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RADIOFREQUENCY (RF) SEALERS AND HEATERS:

POTENTIAL HEALTH HAZARDS AND THEIR PREVENTION

U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service
Center for Disease Control
National Institute for Occupational Safety and Health

U.S. DEPARTMENT OF LABOR
Occupational Safety and Health Administration

This Current Intelligence Bulletin is a joint effort of the National Institute for Occupational Safety and Health (NIOSH) and the Occupational Safety and Health Administration (OSHA), and is a product of the NIOSH Current Intelligence System. The staff of the NIOSH Technical Evaluation and Review Branch, Office of Extramural Coordination and Special Projects, was responsible for the preparation of the Bulletin. Major contributions to the content of the Bulletin were made by NIOSH Division of Criteria Documentation and Standards Development and Division of Biomedical and Behavioral Science and by staff of the Occupational Safety and Health Administration.

The purpose of the NIOSH Current Intelligence System is to promptly review, evaluate, and supplement new information received by NIOSH on occupational hazards that are either unrecognized or are greater than generally known. As warranted by its evaluation, the information is capsulized and disseminated to NIOSH staff, other government agencies, and the occupational health community, including labor, industry, academia, and public interest groups. With respect to currently known hazard information this system also serves to advise appropriate members of the above groups of recently acquired specific knowledge which may have an impact on their programs or perception of the hazard. Above all, the Current Intelligence System is designed to protect the health of American workers and to allow them to work in the safest possible environment.

> "Employers in every state who want help in recognizing and correcting safety and health hazards in their workplaces can get it from a free onsite consultation service funded by the Occupational Safety and Health Administration. The service is delivered by state governments or private sector contractors using well trained professional staff. Employers can obtain from OSHA the name, address, and phone numbers of the state agency or contractor that provides this service."

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JOINT NIOSH/OSHA
CURRENT INTELLIGENCE BULLETIN: #33

Radiofrequency (RF) Sealers and Heaters: Potential Health Hazards and Their Prevention

December 4, 1979

The National Institute for Occupational Safety and Health (NIOSH) and the Occupational Safety and Health Administration (OSHA) are concerned about potential health hazards to workers exposed to radiofrequency (RF) energy emitted from RF dielectric heaters (more widely known as RF sealers and heaters). RF energy is nonionizing electromagnetic radiation and should not be confused with X-rays and other ionizing radiation. RF energy, when absorbed in sufficient amounts by workers, may produce adverse thermal effects resulting from heating of deep body tissue which may include potentially damaging alterations in cells. Absorption of RF energy may also result in "nonthermal" effects on cells or tissue, which may occur without a measureable increase in tissue or body temperature. "Nonthermal" effects have been reported to occur at exposure levels lower than those that 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 evidence of such effects to cause concern about human exposures. NIOSH and OSHA recommend that precautionary measures be instituted to minimize the risk to workers from unwarranted exposure to RF energy. Section V of the Appendix to this Bulletin lists engineering controls, such as shielding, and other immediate actions that should be taken. Also, NIOSH and OSHA are issuing this Bulletin to alert employers and workers to the potential for overexposure of workers to RF energy from RF sealers and heaters, and to recommend control technology that can prevent unwarranted exposures.

Workers near RF sealers may be unaware of their exposure to RF emissions, because the RF energy from sealers and heaters can penetrate deeply into the body without activating the heat sensors located in the skin. A false sense of employee safety may exist; in many instances, worker exposures to RF energy may not have been properly assessed. This has been due, largely, to the complex problems of measurement and thus the misapplication of the instruments available for monitoring RF energy levels. Recently, monitoring instruments that facilitate accurate measurement of worker exposure have been developed. Federal survey teams, equipped with these new instruments, have detected excessive exposures of workers to RF energy.

NIOSH is seeking additional information about the adverse effects of RF energy and effective control technology. The Institute would appreciate receiving information concerning adverse health effects among workers which might be associated with their exposure to RF energy in the workplace and information on methods for retrofitting existing RF sealers and heaters in order to control the

emission of RF energy. NIOSH and OSHA request that manufacturers, distributors, and users of RF sealers and heaters transmit the information in this Bulletin to their customers and employees, and that professional societies, trade associations, and unions inform their members.

BACKGROUND

RF sealers have been used for more than 30 years, but there are no reliable, documented estimates of the number of units in present use or of the number of workers operating RF sealers. However, it is generally believed that the number of RF sealers and heaters in use is approximately 20,000 and that there are about 30,000 to 40,000 workers operating these units. A list of companies believed to manufacture RF sealers and/or heaters appears in Section I of the attached Appendix.

