HETA 97-0220-2671
Remington Industries, Incorporated
Benton, Tennessee

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PREFACE

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ACKNOWLEDGMENTS AND AVAILABILITY OF REPORT

This report was prepared by C. Eugene Moss, Health Physicist, Industrial Hygiene Section of the Hazard Evaluations and Technical Assistance Branch, Division of Surveillance, Hazard Evaluations and Field Studies (DSHEFS) and David L. Conover, Ph.D., Scientist, Physical Agents Effects Branch, Division of Biomedical and Behavioral Science. Desktop publishing by Juanita Nelson. Review and preparation for printing by Penny Arthur.

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SUMMARY

In August 1997, the National Institute for Occupational Safety and Health (NIOSH) conducted a health hazard evaluation at Remington Industries, Incorporated (RII) in Benton, Tennessee. The evaluation was made in response to a confidential request to evaluate occupational exposure to radiofrequency (RF) radiation from four heat sealers at the facility. The requestor was concerned because three women in the heat sealing area had all recently undergone gall bladder operations.

Electric (E-field) and magnetic (H-field) field strengths and induced body current levels were measured during routine use of the heat sealers, and interviews were conducted with all heat sealer operators. The waist E-field measurement on one heat sealer exceeded occupational exposure criteria for its operating frequency of 27.1 MHZ. This elevated reading was taken in front of the heat sealer, where a metal shielding enclosure around the welding head had become loose. After the enclosure was tightened, re-measurements indicated that the leakage site produced levels well below the occupational standards. There was one location near the back of a heat sealer where the magnetic field strength exceeded the occupational exposure criteria, however no operator worked in that location.

Induced body current levels measured at workers' wrist and ankle ranged from 15 to 53 milliamperes (mA). These levels are below the Institute of Electrical and Electronics Engineers (IEEE) recommended body current levels of 100 mA.

Factors such as low duty cycle, lack of RF biological reports involving gall bladder damage, workers not reporting perceptible body heating, and measured body current levels below occupational guidelines suggest no relationship between RF exposure and gall bladder effects. Recommendations for reducing RF exposures and induced body current levels are made in the report.

Keywords: SIC 3089 (plastic products, not elsewhere classified), RF radiation, heat sealer, body current, gall bladder.

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INTRODUCTION

In May 1997, the National Institute for Occupational Safety and Health (NIOSH) received an employee request for a health hazard evaluation at Remington Industries, Incorporated (RII) located in Benton, Tennessee. NIOSH was asked to evaluate occupational exposures to radiofrequency (RF) radiation from four RF heat sealers, and investigate a possible link between these exposures and gall bladder disease. Three of the women heat sealer operators had recently had gall bladder operations and had expressed concern about possible association with radiofrequency exposures. On August 13-14, 1997, NIOSH investigators conducted an environmental evaluation, interviewed heat sealer workers, and presented preliminary recommendations at a closing meeting.

BACKGROUND

RII manufacturers several different types of floor mats for automobiles. During the manufacturing process RF heat sealers are used to join sections of floor mats. These heat sealers are of conventional design, have a two-foot welding head contained within a metal shield, and can be operated by one worker. The floor mats are brought to the RF weld area by use of a six foot diameter turntable. The heat sealers were manufactured by either Solidyne® or Thermax®, operate on a frequency of 27.1 megahertz (MHZ) and are capable of producing 10 to 20 kilowatts (kW) of power. The ten heat sealer operators (including supervisors) work on two shifts of approximately 12 hours and are not permanently assigned to a given heat sealer. The workers rotate work on each of the sealers depending on the particular work tasks assigned to them for that day. There is no union at this facility.

RII had been inspected by the State of Tennessee's Department of Labor several times in 1996 as a result of employee complaints regarding a rash problem. During the course of these investigations comments were made by the state inspector regarding possible RF exposure. Although the state inspector performed RF measurements, the results were questionable due to use of inappropriate equipment. In fact, in the closeout letter the inspector recommended that RII obtain the services of a consultant to make RF measurements, and train workers on hazards associated with such fields.

