Glaser

Measurements of electric and magnetic field strengths from industrial radiofrequency heaters

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Abstract

There are several hundred radiofrequency heaters in industrial use in Finland. No exposure nor performance standards have been established for this kind of radiation in our country. This paper describes the measuring results of electric and magnetic field strengths caused by 35 plastic welding machines, all operating at 27 MHz with nominal power outputs ranging from 0,5 to 35 kW. Approximately 70 % of the heaters radiated field strengths, which exceeded the common standards (200 V/m, 0,2 A/m). The Finnish proposal to safety standard (60 V/m, 0,2 A/m) was exceeded by 80 % of cases. The results show that both electric and magnetic fields has to measure separately.

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INTRODUCTION

There are no reliable statistics on the number of devices emitting non-ionizing electromagnetic energy in Finland, however, at least a few hundred industrial radiofrequency heaters are in use in our country. Most of them are operated by persons without any special education.

During the last few years suspicions on health hazards caused by these devices have arosen. At the same time setting of hygienic norms for exposure and equipment is being prepared. Probably the radiation standard will correspond "power" level 10 W/m^2 (60 V/m, 0.2 A/m). D.L. Conover et al (1975) have measured the field strengths from 10 RF heaters used in U.S.A. These results showed that 90 % of the sources emitted electric-field-strengths greater than 200 V/m and 80 % of the sources produced magnetic-field-strengths in excess of 0.5 A/m.

Electric and magnetic field strengths from 35 equipment utilized on plastic industry (27.12 MHz) were measured and compared with international recommended values to ascertain the nature of the matter in Finland.

MATERIALS AND METHODS

The electric and magnetic fields of 35 heaters from 9 manufacturers as listed in Table 1 were measured.

TABLE 1 List of heaters in study

Manufacturer	Number of devices	Average nominal power
1. Flodings Industry AB (FIAB)	12	7 kW
2. Radyne	5	1.5 kW
3. Colpitt	5	10 kW
4. Weldan	4	5 kW
5. Herfurth	2	3 kW
6. SIE	2	1 kW
7. Helvar	3	1 kW
8. Schwalbach	1	2.5 kW
9. S.E.F.	1	2.5 kW

When measuring field-strength very close to a 27 MHz plastic welder, we are in the near-field, where the power density S is difficult to measure. Anyway, in the near-field the propagating power density is no good measure of the possible health hazard and we should measure both electric and magnetic field components.

For electric field measurements a simple passive dipole antenna was constructed where the induced voltage is rectified with a Schottky diode connected in the gap of the dipole. The rectified voltage is measured with a 50 μA instrument in series with two 15 kΩ resistors. The circuit diagram of this electric field probe is shown in fig. 1. The frequency range extends from about 2.5 MHz to a few hundred megaherz. The normally 0.23 m long dipole can be extended to a length of 1 m with extra aluminium tubes.