RF sealers are used to heat, melt, or cure materials such as plastic, rubber, or glue. Specific uses include: 1) the manufacture of many plastic products such as toys, vinyl loose-leaf binders, rain apparel, waterproof containers, furniture slip covers, and packaging materials; 2) wood lamination and veneer processes, including glue setting; 3) embossing and drying operations in the textile, paper, plastic, and leather industries; and 4) curing of various materials including plasticized polyvinyl chloride, wood resins, polyurethane foam, concrete binder materials, rubber tires, and epoxy resins. An extensive list of occupations involving the use of RF sealers and heaters is presented in Section II of the attached Appendix.

Experiments in animals suggest that the potential consequences of absorbing excessive amounts of RF energy may include changes in: the eye, the central nervous system, conditioned reflex behavior, heart rate, chemical composition of the blood, and the immunologic system. Effects on reproduction and on the development of offspring of females exposed during pregnancy have also been reported.

As previously mentioned, a false sense of employee safety may exist in many industrial settings because worker exposures to RF energy may not have been properly assessed. The recent development of monitoring instruments that facilitate accurate measurement of worker exposure to RF energy allowed for a series of studies at workplaces where RF sealers and heaters are used. The results of a NIOSH study indicate that the majority of the workers surveyed were exposed to RF energy at levels exceeding values citable by OSHA.[1] RF energy in the immediate area of a worker has been measured at levels as great as ten times the values citable by OSHA.[1,2] A list of manufacturers of instruments suitable for measurement of RF energy is presented in Section III of the attached Appendix.

This Bulletin will provide an overview of the potential adverse health effects associated with the use of RF dielectric heaters. The Appendix contains technical information to assist research, engineering, and manufacturing personnel in evaluating this potential hazard and for initiating appropriate modification and controls to prevent unwarranted worker exposure.

BIOLOGICAL EFFECTS OF RF ENERGY

Excess amounts 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 mW/cm^2 (see Section IV.C of the attached Appendix) can cause net increases in tissue or body temperatures, and that exposures at or above these values should be avoided.[3] In the far field, a power density of 10 mW/cm^2 is equivalent to a mean squared electric field strength of 40,000 $volts^2/meter^2$ or a mean squared magnetic field strength of 0.25 $amperes^2/meter^2$. 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. "Nonthermal" effects are reported to occur from exposure to RF energy at field strengths lower than those necessary to cause thermal effects.[4,5] 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,[6] conditioned reflex behavior,[6,7] chemical composition of the blood,[6] the endocrine (hormonal) system,[6,8] and the immunologic (infection defense) system.[6,9] Details of these experiments are summarized in Section IV.E of the attached Appendix. For the frequencies at which these observations have been made the rates of energy absorption in man are much greater than in the laboratory animals.[10] 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 (see Section IV.A of the attached Appendix). 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.[4] Reports have described chromosomal abnormalities in animal and human cells cultured in the laboratory after exposure to RF energy.[11,12] 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.[13] Retarded fetal development and increased congenital anomalies have been noted among exposed offspring.[13] 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.[14]

There is a report of changes in spermatogenesis (production of male germ cells in the testicles) among workmen exposed to nonionizing electromagnetic energy.[15] 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.[16,17] 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.[18] 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.

PRESENT OCCUPATIONAL EXPOSURE STANDARD

The Occupational Safety and Health Administration radiation protection standard for occupational exposure to RF and microwave radiation (29 CFR 1910.97) applies to the frequencies 10 - 100,000 MHz. It establishes as a limit for occupational exposures a maximum power density of 10 mW/cm^2, as averaged over any possible 6-minute period.[19] In the far field, a power density of 10 mW/cm^2 is equivalent to a mean squared electric field strength of 40,000 $volts^2/meter^2$ or a mean squared magnetic field strength of 0.25 $amperes^2/meter^2$. 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).

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.

NIOSH RECOMMENDATIONS

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, as listed in Section V of the attached Appendix, be instituted to protect workers from unwarranted exposure to RF energy.