METHODS

Occupational RF field strength measurements were made over both shifts at five different anatomical locations (head, chest, waist, knee, and foot) at distances from the heat sealer where the workers normally stood in performing their tasks. The meter was held at each anatomical location for about 10 seconds and the maximum reading recorded. In addition to documenting worker exposures, RF field strength measurements were made to identify potential RF leakage at locations around each heat sealer not occupied by operators.

Body current measurements were made at the wrist and ankle with the workers located at their normal working distance from the heat sealer. The maximum current level obtained during each measurement trial was recorded.

The RF field strength measurements were made with a Holaday Model 3002 survey meter using two probes, a Model STE-02 probe for the electric (E) field, and a Model STH-02 probe for the magnetic (H) field. The E-field probe is designed for the frequency range of 0.5 to 6000 MHZ and measures the electric field strength in units of volts squared per meter squared $(V/m)^2$. The H-field probe is designed for the frequency range of 5 to 300 MHZ and measures the magnetic field strength in units of amperes squared per meter squared $(A/m)^2$.

Body currents resulting from occupational exposure to electric fields were evaluated using a commercially available body current detector system (model MG-4501) manufactured by Mission

Research, Incorporated. This system is based on the principle that when RF energy is absorbed, RF currents are induced within the body. These body currents can be measured by using a current sensor designed to fit around either the ankle or wrist. The sensor responds only to currents induced by external electric fields.

The particular operating frequency of each heat sealer was documented using a Continental Specialties Corporation Mini-max Model MM 50 battery-powered frequency counter.

Since the RF output of the heat sealers was not continuous (operations were performed for short periods of time over the course of the work day), all E and H field measurements were corrected for the work cycle duration before comparison with applicable occupational exposure criteria. This was accomplished by multiplying the measured duty cycle factor by the recorded RF exposure level. The total length of RF on-time (in seconds) was measured during a six minute (360 second) sampling period. The duty cycle is defined as the total RF on-time (seconds) divided by 360 seconds. The duty cycle is expressed as a fraction, and for this evaluation was found to be about 0.1 (meaning that the RF heat sealers were on about 36 seconds over each 360 second period). Body current values are not required to be corrected for the duty cycle.

In addition to RF exposure measurements, the NIOSH investigators interviewed the heat sealer workers on both shifts, including the three who had gall bladder operations. The interviews centered on types of effects the workers had experienced since beginning work at RII. Finally, the NIOSH investigators reviewed with the heat sealer workers all the reported health effects associated with RF radiation exposure.

EVALUATION CRITERIA

Health Effects of Exposure to Radiofrequency Radiation

Human and animal studies indicate that exposure to RF fields above occupational exposure criteria may cause harmful biological effects which are accompanied by heating of internal tissues. The effects include changes in the eye, nervous system, behavior, chemical composition of the blood, cell biochemistry, immune system, reproduction, growth, and endocrine (hormone) system.[1-2] In contrast, human exposure below occupational RF exposure criteria have not been conclusively associated with adverse health outcomes.

There is general agreement that the incidence and severity of RF biological effects are related to the rate of RF energy absorption in the body.[3] This absorption rate depends strongly upon the frequency and intensity of the fields, the size and shape of the exposed worker, and the worker's orientation in the RF field. The human body absorbs maximally in the frequency range of 30 to 300 MHz.[3] Outside this range, the rate of energy absorption in the body is much less. Occupational RF exposure criteria are based on the rate of energy absorption in the body and account for the frequency dependence of the energy absorption rate.[3-5] There are no literature reports associating gall bladder effects with RF exposure.

Occupational Exposure Limits

Occupational exposure limits for RF radiation have been developed by the Occupational Safety and Health Administration (OSHA), the American Conference of Governmental Industrial Hygienists (ACGIH)®, and the Institute of Electrical and Electronics Engineers (IEEE).[3-5] The IEEE standard also fulfills requirements developed for standards by the American National Standards Institute (ANSI). Exposures for these standards are averaged over a six

minute period. There are no NIOSH recommended exposure limits for RF radiation.

