STRAYFIELD MEASUREMENTS AROUND MICRO-WAVE-AND SHORTWAVE-DIATHERMY DEVICES IN THE FEDERAL REPUBLIC OF GERMANY

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Radiofrequency radiation(RF) with frequencies between 13.56 MHz and 2.45 GHz has been used for many years for therapeutic heating in various deseases including cancer. Besides radio- and TV-stations, radar, industrial dielectric or inductive heaters and microwave ovens these diathermy devices are one potential source of exposure of persons to non-ionizing radiation. The reason is that a considerable part of the therapeutic radiation is not absorbed by the target body-region, but is emitted as "stray-radiation" in the surrounding and thus may expose unintendedly the patient himself and the operator of the device.

Methods

To obtain detailed information about the amount of exposure, we measured the stray-fields around RF-therapy -units both with test persons and with phantoms.In order to have reproducible conditions the systematic measurements were carried out on plexiglass phantoms exposed to the therapy-units most commonly used in Germany, i.e. the Siemens ULTRATHERM 708 S (shortwave, 27.12 MHz), SIRETHERM 609 S (UHF, 433.92 MHz) and RADIOTHERM 306 (microwave, 2450 MHz).The phantoms were filled with saline, with approximately the same conductivity as human muscle-tissue at the different frequencies(27.12 MHz: 5.9mS/cm; 433.92 MHz: 11.7mS/cm;2.45GHz: 18.2mS/cm). Control-measurements with different "patients" indicated differences between phantom and patient ranging from 10 to 50%.Since the variance of the stray-radiation of different patients was of the same magnitude,the results of the phantom measurements are thought to be valid for any patient with a maximum uncertainty of a factor 2.

In the shortwave region(27.12 MHz) the electric and magnetic fieldstrength of the stray-radiation was measured with the AERITALIA field strength measuring equipment TE307 in combination with 2 electric sensors, 14RV and 15RV, and 2 magnetic sensors,16RV and 17RV.

In the microwave region(433.92 and 2450 MHz) the power density of the stray-radiation was measured with the NARDA radiation monitor 8316 and 2 sensors 8321 and 8323.

Measurements

The most important parameters, determining the stray-radiation are the power setting of the device, the type and size of the electrode or applicator, the applicator-phantom distance (d_o) and, of course, the distance (d) between the measuring point and the applicator.

Instead of simulating all possible treatments under the various conditions, we used at every frequency that applicator where we found the maximum stray-field, and studied the influence of the above mentioned parameters on the stray-radiation, to find out "worst case"-conditions, according to which "security-areas" could be proposed. The following measurements were carried out:

- stray-radiation as a function of the power setting for a given distance (d) and applicator-phantom distance (d_o).
- stray-radiation as a function of the applicator-phantom distance for a given distance (d) and power setting.
- stray-radiation as a function of the distance (d) for a given power setting and applicator-phantom distance(d_o).
- determination of places of equal fieldstrength or power density around the applicator in 22.5^o steps for different conditions. The exposure limits valid in the Federal Republic of Germany(1) were, of course, of particular interest and used for comparison. In the frequency-range from 30 MHz to 3 GHz these limits are: 100 V/m , 0.25 A/m and 2.5 mW/cm^2 respectively.

