OCCUPATIONAL SAFETY IN THE NEAR FIELD OF GSM BASE STATIONS

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ABSTRACT

The German E-Plus GSM 1800 base station antenna technology is assessed according to the basic restrictions and reference levels for occupational exposure [1][2][3][6]. In a first step the exposure is investigated with respect to the reference levels. Afterwards compliance with the basic restrictions is evaluated by a suitable measurement procedure. It is shown, that all E-Plus base station antennas are compliant with the basic restrictions in the direct near field. The necessary compliance distances are shown. All results are discussed with respect to the consequences for occupational health and safety.

INTRODUCTION

Cellular networks are necessary in cases where a high number of users in a large area must be supplied with a limited number of radio links. The network is divided in cells with each cell equipped with a permanently installed base station. In urban areas the cells have a radius ranging from 1 km to 5 km, while in rural regions the radius can be up to 10 km. In the E-Plus GSM 1800 network the base stations are located at the edge of the cell, so that three cells can be operated by one location at the same time.

Depending on the traffic requirements the cells are operated with one or more frequencies. Normally the base station antenna part consists of separate TX and RX antennas. Each antenna has a horizontal beam width of 120°, so that in total 6 antennas are necessary to guarantee azimuth coverage. The typical antenna gain is ranging from 14 to 18 dBi.

For a single frequency base station the TX output power is approx. 10 W (measured at the antenna connector). If several frequencies are used simultaneously the output power is reduced to 5W per channel. In case of two different frequency channels it is sufficient to reuse the same TX antenna. If three or four channels are necessary the RX antenna is also used for transmitting purposes. Thus at present a maximum of 10 W TX output power can occur per antenna.

Especially in urban areas buildings are used to install base stations. Direct access to these locations is not only restricted to the service technicians of the different network operators but also is necessary for other occupational groups like e.g. roofers and chimneysweeps. Thinking of typical GSM 1800 antenna heights of 1.5 m far field assumptions can be used for distances above 30 m only. Therefore near field investigations or even more sophisticated methods are necessary for the exposure assessment.

RADIOFREQUENCY FIELD EXPOSURE STANDARDS

In the international field exposure standards basic restrictions and reference levels are defined. For the high frequency range the basic restriction for the specific absorption rate (SAR) is a useful and a biologically relevant quantity to describe the effect of electromagnetic fields. The SAR may be spatially averaged over the total mass of an exposed body or its parts, and may be time-averaged over a given time of exposure or even a single pulse or modulation period

of the radiation. The SAR is calculated from the electric field strength E_{rms}, the conductivity σ and the mass density ρ of the material (e.g. biological tissue):

$$SAR = \sigma \frac{E_{\mathrm{rms}}^2}{\rho} = c \left. \frac{\partial T}{\partial t} \right|_{t \to 0} \quad . \tag{1}$$

The SAR describes the temperature rise $\partial T / \partial t$ as a function of the specific heat c of the tissue. A limitation of the specific absorption rate prevents an excessive heating of the human body by electromagnetic energy.

As it is difficult to determine these basic quantities directly by measurement, the international standards specify a set of more-readily-measurable reference levels in terms of external electric and magnetic field strength and power density, derived from the basic restrictions. The limits for E_{rms} , H_{rms} and the power density $S = E_{\mathrm{rms}} \times H_{\mathrm{rms}}$ have been fixed so that even under worst case conditions, the basic limits are not exceeded. The reference levels may be exceeded if the exposure condition can be shown by appropriate techniques to produce an SAR below the corresponding limit.

Having in mind a worst case consideration the basic restrictions and the reference levels listed in Table 1 and Table 2 correspond to continuous exposure.

part of the body	*SAR* [W/kg]
whole body	0.4
tissue other than hand, wrists, feet, ankles	10 (averaged over 10 g tissue)
hand, wrists, feet, ankles	20 (averaged over 10 g tissue)

Table 1: Basic restrictions for occupational exposure for the specific absorption rate (SAR) [2][3].

E_{rms} [V/m]	H_{rms} [A/m]	S [W/m^2]
130.2	0.345	45

Table 2: Reference levels for occupational exposure in a GSM 1800 base station environment [2][3].

RESULTS

In a first step a derived field quantity in terms of the power density is investigated for a typical 65°/18 dBi GSM 1800 base station antenna. In Fig. 1 the power density in the near field of the antenna is depicted. The input power is 10 W. It can be seen that for distances above 0.5 m in the main beam of the antenna the reference level for the power density according to Table 2 is met. Below this distance a more sophisticated analysis of the exposure is necessary.

