Evaluation of Non-Ionizing Radiation Around The Shortwave Diathermy Devices

ªükrü Özen
Akdeniz University
Technical Vocational
School of Higher
Educational Deptartment of
Biomedical
Antalya / Turkey
e-mail:
ozen@teknik.akdeniz.edu.tr

Selçuk Çömlekçi
Suleyman Demirel
University Department
of Electronics and
Communication
Engineering
Isparta / Turkey
e-mail:
scom@sdu.edu.tr

Osman Çerezci
Sakarya University
Science Institue
Department of Electrical
and Electronics
Engineering
Adapazarý/Turkey
e-mail:
cerezci@sakarya.edu.tr

A. ªükrü Onural
Akdeniz University
Technical Vocational
School of Higher
Educational Deptartment of
Biomedical
Antalya / Turkey
aonural@teknik.akdeniz.edu.tr

Abstract: Short Wave and Microwave equipment are used for treatment purpose in physiotherapy units. Such equipments' stray fields can affect around them in the near field region. This fact has been stressed in current studies. In this way, some "safe operating area"s or safe proximity distances have been recommended. Effects on the health of EM energy, nowadays, have been discussed topic frequently. So, controlled Medical Aimed Radiofrequency Energy gained more and more importance at the Hospitals. In this study; leakage or stray fields of shortwave diathermy (27.12 MHz) equipments are measured and evaluated in terms of standards and safe proximity or approach distances. Also, placement of various types of treatment equipments is be evaluated in order to avoid over exposure and electromagnetic interference (EMI). A practical measuring methode is for new or old equipment in medical units.

Keywords: Short-wave diathermy, EMI, RF radiation

Introduction

In recent years the notable increase of the aplication of generators of electromagnetic fields at the radio frequency (RF) in the field of industry, health and telecommunications has been accompanied by the deepening of knowledge of the biological effects due to exposure to such radiation. The internal field is frequently described in terms of the specific absorption rate (SAR) which expresses the rate of energy absorption and is proportional to the square of the internal electric field intensity [1].

Short-wave diathermy is used in medical therapy to produce heating tissue by way of the conversion of electromagnetic energy. This therapeutic modality has been in use since the mid-thirties, and it has been almost exclusively conducted at 27 MHz since 1947, one of the frequency allocated for industrial, scientific and medical uses [2].

Compherensive measurements of the intensities of stray fields around short-wave diathermy devices indicated that there is a potential for operator exposure in excess of the levels recommended by some organization. However we think that these recommendations are not enough and clear. Exposure such high intens radio frequency (RF) radiation can cause adverse health effects.

Biological Effects of RF Exposure

Electromagnetic radiations at the operation frequency of short-wave diathermy (27MHz) is known to have various biological effects. The interactions of RF radiation with living systems, including human beings, is a complex function of many parameters. The electrical properties of the living system and its geometry determine the amount of radiations reflected, transmitted and absorbed for a given exposure field. The exposure field is characterized by the frequency, intensity, polarization (direction) and type or, a plane wave, leakage field, the near-field or far-field[3].

Quite apart from the interaction mechanisms involved, biological effects are the related to the intensities of the fields within the living body, not to the external intensity of an exposure field. The internal fields are complex functions of exposure conditions and other parameters. The internal fields are frequently described in terms of the specific absorption rate (SAR) which expresses the rate of energy absorbtion and is proportional to the square of the internal electric field intensity.

The characteristics of a biological media which are important in the determination of the interaction with electromagnetic fields. These are the physical shape and dimensions to be affected the medium dielectric constant ε is defined as $\varepsilon = \varepsilon_0(\varepsilon' - \varepsilon'')$, and the losses tangent is defined as $\tan\delta = \varepsilon''/\varepsilon'$, where ε_0 is the permitivity of vacuum, ε' is the relative dielectric constant, and ε'' is the relative loss factor. The conductivity σ is expressed as $\sigma = 2\pi f \varepsilon_0 \varepsilon''$ [4].

