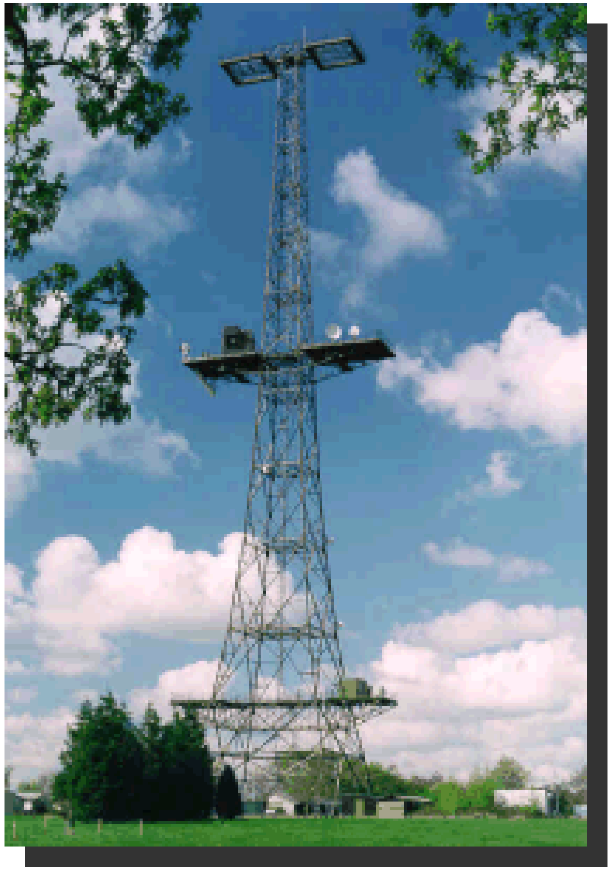
Electromagnetic fields protection

Basics and standarisation

Long tradition
New equipment and infrastructure

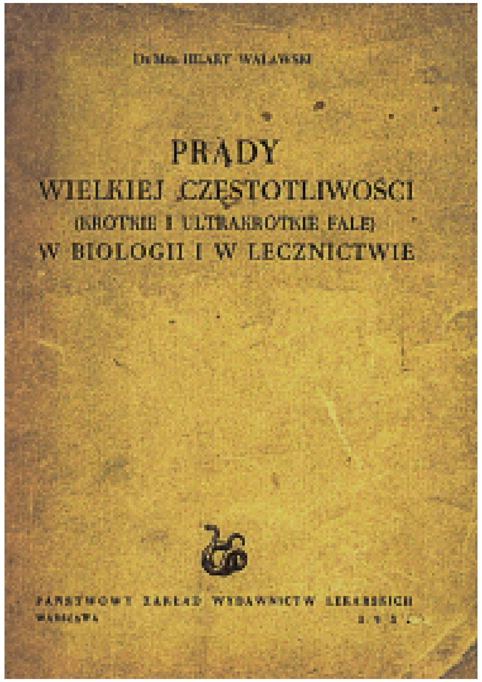
Long tradition
New equipment and infrastructure



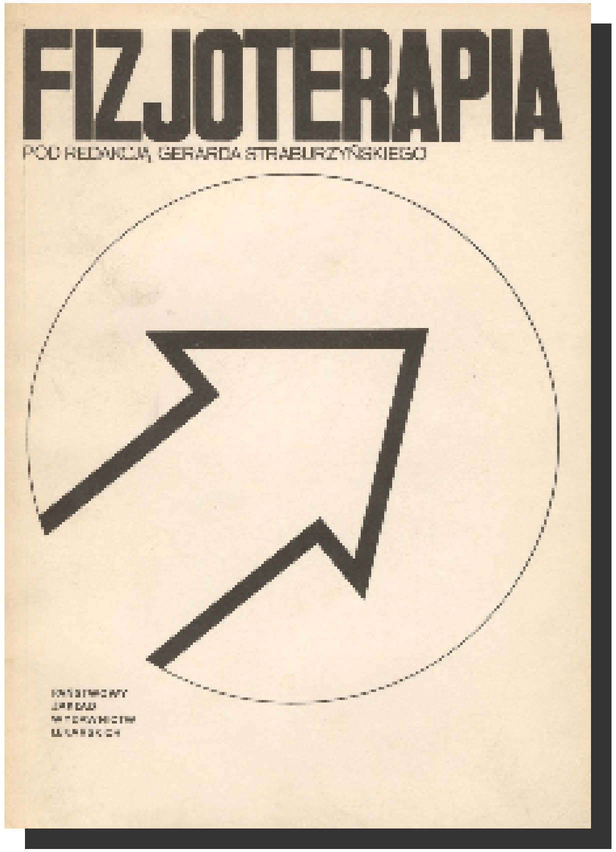
Long tradition
New equipment and infrastructure

Main mechanisms
Literature example from 1953

(High frequency currents in
biology and medicine)

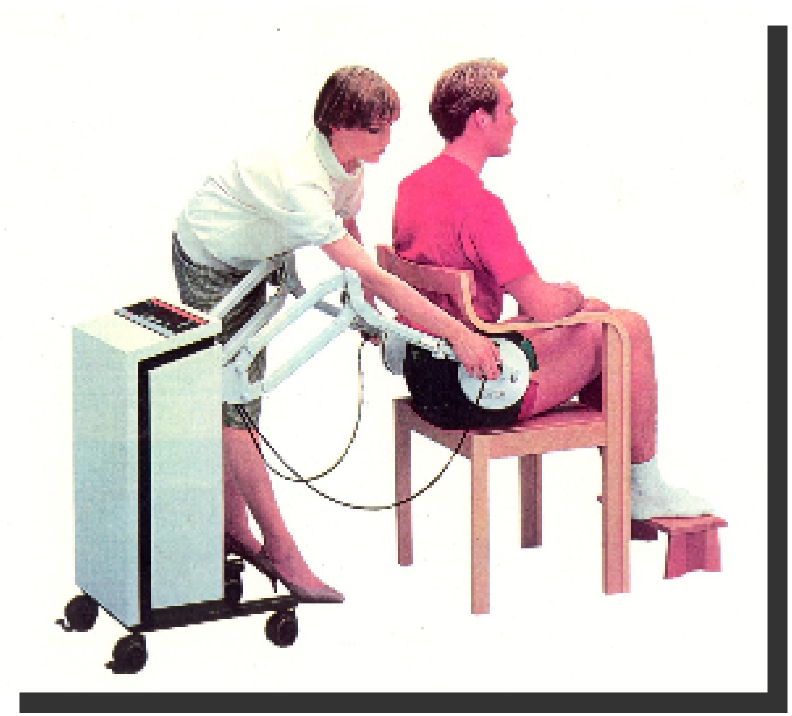


Phisiotherapy



1988

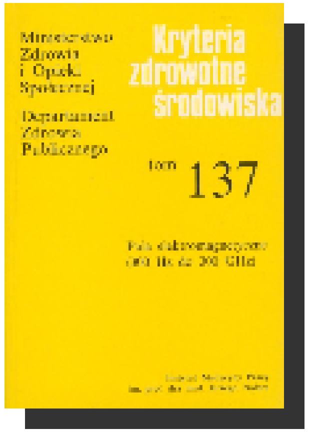
HF and UHF heating



ENVIRONMENTAL HEALTH CRITERIA 137 ELECTROMAGNETIC FIELDS (300 HZ TO 300 GHZ)

This report contains the collective views of an international group of experts and does not necessarily represent the decisions or the stated policy of the United Nations Environment Programme, the International Radiation Protection Association, or the World Health Organization.

Published under the joint sponsorship of the United Nations Environment Programme, the International Radiation Protection Association, and the World Health Organization World Health Orgnization Geneva, 1993 WHO Library Cataloguing in Publication Data Electromagnetic fields (300 Hz to 300 GHz)



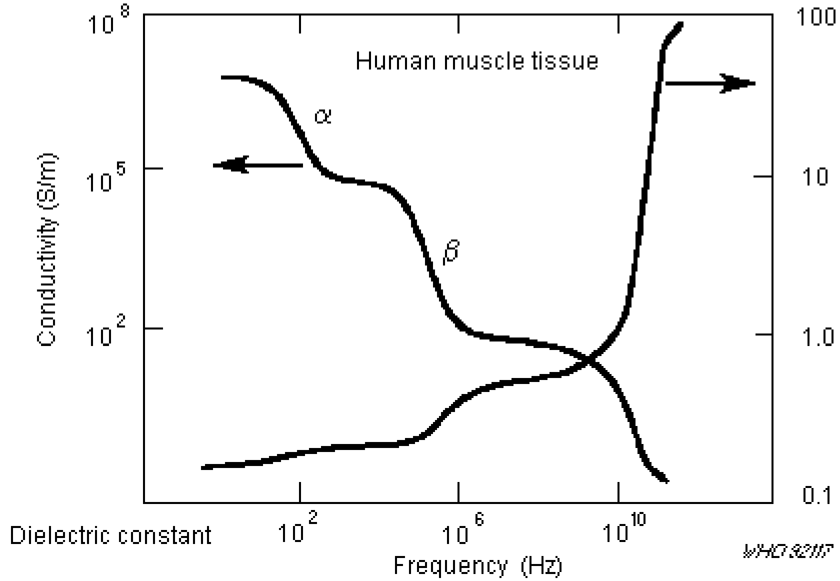


Fig. 9. The dielectric constant and conductivity of typical biological tissue as functions of frequency. From: Schwan (1985).

Source: EHC 137

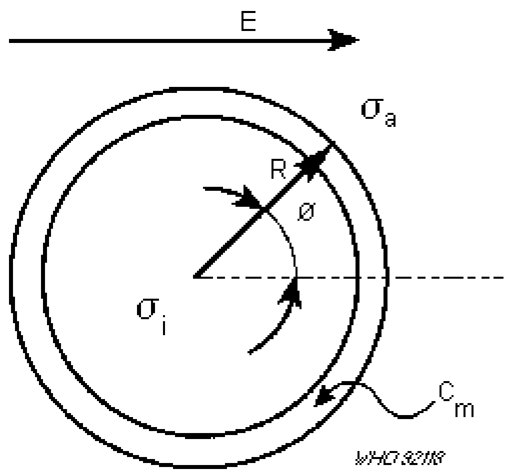
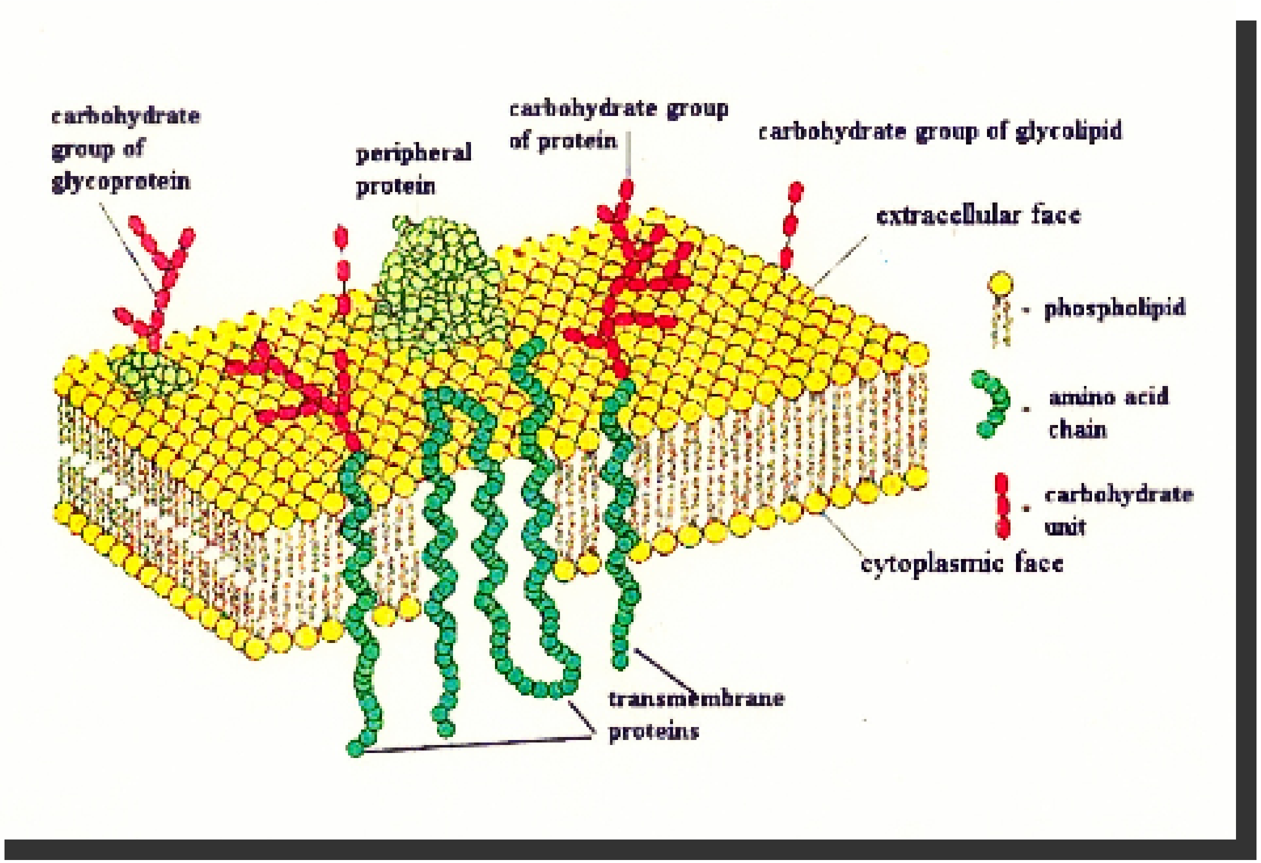
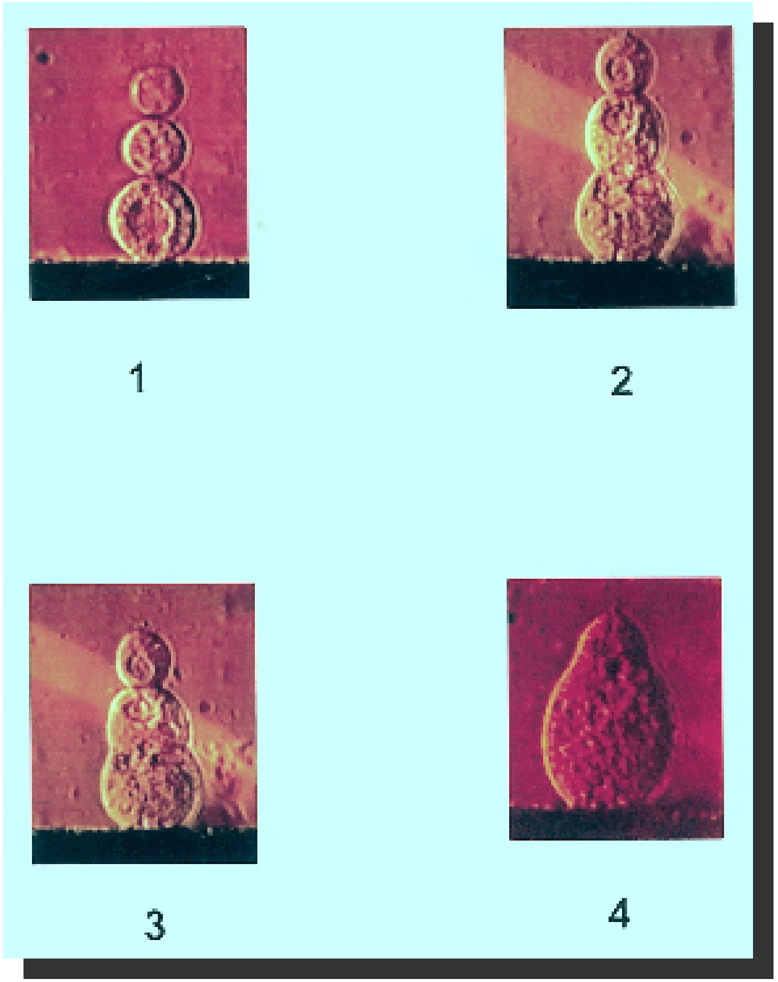


