MANUSCRIPT CUT IN LENGTH !

FOR FURTHER INFORMATION PLEASE CONTACT AUTHOR

Occupational exposure to radiofrequency radiation from (4 - 7 MHz) RF dielectric heat sealers.

S.Y. Acram and M.J. Smit
Netherlands Institute for Radiation Technology
P.O. Box 1359, 1000 BJ Amsterdam, The Netherlands.

Introduction

We have conducted radiation measurements on 12 welding machines which were operated in a factory in the Netherlands. These machines were welded through electromagnetic fields, used to weld plastic parts through rapid heating. High temperatures are reached through application of frequencies between 5 and 7 MHz. The present investigation includes 3 different machine types: EA20 (5 machines), EA50 (4 machines) and HD500 (3 machines).

The production process

RF heaters are usually operated by women in their fertile ages. They perform their work standing upright in front of the RF sealers. Three machines however were operated by two women, who alternatively performed an operation on one of the machines. This regards the machines numbers 6, 7 and 8.

The purpose of the measurements was to determine the radiation level. It was to be investigated whether the RF radiation doses received from the RF sealing apparatus was acceptable according to the international regulations provided by the International Radiation Protection Association/International Non-Ionizing Radiation Committee (abbreviated as IRPA/INIRC). These regulations are strongly recommended by the Netherlands Institute for Radiation Technology (NIFRT).

A good assessment of the exposure levels is required because the operators of the RF welding apparatus are in close proximity, i.e. within two wavelengths from the radiation source. Both the electric as well as the magnetic field should be measured. For each, the strength is measured on seven locations on the body. During the measurements, the operator was in his normal working position. In cases where the readings went off the scale, a second (control) measurement was carried out at a larger distance. However, these did not affect the outcome of the investigation.

Description of equipment

Field strength measurements were done using a "Holaday Broadband Isotropic Field Strength Meter" type HI-3012. This is an analog instrument which displays Field Strength Units squared ($|FSU|^2$). Both electric as well as magnetic fields can be measured. The instrument has been manufactured in the United States in 1991. It come with two probes:
an MSE E-field probe with a range between 10^2 and 10^9 V^2/m^2;
and the HCH H-field probe with a range from 0.05 to 10.0 A^2/m^2.
The working range of the HI-3012 is between 0.5 MHz and 5 GHz (for electric fields) and between 0.5 and MHz and 300 MHz (for magnetic fields).

For both probes the accuracy is ±0.5 dB.
The apparatus has to be calibrated before use. The calibration is done by a specialised institution which provides a calibration factor (CF). This factor can be used to correct possible deviations. This factor (a number) is determined separately for each probe and is reported in a calibration report. Furthermore measurements were corrected for the time (during an operation) that the machine was not active. For this purpose a so-called Duty Cycle (DC) was determined. This is an effective average.

Results

The results have been combined in the following two tables. The strengths of the electric and magnetic fields provide an indication of the radiation levels to which the operator is exposed during the regular production process. Measurements have been corrected with the Duty Factor and the Calibration Factor. Comparison of the relative strengths of radiation exposure on different areas of the body shows that the eyes and the abdomen are more exposed to both E and H-field than knees and feet. In other words, those body parts that are at the same height or slightly above the welding spool are more exposed.

The table shows that excessively high electric fields are present near machines 2, 4, 6, 9, 11 and 12. The remaining 6 machines do not appear to deviate substantially from the accepted exposure-value as regards the E-field. The norm is derived from the peak-frequency. This results in a more rigorous value. Using an average frequency would result in a less stringent norm. However, this makes hardly any difference as regards the number of machines where the norm is exceeded.

As regards the different types of machines this means the following:

for the HD-500 and the EA-50 the norm is established using a frequency of 7 MHz. This results in a norm of 87.71 V/m (electric) and 0.23 A/m (magnetic).

for the EA-20 the norm is established using a frequency of 5 MHz. This results in a norm of 122.80 V/m (electric) and 0.32 A/m (magnetic).

Table 1 Electric Field Strength [V/m]

#	Eyes	Neck	Chest	Abdomen	Pelvic	Knees	Feet	Norm
1	64.42	91.10	128.83	78.89	40.74	14.40	12.88	122.80
2	225.89	338.84	>357.17	>357.17	>357.17	87.49	56.47	122.80
3	4.40	6.22	11.35	8.03	5.08	0.00	0.00	122.80
4	>53.52	107.04	>169.25	>169.25	65.55	16.93	15.14	122.80
5	8.28	5.23	6.92	5.85	4.14	3.70	2.48	122.80
6	>107.60	131.78	263.56	284.67	152.16	48.12	48.12	87.71
7	2.07	1.46	6.54	4.63	4.14	1.46	0.65	87.71
8	25.44	25.44	31.15	17.99	17.99	1.80	0.00	122.80
9	89.89	>201.00	0.64	>201.00	142.13	34.81	49.23	87.71
10	60.56	54.16	66.34	60.56	46.91	13.54	23.45	87.71
11	>156.08	78.54	99.35	86.04	60.84	19.24	14.90	87.71
12	112.84	138.20	9.03	338.52	178.42	30.90	0.00	87.71

Magnetic field measurements are less favourable than those for the electric field.
This follows from the data in the table.
In fact, only machines 5 and 7 are within the established norm.

Table 2 Magnetic Field Strength [A/m]

#	Eyes	Neck	Chest	Abdomen	Pelvic	Knees	Feet	Norm
1	1.52	1.07	1.32	1.07	0.29	0.17	0.15	0.32
2	1.33	1.33	1.33	1.33	1.33	0.52	0.21	0.32
3	0.42	0.30	0.37	0.42	0.60	0.04	0.01	0.32
4	>0.63	>0.63	>0.63	>0.63	>0.63	0.35	0.12	0.32
5	0.14	0.23	0.31	0.22	0.22	0.04	0.02	0.32
6	>1.27	>1.27	>1.27	>1.27	>1.27	1.06	0.57	0.23
7	0.04	0.05	0.15	0.17	0.09	0.02	0.01	0.23
8	0.56	0.21	0.30	0.30	0.30	0.21	0.03	0.32
9	>0.75	>0.75	>0.75	>0.75	>0.75	0.17	0.17	0.23
10	0.55	0.32	0.64	>0.71	>0.71	0.23	0.07	0.23
11	0.56	0.49	>0.59	>0.59	>0.59	0.26	0.02	0.23
12	1.33	1.11	>1.33	>1.33	>1.33	0.73	0.16	0.23

As regards exposure numbers for operators the following remarks are in order:

It can be seen that there is no relation between E-field radiation and H-field radiation
The radiation emitted varies with size, shape and thickness of the material to be processed
There is no proportional increase for exposure levels for either E-fields or H-fields with machine power (in kilowatts)

Conclusion

The present investigation shows clearly that RF-welders 2, 4, 6, 9, 11 and 12 very significantly exceed the standard norm. For some machines the readings were off scale, therefore an extra measurement was done at a larger distance.

It follows that for the machines mentioned certain provisions are necessary. People who are carrying certain medical aids such as pacemakers and other electronically regulated life-supporting equipment should not be allowed to enter the area where the RF welders are located if the welders are in operation. Pregnant women should not participate in this stage of the production process.

Recommendations

Machines where the norm is exceeded should be insulated in order to minimize the radiation exposure of the operator. Metal foil can already reduce the RF radiation.
The area where the machines are situated should be marked with special warning signs.
It is recommended that a medical file is created for each of the operators. This file should be updated twice yearly.