American Industrial Hygiene Association Journal

ISSN: 0002-8894 (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/aiha20

Occupational exposures to radiofrequency radiation (18–31 MHz) from RF dielectric heat sealers

CLINTON COX , WILLIAM E. MURRAY & EDWARD P. FOLEY

To cite this article: CLINTON COX , WILLIAM E. MURRAY & EDWARD P. FOLEY (1982) Occupational exposures to radiofrequency radiation (18–31 MHz) from RF dielectric heat sealers, American Industrial Hygiene Association Journal, 43:3, 149-153, DOI: 10.1080/15298668291409523

To link to this article: https://doi.org/10.1080/15298668291409523

Published online: 04 Jun 2010.

The National Institute for Occupational Safety and Health (NIOSH) has initiated an epidemiologic study to evaluate whether or not radiofrequency (RF) radiation in the 10-100 MHz range has any effects on the reproductive functions of exposed workers. Initial investigations indicated that a suitable population for this study might exist in industries utilizing RF dielectric heat sealers. To estimate exposure levels of RF heat sealer operators, NIOSH made exposure measurements for 82 operators in 13 facilities with a Narda Broadband Isotropic Radiation Monitor, Model 25540 with an electric (E) field probe, Model 8644 and a magnetic (H) field probe, Model 8635. The geometric mean of the maximum measured exposures was at least 200 V/m for the E-field and 0.094 A/m for the H-field. The Occupational Safety and Health Administration (OSHA) exposure standard for RF radiation in the range of 10-100,000 MHz is 10 mW/cm^2 as averaged over any 0.1-hour period. This value corresponds to an exposure of 200 V/m for the E-field and 0.5 A/m for the H-field. NIOSH found that 55% of the heat sealer operators were exposed to levels for the E-field above 200 V/m; for the H-field, 21% of the operators were exposed to levels above 0.5 A/m. For the heat sealers evaluated, the frequencies ranged from 18 to 31 MHz. On the basis of these environmental data, RF heat sealer operators experience a wide range of exposures both above and below the OSHA standard. The exposure range is sufficiently broad to make these operators adequate candidates for epidemiologic study.

Occupational exposures to radiofrequency radiation (18-31 MHz) from RF dielectric heat sealers

CLINTON COX, WILLIAM E. MURRAY, JR. and EDWARD P. FOLEY, JR.
U.S. 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, OH 45226

introduction

Radiofrequency (RF) radiation is that portion of the nonionizing electromagnetic spectrum from approximately 0.01-300,000 megahertz (MHz). Within the RF spectrum, researchers have reported biologic effects in exposed animals and humans. Of particular concern are effects associated with exposure levels belos 10 milliwatts per square centimeter (mW/cm^2), the current Occupational Safety and Health Administration (OSHA) standard.[1] These reported effects in animals include microscopic ocular changes,[2,3] alterations in neuroendocrine function[4,5] and in the central nervous system,[6,7] behavioral changes,[8,9] changes in the immunologic system, [5,10] and embryotoxic[6,11] and reproductive effects.[12,13] Since the literature indicates that deviations in normal biologic variables can occur after exposure to RF energy below 10 mW/cm^2, the National Institute for Occupational Safety and Health (NIOSH) initiated an epidemiologic study to determine the effects of RF radiation on reproductive functions in an exposed worker population. Preliminary investigations indicated that a potentially exposed worker population of 30,000-50,000 may exist within industries utilizing RF dielectric heat sealers that operate in the 3-100 MHz range.

background

NIOSH visited 13 facilities using RF dielectric heat sealers. Within these facilities the heat sealers are used to seal, fuse, and emboss light plastics, usually polyvinyl chloride (PVC). RF energy is especially well suited for this purpose, due to its