Fig. 10. A spherical cell in an electric field.

Source: EHC 137


carbohydrate group of glycoprotein
peripheral protein
carbohydrate group of protein
carbohydrate group of glycolipid
extracellular face
phospholipid
amino acid chain
carbohydrate unit
cytoplasmic face
transmembrane proteins



Electrofusion of the living cell
Effect of very high amplitude pulse

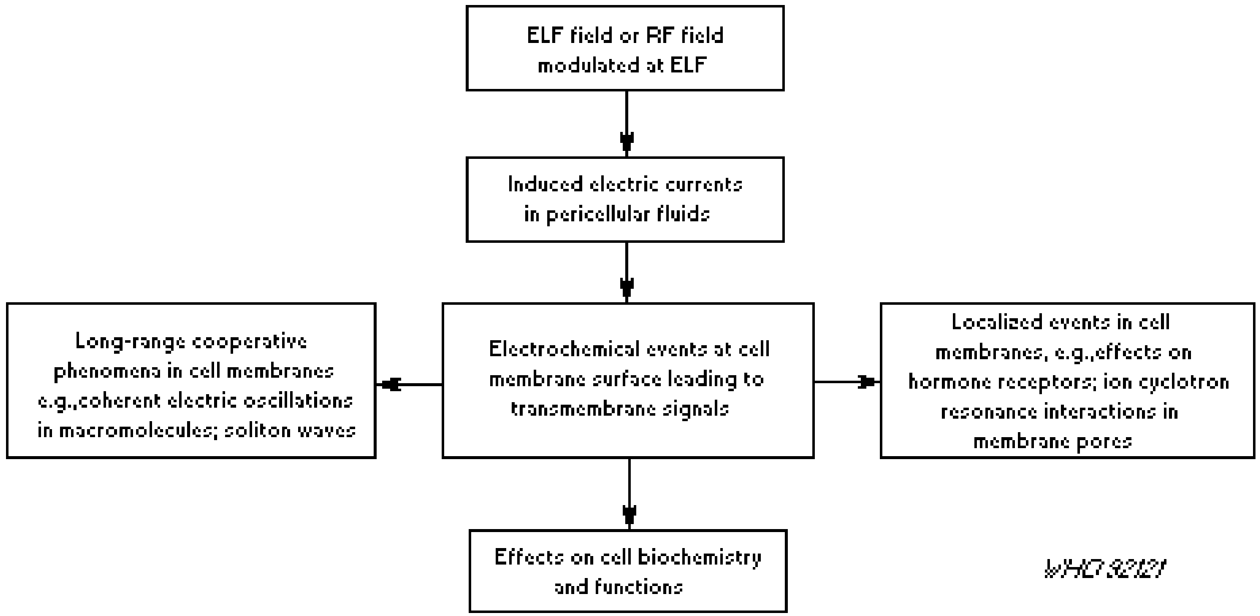


Fig. 13. Hypothetical interaction mechanisms of ELF fields or RF fields modulated at ELF. Modified from: Tenforde & Kaune (1987).

Source: EHC 137

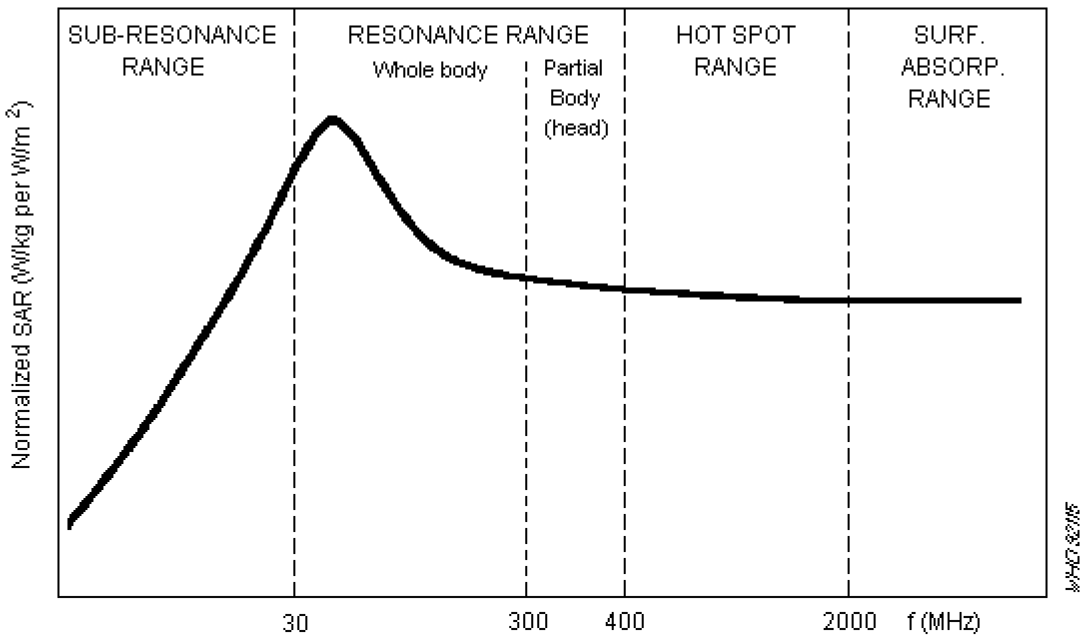
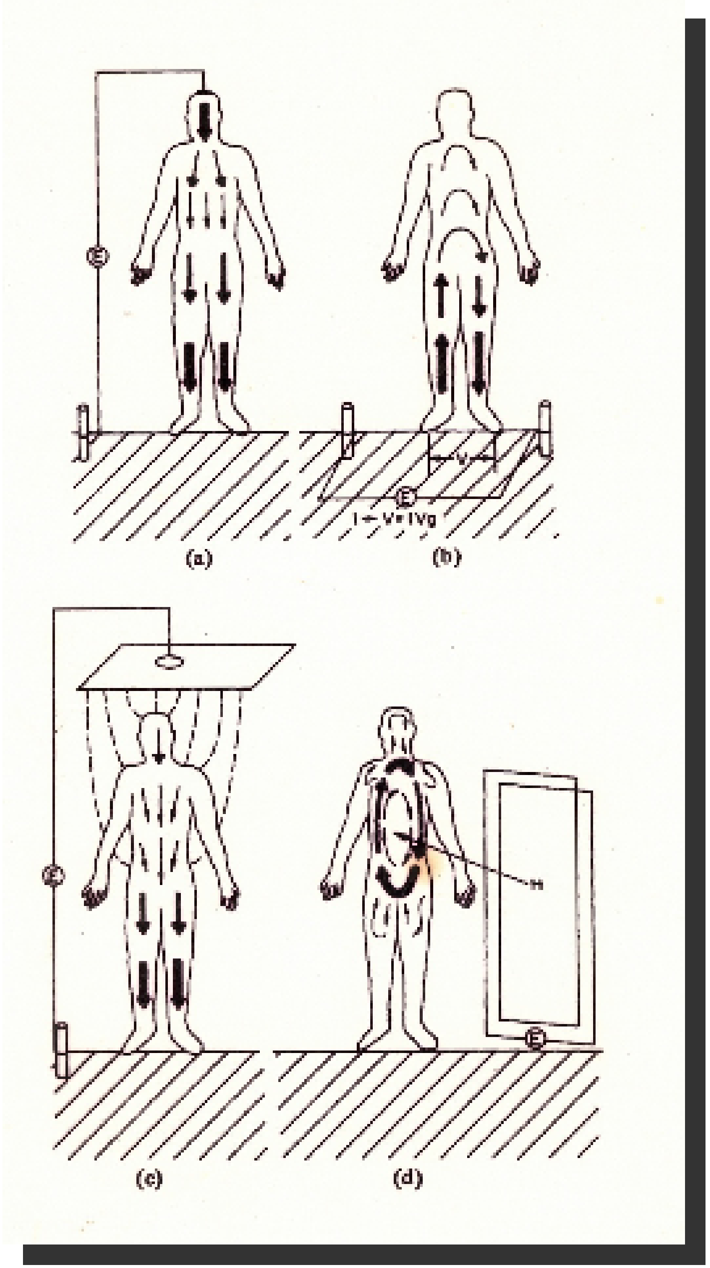
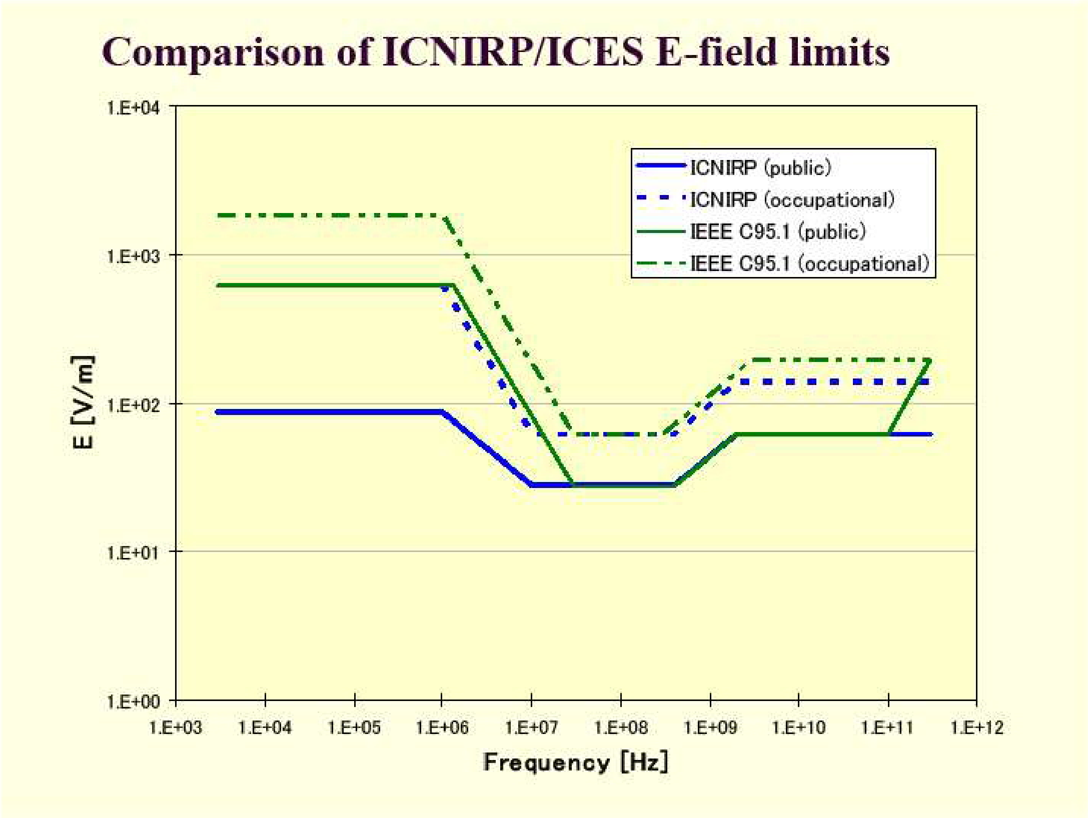


Fig. 7. Variation of normalized SAR with frequency and related absorption characteristics in living organisms.