Since the OSHA RF exposure standard was adopted over 10 years ago and has not been revised, it does not represent the most up-to-date standard upon which to base RF radiation health effects. For example, the biological effects of RF radiation are frequency dependent, a fact noted by both ACGIH and IEEE but not addressed by the OSHA standard. A more appropriate exposure criteria for heat sealers is the IEEE C-95.1 standard. The ACGIH TLV has also been changed to reflect the same criteria as IEEE.

Under the IEEE C-95.1 standard for 27.1 MHz (the operating frequency of the RII heat sealers) the electric field strength criteria is 4620 $(V/m)^2$ and the magnetic field strength criteria is 0.36 $(A/m)^2$. In addition to electric and magnetic field exposure limits, the IEEE C-95.1 - 1991 Committee has adopted a body current limit of 100 milliamperes (mA) through an arm or leg to prevent RF shocks and burns.[3]

RESULTS

The electric and magnetic field strength measurements made at different body locations during the operation of all four heat sealers (designated by letters) are shown in Table 1. The measured operating frequencies of the heat sealers are all nominally 27.1 MHz. All the electric and magnetic field strengths shown in Table 1 have been corrected by the appropriate duty cycle factor to enable direct comparison with the IEEE exposure criteria. Only one E-field measurement exceeded the IEEE criteria for a operating frequency of 27.1 MHz, at the waist level for unit A. The location of this reading was almost directly in front of the heat sealer. Upon closer inspection it was noted that the metal shielding enclosure which goes around the RF sealer head had become loose over time and needed to be tightened. When this was performed re-measurements indicated that the leakage site was reduced to levels below the occupational standards. Table 1 shows that no magnetic field strength measurements exceeded the occupational criteria. Table 1 also shows that body current levels, measured at either wrist or ankle locations ranged from 15 to 53 mA, with the highest value being measured on Unit A. These levels all are below the IEEE criteria of 100 mA.

Table 2 shows the results of duty cycle corrected field strength measurements made mainly at waist level at similar locations around the four heat sealers. The highest E-field strength of 10,000 $(V/m)^2$ recorded in Table 2 was on Unit A (location 4) which agrees with the previous waist result for Unit A shown in Table 1. The highest H-field strength recorded in Table 2 was 0.6 $(A/m)^2$ at the side of Unit D. A non-heat sealer worker was seen standing at this location near the end of the shift and the NIOSH investigators made measurements. While it was observed that no sealer operator worked at these locations, non-heat sealer personnel need to be trained to move away from these areas due to electrical and RF exposure concerns.

DISCUSSION AND CONCLUSIONS

All occupational RF exposure measurements made on the day of evaluation were below exposure guidelines after appropriate shielding improvements were made. Even though one of the units produced RF leakage at one location that was above the occupational exposure criteria, the induced body current for that particular heat sealer, as measured at the hand or ankle, was below guideline levels. This is important since body current (as opposed to field strength) measurements are more reliable when determining adherence to occupational exposure guidelines.[6] Occupational exposure guidelines are based on the rate of RF energy absorption in the body, and body current measurements are the optimum way to determine energy absorption rate. Factors such as short duty cycle, lack of RF

biological reports involving gall bladder effects, workers not reporting perceptible body heating, and all body current levels below appropriate occupational guidelines tend to suggest no connection between RF exposure and gall bladder effects.

While scientists are not in complete agreement on the interpretation of available data on biological effects of RF radiation, NIOSH recommends that heat sealer workers become aware of their exposures to E and H fields and induced body currents and make every effort to reduce that exposure to levels below occupational guidelines. The joint NIOSH/OSHA Current Intelligence Bulletin entitled Radiofrequency (RF) Sealers and Heaters: Potential Health Hazards and their Prevention[1] and the IEEE RF heater and Sealer Technical Information Statement[7] contain more detailed information on health issues associated with heat sealers and methods to reduce worker RF exposures. Additional information on evaluating operator exposure from RF heat sealer and the use of shielding to reduce operator exposure to RF radiation is available and can be consulted for further information.[8-9]

What is clear from this evaluation is that preventive maintenance, training, periodic exposure measurements (including body currents), and improved shielding can greatly help to minimize, if not eliminate, most of the RF radiation exposure produced during heat sealing operations at RII.

