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Report

Dosimetric Assessment of the Mobile Nokia 5110 with and without the PAM System devices According to the European CENELEC Requirements

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Executive Summary

The PRO TECH PLUS (My Shield Plus, Mouse Plus, etc.) from PAM System Technology is an accessory for cellular phones which is designed to reduce the electromagnetic field inside the human head. The reduction in the specific absorption rate (SAR) is tested using a Nokia 5110 mobile phone. A dosimetric assessment of the mobile phone is conducted with and without PRO TECH PLUS. The mobile phone has a helix antenna and operates in the GSM 900 standard. The examinations have been carried out with the dosimetric assessment system „DASY“.

The measurements were made according to the European Specification ES 59005 [ES 59005 1998] for evaluating compliance of mobile phones with the ICNIRP 1998 Guidelines [ICNIRP 1998] and the European Council Recommendation [1999 519 EC]. In [ICNIRP 1998][1999 519 EC] limits are defined to avoid adverse health effects due to electromagnetic fields.

Using the PRO TECH PLUS accessory with a Nokia 5110 in GSM 900 mode a reduction in SAR between 88% and 89% is measured.

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1 Subject of Investigation

The PRO TECH PLUS (My Shield Plus, Mouse Plus, etc.) from PAM System Technology is an accessory for cellular phones which is designed to reduce the electromagnetic field inside the human head. The reduction in the specific absorption rate (SAR) is tested using a Nokia 5110 mobile phone. A dosimetric assessment of the mobile phone is performed with and without PRO TECH PLUS. The mobile phone has a helix antenna and operates in the GSM 900 standard. The examinations have been carried out with the dosimetric assessment system „DASY“.

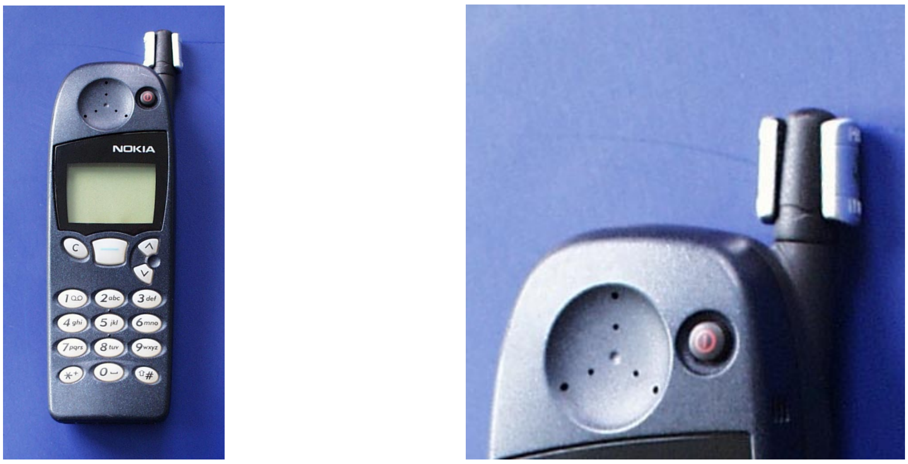


Fig. 1: Pictures of a Nokia 5110 with the PRO TECH PLUS accessory.

2 The ICNIRP 1998 Guidelines and the European Council Recommendation

In 1998 ICNIRP (International Commission on Non-Ionizing Radiation Protection) published its recent guidelines covering the frequency range up to 300 GHz [ICNIRP 1998]. In 1999 this guidelines were adopted by the European Union in terms of the European Council Recommendation [1999 519 EC]. Therefore only the ICNIRP 1998 Guidelines are referenced in this report.

2.1 Distinction Between Exposed Population, Duration of Exposure and Frequencies

The ICNIRP Guidelines distinguish between occupational and general public exposure. The occupationally exposed population consists of adults who are generally exposed under known conditions and are trained to be aware of potential risk and to take appropriate precautions. By contrast, the general public comprises individuals of all ages and of varying health status, and may include particularly susceptible groups or individuals. In many cases, members of the public are unaware of their exposure to electromagnetic fields. Moreover, individual members of the public cannot reasonably be expected to take precautions to minimise or avoid exposure.

In the ICNIRP Guidelines the general public exposure limits are derived from values one fifth those of occupational exposure.

In addition the duration of exposure is considered. A limit is made at 6 minutes exposure time. For short-term exposure below a duration of 6 minutes, higher field strengths are admissible.