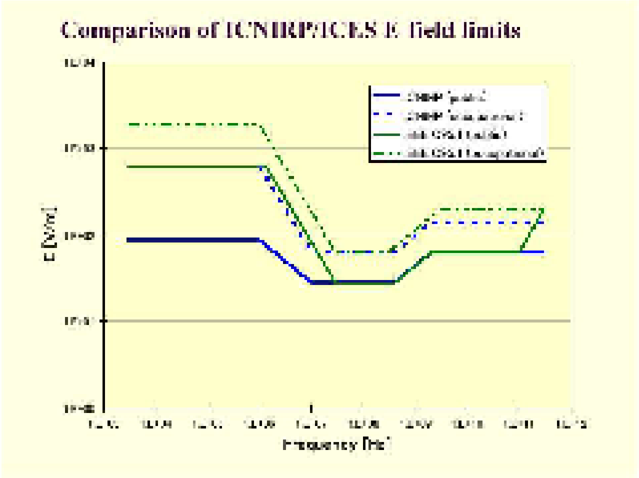
Source: EHC 137



E
V
E
I ← V÷IVg
(a)
(b)
E
H
E
(c)
(d)



Comparison of ICNIRP/ICES E-field limits
1.E+04
1.E+03
1.E+02
1.E+01
1.E+00
E [V/m]
ICNIRP (public)
ICNIRP (occupational)
IEEE C95.1 (public)
IEEE C95.1 (occupational)
1.E+03
1.E+04
1.E+05
1.E+06
1.E+07
1.E+08
1.E+09
1.E+10
1.E+11
1.E+12
Frequency [Hz]



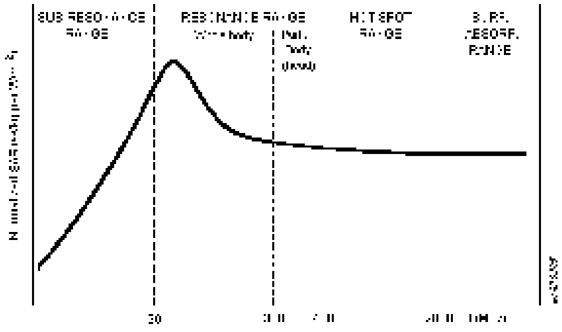
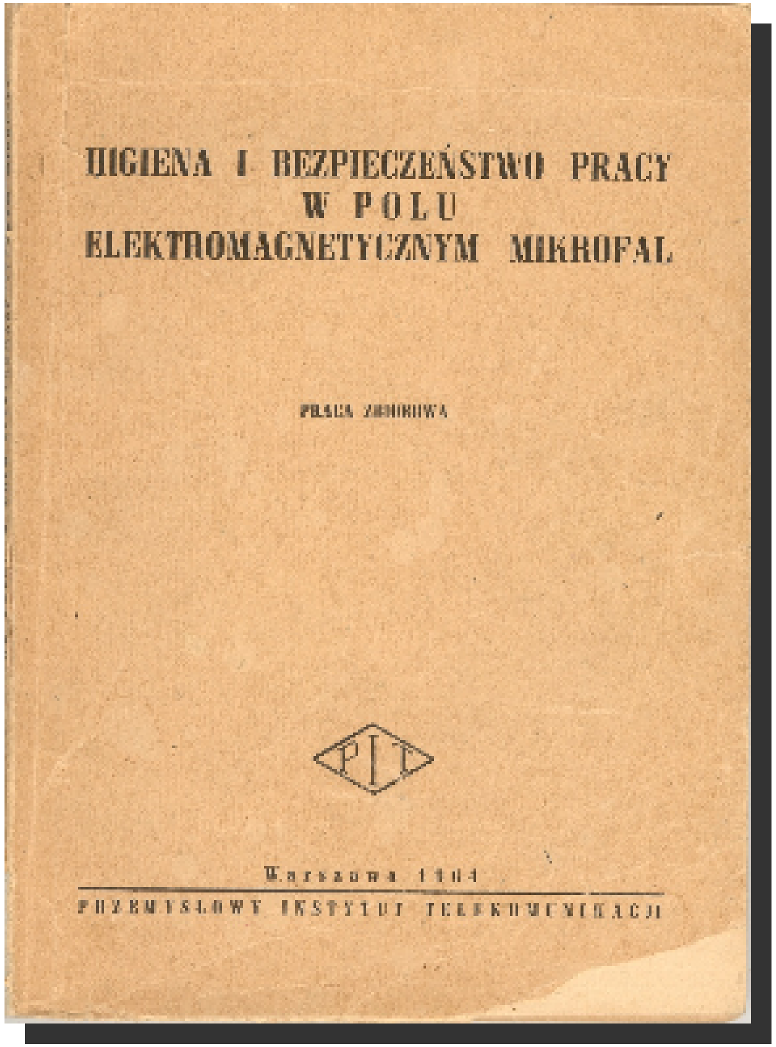


Fig. 7. Variation of normalized SAR with frequency and related absorption characteristics in living organisms.

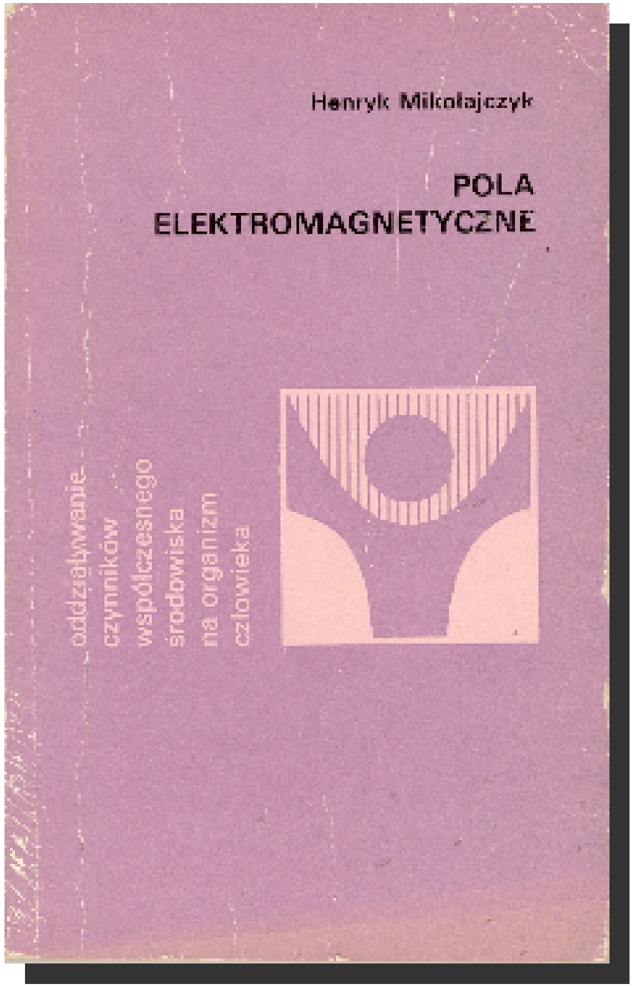


HIGIENA I BEZPIECZEŃSTWO PRACY
W POLU
ELEKTROMAGNETYCZNYM MIKROFAL

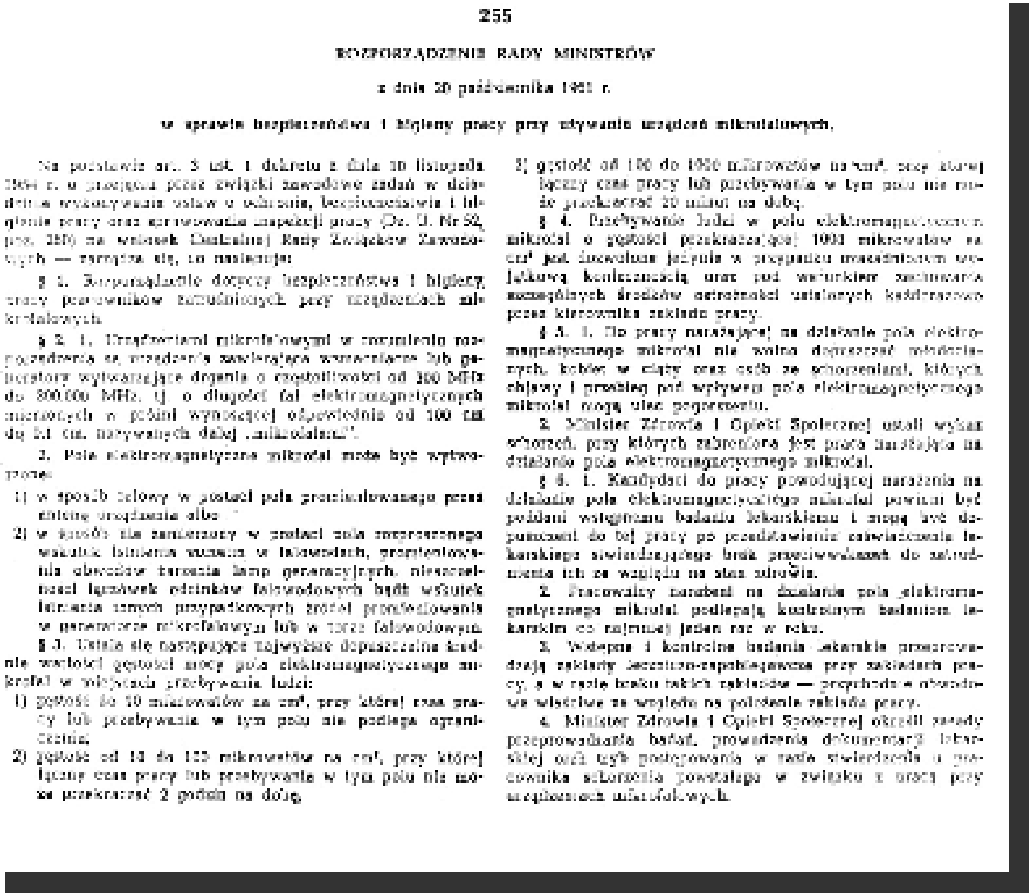
PRACA ZBIOROWA

Warszawa 1964

PRZEMYSŁOWY INSTYTUT TELEKOMUNIKACJI


Henryk Mikołajczyk
POLA
ELEKTROMAGNETYCZNE
oddziaływanie
czynników
współczesnego
środowiska
na organizm
człowieka

Example of the old regulations



255

ROZPORZĄDZENIE RADY MINISTRÓW

z dnia 20 października 19[illegible] r.

w sprawie bezpieczeństwa i higieny pracy przy używaniu urządzeń mikrofalowych.

Na podstawie art. 3 ust. 1 dekretu z dnia 10 listopada 1954 r. o przejęciu przez związki zawodowe zadań w dziedzinie wykonywania ustaw o ochronie, bezpieczeństwie i higienie pracy oraz sprawowania inspekcji pracy (Dz. U. Nr 52, poz. 260) na wniosek Centralnej Rady Związków Zawodowych — zarządza się, co następuje:

§ 1. Rozporządzenie dotyczy bezpieczeństwa i higieny pracy pracowników zatrudnionych przy urządzeniach mikrofalowych.

§ 2. 1. Urządzeniami mikrofalowymi w rozumieniu rozporządzenia są urządzenia zawierające wzmacniacze lub generatory wytwarzające drgania o częstotliwości od 300 MHz do 300.000 MHz, tj. o długości fal elektromagnetycznych mierzonych w próżni wynoszącej odpowiednio od 100 cm do 0,1 cm, nazywanych dalej „mikrofalami".

2. Pole elektromagnetyczne mikrofal może być wytwarzane:

1) w sposób celowy w postaci pola promieniowanego przez anteny urządzenia albo

2) w sposób nie zamierzony w postaci pola rozproszonego wskutek istnienia szczelin w falowodach, promieniowania obwodów zasilania lamp generacyjnych, nieszczelności łączówek odcinków falowodowych bądź wskutek istnienia innych przypadkowych źródeł promieniowania w generatorze mikrofalowym lub w torze falowodowym.