RECOMMENDATIONS

The following methods should be considered to further reduce operator exposure to RF radiation produced by the heaters and reduce potential safety hazards:

1. Move the activating buttons further away from the RF heater head, thereby increasing the worker-unit distance;

2. Improve the shielding of the units (See reference 9);

3. Periodic evaluation of RF field strength and body current levels;

4. Provide formal training programs for all new and existing heat sealer operators on the health and safety aspects of working in close proximity of heat sealers. Training should include the need to keep hands and arms away from the units during the RF "on" cycle;

5. No worker should be permitted to stand behind any operating heat sealer due to electrical shock and RF exposure concerns;

6. The heat-sealing area should be appropriately posted to identify the presence of RF energy;

7. The posting of operator instruction on proper heater operation and the use of insulating floor covering (e.g. pads) to reduce operator body current exposures;

8. RF field strength and body current measurements should be made during the installation of any new RF heat sealing unit and whenever changes in work practices or operations are made for any existing unit.

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Table 1

Operator RF field strength and body current values as a function of heat sealer and body location

RF Unit	Head		Chest		Waist		Knee		Foot		Body Current
	$E(V/m)^2$	$H(A/m)^2$	$E(V/m)^2$	$H(A/m)^2$	$E(V/m)^2$	$H(A/m)^2$	$E(V/m)^2$	$H(A/m)^2$	$E(V/m)^2$	$H(A/m)^2$	mA
A	250	ND	750	ND	10,000	0.008	1500	0.008	500	0.008	53
B	113	ND	113	0.003	75	ND	ND	ND	ND	ND	29
C	ND	ND	37.5	.002	188	ND	ND	ND	ND	ND	15
D	ND	0.001	ND	.001	ND	0.002	ND	ND	ND	0.001	17
Maximum level measured	250	0.001	750	.003	10,000	0.008	1500	0.008	500	0.008	53

Comments:

Frequency of all RF units surveyed was 27.1 MHz
Body Current value was highest recorded on either ankle or waist
All E and H values have been corrected for duty cycle
ND = Not Detected on lowest scale
mA = Milliamperes
IEEE C-95.1 E-field level = 4620 $(V/m)^2$
IEEE C-95.1 H-field level = 0.36 $(A/m)^2$

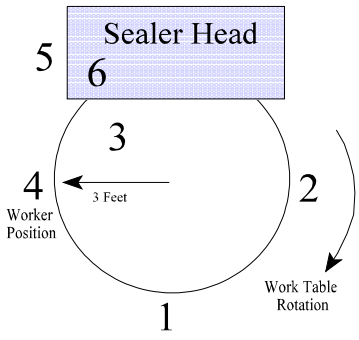
Table 2

Occupational RF field strength values at waist level at different heat sealer locations (except for chest level result made at location 6 on Unit D)

Unit	Measurement Locations (see diagram below)	E(V/m)^2	H(A/m)^2
A	1	1750	ND
	2	1750	ND
	3	500	ND
	4	10,000	0.008
	5	*	*
B	1	300	ND
	2	1130	ND
	3	ND	0.06
	4	75	ND
	5	*	0.006
C	1	ND	0.02
	2	263	ND
	3	ND	*
	4	188	0.006
	5	1500	*
D	1	2500	0.02
	2	875	ND
	3	*	*
	4	ND	0.002
	5	750	0.6
(At chest)	6	375	0.3
Maximum level measured		10,000	0.6

Comments:

* No Data Taken
All E and H values are duty cycle corrected
ND = Not Detected on lowest scale
IEEE C-95.1 E-field level = 4620 (V/m)^2
IEEE C-95.1 H-field level = 0.36 (A/m)^2



Measurement Locations

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