Due to the influence of frequency on important parameters, as the penetration depth of the electromagnetic fields into the human body and the absorption capability of different tissues, the limits in general vary with frequency.

2.2 Basic Restrictions and Reference Levels

The biological relevant parameter describing the effects of electromagnetic fields in the frequency range of interest (30 MHz – 6 GHz) is the specific absorption rate SAR (dimension: power/mass). It is a measure of the power absorbed per unit mass. The SAR may be spatially averaged over the total mass of an exposed body or its parts. The SAR is calculated from the r.m.s. electric field strength E inside the human body, the conductivity σ and the mass density ρ of the biological tissue:

$$SAR = \sigma \frac{E^2}{\rho} = c \left. \frac{\partial T}{\partial t} \right|_{t \to 0+} . \qquad (1)$$

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

As it is sometimes difficult to determine the SAR directly by measurement (e.g. whole body averaged SAR), a set of more readily measurable reference levels in terms of external electric E and magnetic field strength H and power density S, derived from the SAR limits, is defined. The limits for E, H and S have been fixed so that even under worst case conditions, the basic restrictions for the specific absorption rate SAR are not exceeded.

The reference levels may be exceeded if the exposure can be shown by appropriate techniques to produce SAR values below the corresponding basic restrictions.

2.3 SAR Limits

In this report the comparison between the measured data and the exposure limits defined in the ICNIRP Guidelines is made using the spatial peak SAR; the power level of the device under test guarantees that the whole body averaged SAR is not exceeded.

Having in mind a worst case consideration, the SAR limit is valid for general public exposure and for exposure times longer than 6 minutes [ICNIRP 1998]. According to Table 1 the SAR values have to be averaged over a mass of 10 g (SAR_{10g}) with the shape of a cube.

Standard	Status	SAR limit [W/kg]
ICNIRP 1998	Guidelines	2.0

Table 1: Relevant spatial peak SAR limit averaged over a mass of 10 g.

3 The European Measurement Procedure

CENELEC has published a European Specification [ES 59005 1998] for evaluating compliance of mobile phones with the ICNIRP 1998 Guidelines [ICNIRP 1998]. This European Specification describes the test method and measurement requirements to measure the specific absorption rate SAR. It applies to mobile telecommunication equipment in the frequency range from 30 MHz to 6 GHz.

3.1 Phantom Requirements

The measurements shall be made in a homogeneous phantom which at least must include the upper body for frequencies above 380 MHz. The thickness of the shell of the phantom should be not greater than 4 mm. The compressed ear shall not be modelled thicker than 6 mm including the shell in the experimental setup. The design of the phantom should be selected such that the localised SAR values do not underestimate the SAR values in the human body. The phantom shall enable to simulate both right and left hand operation.

3.2 Basic Requirements and Test Operational Conditions

The SAR test shall be performed with the device under test on the left hand and right hand sides of the phantom. The device under test has to operate at the highest power at the central transmitting band frequency during the measurement. For devices with retractable antenna the tests shall be performed with the antenna fully extended and fully retracted.

3.3 Test Positions

As it cannot be expected that the user will hold the mobile phone exactly in one well defined position, different operational conditions shall be tested. The European Specification requires four test positions. In each test position the center of the ear piece shall be placed directly at the entrance of the auditory canal. For an exact description helpful geometrical definitions are introduced and shown in Fig. 2.

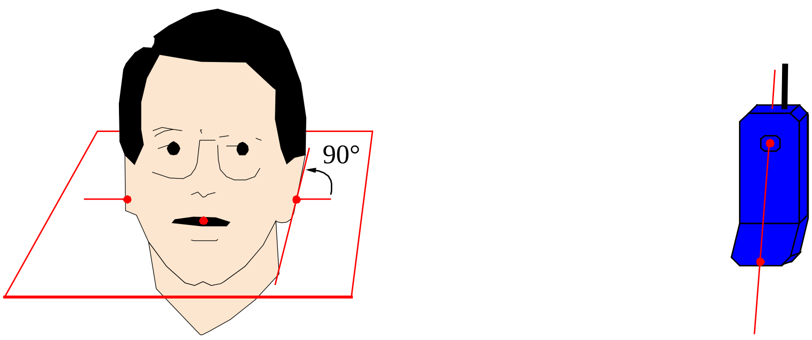
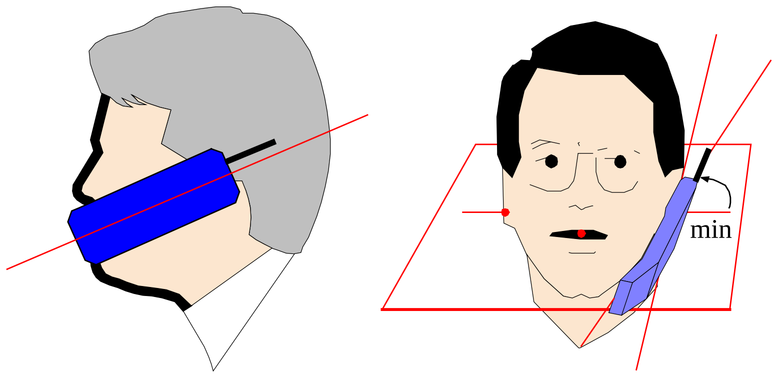