§ 3. Ustala się następujące najwyższe dopuszczalne średnie wartości gęstości mocy pola elektromagnetycznego mikrofal w miejscach przebywania ludzi:

1) gęstość do 10 mikrowatów na cm², przy której czas pracy lub przebywania w tym polu nie podlega ograniczeniu;

2) gęstość od 10 do 100 mikrowatów na cm², przy której łączny czas pracy lub przebywania w tym polu nie może przekraczać 2 godzin na dobę;

3) gęstość od 100 do 1000 mikrowatów na cm², przy której łączny czas pracy lub przebywania w tym polu nie może przekraczać 20 minut na dobę.

§ 4. Przebywanie ludzi w polu elektromagnetycznym mikrofal o gęstości przekraczającej 1000 mikrowatów na cm² jest dozwolone jedynie w przypadku nieodzownej wyjątkowej konieczności, oraz pod warunkiem zastosowania szczególnych środków ostrożności ustalonych każdorazowo przez kierownika zakładu pracy.

§ 5. 1. Do pracy narażającej na działanie pola elektromagnetycznego mikrofal nie wolno dopuszczać młodocianych, kobiet w ciąży oraz osób ze schorzeniami, których objawy i przebieg pod wpływem pola elektromagnetycznego mikrofal mogą ulec pogorszeniu.

2. Minister Zdrowia i Opieki Społecznej ustali wykaz schorzeń, przy których zabroniona jest praca narażająca na działanie pola elektromagnetycznego mikrofal.

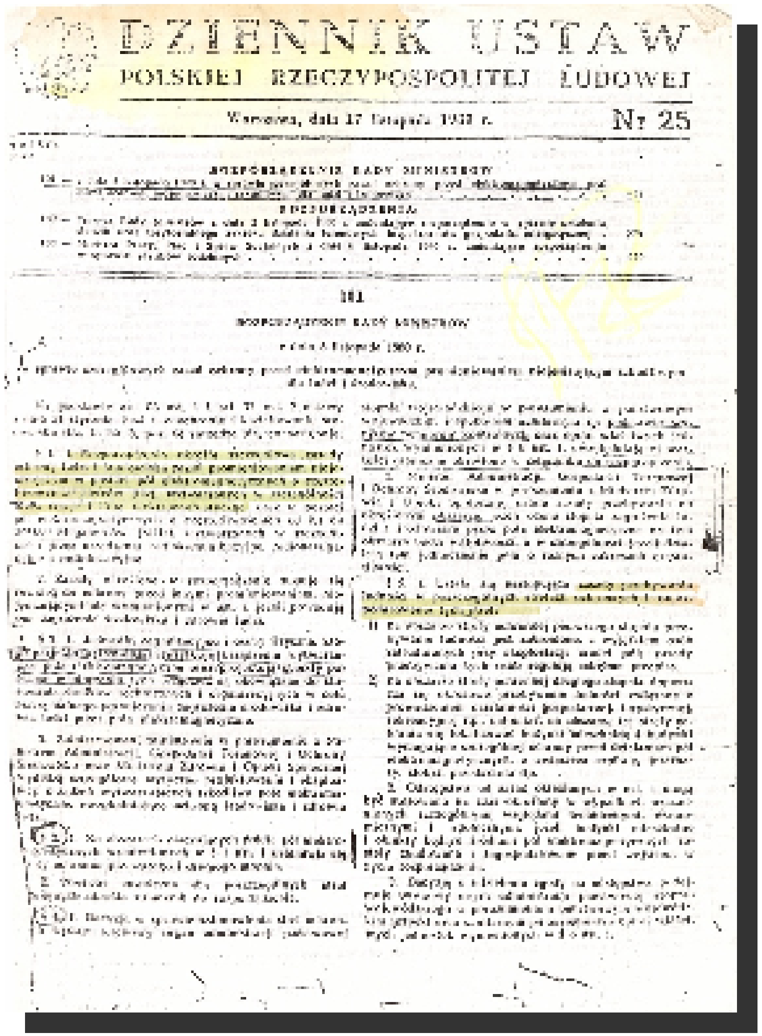
§ 6. 1. Kandydaci do pracy powodującej narażenie na działanie pola elektromagnetycznego mikrofal powinni być poddani wstępnemu badaniu lekarskiemu i mogą być dopuszczeni do tej pracy po przedstawieniu zaświadczenia lekarskiego stwierdzającego brak przeciwwskazań do zatrudnienia ich ze względu na stan zdrowia.

2. Pracownicy narażeni na działanie pola elektromagnetycznego mikrofal podlegają kontrolnym badaniom lekarskim co najmniej jeden raz w roku.

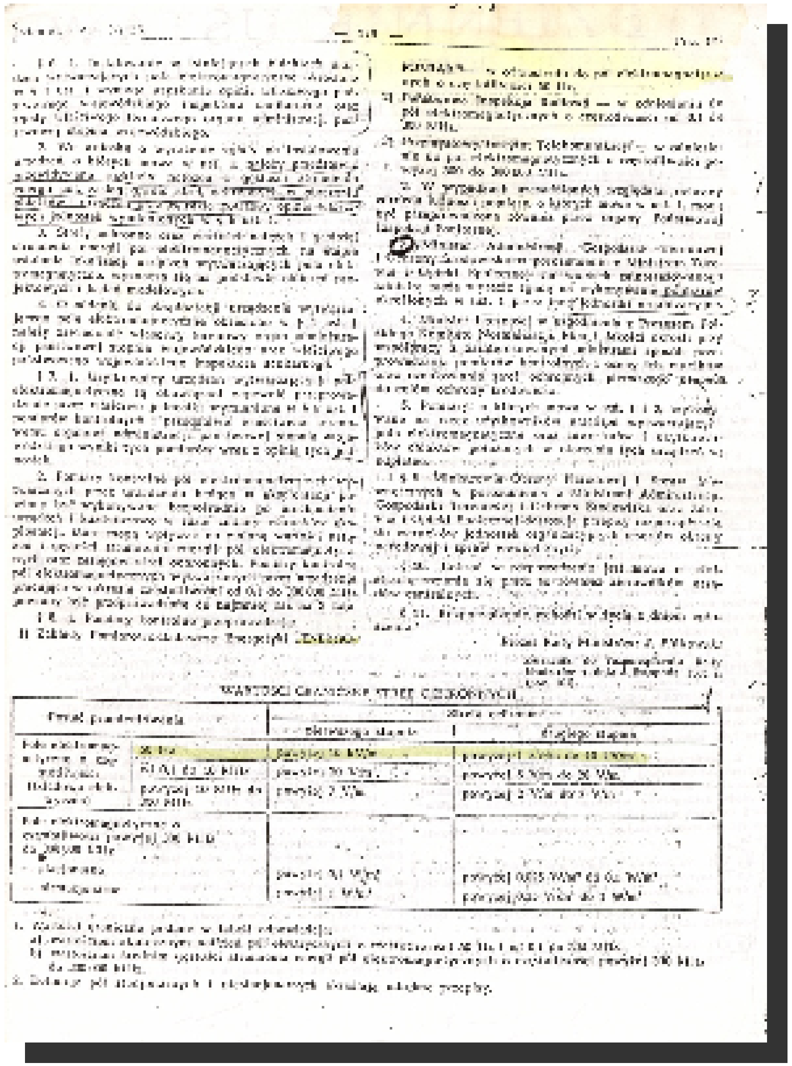
3. Wstępne i kontrolne badania lekarskie przeprowadzają zakłady leczniczo-zapobiegawcze przy zakładach pracy, a w razie braku takich zakładów — przychodnie obwodowe właściwe ze względu na położenie zakładu pracy.

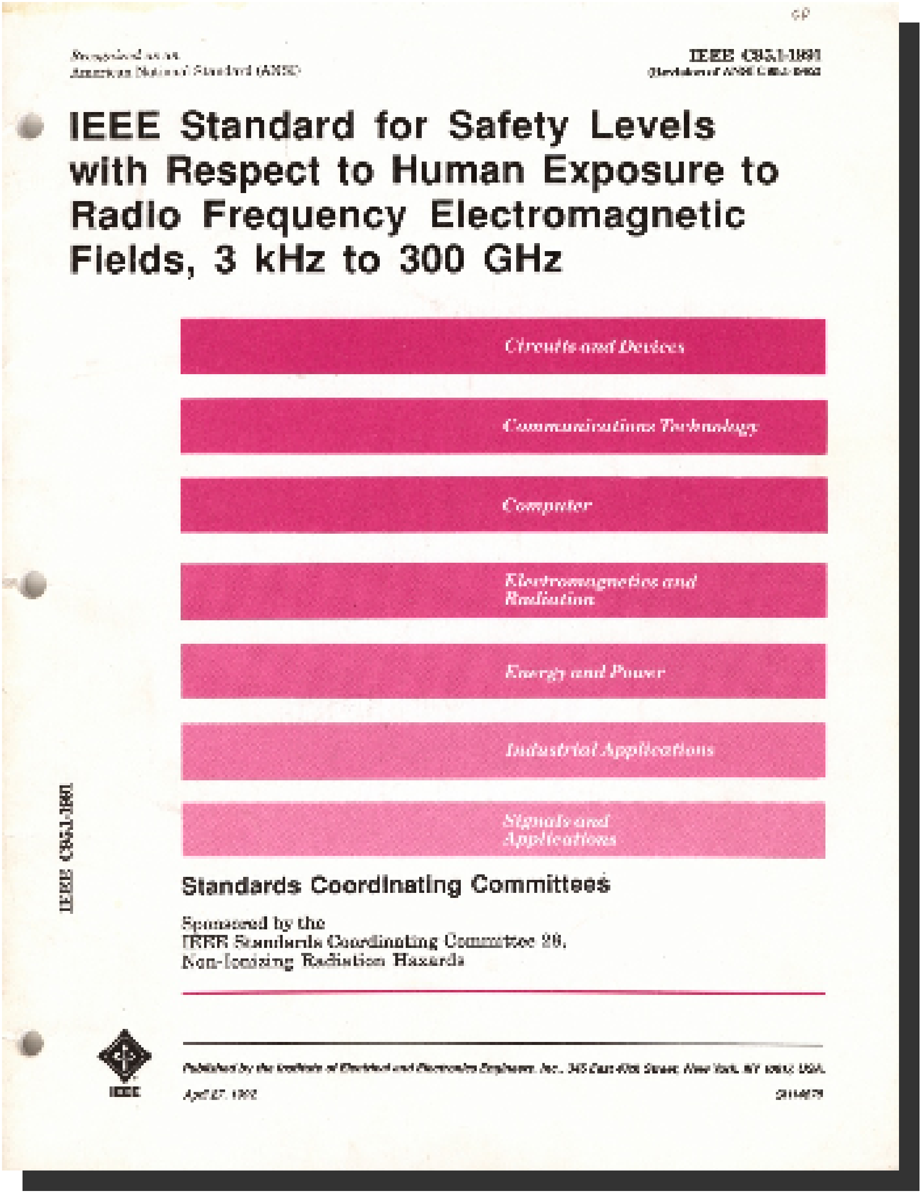
4. Minister Zdrowia i Opieki Społecznej określi zasady przeprowadzania badań, prowadzenia dokumentacji lekarskiej oraz trybu postępowania w razie stwierdzenia u pracownika schorzenia powstałego w związku z pracą przy urządzeniach mikrofalowych.

Example of the old regulations


DZIENNIK USTAW
POLSKIEJ RZECZYPOSPOLITEJ LUDOWEJ
Warszawa, dnia 17 listopada [illegible] r.
Nr 25

Example of the old regulations




IEEE C95.1-1991

IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz

Circuits and Devices

Communications Technology

Computer

Electromagnetics and Radiation

Energy and Power

Industrial Applications

Signals and Applications

Standards Coordinating Committees

Sponsored by the
IEEE Standards Coordinating Committee 28,
Non-Ionizing Radiation Hazards

IEEE

1998

ICNIRP Guidelines

GUIDELINES FOR LIMITING EXPOSURE TO TIME-VARYING ELECTRIC, MAGNETIC, AND ELECTROMAGNETIC FIELDS (UP TO 300 GHz)

International Commission on Non-Ionizing Radiation Protection

In establishing exposure limits, the Commission recognizes the need to reconcile a number of differing expert opinions. The validity of scientific reports has to be considered, and extrapolations from animal experiments to effects on humans have to be made. The restrictions in these guidelines were based on scientific data alone; currently available knowledge, however, indicates that these restrictions provide an adequate level of protection from exposure to time-varying EMF.

Two classes of guidance are presented:

Basic restrictions: Restrictions on exposure to time-varying electric, magnetic, and electromagnetic fields that are based directly on established health effects are termed “basic restrictions.” Depending upon the frequency of the field, the physical quantities used to specify these restrictions are current density (J), specific energy absorption rate (SAR), and power density (S). Only power density in air, outside the body, can be readily measured in exposed individuals.

