Danish National Board of Health (Sundhedsstyrelsen)
Finnish Radiation and Nuclear Safety Authority (Säteilyturvakeskus, STUK)
Icelandic Radiation Safety Authority (Geislavarnir Rikisins)
Norwegian Radiation Protection Authority (Statens strålevern)
Swedish Radiation Safety Authority (Strålsäkerhetsmyndigheten)

EXPOSURE OF THE GENERAL PUBLIC TO RADIOFREQUENCY ELECTROMAGNETIC FIELDS

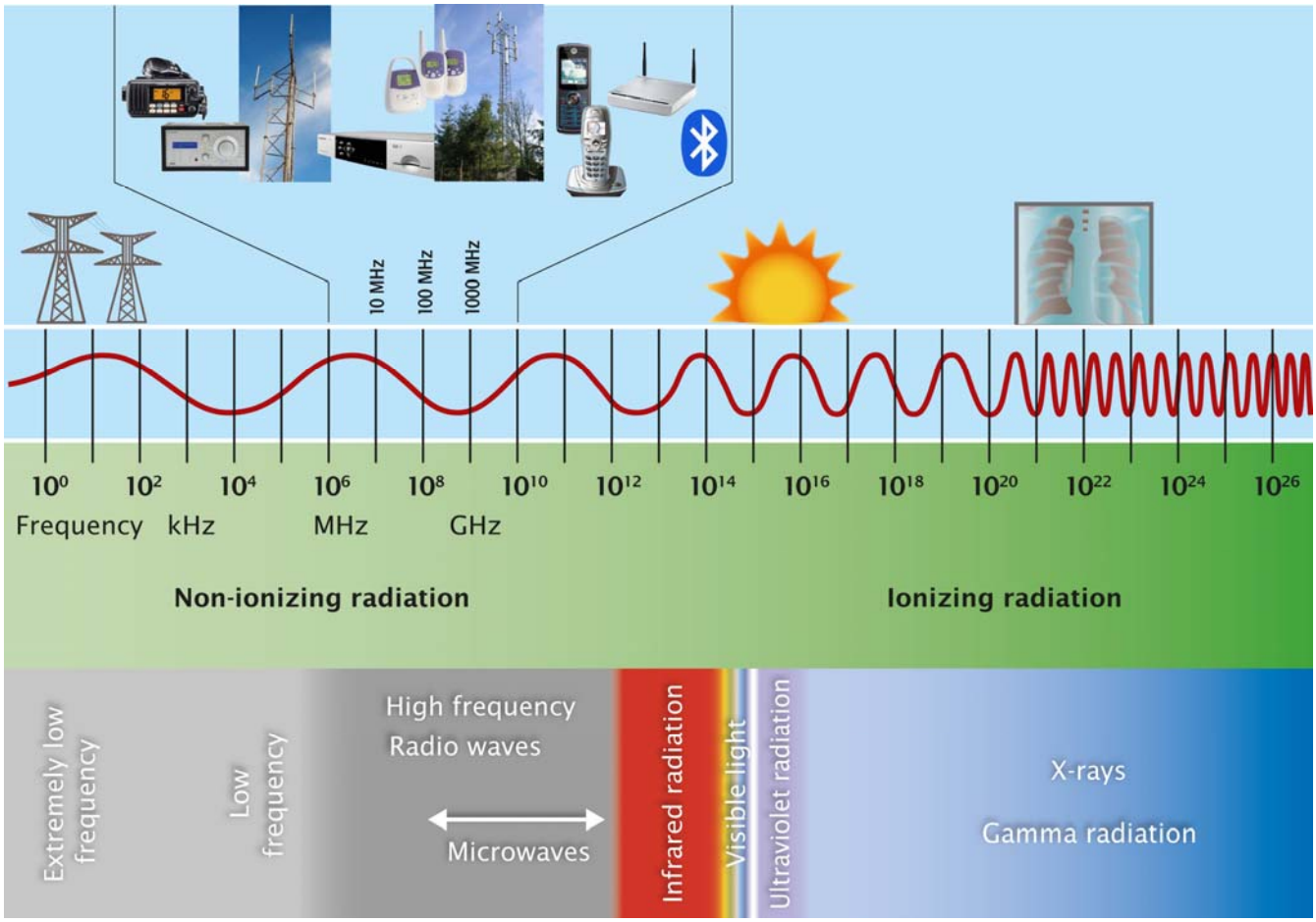
- A joint statement from the Nordic Radiation Safety Authorities -

This statement addresses the exposure of the general public to radiofrequency (RF) radiation emitted continuously by fixed transmitters located in our surroundings. The joint statement regarding mobile phones issued in 2004 is still valid (Mobile Telephony and Health – A common approach for the Nordic competent authorities).

