site C	551	0.80	4-5
PLASMALINE				
@ 300 W	Site A	N.D.	0.33	1-2
oscillating between	Site B	N.D.	0.33	1-2
11.42 and 13.56 MHZ				
RANDEX				
@ 1.5 KW				
13.56 MHZ				
Gold	Site A	N.D.	0.40	3
	Site B	N.D.	2.40	3
	Site C	N.D.	1.58	3
	Site D	N.D.	0.81	2-3
Molybdenum	Site E	N.D.	2.09	3
	Site F	N.D.	1.81	4
	Site G	N.D.	1.81	4

* See Figures 1-3 in Section XI of the Appendix for schematic indicating site locations.

** N.D. - Non-detectable at less than 25 V/m and 0.2 A/m.

The SEPE system was emitting RF radiation above the current OSHA standard at three sites. The PLASMALINE system was emitting RF radiation below the current OSHA standard but above the tentatively proposed NIOSH recommended standard at two sites; and, the RANDEX, which has the highest emission levels, was emitting RF radiation in excess of current standards at several sites. However, these are detectable emission levels, not personal exposure levels. The operators of these systems would be exposed to substantially reduced RF radiation levels. As shown in the table of results, the levels are non-detectable beyond 1-5 inches from the surface. Normally only the operator's hands and possibly (for the RANDEX system) the eyes would be within this distance, and then for only a short time period.

Although RF radiation is being emitted above current standards at some sites, operators due to normal operating distances and total daily operational time are not likely to receive personal exposure to RF radiation in excess of the current OSHA standard. Nor does it appear that operators are exposed in excess of the tentatively proposed NIOSH recommended standard.

VII. RECOMMENDATIONS

Although operators of the RF plasma systems surveyed do not appear to be exposed in excess of current standards, the following recommendations are made to further reduce exposure levels.

1. Operators of the SEPE, PLASMALINE, and RANDEX systems should receive training as to the hazards associated with RF radiation to include means of reducing exposure such as, increasing the distance from the source (especially for the eyes) and decreasing the exposure time.

2. Management should consider the posting of warning signs as indicated in 29 CFR 1910.97(a)(3).

3. Additional surveys should be conducted when new systems are installed or when modifications of existing systems are made.

VIII. AUTHORSHIP AND ACKNOWLEDGEMENTS

Report Written By:

Clinton Cox
Industrial Hygiene Engineer
Industrial Hygiene Section
IWSB, DSHEFS, NIOSH

Survey Conducted By:

Clinton Cox, IWSB, NIOSH
Jerry Flesch, HETAB, NIOSH
Bobby Gunter, Region VIII, NIOSH

Originating Office:

Hazard Evaluations and Technical Assistance Branch
Division of Surveillance, Hazard Evaluations, and Field Studies
Cincinnati, Ohio

Monica Whitlock
Clerk Typist
Industrial Hygiene Section

IX. DISTRIBUTION AND AVAILABILITY

Copies of this report are currently available, upon request, from NIOSH, Division of Technical Services, Publications Dissemination, 4676 Columbia Parkway, Cincinnati, Ohio 45226. After 90 days, the report will be available through the National Technical Information Service (NTIS), Springfield, Virginia 22161.

Copies of this report have been sent to:

1. Hewlett-Packard Company
2. NIOSH, Region VIII
3. OSHA, Region VIII

For the purpose of informing the potentially affected employees, the employer shall promptly post this report for a period of 30 days in a prominent place near the entrance to the work area.

X. REFERENCES

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XI. APPENDIX

Figure 1. SEPE System at Hewlett-Packard in Loveland, Colorado

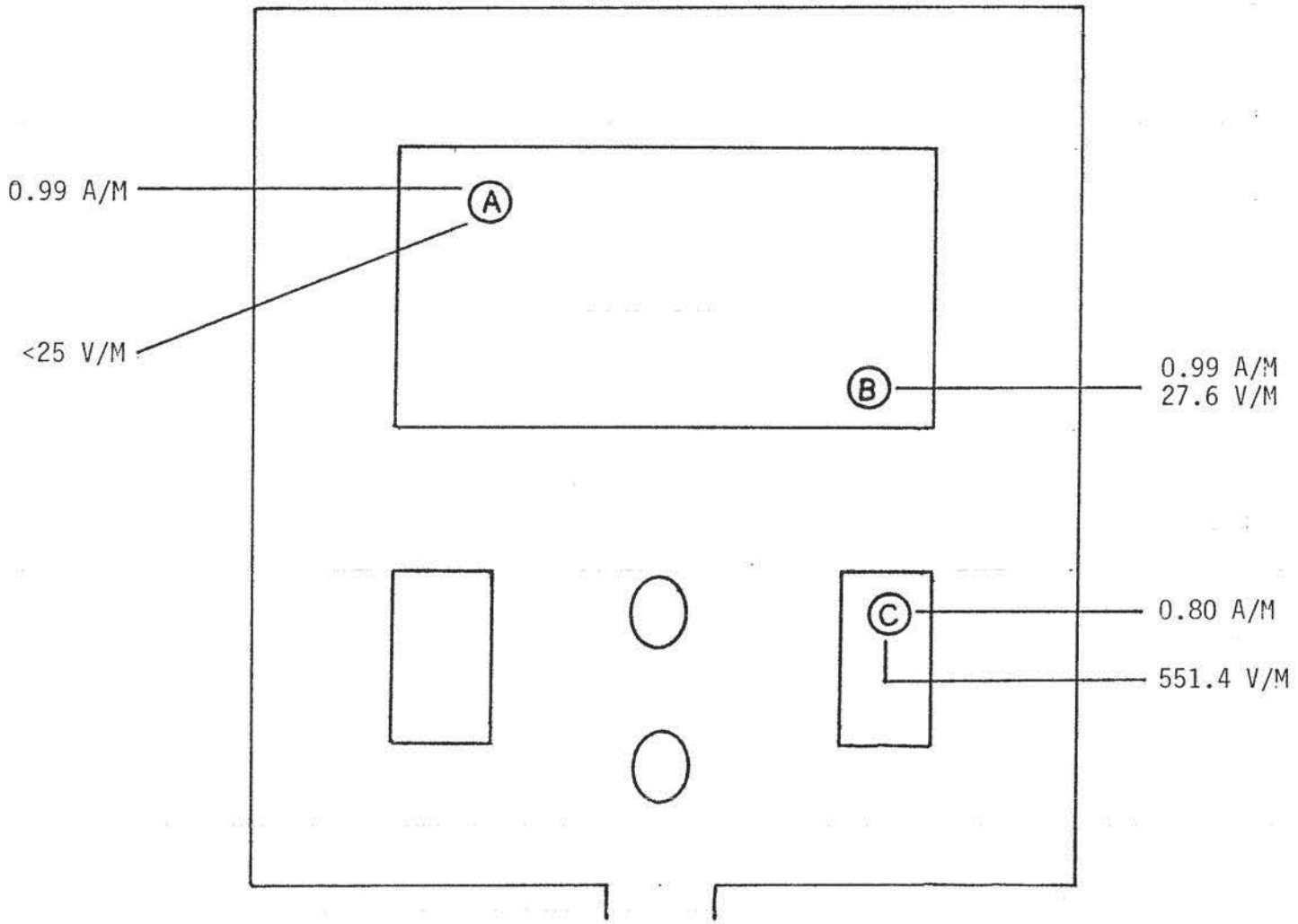

Figure 2. Plasmaline System at Hewlett-Packard in Loveland, Colorado