1998

ICNIRP Guidelines

GUIDELINES FOR LIMITING EXPOSURE TO TIME-VARYING ELECTRIC, MAGNETIC, AND ELECTROMAGNETIC FIELDS (UP TO 300 GHz)

International Commission on Non-Ionizing Radiation Protection

Reference levels: These levels are provided for practical exposure assessment purposes to determine whether the basic restrictions are likely to be exceeded. Some reference levels are derived from relevant basic restrictions using measurement and/or computational techniques, and some address perception and adverse indirect effects of exposure to EMF. The derived quantities are electric field strength (E), magnetic field strength (H), magnetic flux density (B), power density (S), and currents flowing through the limbs (*IL).* Quantities that address perception and other indirect effects are contact current (*IC) and, for pulsed* fields, specific energy absorption (SA). In any particular exposure situation, measured or calculated values of any of these quantities can be compared with the appropriate reference level. Compliance with the reference level will ensure compliance with the relevant basic restriction. If the measured or calculated value exceeds the reference level, it does not necessarily follow that the basic restriction will be exceeded. However, whenever a reference level is exceeded it is necessary to test compliance with the relevant basic restriction and to determine whether additional protective measures are necessary.

1998

Table 4. Basic restrictions for time varying electric and magnetic fields for frequencies up to 10 GHz.[a]

Exposure characteristics	Frequency range	Current density for head and trunk ($mA\ m^{-2}$) (rms)	Whole-body average SAR ($W\ kg^{-1}$)	Localized SAR (head and trunk) ($W\ kg^{-1}$)	Localized SAR (limbs) ($W\ kg^{-1}$)
Occupational exposure	up to 1 Hz	40	—	—	—
	1–4 Hz	40/f	—	—	—
	4 Hz–1 kHz	10	—	—	—
	1–100 kHz	f/100	—	—	—
	100 kHz–10 MHz	f/100	0.4	10	20
	10 MHz–10 GHz	—	0.4	10	20
General public exposure	up to 1 Hz	8	—	—	—
	1–4 Hz	8/f	—	—	—
	4 Hz–1 kHz	2	—	—	—
	1–100 kHz	f/500	—	—	—
	100 kHz–10 MHz	f/500	0.08	2	4
	10 MHz–10 GHz	—	0.08	2	4

[a] Note:

1. f is the frequency in hertz.
2. Because of electrical inhomogeneity of the body, current densities should be averaged over a cross-section of 1 cm^2 perpendicular to the current direction.
3. For frequencies up to 100 kHz, peak current density values can be obtained by multiplying the rms value by $\sqrt{2}$ (~1.414). For pulses of duration t_p the equivalent frequency to apply in the basic restrictions should be calculated as $f = 1/(2t_p)$.
4. For frequencies up to 100 kHz and for pulsed magnetic fields, the maximum current density associated with the pulses can be calculated from the rise/fall times and the maximum rate of change of magnetic flux density. The induced current density can then be compared with the appropriate basic restriction.
5. All SAR values are to be averaged over any 6-min period.
6. Localized SAR averaging mass is any 10 g of contiguous tissue; the maximum SAR so obtained should be the value used for the estimation of exposure.
7. For pulses of duration t_p the equivalent frequency to apply in the basic restrictions should be calculated as $f = 1/(2t_p)$. Additionally, for pulsed exposures in the frequency range 0.3 to 10 GHz and for localized exposure of the head, in order to limit or avoid auditory effects caused by thermoelastic expansion, an additional basic restriction is recommended. This is that the SA should not exceed 10 $mJ\ kg^{-1}$ for workers and 2mJ kg^{-1} for the general public, averaged over 10 g tissue.

1998

Table 6. Reference levels for occupational exposure to time-varying electric and magnetic fields (unperturbed rms values).[a]

Frequency range	E-field strength ($V\ m^{-1}$)	H-field strength ($A\ m^{-1}$)	B-field (μT)	Equivalent plane wave power density S_{eq} ($W\ m^{-2}$)
up to 1 Hz	—	1.63×10^5	2×10^5	—
1–8 Hz	20,000	$1.63 \times 10^5/f^2$	$2 \times 10^5/f^2$	—
8–25 Hz	20,000	$2 \times 10^4/f$	$2.5 \times 10^4/f$	—
0.025–0.82 kHz	$500/f$	$20/f$	$25/f$	—
0.82–65 kHz	610	24.4	30.7	—
0.065–1 MHz	610	$1.6/f$	$2.0/f$	—
1–10 MHz	$610/f$	$1.6/f$	$2.0/f$	—
10–400 MHz	61	0.16	0.2	10
400–2,000 MHz	$3f^{1/2}$	$0.008f^{1/2}$	$0.01f^{1/2}$	$f/40$
2–300 GHz	137	0.36	0.45	50

[a] Note:
1. f as indicated in the frequency range column.
2. Provided that basic restrictions are met and adverse indirect effects can be excluded, field strength values can be exceeded.
3. For frequencies between 100 kHz and 10 GHz, S_{eq}, E^2, H^2, and B^2 are to be averaged over any 6-min period.
4. For peak values at frequencies up to 100 kHz see Table 4, note 3.
5. For peak values at frequencies exceeding 100 kHz see Figs. 1 and 2. Between 100 kHz and 10 MHz, peak values for the field strengths are obtained by interpolation from the 1.5-fold peak at 100 kHz to the 32-fold peak at 10 MHz. For frequencies exceeding 10 MHz it is suggested that the peak equivalent plane wave power density, as averaged over the pulse width, does not exceed 1,000 times the S_{eq} restrictions, or that the field strength does not exceed 32 times the field strength exposure levels given in the table.
6. For frequencies exceeding 10 GHz, S_{eq}, E^2, H^2, and B^2 are to be averaged over any $68/f^{1.05}$-min period (f in GHz).
7. No E-field value is provided for frequencies <1 Hz, which are effectively static electric fields. Electric shock from low impedance sources is prevented by established electrical safety procedures for such equipment.

Table 7. Reference levels for general public exposure to time-varying electric and magnetic fields (unperturbed rms values).[a]

Frequency range	E-field strength ($V\ m^{-1}$)	H-field strength ($A\ m^{-1}$)	B-field (μT)	Equivalent plane wave power density S_{eq} ($W\ m^{-2}$)
up to 1 Hz	—	3.2×10^4	4×10^4	—
1–8 Hz	10,000	$3.2 \times 10^4/f^2$	$4 \times 10^4/f^2$	—
8–25 Hz	10,000	$4,000/f$	$5,000/f$	—
0.025–0.8 kHz	$250/f$	$4/f$	$5/f$	—
0.8–3 kHz	$250/f$	5	6.25	—
3–150 kHz	87	5	6.25	—
0.15–1 MHz	87	$0.73/f$	$0.92/f$	—
1–10 MHz	$87/f^{1/2}$	$0.73/f$	$0.92/f$	—
10–400 MHz	28	0.073	0.092	2
400–2,000 MHz	$1.375f^{1/2}$	$0.0037f^{1/2}$	$0.0046f^{1/2}$	$f/200$
2–300 GHz	61	0.16	0.20	10

[a] Note:
1. f as indicated in the frequency range column.
2. Provided that basic restrictions are met and adverse indirect effects can be excluded, field strength values can be exceeded.
3. For frequencies between 100 kHz and 10 GHz, S_{eq}, E^2, H^2, and B^2 are to averaged over any 6-min period.
4. For peak values at frequencies up to 100 kHz see Table 4, note 3.
5. For peak values at frequencies exceeding 100 kHz see Figs. 1 and 2. Between 100 kHz and 10 MHz, peak values for the field strengths are obtained by interpolation from the 1.5-fold peak at 100 kHz to the 32-fold peak at 10 MHz. For frequencies exceeding 10 MHz it is suggested that the peak equivalent plane wave power density, as averaged over the pulse width does not exceed 1,000 times the S_{eq} restrictions, or that the field strength does not exceed 32 times the field strength exposure levels given in the table.
6. For frequencies exceeding 10 GHz, S_{eq}, E^2, H^2, and B^2 are to be averaged over any $68/f^{1.05}$-min period (f in GHz).
7. No E-field value is provided for frequencies <1 Hz, which are effectively static electric fields. perception of surface electric charges will not occur at field strengths less than 25 kVm^{-1}. Spark discharges causing stress or annoyance should be avoided.

COUNCIL

COUNCIL RECOMMENDATION
of 12 July 1999
on the limitation of exposure of the general public to electromagnetic fields (0 Hz to 300 GHz)

(1999/519/EC)

ANNEX II

BASIC RESTRICTIONS

Depending on frequency, the following physical quantities (dosimetric/exposimetric quantities) are used to specify the basic restrictions on electromagnetic fields:

— between 0 and 1 Hz basic restrictions are provided for magnetic flux density for static magnetic fields (0 Hz) and current density for time-varying fields up to 1 Hz, in order to prevent effects on the cardiovascular and central nervous system,

— between 1 Hz and 10 MHz basic restrictions are provided for current density to prevent effects on nervous system functions,

— between 100 kHz and 10 GHz basic restrictions on SAR are provided to prevent whole-body heat stress and excessive localised heating of tissues. In the range 100 kHz to 10 MHz, restrictions on both current density and SAR are provided,

— between 10 GHz and 300 GHz basic restrictions on power density are provided to prevent heating in tissue at or near the body surface.

The basic restrictions, given in Table 1, are set so as to account for uncertainties related to individual sensitivities, environmental conditions, and for the fact that the age and health status of members of the public vary.

Table 1

Basic restrictions for electric, magnetic and electromagnetic fields (0 Hz to 300 GHz)

Frequency range	Magnetic flux density (mT)	Current density (mA/m²) (rms)	Whole body average SAR (W/kg)	Localised SAR (head and trunk) (W/kg)	Localised SAR (limbs) (W/kg)	Power density, S (W/m²)
0 Hz	40	—	—	—	—	—
>0-1 Hz	—	8	—	—	—	—
1-4 Hz	—	8/f	—	—	—	—
4-1 000 Hz	—	2	—	—	—	—
1 000 Hz-100 kHz	—	f/500	—	—	—	—
100 kHz-10 MHz	—	f/500	0,08	2	4	—
10 MHz-10 GHz	—	—	0,08	2	4	—
10-300 GHz	—	—	—	—	—	10

Notes:

1. *f* is the frequency in Hz.

2. The basic restriction on the current density is intended to protect against acute exposure effects on central nervous system tissues in the head and trunk of the body and includes a safety factor. The basic restrictions for ELF fields are based on established adverse effects on the central nervous system. Such acute effects are essentially instantaneous and there is no scientific justification to modify the basic restrictions for exposure of short duration. However, since the basic restriction refers to adverse effects on the central nervous system, this basic restriction may permit higher current densities in body tissues other than the central nervous system under the same exposure conditions.

3. Because of electrical inhomogeneity of the body, current densities should be averaged over a cross-section of 1 cm² perpendicular to the current direction.

ANNEX III

REFERENCE LEVELS

Reference levels of exposure are provided for the purpose of comparison with values of measured quantities. Respect of all recommended reference levels will ensure respect of basic restrictions.

If the quantities of measured values are greater than the reference levels, it does not necessarily follow that the basic restrictions have been exceeded. In this case, an assessment should be made as to whether exposure levels are below the basic restrictions.

The reference levels for limiting exposure are obtained from the basic restrictions for the condition of maximum coupling of the field to the exposed individual, thereby providing maximum protection. A summary of the reference levels is given in Tables 2 and 3. The reference levels are generally intended to be spatially averaged values over the dimension of the body of the exposed individual, but with the important proviso that the localised basic restrictions on exposure are not exceeded.

In certain situations where the exposure is highly localised, such as with hand-held telephones and the human head, the use of reference levels is not appropriate. In such cases respect of the localised basic restriction should be assessed directly.

Field levels

Table 2

Reference levels for electric, magnetic and electromagnetic fields (0 Hz to 300 GHz, unperturbed rms values)

Frequency range	E-field strength (V/m)	H-field strength (A/m)	B-field (μT)	Equivalent plane wave power density S_{eq} (W/m²)
0-1 Hz	—	$3,2 \times 10^4$	4×10^4	—
1-8 Hz	10 000	$3,2 \times 10^4/f^2$	$4 \times 10^4/f^2$	—
8-25 Hz	10 000	$4\,000/f$	$5\,000/f$	
0,025-0,8 kHz	$250/f$	$4/f$	$5/f$	—
0,8-3 kHz	$250/f$	5	6,25	—
3-150 kHz	87	5	6,25	—
0,15-1 MHz	87	$0,73/f$	$0,92/f$	—
1-10 MHz	$87/f^{1/2}$	$0,73/f$	$0,92/f$	—
10-400 MHz	28	0,073	0,092	2
400-2 000 MHz	$1,375\ f^{1/2}$	$0,0037\ f^{1/2}$	$0,0046\ f^{1/2}$	$f/200$
2-300 GHz	61	0,16	0,20	10

Notes

1. f as indicated in the frequency range column.
2. For frequencies between 100 kHz and 10 GHz, S_{eq}, E^2, H^2, and B^2 are to be averaged over any six-minute period.
3. For frequencies exceeding 10 GHz, S_{eq}, E^2, H^2 and B^2 are to be averaged over any $68/f^{1,05}$-minute period (f in GHz).
4. No E-field value is provided for frequencies < 1 Hz, which are effectively static electric fields. For most people the annoying perception of surface electric charges will not occur at field strengths less than 25 kV/m. Spark discharges causing stress or annoyance should be avoided.