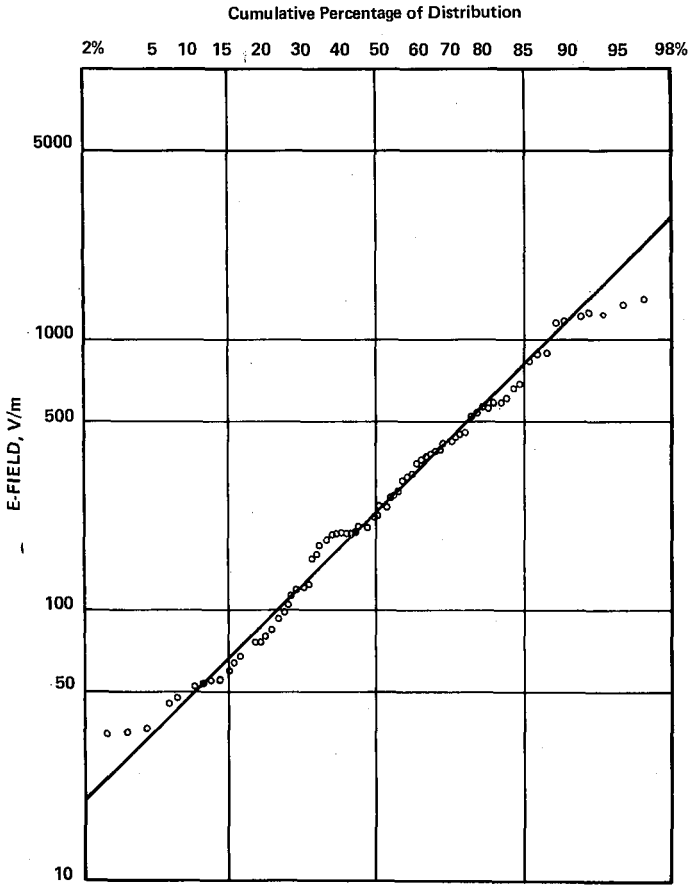

Figure 1 — Lognormal probability plot of E-field exposure levels.

TABLE I
E-Field Summary Exposure Data Per Anatomical Position For 82 Operators From 13 Facilities[A]

Anatomical Position	Eye	Waist	Knees	Units
# of Measurements	82	82	82	
Smallest Measurement	0.001	0.001	0.001	V/m
Largest Measurement	1461 (8*)	1412 (6*)	1493 (6*)	V/m
Geometric Mean	74.4	97.5	32.9	V/m
Geometric Std. Dev.	35.8	16.9	30.0	
Lower Conf. Limit (95%)	33.9	52.4	15.6	V/m
Upper Conf. Limit (95%)	163.3	181.5	69.4	V/m

[A]Values Work-Cycle Corrected
*Number of greater than values - these values occurred when the monitor meter was pegged full scale on maximum scale.

TABLE II
H-Field Summary Exposure Data Per Anatomical Position For 82 Operators From 13 Facilities[A]

Anatomical Position	Eye	Waist	Knees	Units
# of Measurements	82	82	82	
Smallest Measurement	0.001	0.001	0.001	A/m
Largest Measurement	3.16	6.52	2.89	A/m
Geometric Mean	0.05	0.06	0.04	A/m
Geometric Std. Dev.	12.97	11.26	10.01	
Lower Conf. Limit (95%)	0.03	0.04	0.03	A/m
Upper Conf. Limit (95%)	0.10	0.11	0.07	A/m

[A]Values Work-Cycle Corrected

production of rapid and concentrated internal heat. In the facilities visited, RF heat sealers were used in the manufacture of products such as book covers, checkbook covers, cosmetic accessories, display boxes, gas masks, handbags, luggage, notebooks, toys, travel cases, and water beds. The heat sealer operators were predominantly females; approximately 75% were of child-bearing age. These operators worked in a standing or sitting position depending on the operation. The operating frequency of the RF dielectric heat sealers evaluated varied from 18 to 31 MHz.