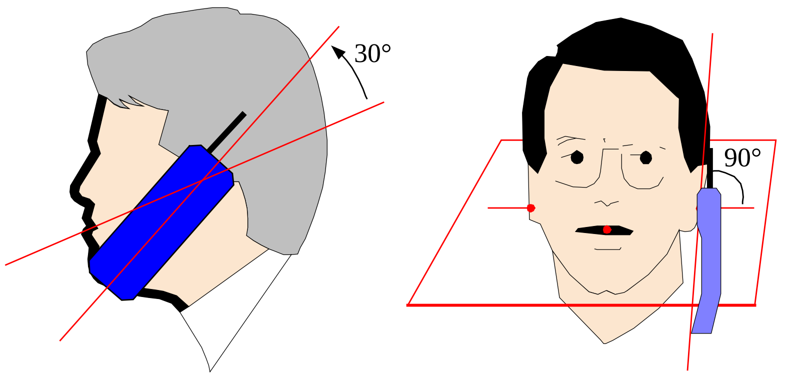
Fig. 2: Geometrical definitions for the description of the test positions.

A reference line describing the phone is defined as a line (on the surface of the phone facing the phantom) which connects the center of the ear piece with the center of the bottom of the case (typically near the microphone). The human head position is given by means of a reference plane defined by the following three points: auditory canal opening of both ears and the center of the closed mouth. With this definitions the test positions are given by:



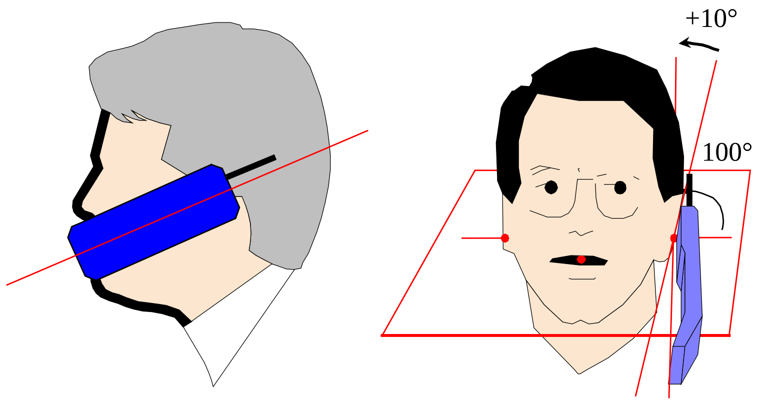
The telephone line shall lie in the reference plane. The angle between the phone line and the line connecting both auditory canal openings shall be reduced until the device touches the surface of the phantom.

Fig. 3: The touch position.



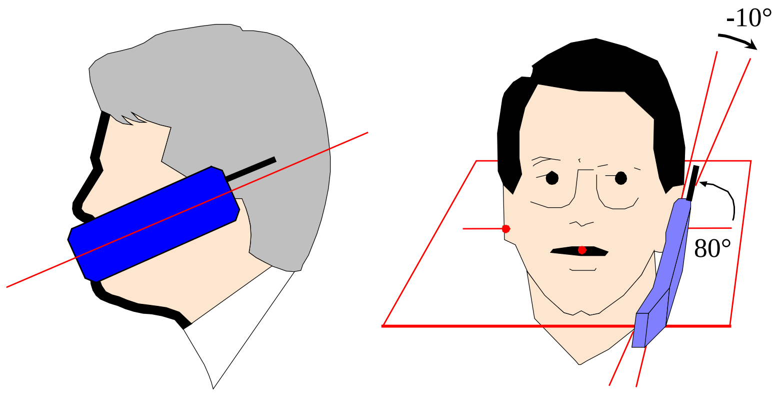
The telephone line shall be tilted by 30° in the direction of the body's axis, whereby the angle between the reference line of the phone and the line connecting both auditory canals shall be 90°.