DIRECTIVE 2004/40/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL
of 29 April 2004
on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (electromagnetic fields) (18th individual Directive within the meaning of Article 16(1) of Directive 89/391/EEC)

Article 1
Aim and scope

1. This Directive, which is the 18th individual Directive within the meaning of Article 16(1) of Directive 89/391/EEC, lays down minimum requirements for the protection of workers from risks to their health and safety arising or likely to arise from exposure to electromagnetic fields (0 Hz to 300 GHz) during their work.

2. This Directive refers to the risk to the health and safety of workers due to known short-term adverse effects in the human body caused by the circulation of induced currents and by energy absorption as well as by contact currents.

3. This Directive does not address suggested long-term effects.

4. This Directive does not address the risks resulting from contact with live conductors.

5. Directive 89/391/EEC shall apply fully to the whole area referred to in paragraph 1, without prejudice to more stringent and/or more specific provisions contained in this Directive.

Table 1

Exposure limit values (Article 3(1)). All conditions to be satisfied

Frequency range	Current density for head and trunk J (mA/m^2) (rms)	Whole body average SAR (W/kg)	Localised SAR (head and trunk) (W/kg)	Localised SAR (limbs) (W/kg)	Power density S (W/m^2)
Up to 1 Hz	40	—	—	—	—
1 — 4 Hz	40/f	—	—	—	—
4 — 1 000 Hz	10	—	—	—	—
1 000 Hz — 100 kHz	f/100	—	—	—	—
100 kHz — 10 MHz	f/100	0,4	10	20	—
10 MHz — 10 GHz	—	0,4	10	20	—
10 — 300 GHz	—	—	—	—	50

Notes:

1. f is the frequency in Hertz.
2. The exposure limit values on the current density are intended to protect against acute exposure effects on central nervous system tissues in the head and trunk of the body. The exposure limit values in the frequency range 1 Hz to 10 MHz are based on established adverse effects on the central nervous system. Such acute effects are essentially instantaneous and there is no scientific justification to modify the exposure limit values for exposure of short duration. However, since the exposure limit values refer to adverse effects on the central nervous system, these exposure limit values may permit higher current densities in body tissues other than the central nervous system under the same exposure conditions.
3. Because of the electrical inhomogeneity of the body, current densities should be calculated as averages over a crosssection of 1 cm2 perpendicular to the current direction.
4. For frequencies up to 100 kHz, peak current density values can be obtained by multiplying the rms value by (2)˝.
5. For frequencies up to 100 kHz and for pulsed magnetic fields, the maximum current density associated with the pulses can be calculated from the rise/fall times and the maximum rate of change of magnetic flux density. The induced current density can then be compared with the appropriate exposure limit value. For pulses of duration tp, the equivalent frequency to apply for the exposure limit values should be calculated as f = 1/(2tp).
6. All SAR values are to be averaged over any six-minute period.
7. Localised SAR averaging mass is any 10 g of contiguous tissue; the maximum SAR so obtained should be the value used for estimating exposure. These 10 g of tissue are intended to be a mass of contiguous tissue with nearly homogeneous electrical properties. In specifying a contiguous mass of tissue, it is recognised that this concept can be used in computational dosimetry but may present difficulties for direct physical measurements. A simple geometry such as cubic tissue mass can be used provided that the calculated dosimetric quantities have conservative values relative to the exposure guidelines.
8. For pulsed exposures in the frequency range 0,3 to 10 GHz and for localised exposure of the head, in order to limit and avoid auditory effects caused by thermoelastic expansion, an additional exposure limit value is recommended. This is that the SA should not exceed 10 mJ/kg averaged over 10 g of tissue.
9. Power densities are to be averaged over any 20 cm2 of exposed area and any 68/f1,05-minute period (where f is in GHz) to compensate for progressively shorter penetration depth as the frequency increases. Spatial maximum power densities averaged over 1 cm2 should not exceed 20 times the value of 50 W/m2.
10. With regard to pulsed or transient electromagnetic fields, or generally with regard to simultaneous exposure to multiple frequency fields, appropriate methods of assessment, measurement and/or calculation capable of analysing the characteristics of the waveforms and nature of biological interactions have to be applied, taking account of European harmonised standards developed by Cenelec.

Table 2

Action values (Article 3(2)) (unperturbed rms values)

Frequency range	Electric field strength, E (V/m)	Magnetic field strength, H (A/m)	Magnetic flux density, B (μT)	Equivalent plane wave power density, S_{eq} (W/m²)	Contact current, I_C (mA)	Limb induced current, I_L (mA)
0 — 1Hz	—	$1,63 \times 10^5$	2×10^5	—	1,0	—
1 — 8 Hz	20 000	$1,63 \times 10^5/f^2$	$2 \times 10^5/f^2$	—	1,0	—
8 — 25 Hz	20 000	$2 \times 10^4/f$	$2,5 \times 10^4/f$	—	1,0	—
0,025 — 0,82kHz	500/f	20/f	25/f	—	1,0	—
0,82 — 2,5 kHz	610	24,4	30,7	—	1,0	—
2,5 — 65 kHz	610	24,4	30,7	—	0,4 f	—
65 — 100 kHz	610	1 600/f	2 000/f	—	0,4 f	—
0,1 — 1 MHz	610	1,6/f	2/f	—	40	—
1 — 10 MHz	610/f	1,6/f	2/f	—	40	—
10 — 110 MHz	61	0,16	0,2	10	40	100
110 — 400 MHz	61	0,16	0,2	10	—	—
400 — 2 000 MHz	$3f^{½}$	$0,008f^{½}$	$0,01f^{½}$	f/40	—	—
2 — 300 GHz	137	0,36	0,45	50	—	—

Notes:

1. f is the frequency in the units indicated in the frequency range column.
2. For frequencies between 100 kHz and 10 GHz, S_{eq}, E, H, B and I_L are to be averaged over any six-minute period.
3. For frequencies exceeding 10 GHz, S_{eq}, E, H and B are to be averaged over any $68/f^{1,05}$-minute period (f in GHz).
4. For frequencies up to 100 kHz, peak action values for the field strengths can be obtained by multiplying the rms value by $(2)^{½}$. For pulses of duration t_p, the equivalent frequency to apply for the action values should be calculated as $f = 1/(2t_p)$.

   For frequencies between 100 kHz and 10 MHz, peak action values for the field strengths are calculated by multiplying the relevant rms values by 10 , where a = (0,665 log (f/10) + 0,176), f in Hz.

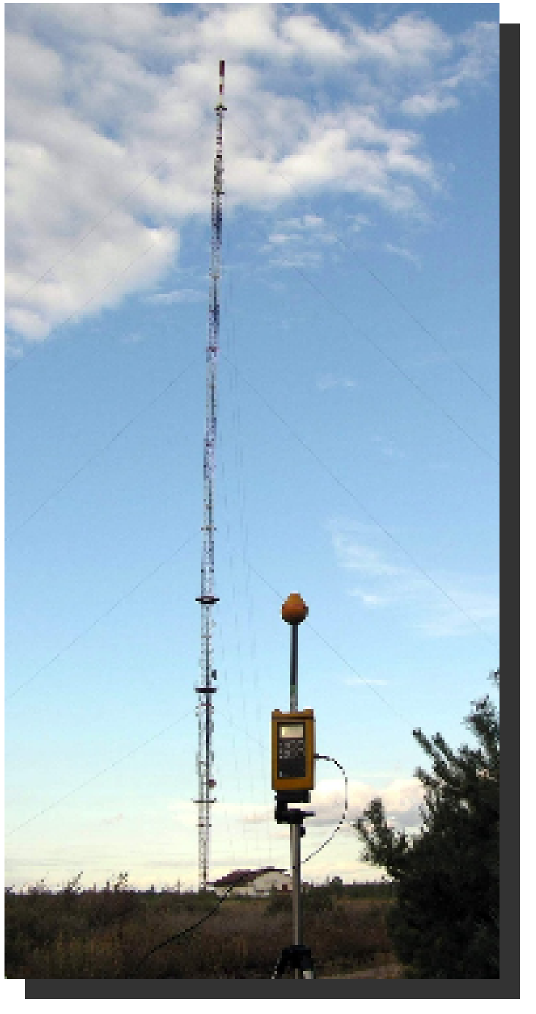
   For frequencies between 10 MHz and 300 GHz, peak action values are calculated by multiplying the corresponding rms values by 32 for the field strengths and by 1 000 for the equivalent plane wave power density.
5. With regard to pulsed or transient electromagnetic fields, or generally with regard to simultaneous exposure to multiple frequency fields, appropriate methods of assessment, measurement and/or calculation capable of analysing the characteristics of the waveforms and nature of biological interactions have to be applied, taking account of harmonised European standards developed by Cenelec.
6. For peak values of pulsed modulated electromagnetic fields, it is also suggested that, for carrier frequencies exceeding 10 MHz, S_{eq} as averaged over the pulse width should not exceed 1 000 times the S_{eq} action values or that the field strength should not exceed 32 times the field strength action values for the carrier frequency.

IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz

Sponsored by the
IEEE International Committee on Electromagnetic Safety (SCC39)

IEEE Std C95.1™-2005
(Revision of IEEE Std C95.1-1991)

EMF Measurements



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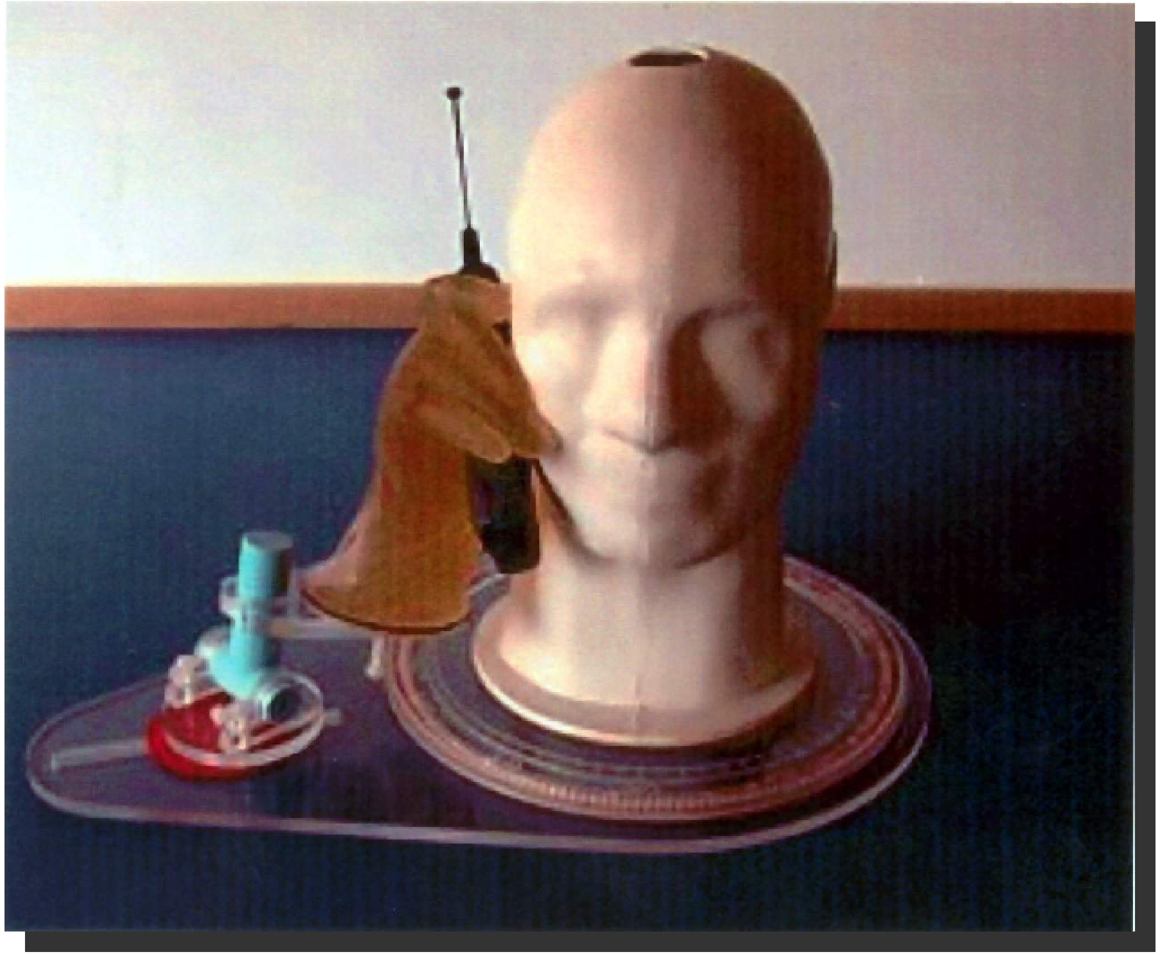