For human beings maximum energy absorption takes place between 30 and 100 MHz, depending on the body size and the environment. The SAR depends on the following: (a) The incident field parameters; intensitiy, polarization and source-object configuration (far-and near-field). (b) The characterstics of the exposed body; the size, external and internal geometry, dielectric properties of the various tissue layers in an inhomogeneous multi-layered object (such as a human or animal body). (c) Ground effects and reflector effects of other objects in the field, such as metal surface near the exposed body.

Short Wave Diathermy Equipment

Short wave equipment operates at 27 MHz with two type treatment arrangement. In the first, known as the capacitive methode, the part of the body to be treated is placed between two electrodes so that it forms the dielectric material between the plates of a capacitor. In the second, known as the inductive methode, a coil is positioned close to the body so that the changing magnetic flux induces eddy currents in the tissue. The applicator is connected to an convenient RF power generator.

Stray RF Fields In the Vicinity of Diathermy Equipment

The stray field close to the aplicator, but outside the treatment area, are relatively strong and highly irregular[5,6]. High intensity fields are also produced near the cables. The radiation field close to the short wave diathermy aplicator is of the near field type, so that the intensities of the electric and magnetic field are not at a constant ratio of 377 as they are for the far field. There is no simple formula to predict the intensity of stray field, except that the higher the power setting the stronger they are, if all other parameters (e.g., electrode placement) remain unchanged[2].

RF Fields Close to the Diathermy Devices

The dominant source of fields at the operator's position may be the leads. Two major studies found similar values for the fields at the operator's eyes and waists[7]. The range of value far from the operators was 2 to 135 (V/m) for electric field strength and 0.05 to 0.95 (A/m) for the magnetic field strength. In diathermy operation area many of studies show that; operators, physiotherapists, and patients are under threat because of exposing to unwanted stray fields[8].

In current study [9], stray electric and magnetic field close to equipment were measured and compared with exposure levels by the INIRCP and NRPB. Fields above the recommended whole body levels extend to 0.5-1.0 m from the electrodes and cables for continuous wave (cw) short-wave equipment, and up to 0.5 m for microwave units and pulsed shortwave models. Operators were exposed to local fields above these values for 2-3 min. during cw short wave treatments, but rarely they exceeded the recommended exposure. Physiotherapists are advised to remain at least 1m away during cw treatments, and not to approach within 0.5m of the electrodes and cables even for a short period.

Occupational Safety Standards

Terms such as "safety satandards" and "exposure standards" are generally applied to, and frequently used interchangeably, specifications or guidelines for permisible occupational and/or nonoccupational exposure of human to electromagnetic fields. According to IRPA standards, exposure limit for 6min at 27 MHz is 02 mW/cm^2 for the public and 1mW/cm^2 for occupational personnel[10]. We have to consider occupational exposure limit.

For a whole or partial body exposure (including extremities) for periods longer than 1 minute, but shorter than 1hour, the maximum time, t (min.), that a person can be exposed to the field must not exceed t=60/W, where S (mW/cm^2) is the equivalent plane-wave power density[2].

The equivalent plane-wave power density S is related to E and H as follows:

$$S=E^2/3770, \qquad S=37.7H^2 \qquad (1)$$

Where E is electric field (rms, V/m); H is magnetic field (rms, A/m), and S is power density (mW/cm^2).

Table 1. Occupational Exposure Limits To RF EM Fields For Short-Wave Diathermy Devices [1].

Exposure situation	E (V/m)	H (A/m)	S (mW/cm^2)
For-whole-or partial body exposure average over 1 min period (including extremities)	300	0.8	25
For-whole-or partial body exposure (including extremities) average over 1hour period.	60	0.16	1
For exposure of the extremities averaged over a 1hour period.	200	0.5	10

RF Radiation Instrumentation

The need to measure stray RF fields around a short-wave diathermy devices may arise when new electrodes or even complete devices are introduced, especially when the device operates at high power settings (above 500W). For instance, some RF diathermy devices used for cancer treatment operate at such high powers, and the design of the applicators may be such that intense stray fields are produced even at greater distance [3,11].