description of process

A dielectric heat sealer consists of a RF radiation source, control panel, workhead (normally vertical) with die, and work table. A normal heat sealing operation joins two or more plastic parts to form a final product although other operations may be performed such as embossing. The plastic parts are placed in a holder (lower plate) on the work table of the heat sealer. When dual activation buttons are pushed simultaneously, the upper die moves downward until contact is made with the tabletop. As the die contacts the tabletop, the RF source is activated usually for periods of 1 to 10 s. The RF radiation heats the plastic at surfaces in contact with the die. As the plastic melts, a seal is formed which joins the parts together. Because of long processing times (30 s to 5 min per unit), the work cycle which is the ratio of the heat sealer on-time to the total process time is relatively low, ranging from 0.05 to 0.30. The exposure levels during the on-time of the heat sealer are lowered significantly to account for the work cycle.

description of equipment and measurement procedures

RF field strength measurements were made with a National Bureau of Standards calibrated Narda Broad-Band Isotropic Radiation Monitor, Model 25540 using an electric (E) field probe, Model 8644 and a magnetic (H) field probe, Model 8635. Both E- and H-field probes are necessary to measure exposure levels since the heat sealer operators are in the near field. In the near field, i.e., within 1-2 wavelengths of the radiation source, the power density of the field cannot be readily measured as it can be in the far field. To properly characterize exposure conditions in the near field, the E- and H-field strengths must both be measured.

Measurements were made at the eye, waist, and knee areas with the operator in a normal working position. The measurements were corrected for the work cycle of the heat

TABLE III
Analysis of Highest Exposure Measurement for Each of the 82 Operators From 13 Facilities[A]

	E-Field	H-Field
# of Measurements	82	82
Smallest Measurement	0.001 V/m	0.001 A/m
Largest Measurement	1493 V/m (9*)	6.52 A/m
Geometric Mean	200 V/m	0.094 A/m
Geometric Std. Dev.	5.64	10.59
Lower Conf. Limit (95%)	137 V/m	0.056 A/m
Upper Conf. Limit (95%)	292 V/m	0.16 A/m

[A]Values Work-Cycle Corrected
*Number of greater than values — these values occurred when the monitor meter was pegged full scale on maximum scale.

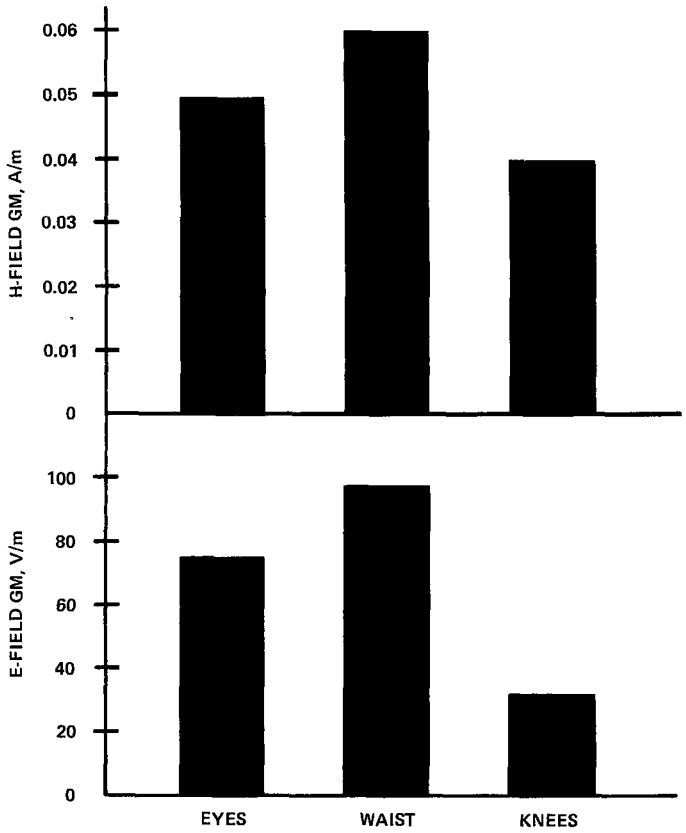

Figure 2 — Geometric means of exposure levels versus anatomical positions.

sealer as follows: corrected value = measured value x (on-time/total process time)$^{1/2}$. These corrected measurements can then be used to effectively average over a 0.1-hour time period as specified in the OSHA standard.[1]

TABLE IV
Percent of Operators Exposed to Levels Above Current OSHA Occupational Exposure Standards