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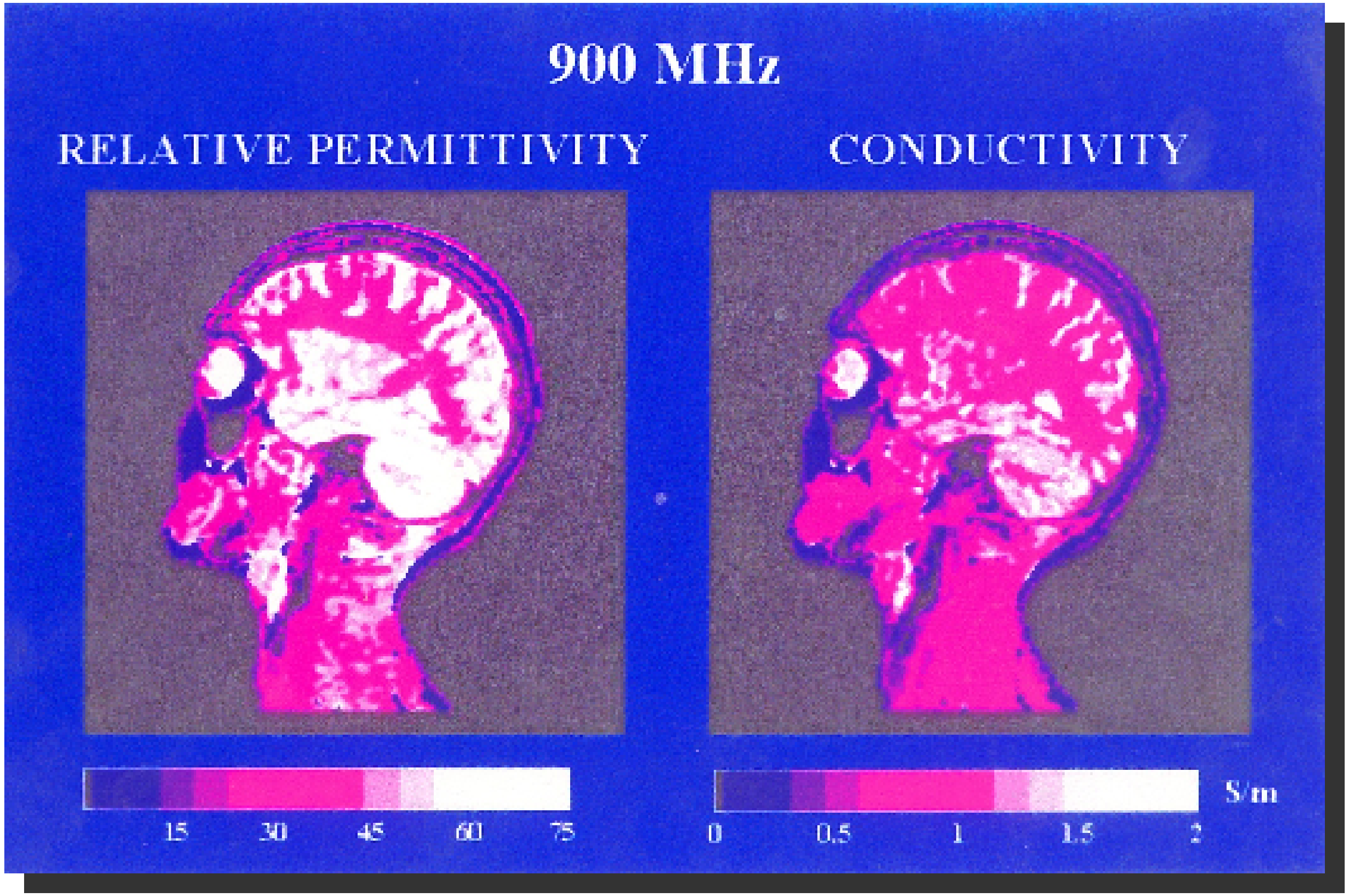

http://www.who.int/peh-emf/en/

http://www.jrc.cec.eu.int/emf-net/index.cfm

NATURA 2000

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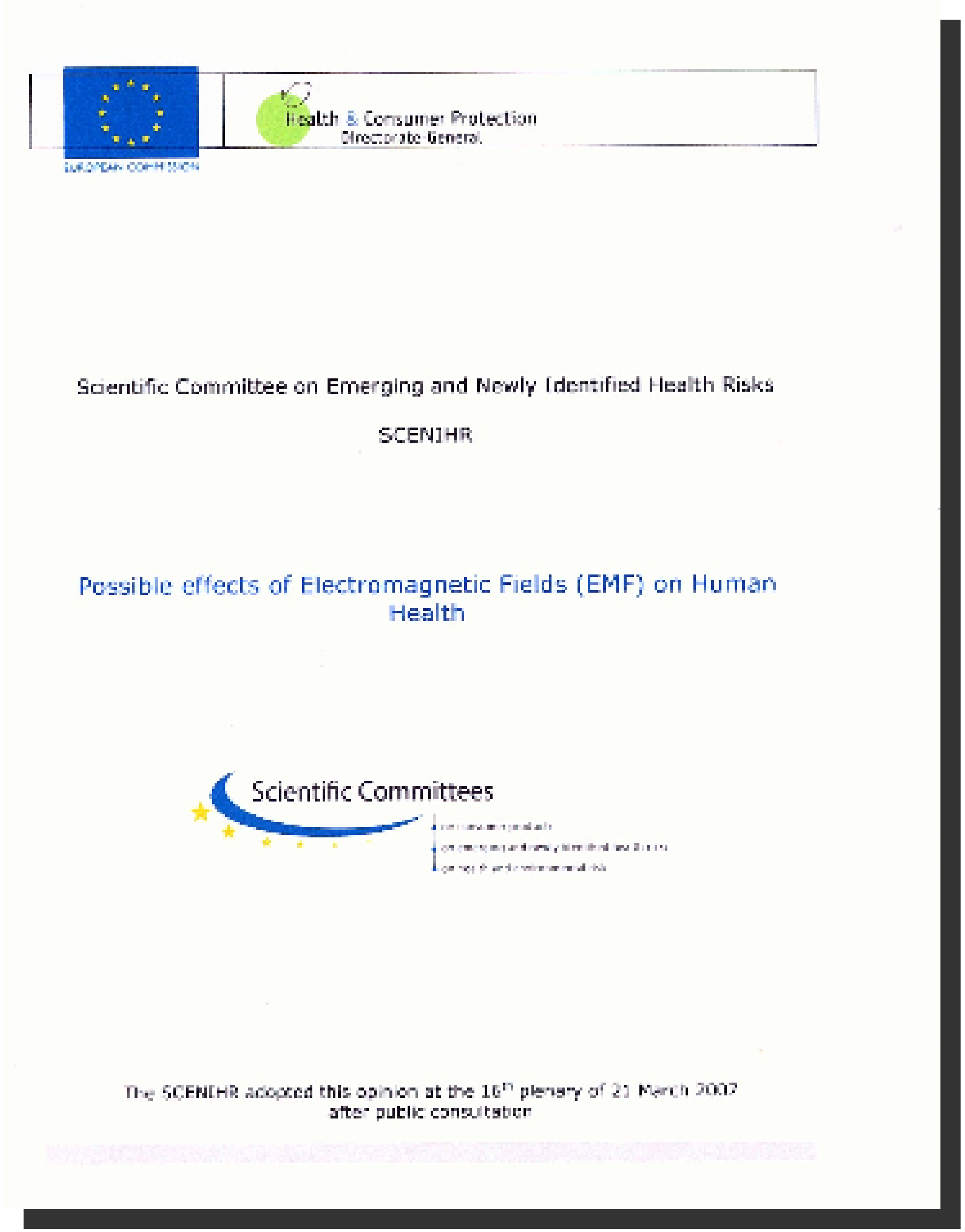

EUROPEAN COMMISSION

Health & Consumer Protection
Directorate General

Scientific Committee on Emerging and Newly Identified Health Risks

SCENIHR

Possible effects of Electromagnetic Fields (EMF) on Human Health

The SCENIHR adopted this opinion at the 16th plenary of 21 March 2007 after public consultation


WHO | Electromagnetic fields - Windows Internet Explorer
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Electromagnetic fields
EMF
Electromagnetic fields of all frequencies represent one of the most common and fastest growing environmental influences, about which anxiety and speculation are spreading. All populations are now exposed to varying degrees of EMF, and the levels will continue to increase as technology advances.
As part of its Charter to protect public health and in response to public concern, the World Health Organization (WHO) established the International EMF Project in 1996 to assess the scientific evidence of possible health effects of EMF in the frequency range from 0 to 300 GHz.
The EMF Project is open to broad participation
The EMF Project is open to any WHO Member State government, i.e. department of health, or representatives of other national institutions concerned with radiation protection. The project is fully funded by participating countries and agencies.
Further information
for more information on the EMF Project, please email:
Participating countries & entities in EMF Project
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More information
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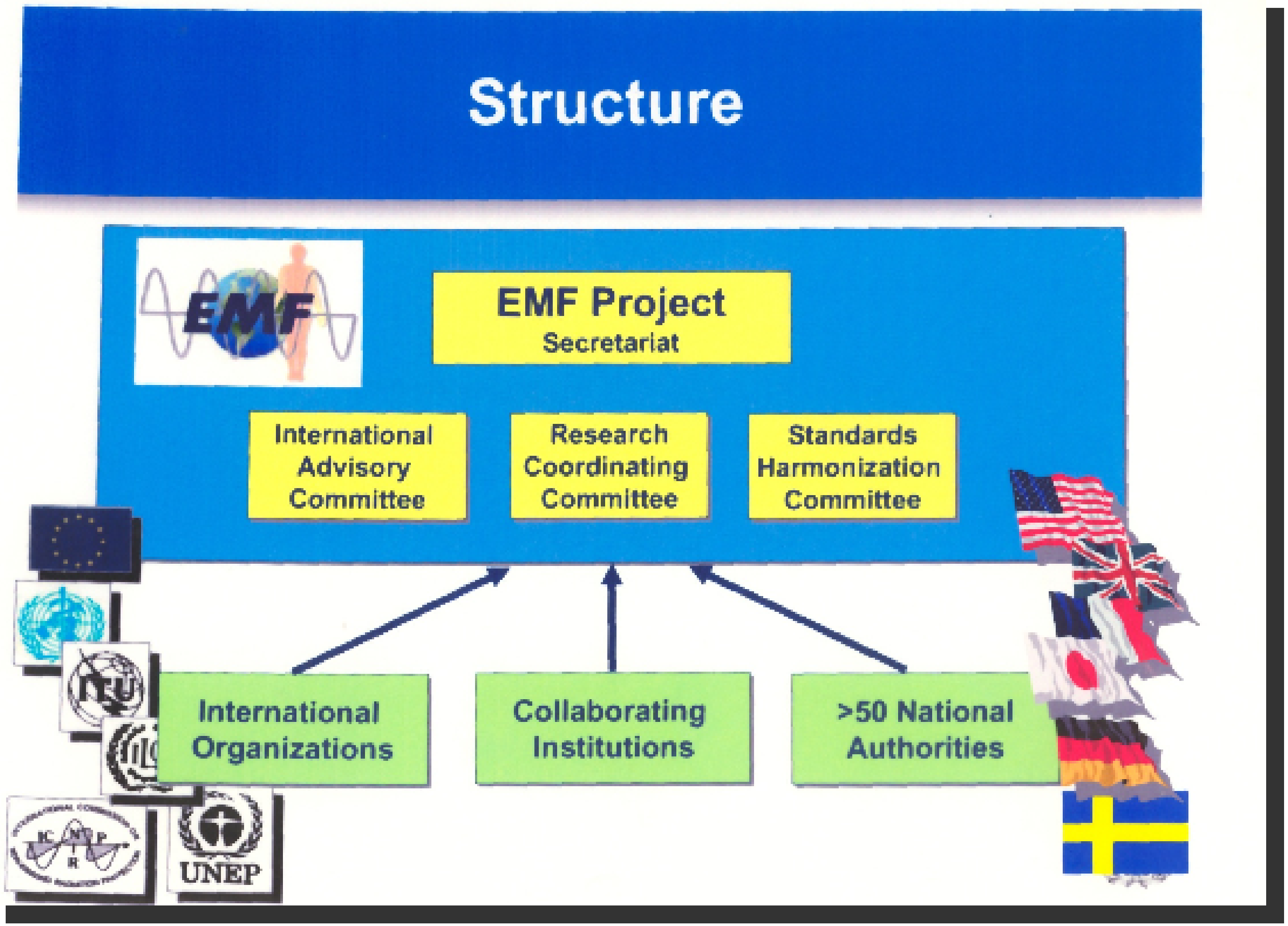
Structure
EMF
EMF Project
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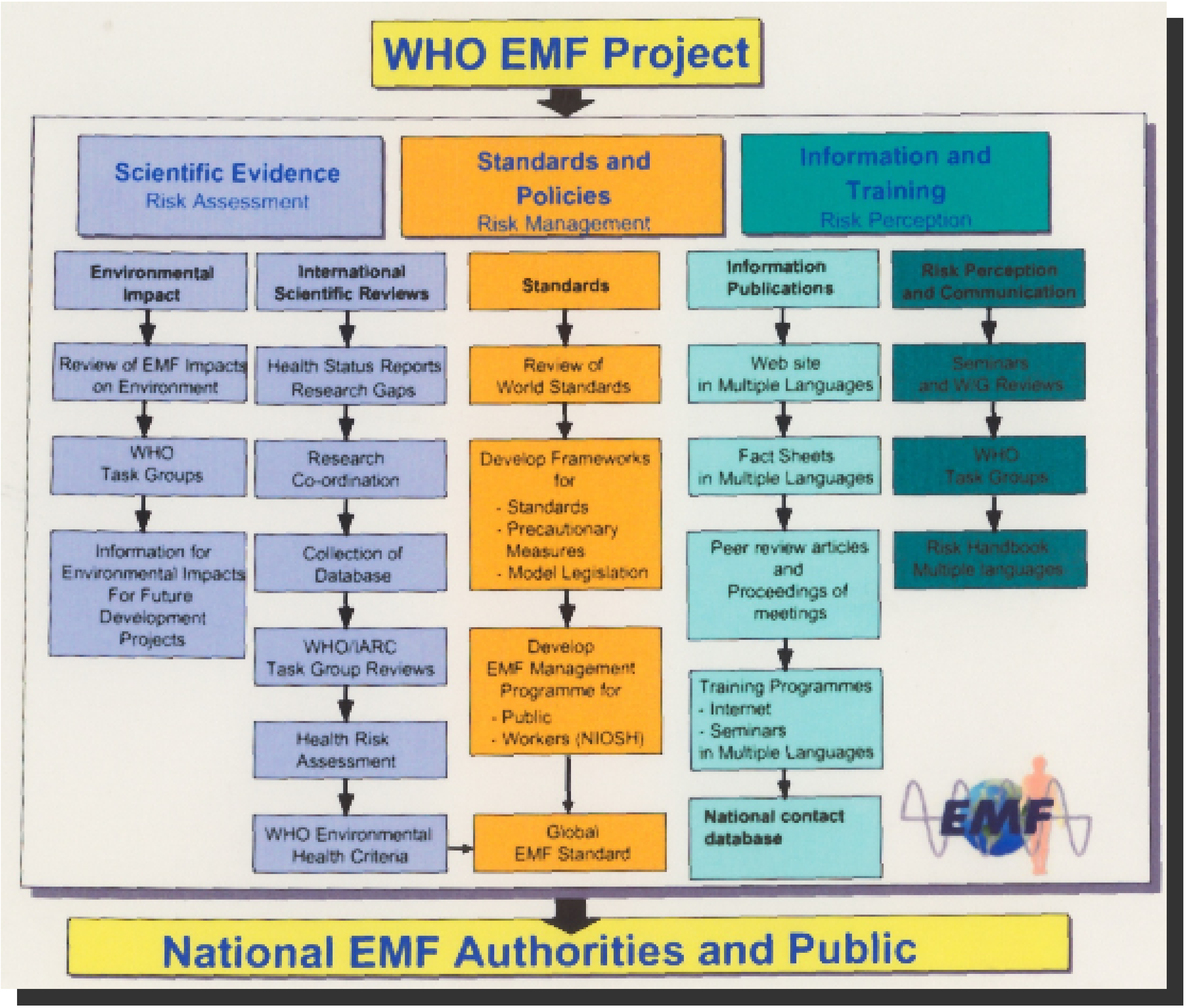
Research Coordinating Committee
Standards Harmonization Committee
International Organizations
Collaborating Institutions
>50 National Authorities
UNEP