Several steps are necessary for the accurate assessment of RF exposure. The source and exposure situation must be characterized, so that the most appropriate measurement technique and instrumentation can be selected[8]. The correct use of the instrumentation requires knowledge of the quantity to be measured and the limitations of the instrument used. A knowledge of relevant exposure standards is essential.The following general recommendations on RF radiation surveys should be followed:

1.The electrode should be positioned over a test treatment area of an appropriate patient receiving a prescribed treatment. 2.When an RF survey is performed, the electric field, magnetic field and power density should be measured and their intensities compared to the standards. 3.The measurement should be done in the plane of the applicator

and the plane of the cables. 4. If an output power indicator is provided, low power setting should be used and the measurement results extrapolated to higher power settings assuming the power setting control operates linearly. For instance, if for a power setting of 100W the electric field intensity at 1m from the applicator is 15V/m, then the electric field intensity at 1m for a power setting of 400W will be 30 V/m $[(400/100)^{1/2}x15=30]$. This level should be compared with the recommended exposure standards[1].
For our survey, we has used a spectrum analyzer and a small loop sensor. Instrumentation of signal level measurement have been carried out by Promax labelled, AE-566 Model spectrum analyzer has 1 GHz frequency range and 15-130 dBµV input sensitivity. Loop probe has been made as 15 turns of 1.3 mm diameter Cu wire. This wire is not ordinary enameled wire. It has very thick and special insulations (Submersible pump wire). So the stray capacitance of 15 turns is very low. Radius of this loop probe is 2.95 cm and wire radius is 0.065 cm.

The near-field measurement setup is shown Figure 1.

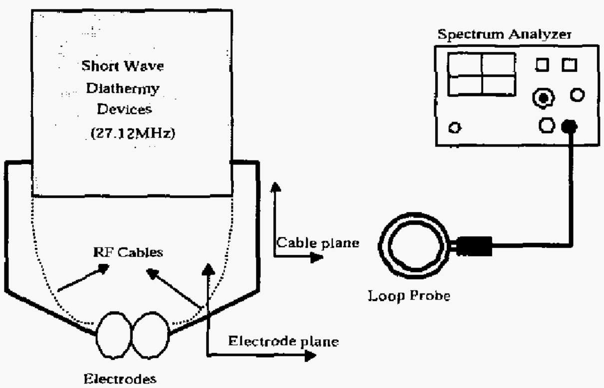

Figure 1. Near-field measurement setup

Feature of Short Wave Diatermy Devices:

Operating frequency	: 27.12 MHz ±0.6Hz
Power	:400W(continious, 50Ω).
Pulsed power	:28W(con., 50ohms).
Repeating frequency	:20-180Hz.

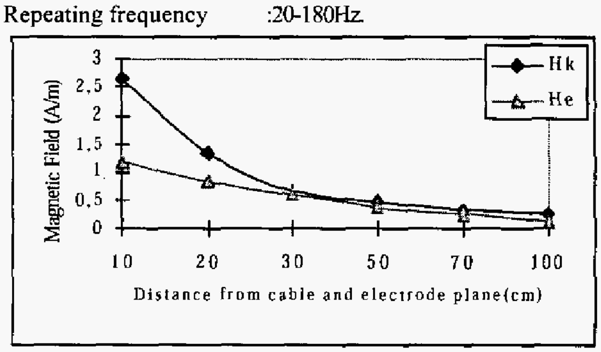

Figure 2. Variation of magnetic field from cable and electrode planes

Measurements have been taken for 100W power setting at various distances on the planes of RF cable and electrodes in order to simulate the position of the operator. Signal levels read in dBµV's have been converted into power densities in mW/cm^2. To obtain results corresponding to 400W power the interpolation of factor $(400/100)^{1/2}=2$ has been used. Variation of magnetic field from cable and electrode plane have been calculated by using equation(1) are shown Figure 2. and variation of power densities around diathermy equipment is shown in Figure 3.