Standard		% of Operators Exposed Above Standard
Electric	200 V/m	55
Magnetic	0.5 A/m	21

results and discussion

The results are presented using geometric means (GM) of the exposure levels since the log-normal probability plot indicates a log-normal distribution (e.g., see Figure 1). For all zero values, 0.001 volts per meter (V/m) or amperes per meter (A/m) are used. For all "less than" values, the midpoint between the corrected value and zero is used. For all "greater than" values, the greater than value is used in the statistical analysis of the exposure data. These results are presented in Table I, II, and III. Tables I and II show the statistical summary of the exposure levels that the operators experienced in different anatomical positions; this summary is also presented graphically in Figure 2. Comparing the relative magnitudes, the waist area received the highest exposure from both the E- and H-fields.

Since the current standard applies to whole body and partial body exposure, the highest measured exposure level at any anatomical position of the operator was used to compile the exposure data presented in Table III. The geometric mean for the E-field is at least as large as the OSHA standard of 200 V/m [equivalent plane-wave (epw) of 10 mW/cm^2]; but that for the H-field is less than 0.5 A/m (epw of 10 mW/cm^2).

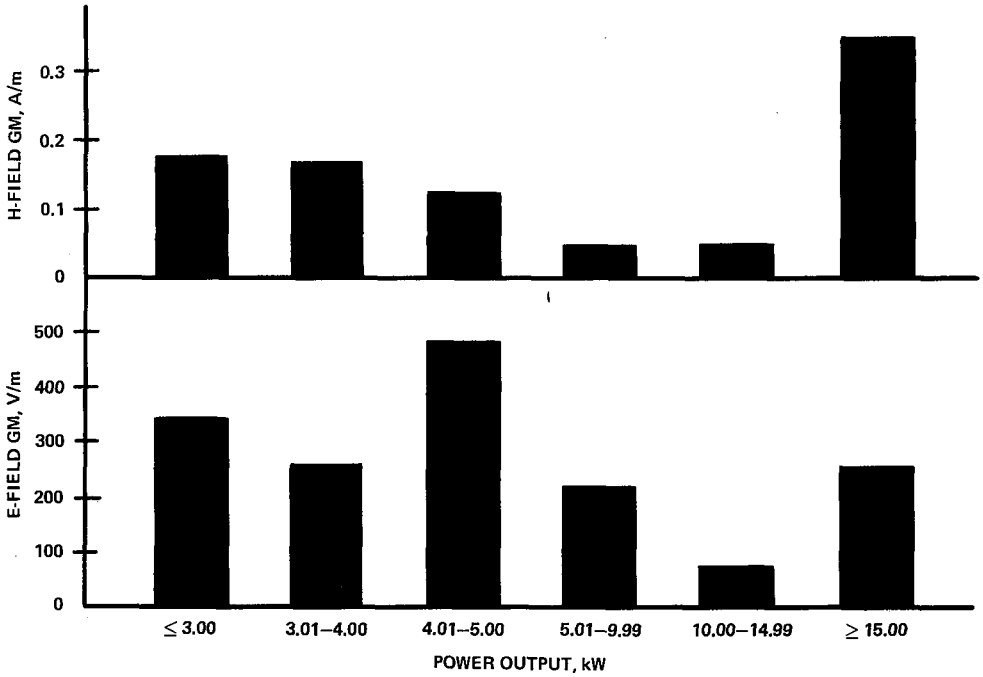

Figure 3 — Geometric means of exposure levels versus power output of heat sealers.

Additionally, as shown in Table IV for the E-field, 55% of the operators experienced exposure levels above 200 V/m. Likewise, for the H-field, 21% of the operators experienced exposure levels above 0.5 A/m. Although the OSHA standard is 10 mW/cm^2, compliance with the standard requires that the operator must not be exposed above either the electric or magnetic field strength equivalent limits.