Fig. 4: The 30° position.



The telephone line shall lie in the head plane and the angle between the telephone line and the line connecting both auditory canal openings shall be 100°.

Fig. 5: The 100° position.



The telephone line shall lie in the reference plane and the angle between the telephone line and the line connecting both auditory canal openings shall be 80°.

Fig. 6: The intended use position.

4 The Measurement System

DASY is an abbreviation of „Dosimetric Assessment System“ and describes a system which is able to determine the SAR distribution inside a phantom of a human being according to different standards. It consists of a robot, several field probes calibrated for use in liquids, a shell phantom, tissue simulating liquid and software. The software controls the robot and processes the measured data to compare them with safety levels with respect to human exposure to radio frequency electromagnetic fields. Fig. 7 shows the equipment, similar to the installations in other laboratories [DASY 1995].

Fig. 7: The measurement setup with a phantom containing tissue simulating liquid and a device under test.

A mobile phone operating at the maximum power level is placed by a non metallic device holder in a well-defined position at a shell phantom of a human being. The distribution of the electric field strength *E* is measured in the tissue simulating liquid within the shell phantom. For this miniaturised field probes with high sensitivity and low field disturbance are used. Afterwards the corresponding SAR values are calculated with the known electrical conductivity σ and the mass density ρ of the tissue. The system software is able to determine the averaged SAR values (averaging region 1 g or 10 g) for compliance testing.

This is done by two scans: first a coarse scan determines the region of the maximum SAR, afterwards the 1 g or 10 g averaged SAR is measured in a second fine scan. The measurement time takes about 20 minutes.

The phantom (generic twin phantom) is a fibreglass shell integrated in a wooden table. The thickness of the phantom amounts to 2 mm ± 0.1 mm. It enables the dosimetric evaluation of left and right hand phone usage. The phantom setup includes a coverage (polyethylene) which prevents the evaporation of the liquid. The ear is simulated by ensuring a space of 4 mm thickness between the tissue simulating liquid and the speaker of the phone.

4.1 Technical Parameters of the Measurement System

Parameter	DASY
Spatial resolution	5 mm
Repeatability of probe position	± 0.1 mm
Dynamic range	5 mW/kg - 100 W/kg

Table 2: DASY system specification.

Parameter	Accuracy
Frequency linearity	± 0.2 dB
Deviation from isotropy (in air)	± 0.8 dB
Surface detection	± 0.2 mm

Table 3: Probe specification.

Parameter	Noise floor
SAR values	< 0.005 W/kg
Electric field strength *E*	< 1 V/m

Table 4: Sensitivity of DASY.

Accuracy influencing conditions	Accuracy of SAR values
Isotropy, calibration, noise floor	< 13 % @ 1 W/kg
Extrapolation of SAR values	< 7 %
Dielectric parameters	< 5 %

Table 5: Accuracy of the SAR values determined by measurements [Kuster 1997].

5 SAR Results

The Tables below contain the measured SAR values averaged over a mass of 10 g.

Position	Remark	SAR(10g) W/kg	File
touch		1.090 ± 0.272	51OGLM_4.MEA
30 grd		0.658 ± 0.166	51OGLM_3.MEA
100 grd		0.610 ± 0.154	51OGLM_2.MEA
intended use		0.898 ± 0.225	51OGLM_1.MEA

Table 6: Measurement results for GSM 900 for the Nokia 5110, without the PRO TECH PLUS in left hand position.

Position	Remark	SAR(10g) W/kg	File
touch		0.122 ± 0.035	51MGLM_4.MEA
30 grd		0.076 ± 0.024	51MGLM_3.MEA
100 grd		0.075 ± 0.023	51MGLM_2.MEA
intended use		0.108 ± 0.031	51MGLM_1.MEA

Table 7: Measurement results for GSM 900 for the Nokia 5110, with the PRO TECH PLUS in left hand position .