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APPENDIX

JOINT NIOSH/OSHA CURRENT INTELLIGENCE BULLETIN #33

Radiofrequency (RF) Sealers and Heaters:

Potential Health Hazards and Control

I. Manufacturers of Radiofrequency Sealing and/or Heating Equipment

II. Occupations Which May Involve Use of Radiofrequency Sealing and Heating Equipment

III. Manufacturers of Instruments for Measurement of Radiofrequency Energy in the Near Field

IV. Supporting Technical Information
- A. Electromagnetic Radiation
- B. RF Sealers and Heaters
- C. Measurements of RF Energy Fields
- D. Absorption of RF Energy
- E. Biological Effects of Absorbed RF Energy

V. Recommendations for Hazard Control

References

I. Manufacturers of Radiofrequency Sealing and/or Heating Equipment

Mention of company name or product does not constitute endorsement by the National Institute for Occupational Safety and Health or the Occupational Safety and Health Administration.

Chemetron Corp. (Voltator),	Louisville, Kentucky
Compo Industries, Inc.	Waltham, Massachusetts
Cosmos Electronic Machine Corporation	Farmingdale, New York
Duomatic Electronics Corporation	Brooklyn, New York
Gallery Services Fara-Dine	So. El Monte, California
Gerling Moore, Inc.	Santa Clara, California
Guild Electronics, Inc.	Brooklyn, New York
Hall Dielectric Machine Company	Deer Park, New York
J.A. Callanan Company	Chicago, Illinois
Kabar Manufacturing Corporation	Farmingdale, New York
Lepel High Frequency Laboratories, Inc.	Maspeth, New York
Mann-Russell Electronic Devices, Inc.	Tacoma, Washington
Pillar Corporation	Milwaukee, Wisconsin
P.S.C. Inc.	Cleveland, Ohio
Radio Frequency Company, Inc.	Medfield, Massachusetts
Seal-Pac Services and Machine, Inc.	Brooklyn, New York
Solidyne, Inc.	Bay Shore, New York
Divisions: Thermatron Sealomatic Faratron Stanelco, Ltd Colpitt, B.V.	
Thermo Dielectric Machine Company, Inc.	Brooklyn, New York
Welduction, Inc.	Plymouth, Michigan
W.T. LaRosa and Associates, Inc.	Troy, New York

*This list is complete and accurate to the best knowledge of NIOSH; however, there may be other manufacturers of this equipment of which the Institute is not aware.

II. Occupations Which May Involve Use of Radiofrequency Sealing and Heating Equipment

Automotive workers
- Drying of trim base panels
- Embossing of heel pads to carpets
- Heat sealing body interior trim panels
- Heat sealing convertible tops and vinyl roofs
- Heat sealing upholstery covers for seats and backs

Furniture and wood workers
- Decking assembly
- Door lamination
- Fabrication of posts and rafters
- Fiberboard fabrication
- Laminated beams
- Lumber edge glueing
- Plywood panel patching
- Plywood or particleboard scarf glueing
- Ski lamination
- Veneer panel glueing

Glass fiber workers
- Drying and curing sizing on machine packages
- Drying coatings on continuous moving strands
- Drying glass fibers on forming tubes
- Drying roving packages

Paper product workers
- Correcting moisture profile on continuously moving webs
- Drying resin coatings
- Drying twisted twine packages
- Gluing paper
- Heating coating on continuous webs

Plastic heat-sealing workers involved in the manufacture/fabrication of:
- Acetate box covers
- Advertising novelties
- Appliance covers
- Aprons
- Baby pants
- Beach balls
- Belts and suspenders
- Blister packages
- Book covers
- Capes
- Charge cards
- Checkbook covers
- Convertible tops
- Cushions
- Diaper bags
- Display boxes
- Electric blankets
- Food packages
- Fountain pens
- Garment bags
- Gas masks
- Goggles (industrial)

Plastic heat-sealing workers (continued)
- Handbags
- Hat covers
- Index cards
- Lampshades
- Liquid containers
- Luggage
- Machine covers
- Mattress covers
- Mild cartons
- Oxygen tents
- Packages
- Pharmaceuticals
- Pillowcases
- Pillow packages
- Plastic gloves
- Pool liners
- Protective clothing
- Racket bags
- Rain apparel
- Refrigerator bags
- Shoe bags
- Shoes
- Shower curtains
- Slipcovers
- Splatter mats
- Sponge backings
- Sport equipment
- Tobacco pouches
- Toys
- Travel cases
- Umbrellas
- Wallets
- Waterproof containers
- Wire terminal covers

RF/microwave application workers
- Advertising. RF-excited gas display signs
- Ceramics. Drying of ceramic objects
- Chemical. Activation of chemical reactions
- Electronics. Tube aging and testing
- Laser. RF-excited gas lasers
- Medical. Diathermy and (experimental) cancer therapy
- Scientific equipment. Low temperature ashing of samples
- Welding. RF-stabilized welding

Rubber products workers
- Drying latex foams
- Gelling latex foams
- Preheating prior to curing latex foams
- Preheating prior to molding

Textile workers
- Drying continuous webs
- Drying impregnated or coated yarns
- Drying rayon cake packages
- Drying slasher coatings
- Drying wound packages

III. Manufacturers of Instruments for Measurement of Radiofrequency Energy in the Near Field*

Mention of company name or product does not constitute endorsement by the National Institute for Occupational Safety and Health or the Occupational Safety and Health Administration.