Several additional inferences can be made from the exposure data. For example, Figure 3 shows a graphical comparison of exposure levels versus power output of the heat sealers. Neither the E- nor H-field exposure levels increase proportionally with an increase in power output as might be expected. Several reasons can be suggested to account for this finding. First, although the heat sealer is rated at 10 kilowatts (kW), depending on the product or process, it may be operating at 5 kW, lowering the amount of radiation generated. Second, the radiated energy varies with the size and shape of the die. Third, the shape, area, thickness, and kind of plastic that is being processed greatly affects the energy loss. Fourth, the intensity decreases as the distance from the source increases. An operator using an automatic shuttle or turntable is normally further away from the RF source than an operator at a stationary tabletop, thereby reducing the exposure level of the former. These and other operational parameters together account for the randomness experienced in a comparison of exposure level versus power output. Figure 4 shows a comparison of exposure levels versus heat sealer brands; this is not presented as a conclusive comparison among brands, but only to indicate that exposure levels may vary among brands. Figure 5 shows a comparison of exposure levels and facilities. The E-field portion of the graph presents the data in order of increasing exposure levels. Note that the E-field data do not present the same pattern as that of the H-field. The geometric means of exposure levels at 7 out of 13 facilities exceed the OSHA standard of 200 V/m (epw of 10 mW/cm^2) for the E-field and one exceeds the standard of 0.5 A/m (epw of 10 mW/cm^2) for the H-field.

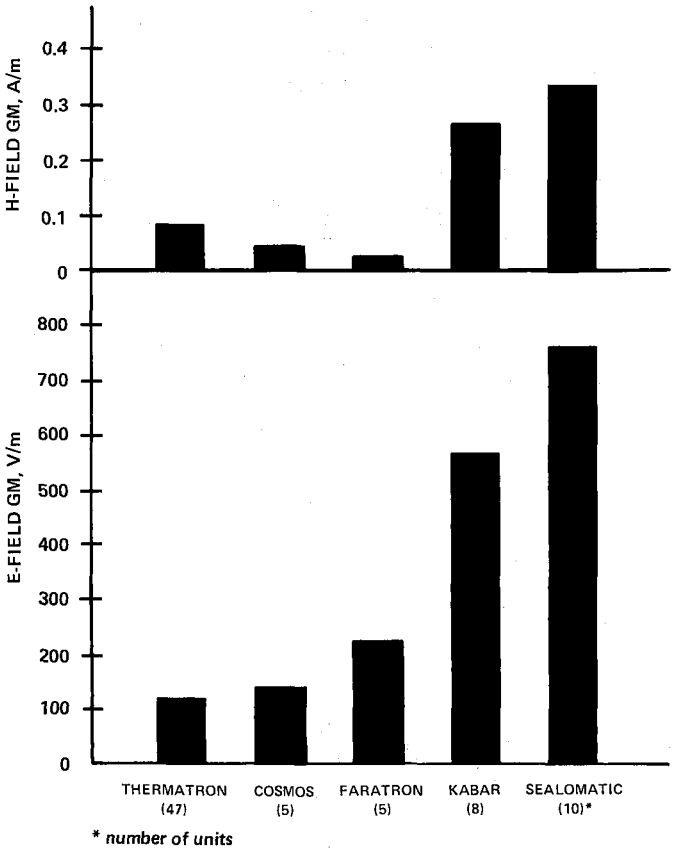

Figure 4 — Geometric means of exposure levels versus brands of heat sealers.