Results

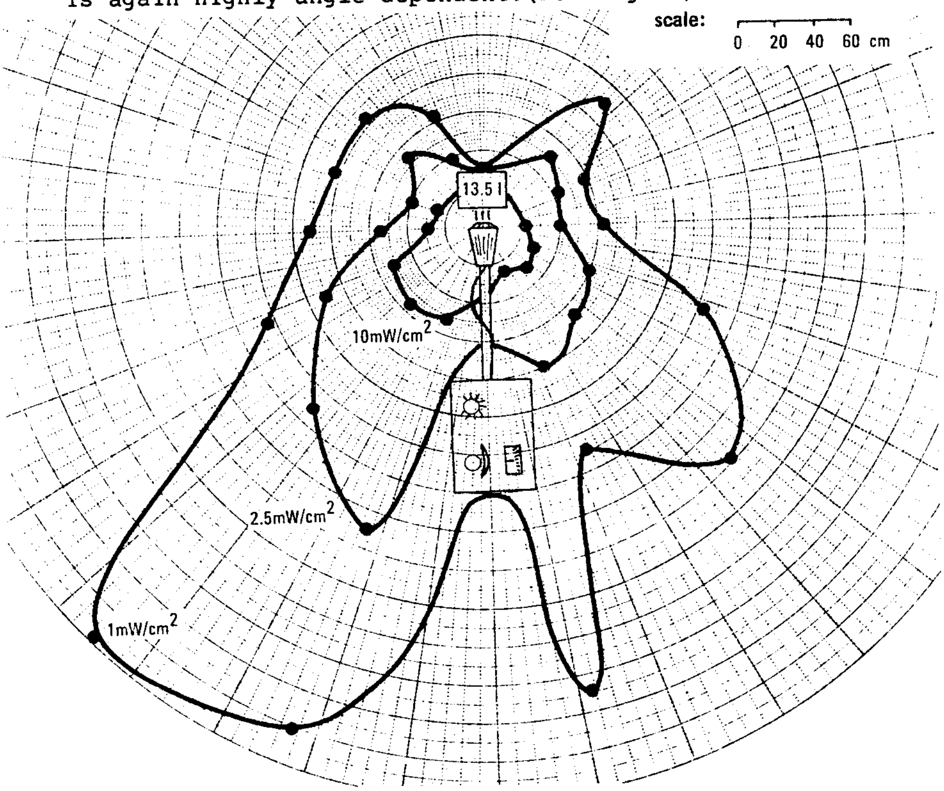
The following results have been obtained:

1. Shortwave (27.12 MHz)
   The maximum stray-fieldstrength results from the capacitor-field electrodes after Schliephake, the E-field being the dominating part of the electromagnetic field in this case. The steps of the power setting 1-8 correspond to a factor of 3-5 in the stray-fieldstrength. Increasing the applicator-phantom distance (d_o) from 0 to 4 cm results again in a four-fold increase of the electric stray-fieldstrength. The exposure-limits are not exceeded in "worst case" (power setting 8, d_o=4 cm) in a distance of 1.5-2m. A significant source of stray-radiation are the unshielded cables, which lead to the electrodes. At the highest power setting we have measured in a distance of 60 cm still 3 A/m and 500 V/m.

2. UHF (433.92 MHz)
   The maximum stray-fieldstrength was measured with the circulatory field director. The steps 1-7 of the power setting make a factor of 6-8 in the power density of

the stray-radiation. Increasing the applicator-phantom distance (d_o) from 1 to 5 cm results in a factor of about 3 in the power density of the stray-radiation, which is highly angle-dependent. In the "worst case" (power setting 7, d_o=3-5 cm), the exposure-limits are not exceeded in a distance of 0.3 - 1 m from the applicator.

3. Microwave (2450 MHz)
There is usually only one applicator: the circulatory field director. At this frequency interference phenomena due to reflections in the room could be recognized. The power density of the stray-radiation is proportional to the power setting. A variation of the applicator-phantom distance (d_o) between 4 and 20 cm results in a factor of 3-4 in the power density of the stray-radiation, which is again highly angle-dependent. (See figure)



Power density polar diagramme in the applicator-plain

Siemens Radiotherm 306, Cirulatory field director

Power: 100 W

distance applicator-phantom : 7 cm

In the "worst case" (power= 200 W, d_o=7 cm) the exposure limits are not exceeded in a distance of 0.5 - 2.4 m, but there is surely still a dependence on the circumstances in the room due to reflections and standing waves.

Conclusions

The exposure limits are valid only for the technical personal (operator) for exposure times longer than 6 minutes, but not for the patient. For shorter exposure times, as they may occur when the operator controls or changes the parameters during treatment, higher values of exposure are tolerated by the guidelines. However both the operator and the patient should, of course, be protected from unnecessary exposure. Therefore the operator should at least stay at those distances, where the exposure limits are not exceeded or, even better, leave the room, if possible. The patients´ non-target tissues, expecially the eyes, gonads and brain should, depending on the kind of treatment, be protected from unnecessary exposure by correct placement of the applicator and, possibly, by using safety goggles (in microwave treatments) or absorbing material. In shortwave treatments non-target body regions of the patient should not come too close to the cables. On the other hand, the manufacturers should attempt to reduce the large stray-fields around the cables. Because of electromagnetic interference problems, it should be clear that two therapies never be made in the same room at the same time.

(1) DIN 57848 Teil 2 VDE 0848 Teil2/...83 — Gefaehrdung durch elektromagnetische Felder, Schutz von Personen im Frequenzbereich 10 kHz bis 3000 GHz