General Microwave Corp.
Farmingdale, Long Island, New York

For electric field only:
High sensitivity isotropic radiation hazard meter, Model 4

Instruments for Industry, Inc.
Farmingdale, Long Island, New York

For electric field only:
Electric field radiation hazard monitor, Model RHM-2

Narda Corporation
Plainview, Long Island, New York

For electric and magnetic fields:
Electric field strength probe, Model 8644
Magnetic field strength probes, Model 8635 or 8633
Readout meters, Model 8619 or Model 1816

*This list is complete and accurate to the best knowledge of NIOSH: however, there may be other manufacturers of comparable equipment of which the Institute is not aware.

IV. Supporting Technical Information

A. ELECTROMAGNETIC RADIATION

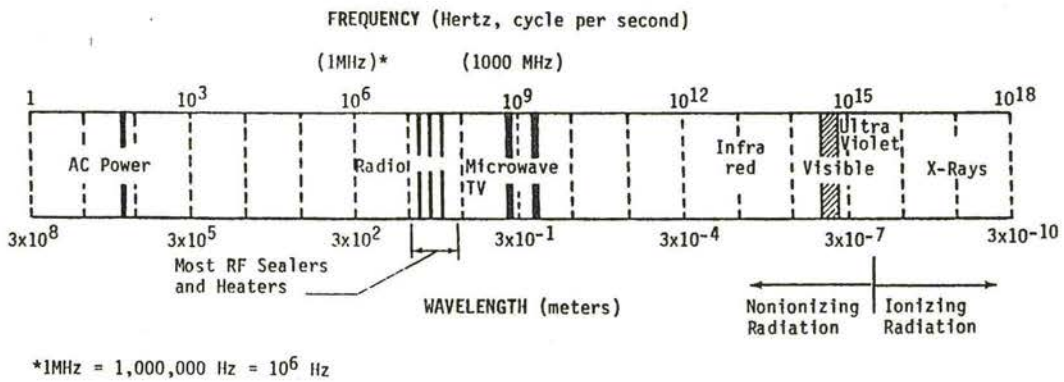
Radiofrequency energy (or RF radiation) is part of the electromagnetic energy spectrum. With regard to the energy emitted from a RF sealer or heater, electromagnetic radiation may be considered as a series of waves of energy propagated through space and composed of oscillating electric and magnetic fields. These waves are produced by moving electric charges, and may be of natural origin (e.g. the sun), or may be of human origin (e.g. produced by electronic devices such as diathermy machines, microwave ovens, and television and radio transmitters). The wave of electromagnetic energy is characterized, in part, by:

1) the strengths of the electric and magnetic fields -- the intensity of electromagnetic forces

2) the frequency of oscillation — the number of complete oscillations per second of the wave

3) the wavelength -- the distance between two consecutive peaks of the wave

Wavelength and frequency are inversely related; as the wavelength increases, the frequency decreases. The energy content of electromagnetic radiation is related to wavelength; waves of longer wavelength (lower frequency) contain less energy per quantum* unit. A graphic representation of the electromagnetic radiation spectrum is presented in Figure 1.



*1MHz = 1,000,000 Hz = 10^6 Hz

Figure 1 The Electromagnetic Spectrum

Electromagnetic energy emitted from a source propagates through space until it is absorbed, reflected, transmitted and/or diffracted by objects in its path. When

*Electromagnetic energy can also be described as discrete particles (or quanta) of energy.

electromagnetic radiation contains sufficient energy (at frequencies much higher than radiofrequencies), it can ionize atoms of the material absorbing the energy (i.e. dislodge electrons from the atoms of the absorbing material). Radiation of sufficient energy to cause ionization of molecules in biological tissue is often referred to as ionizing radiation, whereas radiation of insufficient energy to cause this effect is referred to as nonionizing radiation. The ionizing and nonionizing regions of the electromagnetic spectrum are shown in Figure 1. While nonionizing radiation absorbed by biological tissue is not capable of ionizing atoms or molecules, it nevertheless may produce changes in the vibrational and rotational energies of the biological molecules, leading to changes in the molecules or dissipation of the energy in the form of heat.