conclusions and recommendations

In summary, the exposure levels of the heat sealer operators

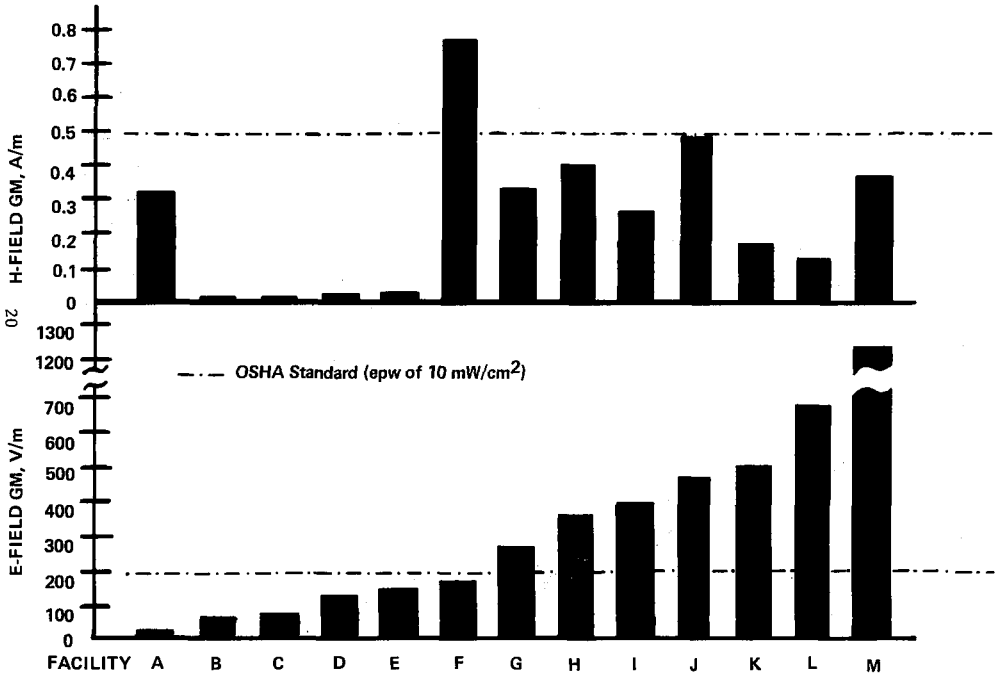

Figure 5 — Geometric means of exposure levels at each facility compared to current occupational standards.

are log-normally distributed. The geometric mean for partial body exposures is highest for the waist area, followed by the eye and knee areas, respectively. For the 82 operators evaluated, the geometric mean for the exposure levels are at least 200 V/m and 0.094 A/m for the E- and H-fields, respectively. Thus as shown in Table IV, operators are exposed in excess of the current OSHA standard. Exposure levels do not increase proportionally with an increase in power output. Exposure levels will vary with heat sealer brands and vary significantly among some facilities.

In conclusion, the study shows that many RF heat sealer operators are exposed to RF levels exceeding the OSHA standard. Some promising means of reducing employee exposures which the users of RF heat sealers may try are the use of automatic feeding devices and shielding. Several RF dielectric heat sealer manufacturers have, or are developing, these types of options. In the meantime, NIOSH will continue its epidemiologic study to assess the effects of RF radiation on reproductive functions of exposed worker populations.