The analysis of the specific absorption rate SAR is done with the dosimetric assessment system DASY [4][5]. The system is based on a high-precision robot which positions an electrical field probe with a repeatability of better than ±0.02 mm. The E field sensor is loaded with a Schottky diode and directly connected to the data acquisition unit via high resistive lines.

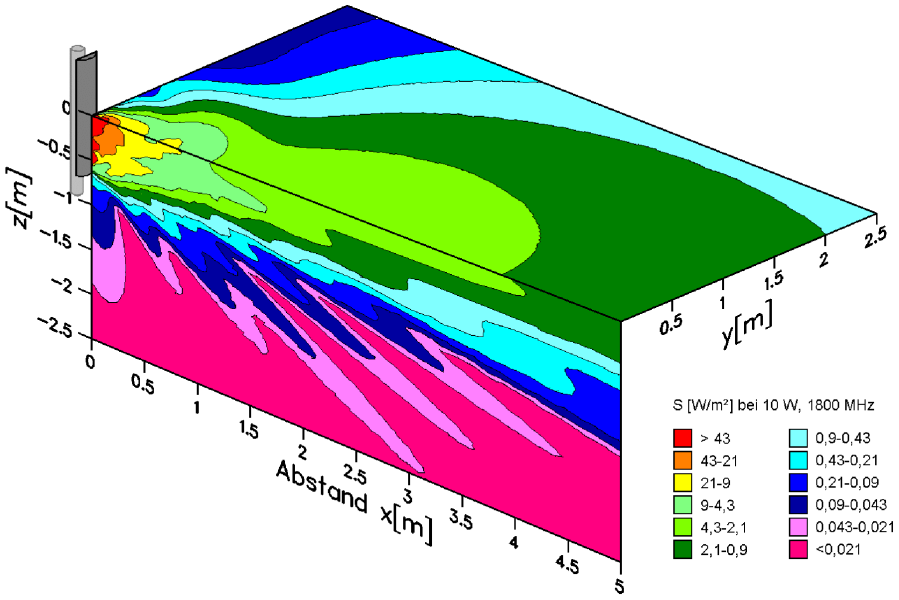

Fig. 1: Near field calculation of a 65°/18 dBi antenna at 1800 MHz with 10 W output power.

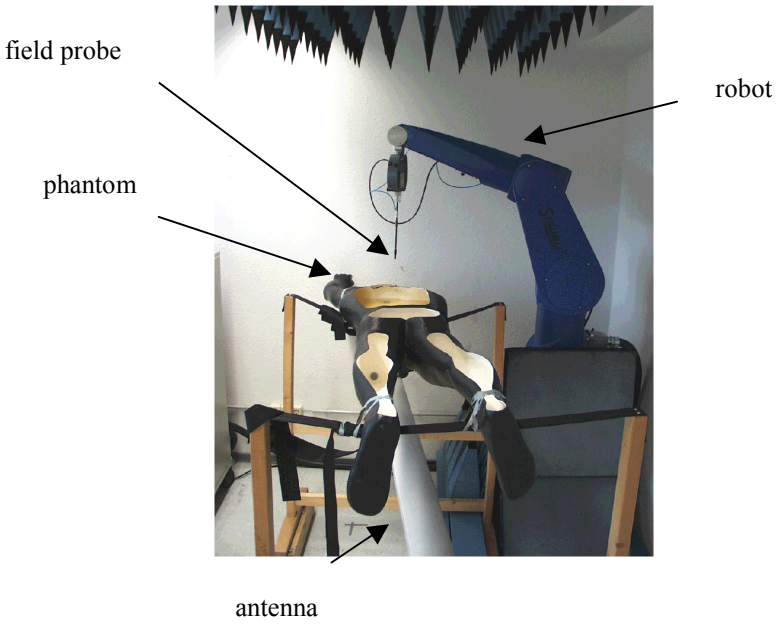

Fig. 2: Arrangement of the base station antenna, the phantom and the field probe for the analysis of the specific absorption rate SAR.

The simulated exposure is shown in Fig. 2. A whole-body mannequin is positioned in front of the base station antenna in the main beam. The phantom is filled with tissue simulating liquid ($\varepsilon_r = 41$, $\sigma = 1.69$ mho/m, $\rho = 1.04$ g/cm^3). The SAR is measured in the trunk of the phantom as a function of the distance *d* between phantom and base station antenna.

