COMAR Reports

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Human Exposure to Electric and Magnetic Fields from RF Sealers and Dielectric Heaters - *A COMAR Technical Information Statement*

Abstract

Radio frequency (RF) sealers and dielectric heaters, operating between 3 and 100 MHz, are used for a variety of industrial applications. There is concern about the safety of such devices because measurements during operation often show leakage of electric and magnetic fields, as well as induced currents in the body, that exceed RF exposure guidelines. Both the leakage of fields and the absorption of RF energy by an operator can be reduced by shielding, proper grounding of the sealers, isolation of the operator from ground, and increasing the distance between the sealer and the operator. Several national and international standards now include limits on body-to-ground and contact currents for humans. Based on present knowledge of the biological effects of RF fields and the reported exposures from such devices, COMAR recommends that the leakage field strengths from RF sealers and dielectric heaters, as well as body-to-ground and contact currents, be monitored and exposure to workers be limited so as to meet the recommended RF exposure guidelines.

Background

Radio frequency (RF) energy at 13.56, 27.12, 40.68, and 100 MHz is used for a variety of industrial heating processes, such as sealing and embossing plastic and drying glue. Devices such as plastic heat sealers and dielectric heaters, both of which use strong RF fields to heat material, are commonly used in the production of plastic tarpaulins, swimming pool and water bed liners, shoes, travel check folders, three ring binders, plywood, and many other products. One 1987 report has estimated that, in the United States alone, there are more than 100,000 RF sealers with over 250,000 people operating them [1].

Studies in the US and other countries show that recommended safe limits for electric and magnetic fields from such devices, and induced electric currents in the body, are often exceeded for heater operators [2-7]. The fields are often strong enough to produce biologically significant exposures to the bodies of the operators, who often experience a warming sensation.

Shielding of heaters is an effective way to reduce operator exposures [1, 8-10]. Measurements in the workplace and numerical modeling calculations (computer simulations) have both shown that the induced electrical current in the operator's body is reduced when the operator's hands and upper torso are moved away from the heater [3, 5, 7, 11-14]. Installing a wooden or plastic table between the operator and the heater can be effective in reducing currents through the foot or hand. Likewise, measurements and simulations have both shown that the wrist and hand currents are minimized when the hands are distant from the heater [3, 15-16]. Calculations have also shown that metallic screen rooms, which are typically used to reduce RF interference with public service and commercial communications, can increase operator wrist current and average whole body energy absorption (specific absorption rate, SAR) when used with heat sealers [17-18]. Thus, for reducing operator exposure, shielding the heater is preferable to placing both the heater and the operator within a screened room.

Radio frequency fields can cause heating of tissue, potentially leading to burns. Moreover, people are slower to perceive warmth and tissue heating from exposure to RF fields than from infrared radiation or from contact with a hot surface. This is because RF fields penetrate the body and heat internal tissues, whereas thermal sensors are located predominantly near the surface of the skin. Therefore, it is possible to sustain damaging exposure to RF energy before pain forces one to move away from the source of exposure.

Animal and human studies have considered the potential for exposure to RF energy causing adverse effects on the reproductive system. Moderate to severe hyperthermia (increase in core body temperature), especially during the first trimester of pregnancy, is teratogenic (can cause defects in the embryo) in all laboratory animals studied [19]. Several animal studies [20-21] have reported teratogenic effects in rats exposed at 27.12 MHz, one frequency used by heat sealers, under exposure conditions that increased the core temperature to levels that would correspond to severe fever (41-42°C, at a whole body exposure level of 11 W/kg), and the effects increased with duration of the exposure [21].

No measurements of core temperature in workers operating RF heat sealers have been reported. These would be helpful for assessing the potential for teratogenic effects. However, the effects cited above have uncertain relevance to users of RF heat sealers. A great deal of RF energy must be deposited in the body to produce a measurable rise in core temperature, far more than is likely to result from use of heat sealers. Also, exposures needed to raise the core body temperature to 41°C would exceed those that would produce noticeable, and even painful, heating of the extremities. Typical exposures from heat sealers are intermittent and primarily localized to the hands of the operator, for which burns (i.e., localized effects of heating) rather than excessive whole body heating are the most likely hazard. Conformance with an RF exposure safety standard, such as IEEE C.95.1-1991 [22], would eliminate the potential for both increases in core body temperature and burns to the extremities.