references

1. **OSHA:** Safety and Health Standards (29CFR 1910), 1910.97 Nonionizing Radiation, U.S. Dept. of Labor, Occupational Safety and Health Administration, Rev. Nov. 7, 1978.
2. **Balutina, A.P. and T.L. Korobkova:** Pathohistological Alteration in the Eyes of Rabbits Exposed to SHF-UHF Radiation. *Gig. Tr. Prof. Zabol. 13(4)*:57-58 (1969) (Rus).
3. **Tajchert, J. and E. Chmurko:** Investigations on the Cataractogenic Influence of Microwaves of 10 cm Band. *Klin. Oczna. 42*:979-983, (1972) (Pol).
4. **Novitskii, A.A., B.F. Murashov, P.E. Krasnovaev and N.F. Markizova:** Functional State of the Hypothalamus — Hypophysis-Adrenal Cortex System as a Criterion in Setting Standards for Superhigh Frequency Electromagnetic Radiation. *Voen. Med. Zh. (8)*:53-56 (1977) (Rus).
5. **Zalyubovskaya, N.P. and R.I. Kiselev:** The Effect of Radio-Waves of a Millimeter Frequency Range on the Body of Man and Animals. *Gig. Sanit. 43(8)*:35-39 (1978) (Rus).
6. **Gordon, A.V., Y.A. Lobanova, I.A. Kitsovskaya and M.S. Togskaya:** Biological Effect of Microwaves of Low Intensity. *Med. Electron. Biol. Eng. 1*:67-69 (1963).
7. **Dumanskii, J.D. and M.G. Shandala:** The Biologic Action and Hygienic Significance of Electromagnetic Fields of Superhigh and Ultrahigh Frequencies in Densely Populated Areas, in *Biologic Effects and Health Hazards of Microwave Radiation — Proceedings of an International Symposium,* Warsaw, Oct. 15-18, 1973. Warsaw, Polis Medical Publishers, 1974, pp. 289-293.
8. **Frey, A.H.:** Behavioral Effects of Electromagnetic Energy, in Hazard DG (ed.): *Symposium on Biological Effects and Measurement of Radio Frequency/Microwaves — Proceedings of a Conference,* Rockville, Feb. 16-18, 1977, HEW Publication No. (FDA) 77-8026. Rockville, U.S. Dept. of Health, Education, and Welfare, Public Health Service, Food and Drug Administration, Bureau of Radiological Health, 1977, pp. 11-22.
9. **Gilliard, J., B. Servantic, G. Betharion, A.M. Servantic, J. Obrenovitch and J.C. Perrin:** Study of Microwave-Induced Perturbations of the Behavior by the Open-Field Test into the White Rat, in Johnson CC, Shore ML (eds.): *Biological Effects of Electromagnetic Waves — Selected Papers of the USNC/URSI Annual Meeting,* Boulder, CO., Oct. 20-23, 1975, HEW Publication No. (FDA) 77-8010. Rockville, U.S. Dept. of Health, Education, and Welfare, Public Health Service, Food and Drug Administration, Bureau of Radiological Health, 1976, Vol. 1, pp. 175-186.
10. **Serdiuk, A.M.:** Biological Effect of Low-Intense Ultrahigh —Frequency Fields. *Vrach. Delo. (11)*:108-111, (1969) (Rus).
11. **Bereznitskaya, A.N. and T.Z. Rysina:** Embryotropic Effects of Microwaves, in Gordon ZV (ed.): *Biological Effects of Radiofrequency Electromagnetic Fields,* JPRS 63321. Arlington, VA, U.S. Joint Publications Research Service, 1974, pp. 230-236.
12. **Bereznitskaya, A.N. and I.M. Kazbekov:** Studies on the Reproduction and Testicular Microstructure of Mice Exposed to Microwaves, in Gordon ZV (ed.): *Biological Effects of Radiofrequency Electromagnetic Fields,* JPRS 63321. Arlington, VA, U.S. Joint Publications Research Service, 1974, pp. 221-229.
13. **Varma, M.M. and E.A. Traboulay, Jr.:** Biological Effects of Microwave Radiation on the Testes of Swiss Mice. *Experientia 31*:301-302 (1975).

NIOSH Current Intelligence Bulletin #37 (10/26/81) . . . Ethylene dibromide (EDB) revised

The National Institute for Occupational Safety and Health (NIOSH) reaffirms its 1977 recommendation that ethylene dibromide (EDB) be treated as a potential occupational carcinogen in the workplace. This includes a ceiling limit of 0.13 ppm (1.0 mg/m^3) as determined over any 15-minute sampling period and use of appropriate controls to reduce worker exposure. Recent animal studies involved exposure to ethylene dibromide by skin application, oral administration, and inhalation. Statistically significant increases in tumors of the respiratory tract, mammary gland, spleen, and nasal cavity were observed. Inhalation studies with rats and mice at ethylene dibromide concentrations below the current Occupational Safety and Health Administration (OSHA) permissible exposure limit (PEL) of 20 ppm demonstrated a carcinogenic risk. In addition, the new animal bioassay studies reaffirm the increased toxic effects reported in 1978 when EDB is administered with disulfiram, a widely-used drug in alcoholism control programs. This increased interaction may not necessarily be restricted to disulfiram, but may occur with similarly structured compounds such as Thiram®, a fungicide and seed disinfectant.

Copies of NIOSH CIB #37 can be obtained from: NIOSH Publications Dissemination, Division of Standards Development and Technology Transfer, 4676 Columbia Parkway, Cincinnati, OH 45226.