B. RF SEALERS AND HEATERS

RF sealers and heaters generate, by means of electronic circuitry, oscillating fields of electric and magnetic energy. RF sealers generally operate within the band of frequencies from 10 to 70 MHz (a megahertz (MHz) is one million cycles per second), although most of the sealers operate at nominal frequencies from 13 to 40 MHz. A few wood glueing machines operate at frequencies as low as 3 - 6 MHz, and a few RF heaters used for plastics operate at frequencies as high as 300 - 400 MHz. RF electromagnetic energy emitted from an RF sealer or heater is considered nonionizing radiation by virtue of its frequency and quantum energy. Unshielded or improperly shielded RF sealers or heaters can leak stray RF energy. Measurements have been made of electric and magnetic field strengths, in the immediate area of an operator, as great as 2000 volts/meter and 10 amperes/meter, respectively.[1,2] The majority of surveyed RF machines leaked stray energy in excess of 200 volts/meter or 0.5 amperes/meter.[2] Measurements of electric and magnetic field strengths will be discussed below.

C. MEASUREMENTS OF RF ENERGY FIELDS

In the measurement of RF energies, the distances from the RF source at which the measurements are being made must be considered. For purposes of this Bulletin, distances from the RF source can be categorized as being either far field or near field. The far field includes all distances from the RF source greater than approximately ten times the wavelength. Wavelengths corresponding to frequencies used by RF sealers and heaters may range from about one meter to a few hundred meters. The frequency of 27 MHz, which is typical for many RF heaters, is associated with a nominal wavelength of about 11 meters. In the far field, the amount of energy associated with the typical wave can be expressed as a power density (with the units of milliwatts per square centimeter, mW/cm^2). The value of the power density in the far field can be measured with a power density monitor, or can be calculated from measurement of the intensity of either the electric field or the magnetic field alone. The strength of the average electric field is expressed in units of volts/meter with the mean squared value expressed in $volts^2/meter^2$; the strength of the average magnetic field is expressed in units of amperes/meter with the mean squared value expressed in $amperes^2/meter^2$.

The near field comprises distances from the RF source less than about five wavelengths, which includes the immediate vicinity of the RF device where most worker exposures to RF energy occur. In the near field, electromagnetic waves have different characteristics than in the far field. Furthermore, in the occupational setting near a RF sealer or heater, the electromagnetic field generally is not uniform, and the energy field incident upon a worker is complex and depends on many factors. A power density monitor, designed for use in the far field, is likely to give exceedingly inaccurate measurements in the near field. Further, in the near field, as opposed to the far field, there is no simple mathematic equivalency between values of power density and measurements of either electric or magnetic field strength.

In the past, values of far-field power density have been used in various public health guides and recommendations for exposure limits, including those intended for occupational settings. However, a power density value, which can be measured or calculated for far-field conditions, is not appropriate for quantifying near-field exposure of a worker operating an RF sealer or similar device. In the near field, measurements of both the electric *and* the magnetic fields are necessary to properly characterize worker exposure conditions. Instruments are now commercially available to make near-field measurements of the electric and magnetic fields. Users should follow instrument manufacturers' use instructions carefully to avoid damage of sensitive instrument probes. A list of manufacturers of these instruments is presented in Section III of the Appendix.

D. ABSORPTION OF RF ENERGY

When RF energy propagating through space encounters an object, it may be reflected by the object (forced to change direction of travel), transmitted through the object, or absorbed by the object. The extent to which RF energy is reflected, transmitted, and/or absorbed depends on the frequency of the RF energy, and on the shape, size, and dielectric properties of the object as well as its orientation relative to the incident RF energy.

Humans can absorb RF energy at the frequencies used by most RF sealers and heaters. In workers who are not in contact with an electrical ground, the highest absorption rates for whole-body irradiation can occur at frequencies between 60 and 100 MHz with a peak at approximately 80 MHz.[3,4] These frequencies of high absorption rates are very close to the frequencies used by most sealers and heaters. Hence, workers near RF sealers and heaters can absorb considerable amounts of the stray energy emitted from the RF machines. Effects of directly touching an electrical ground plane can lower, by as much as one half, the frequency at which an irradiated body will maximally absorb energy.[3] Contact of the worker with an electrical ground plane can shift the frequency of maximum absorption rate to well within the frequency band of most RF sealers and heaters; this could increase the amount of energy absorbed by the worker and worsen the exposure condition. RF shielding material incorporated into the floor, walls, and ceiling of some RF workrooms could constitute such a ground plane.