Position	Remark	SAR(10g) W/kg	File
touch		0.974 ± 0.244	51OGRM_4.MEA
30 grd		0.702 ± 0.177	51OGRM_3.MEA
100 grd		0.547 ± 0.139	51OGRM_2.MEA
intended use		0.818 ± 0.205	51OGRM_1.MEA

Table 8: Measurement results for GSM 900 for the Nokia 5110, without the PRO TECH PLUS in right hand position.

Position	Remark	SAR(10g) W/kg	File
touch		0.115 ± 0.033	51MGRM_4.MEA
30 grd		0.075 ± 0.023	51MGRM_3.MEA
100 grd		0.065 ± 0.021	51MGRM_2.MEA
intended use		0.097 ± 0.029	51MGRM_1.MEA

Table 9: Measurement results for GSM 1800 for the Nokia 5110, with the PRO TECH PLUS in right hand position.

6 Evaluation

In Fig. 8 the SAR results for GSM 900 (left hand position) given in Tables 6 - 7 are summarised and compared to the limits. In Fig. 9 the SAR results for GSM 900 (right hand position) given in Tables 8 - 9 are summarised and compared to the limits.

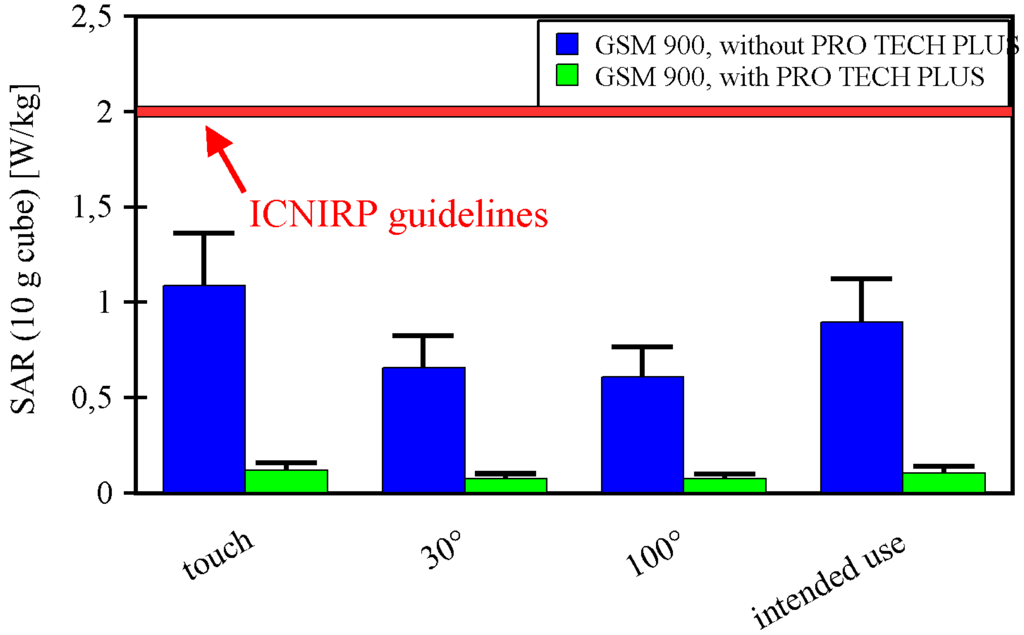


Fig. 8: The measured SAR values for GSM 900 using the Nokia 5110 in comparison to the ICNIRP Guidelines without and with the PRO TECH PLUS (left hand position).