WHO EMF Project
Scientific Evidence
Risk Assessment
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Risk Management
Information and Training
Risk Perception
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Review of EMF Impacts on Environment
WHO Task Groups
Information for Environmental Impacts For Future Development Projects
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WHO Environmental Health Criteria
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Review of World Standards
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- Precautionary Measures
- Model Legislation
Develop EMF Management Programme for
- Public
- Workers (NIOSH)
Global EMF Standard
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Radiation Protection Dosimetry

WEAK ELECTRIC FIELD EFFECTS IN THE BODY

Proceedings of an International Workshop
National Radiological Protection Board, Chilton, Didcot, Oxon, UK
March 24-25 2003

Proceedings Editors

A. McKinlay
M. Repacholi

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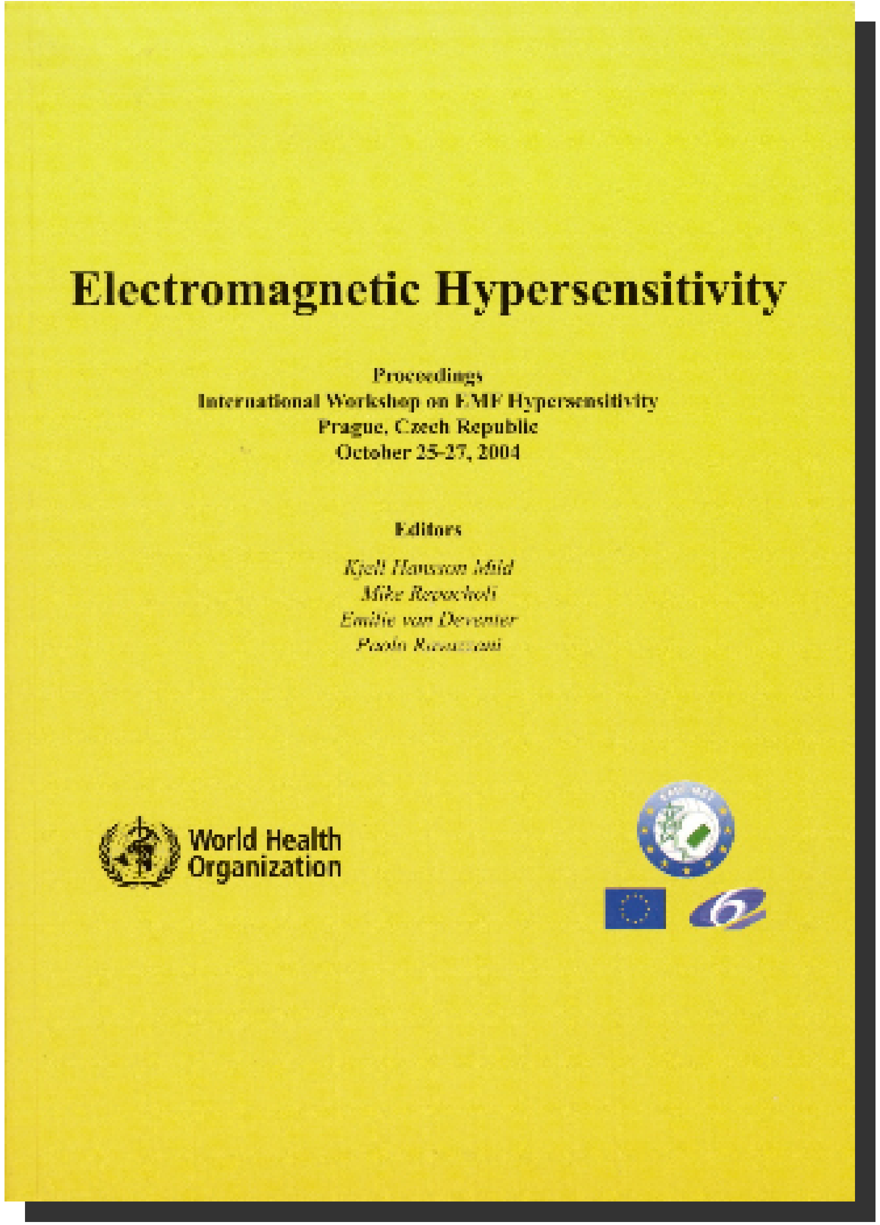


Electromagnetic Hypersensitivity
Proceedings
International Workshop on EMF Hypersensitivity
Prague, Czech Republic
October 25-27, 2004
Editors
Kjell Hansson Mild
Mike Repacholi
Emilie van Deventer
World Health Organization

World Health Organization

Fact sheet N°296
December 2005

Electromagnetic fields and public health
Electromagnetic Hypersensitivity

As societies industrialize and the technological revolution continues, there has been an unprecedented increase in the number and diversity of electromagnetic field (EMF) sources. These sources include video display units (VDUs) associated with computers, mobile phones and their base stations. While these devices have made our life richer, safer and easier, they have been accompanied by concerns about possible health risks due to their EMF emissions.

For some time a number of individuals have reported a variety of health problems that they relate to exposure to EMF. While some individuals report mild symptoms and react by avoiding the fields as best they can, others are so severely affected that they cease work and change their entire lifestyle. This reputed sensitivity to EMF has been generally termed "electromagnetic hypersensitivity" or EHS.

This fact sheet describes what is known about the condition and provides information for helping people with such symptoms. Information provided is based on a WHO Workshop on Electrical Hypersensitivity (Prague, Czech Republic, 2004), an international conference on EMF and non-specific health symptoms (COST244bis, 1998), a European Commission report (Bergqvist and Vogel, 1997) and recent reviews of the literature.

WHAT IS EHS?

EHS is characterized by a variety of non-specific symptoms, which afflicted individuals attribute to exposure to EMF. The symptoms most commonly experienced include dermatological symptoms (redness, tingling, and burning sensations) as well as neurasthenic and vegetative symptoms (fatigue, tiredness, concentration difficulties, dizziness, nausea, heart palpitation, and digestive disturbances). The collection of symptoms is not part of any recognized syndrome.

EHS resembles multiple chemical sensitivities (MCS), another disorder associated with low-level environmental exposures to chemicals. Both EHS and MCS are characterized by a range of non-specific symptoms that lack apparent toxicological or physiological basis or independent verification. A more general term for sensitivity to environmental factors is Idiopathic Environmental Intolerance (IEI), which originated from a workshop convened by the International Program on Chemical Safety (IPCS) of the WHO in 1996 in Berlin. IEI is a descriptor without any implication of chemical etiology, immunological sensitivity or EMF susceptibility. IEI incorporates a number of disorders sharing similar non-specific medically unexplained symptoms that adversely affect people. However since the term EHS is in common usage it will continue to be used here.

PREVALENCE

There is a very wide range of estimates of the prevalence of EHS in the general population. A survey of occupational medical centres estimated the prevalence of EHS to be a few individuals per million in the population. However, a survey of self-help groups yielded much higher estimates. Approximately 10% of reported cases of EHS were considered severe.

World Health Organization

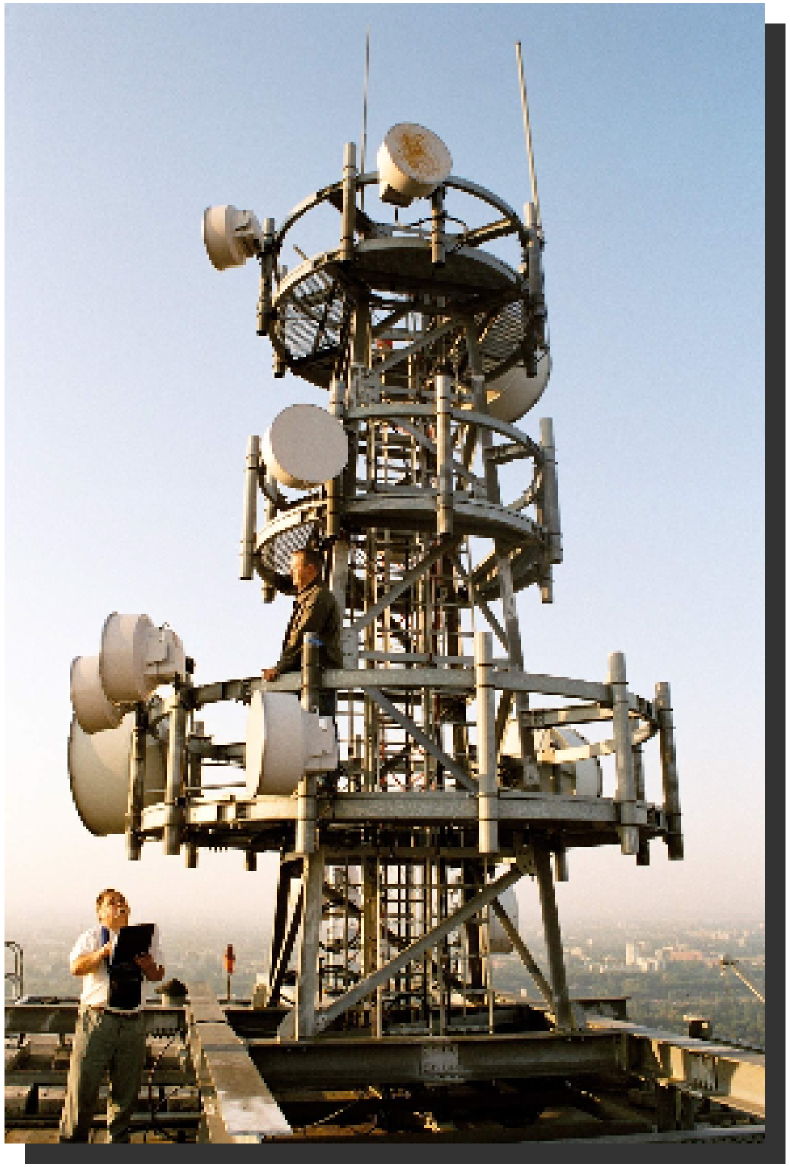
Electromagnetic fields and public health
Base stations and wireless technologies

Health concerns

THE INTERNATIONAL EMF PROJECT

Progress Report
June 2006-2007

World Health Organization



Future?