E. BIOLOGICAL EFFECTS OF ABSORBED RF ENERGY

Details of some experiments performed in laboratory animals with low intensity RF energy at frequencies commonly used with sealers and heaters are summarized in the following table.

Table 1. Some Reported Biologic Effects in Animals Exposed to RF Energy at Frequencies in the Range of 10 to 70 MHz

Frequency (Wavelength)	Exposure Conditions	Animal	Reported Effects	Reference
50 MHz	0.5-6 volts/meter for 10-12 hrs/day; 180 days	rats and/or rabbits	changes in conditioned reflexes changes in encephalograms decreased blood cholinesterase activity increased urine 17-ketosteroids decreased leukocyte count decreased phagocytic activity	5
(4.3 meters)	150 volts/meter for 60 min/day; 4 months	rats	changes in conditioned reflexes	6
69.7 MHz	12 volts/meter for 1 hr/day; 1.5 months	rats	increases weights of adrenal and pituitary glands	7
69.7 MHz	48 volts/meter for 4 hrs/day; 1.5 months	infant rats	decreased weight of thyroid gland increased weight of adrenal gland	7
14.88 MHz	70 volts/meter	infant rats	decreased weights of thyroid and adrenal glands	7
14.88 MHz	100 volts/meter for 4 hrs/day; 10 months	rats	changes in phagocytic activity	8

V. Recommendations for Hazard Control

Immediate Actions

Control of the emission of RF energy from RF sealers and heaters should rely on the application of properly designed and installed shielding material. The shielding should be placed on or around the equipment so as to minimize occupational exposure due to emissions of stray RF energy. All shielding material should be properly grounded. Shielded conductors should be used for conveying RF current, and path impedance should be minimized by using good conductor materials. Many of these control features are available on RF sealers and heaters being marketed new, and some machines already in use can be retrofitted with some of these features. Older machines may require custom modification to control stray emissions.

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.

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

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.

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.

Warnings and Information

Access to the vicinity of RF sealers and heaters where there may be stray RF energy should be limited as much as possible to the operator and necessary assistants, maintenance personnel, and industrial hygiene or safety personnel. Use of the RF equipment should be restricted to properly trained personnel.

Areas in which exposures to RF energy have been determined to be appreciable should be posted. Any signs should be of such size as to be recognizable and readable from a distance of three meters. All warning signs must be printed in English and in the predominant languages of non-English-reading workers, and should conform to the design recommended by OSHA.[9]

Areas in which the RF energy is present at levels higher than the permissible exposure limit also should be posted. The warning signs should contain the following additional information: HAZARD--DO NOT ENTER. The sign must be

readable from a distance of three meters. The perimeter of the restricted area should be clearly demarcated with signs visible to all personnel approaching the area.

Medical Monitoring

A medical surveillance program, tailored to the expected degree of employee use of RF equipment and potential for exposure to RF energy, should be developed. The program should include preplacement examination of all new employees and an initital examination of all present employees subject to occupational exposure to RF energy. In an effort to identify possible adverse effects associated with exposure to RF energy, annual examinations should be considered for workers who may be exposed to RF energy on a regular, long-term basis. Work histories should be included in all examinations.

Medical histories and physical examinations should give particular emphasis upon target organs potentially affected by RF energy including the eye (cataracts), the central nervous system, the blood (decreased leukocyte count), the immune defense system, and the reproductive system. Adverse reproductive effects may involve both maternal and paternal exposure. For persons occupationally exposed to RF energy, medical records including health and work histories should be maintained throughout the period of employment and for an extended period after termination of employment.

Exposure Measurements

Areas in the occupational environment where levels of RF energy have been determined to be appreciable should be surveyed at regular intervals. Immediately following a physical or electronic alteration of the equipment or an alteration in the process, a complete survey should also be performed. If measurements taken during a survey indicate that occupational exposure exceeds the permissible exposure limit, a second survey should be made on the next workday. If the limit is still exceeded, the use of RF equipment producing excessive values should be prohibited until appropriate controls have been instituted. The survey data sheets should contain all information pertaining to the survey, and should include the date and time of measurement, the type of monitoring equipment used, the employees' names, and the remedial actions taken, if any. These records should be maintained for an extended period of time.

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