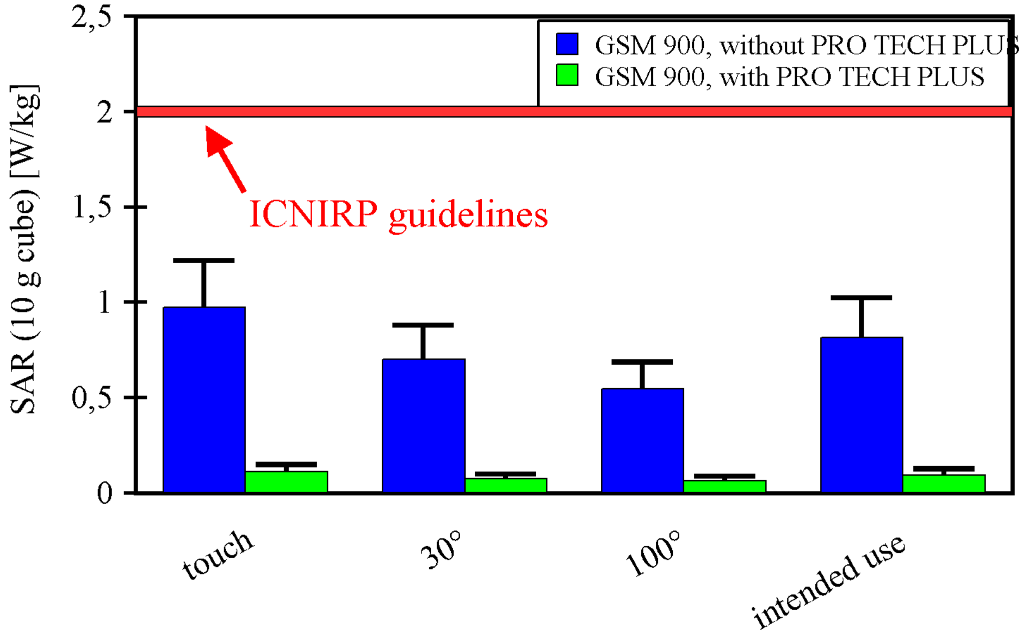


Fig. 9: The measured SAR values for GSM 900 using the Nokia 5110 in comparison to the ICNIRP Guidelines without and with the PRO TECH PLUS (right hand position).

Using the PRO TECH PLUS accessory with a Nokia 5110 in GSM 900 mode a reduction in SAR between 88% and 89% is measured.

Note: The measured SAR values depend on the material parameters. Therefore the material parameters must be enclosed in all copies and publications of these results.

The tests only focus on the specific absorption rate (SAR) inside the users head. The radiation characteristics of the mobile phone are not investigated.

7 Appendix

7.1 Administrative Data

Date of measurement: July 15, 2000 by: Dipl.-Ing. C. Hennes
Data stored: Castelberg_6575_107

7.2 Device under Test and Test Conditions

MTE: Nokia 5110
IMEI: 449209202100752
Date of receipt of MTE: July 15, 2000
Standard: GSM 900
Modulation: GMSK
Frequency Tx: GSM 900, center: ch. 0062
MS Pwr TCH: GSM 900: 33 dBm
Battery status: charged batteries (3.7 V), battery status checked with the battery status bar of the MTE at the end of each measurement
Base station (BS): Wavetek STABILOK 4032 GSM

7.3 DASY Options

Software version: DASY V2.3d
Probe: ET3DV5 SN: 1332
Validation: GSM 900: July 04 2000, dipole validation kit: D900V2 #: 006
Phantom: Schmid & Partner generic twin phantom, left and right hand position

7.4 Material Measurement System

Type: HP85070B
Software version: HP85070 Rev. B.01.05 1993
VNA: HP8753D (6 GHz option)

Material parameters:

	GSM 900
Relative permittivity ε_r	42.1 ± 6.1
Conductivity σ	(0.85 ± 0.12) S/m
Mass density ρ	1.04 g/cm^3

Table 10: Parameters of the tissue simulating liquid.

7.5 Environment

Ambient temperature: 20-23 °C
Tissue simulating liquid: 20-23 °C

8 References

[DASY 1995] Referenzliste des Herstellers, der Fa. Schmid & Partner Engineering AG, über installierte DASY-Systeme mit RX90 Robotern: Deutsche Telekom, Forschungs- und Technologiezentrum; Motorola Cellular - MRO; Motorola; Ericsson Mobile Communications AB; Nokia Mobile Phones LTD; IMST GmbH, 1995.

[1999 519 EC] European Council Recommendation (1999/519/EC): Council Recommendation of July 12 1999 on the limitation of exposure of the general public to electromagnetic fields (0 Hz to 300 GHz), Official Journal L 199, 30/07/1999, 0059-0070.

[ES 59005 1998] European Specification ES59005: Considerations for the Evaluation of Human Exposure to Electromagnetic Fields (EMFs) from Mobile Telecommunication Equipment (MTE) in the Frequency Range 30 MHz - 6 GHz, 1998.

[ICNIRP 1998] ICNIRP: Guidelines for Limiting Exposure to Time-varying Electric, Magnetic, and Electromagnetic Fields (up to 300 GHz), In: Health Physics, Vol. 74, No. 4, 494-522, 1998.

[Kuster 1997] N. Kuster, R. Kästle and T. Schmid: Dosimetric evaluation of handheld mobile communications equipment with known precision, In: IEICE Trans. Commun., Vol. E80-B, No. 5, 645-652, 1997.