Only very limited epidemiological studies have been performed with RF heater operators. These studies have been too small to be able to detect reproductive problems in the workers or birth defects in their children. However, human assessment and epidemiological studies of RF heat sealer operators in Europe [23-26] report that these operators can experience:

- 1. RF burns and/or burns from contact with hot surfaces,

- 2. Warming and discomfort of the legs (possibly arising from RF current flow through the legs to ground), and
- 3. Changes in tactile sensitivity or numbness and tingling sensations in the hands (which may result from ergonomic factors unrelated to RF exposure).

A number of other collateral safety factors may be present in the RF sealer environment, such as dust, noise, paint or chemical fumes, vibration, low lighting levels, repetitive time-pressured work, and ergonomic factors. These should be considered, in addition to RF exposure from heat sealers, in the overall safety assessment of the workplace.

Recommendations

Recommended limits on RF exposure and on contact and body-to-ground currents have been provided by a number of standards organizations. These include the International Radiation Protection Association (IRPA) [26], Health and Welfare Canada [27], National Radiological Protection Board (NRPB, U.K.) [28], American Conference of Governmental Industrial Hygienists (ACGIH) [29], and the Institute of Electrical and Electronics Engineers (IEEE C95.1-1991) [22].

Practical, step-by-step guidance on evaluating and reducing operator exposure is available from ICNIRP [30] and NCRP [31]. Measures that employers can take to ensure the prevention of overexposure of their workers to RF energy from heat sealers include:

- 1. Using appropriate shielding of sealers and dielectric heaters. Typically, such shielding is available from the supplier of the equipment.
- 2. Proper grounding of sealers and dielectric heaters.
- 3. Having the worker stand on thick insulating pads to reduce body-to-ground currents.
- 4. Increasing the distance between RF electrodes and operators by the use of dielectric barriers (e.g., plastic or wooden table tops), changing operator postures and positions, and using shuttle trays.
- 5. Changing work procedures to eliminate the need for operators to place their hands close to the RF electrodes.
- 6. Locating RF sealers away from large metallic reflectors. If the equipment is placed inside shielded enclosures, employers should recognize the tendency of such rooms to increase operator exposure and should ensure that operator exposure is within recommended limits.
- 7. Proper maintenance of the equipment, ensuring that the shields that were installed by the manufacturer remain in place.

Field strength measurements alone do *not* completely evaluate operator exposure to RF fields. Induced current measurements are essential: induced currents in the body can be significant and vary widely with the position of the operator with respect to the electrodes. All measurements must be performed with care and evaluated by knowledgeable individuals.

Summary

COMAR recommends that the following steps should be taken by employers to ensure compliance with IEEE C95.1-1992 [22]:

1. RF sealer manufacturers should assure that RF heat sealers, and other RF generating equipment, are designed with adequate shielding. They should provide clear instructions for equipment operation. Manufacturers should provide instructions that strongly recommend against removal of equipment shielding. They should stress the need to ensure periodic monitoring of RF exposure and caution the user against unauthorized modifications to the equipment.

2. Operator exposures can be strongly influenced by the design of RF work applicators, which may not be supplied by the heater manufacturer, and other modifications to the equipment. Such non-standard usage should be avoided whenever possible.

3. Owners of RF sealers should perform periodic monitoring of RF fields and induced currents in the operator (using appropriate equipment and procedures) to determine whether exposures comply with IEEE C95.1-1992 [22]. They should promptly correct any problems that such monitoring discloses. Additionally, operators should be trained to be aware of the possible hazards of excessive RF exposure, and knowledgeable about recommended exposure guidelines.

Contributors

This document was developed by members of the IEEE-EMBS Committee on Man and Radiation (COMAR). Contributing members include: Eleanor Adair, John Bergeron, C-K Chou, Jules Cohen, Linda Erdreich, Kenneth R. Foster, Gregory D. Lapin, Kjell Mild, Gregory Lapin, Ruth Douglas Miller, John Moulder, John Osepchuk, and Arthur Varanelli (subcommittee chair). It has been reviewed and approved by the full membership of COMAR, whose members have expertise in the general area of the interactions of electromagnetic fields with humans. This final report was accepted by the EMBS's Executive Committee, which sponsors COMAR as a Technical Committee. For more information about COMAR see its website at http://homepage.seas.upenn.edu/~kfoster/comar.htm.

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