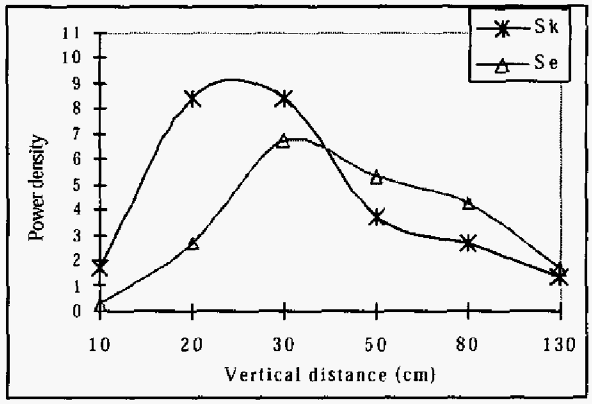

Figure 3. Variations of power densities (mW/cm^2) around diathermy equipment

As seen from Figure 3., during operation, when the operators is standing up, near the cable and electrode especially on the knee and foot is over exposure risk may occurs.

Conclusion

Obtained stray fields values may exceed the recommended limits for 1-meter distance in physiotherapy units. Commonly, there are some other equipments in the same units. All physiotherapy equipments' placement have been carried out without any EMI importance considered at planning stage. For this unit, measurement has been taken by us with obtained value of 56.3 V/m maximally around the other devices. That is over the Medical Electronic Devices EMI Standard (IEC) recommends 3 (V/m). Treatment periods longer than 15 minutes would carry over exposure risk for patients and operators, respectively.

We think that the location desing and periodic nonionizing radiation measurements have to be taken of such type of devices. It's important for training and giving occupational knowledge to operators. A simple loop probe and spectrum analyzer configurations can be used by clinical engineers such these measurements. Further studies in this area will be very interesting, using different configurations and methods.

References

[1] Özen, ª., Çömlekçi S., Merdan, M., *"Overexposure of Electric and Magnetic Field for Patient and Operators from RF Diathermy Equipment"*, Iþýk2000 Workshop on Biomedical Information Engineering, p190-192, 25-27 june, 2000 Istanbul/TURKEY

[2] Canada Safety Code 25, 1998. *Short Wave Diathermy Guidelines For Limiting Radiofrequency Exposure*. Minister of National Health and Welfare, Canada 1998 (83-EHD-98).
[3] ª. Özen, *Measurement of the Magnetic Field Strength Levels at 27 MHz-1000MHz Frequency Range Affects Living Organizms; Comparing of Results by Means of Invivo-Invitro Conditions, and Epidemiologic Data*, Post Graduate Thesis , Isparta, 2000
[4] A. Rosen, Har'el D., Rosen., *RF/ Microwaves in therapeutic medicine*, Iþýk2000 Workshop on Biomedical Information Engineering, p11-16, 25-27 june, 2000 Istanbul/TURKEY
[5] P.S. Ruggera, *Measurement of Emission Levels During Microwave and Short Wave Diathermy Treatments*, U.S. Dept. Of Healt and Human Services Publication (FDA), 80-8119, 1980
[6] M.A. Stuchly, M.H. Repacholi, D.W. Lecuyer, R.D. Mann, 1982. *Exposure to the Operator and Patient During Short Wave Diathermy Treatments*. Healt Physics. 41, 341-366.
[7] E.D. Mantiply, R. Kenneth Pohl, W.P. Samuel, and A.M. Julia, 1997. *Summary of Measurement Radiofrequency Electric and Magnetic Fields (10KHz to30GHz) in the General and Work Environment*. Bioelectromagnetics 18:563-577.
[8] World Health Organization (WHO), 1993. *Environmental Health Criteria 137: Electromagnetic Fields* (300Hz-300GHz). 53, Genowa.
[9] CY. LÝ, and CK. Feg,., *An Evulation of Radio Frequency Exposure from Therapeutic Diathermy Equipment*. Ind Health. 37(4), 465-468, 1999.
[10] IRPA, 1988. *Interim Guidelines on Limits of Exposure to Radifrequency Electromagnetic Fields In The Frequency Range From 100kHz to 300 GHz*. Health Physics. 54(1), 115-123.
[11] M.A. Stchly, M.H. Repacholi, D.W. Lecuyer, 1983. *Over Exposure to Radiofrequency Fields Near a Hyperthermia Devices*. Healt Physics, 43.