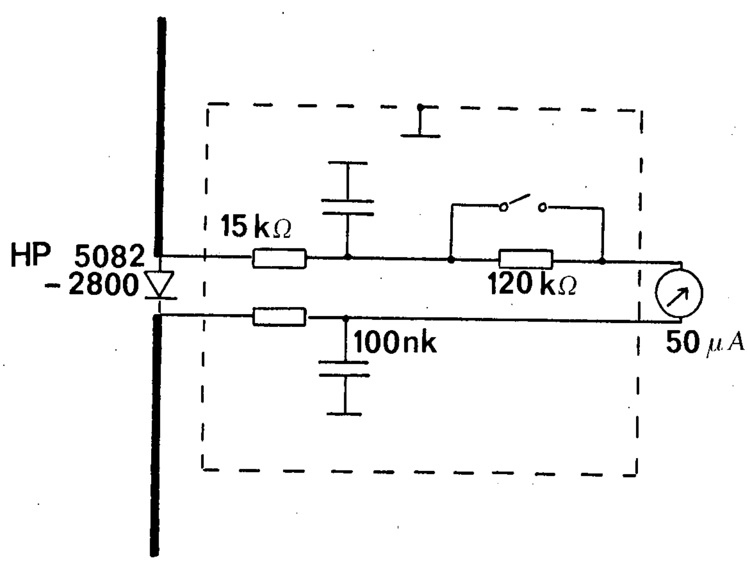

Fig. 1 Circuit diagram of the passive dipole antenna

For magnetic field measurements a small active symmetrical shielded loop antenna was constructed. The circuit diagram of this antenna is shown in fig. 2. The theory of this antenna was explained by Duncan (1974). We wanted to make the antenna factor independent of frequency for as wide a frequency range as possible. Therefore we used a balanced common-base transistor amplifier, achieving a flat frequency response from 20 MHz to 500 MHz. At the higher end the antenna becomes also sensitive to electric field. The effective length is only 2 mm, although the diameter is 50 mm. During the measurements the antenna was used in connection with a microwave power meter Hewlett-Packard 435A with a thermo-element head HP 8481A. We have also used the loop antenna with a spectrum analyzer HP 8558B.

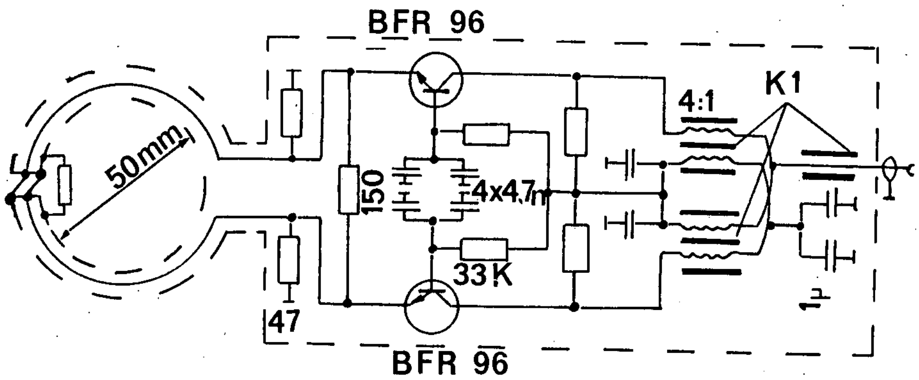

Fig. 2 Circuit diagram of the active loop antenna

The calibration of these antennas was done with a large symmetric 200Ω strip-line with a height of 80 cm. This strip-line generates a calibrated TEM field up to about 100 MHz. When calibrating the 0.23 m dipole, the signal source was a 100 W radio-amateur transmitter and the input power to the strip-line was measured with a Bird thruline power meter. For the calibration of the loop antenna we used the spectrum analyzer HP 8558B and the tracking generator HP 8444A. The 1 m dipole was calibrated by comparing it with a small active dipole which had been calibrated using the strip-line mentioned above.

The magnetic and electric fields were measured at the following regions:

i) the worker's head
ii) the worker's chest area
iii) the worker's pelvis
iv) the region of the worker's hands
v) one meter from the electrodes
vi) two meters from the electrodes

To estimate the exposure the duty cycle of the equipment was checked.

RESULTS AND DISCUSSION

The ratio between the electric and magnetic field strengths was 360Ω as a median (lognormal distribution). This value is about the same as the free space impedance (377Ω). The range of this ratio was from 30 to 5000Ω. The geometric standard deviation was 2.1, which means that 67 % of results are within the limits 170Ω to 760Ω.

The maximum value of electric field strength at the point of worker exceeded 190 V/m (100 W/m^2) in the case of 23 equipment (66 %). The leakage from 30 devices (94 %) exceeded the Finnish proposal of 60 V/m (10 W/m^2).

The maximum value of the magnetic field, exceeded 0.5 A/m (100 W/m^2) in the case of 21 equipment (60 %). The Finnish proposal of 0.2 A/m (10 W/m^2) was exceeded by 26 equipment (74 %).

There was no clear correlation between the nominal power of the equipment and the electric and magnetic field strengths. The field strengths of new, shielded, high power equipment were generally lower than that of old, unshielded, low power devices.

The conclusions that can be drawn from these preliminary measurements are as follows: To evaluate the health risk both electric and magnetic field strengths should be measured separately, if the measured value of one component is near the maximum permissible value. Only when the measured field component is less than one fifth of the safety standard, it is enough to measure only one of the components. Attention should be paid to the original design of these devices, e.q. with an automatic shielding enclosure or with a remote control.

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