The input power at the antenna connector is adjusted to 10 W CW (R&S signal generator SME 23). Six of the most common E-Plus base station antennas (Allgon A718701, Fuba F45451, Kathrein 732332, Kathrein 735141, Kathrein 735147, Kathrein 734330) are analysed. Each antenna is positioned in a way that the top of the antenna corresponds to the top of the phantom.

In Fig. 3 the measured localised SAR values according to [2][3][6] are shown. It can be seen that the basic restriction for the SAR is partly exceeded if the antenna is in direct contact with the base station antenna. For measurement distances *d* above 20 cm all antennas are compliant with the basic restriction. The SAR value as a function of the distance *d* depends on several parameters. For low distances the number of radiators and the thickness of the antenna including the mounting point of the radiators inside the radome is important. For higher distances the antenna gain is significant. For the investigated near field between 20 cm and 1 m the base station antennas show a quite complex behaviour. Nevertheless the SAR always decreases with increasing distance *d*.

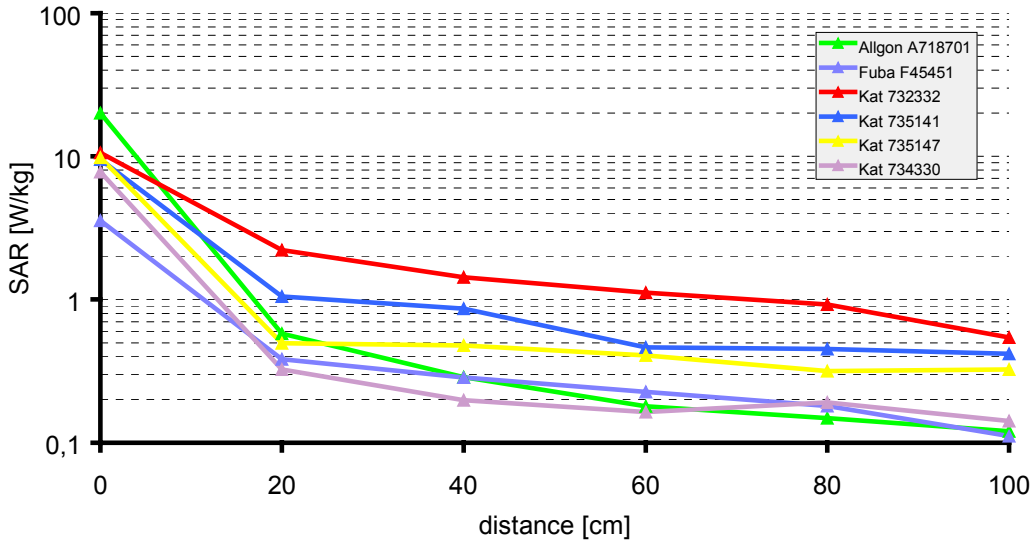

Fig. 3: Maximum localised SAR values (averaged over 10 g tissue) in the trunk of the phantom as a function of the distance *d* between phantom and base station antenna.

CONCLUSION

The German E-Plus GSM 1800 base station antenna technology is assessed according to the basic restrictions and reference levels for occupational exposure. It is shown, that all E-Plus base station antennas are compliant with the basic restrictions for the SAR in the direct near field (≥ 20 cm).

REFERENCES

[1] BG-Vorschrift, Elektromagnetische Felder (BGV 13), Berufsgenossenschaftliche Vorschrift für Sicherheit und Gesundheit bei der Arbeit, Fachausschuß „Elektrotechnik“ der BGZ, Fachausschußentwurf Dezember 1998

[2] DIN VDE 0848 Teil 2: Sicherheit in elektromagnetischen Feldern - Schutz von Personen im Frequenzbereich von 30 kHz bis 300 GHz, Entwurf Oktober 1991

[3] European Prestandard ENV 50166-2: Human exposure to electromagnetic fields - High frequency (10 kHz to 300 GHz), CENELEC, January 1995

[4] IMST GmbH: SAR Arbeitsschutzuntersuchung von DCS 1800 Mobilfunk-Basisstationen, Untersuchungsbericht, Dezember 1998

[5] IMST GmbH: SAR Arbeitsschutzuntersuchung von DCS 1800 Mobilfunk-Basisstationen, Untersuchungsbericht, November 1996

[6] International Commission on Non-Ionizing Radiation Protection (ICNIRP): Guidelines for limiting exposure to time-varying electric, magnetic, and electromagnetic fields (up to 300 GHz), In: Health Physics, Vol. 74 No. 4, pp. 494-522, 1998