Introduction

The introduction of new sources of electromagnetic fields is fast in the Nordic countries due to technological developments. Radio and TV transmitters have existed throughout the Nordic countries for more than 70 and 50 years, respectively. The first generation (NMT) of mobile telecommunication networks were introduced 30 years ago, the second generation (GSM) came 25 years ago and third generation (UMTS) networks started around 2000 while the public safety radio network has been (or soon will be) started up in the Nordic countries. In addition, cordless telephones have been in use for more than 25 years and wireless networks are used in the home, offices and in public areas. Wireless alarm and baby monitoring systems using radiofrequency signals are also common, as well as wireless personal identification systems. Bluetooth technology has been adopted for use in many pc applications such as the wireless mouse and keyboard, as well as in hands-free devices for mobile phones.

The above are all examples of sources emitting electromagnetic fields in the radiofrequency range from 10 MHz to 2.5 GHz. The exposure of the general public in the Nordic countries due to these sources is well below the international recommendations given by International Commission on Non-Ionizing Radiation Protection (ICNIRP).



The electromagnetic spectrum illustrating typical sources in the high frequency range.

Exposure limits

It is well documented in the global scientific community that exposure to electromagnetic fields above a certain level is harmful. ICNIRP published exposure guidelines in 1998 aimed at preventing such harmful health effects [ICNIRP, 1998]. The ICNIRP guidelines are derived by applying a safety factor of 50 (for general public exposure) to the lowest level of exposure resulting in an observed significant biological effect. All of the well-established adverse health effects from electromagnetic fields are caused by a temperature rise in affected tissues. The ICNIRP guidelines are therefore aimed to prevent adverse tissue heating; compliance with the guidelines for the general public ensures that the maximum temperature increase is a few tenths of one degree centigrade. Recently, the ICNIRP reconfirmed their 1998 guidelines in the radiofrequency area until further notice [ICNIRP, 2009].

Exposure levels

With regard to exposure, there are two different types of sources of radiofrequency radiation; hand-held (or body-worn) and fixed transmitters. The exposure level caused by hand-held sources such as mobile phones can be close to the ICNIRP exposure limits in some cases, though exposure only occurs when the device is in use (e.g. during a phone call). Contrary to this, exposure caused by fixed transmitters is continuous and present everywhere. According to measurements performed in all the Nordic countries, however, exposure of the general public to these background fields is typically far below 1/100th of the exposure limits.

For further information about exposure sources and field strengths in normal living environments, see annex ‘Exposure of the general public to radio frequency fields’.

Electromagnetic hypersensitivity (EHS)

Issues regarding reported cases of electromagnetic hypersensitivity (EHS) are complex and not easily addressed. According to the World Health Organisation (WHO) there is no scientific basis to link EHS symptoms to exposure to an electromagnetic field [WHO, 2005]. Therefore, the Nordic radiation safety authorities regard EHS as a medical issue, which needs to be dealt with by health authorities, rather than as a radiation safety issue. The symptoms related to EHS can be real and severe for sufferers, however, and hence it is important to continue studies aimed at achieving a better understanding of the causes of EHS.

Conclusion

The Nordic authorities agree that there is no scientific evidence for adverse health effects caused by radiofrequency field strengths in the normal living environment at present. This conclusion concurs with the opinion of international scientific and advisory bodies listed as references below [ICNIRP, 1998 and 2009; WHO, 2005 and 2006; SCENIHR 2009; SSI`s Independent Expert Group on Electromagnetic Fields, 2007]. The Nordic authorities therefore at present see no need for a common recommendation for further actions to reduce these radiofrequency fields.

It is important to note, however, that many of the technologies which use radiofrequency electromagnetic fields have only been prevalent for less than two decades. It is therefore important to continue active research on the possible health effects of radiofrequency radiation and reappraisal of the scientific literature concerning this issue. It is also important to follow developments in exposure from different sources and the possible health consequences from such development.

The Nordic authorities wish to emphasize the fact that to reduce the total exposure received by the general public from wireless communication systems, it is necessary to carry out integrated planning that takes into account radiation emitted both from fixed antennas and hand-held devices such as mobile phones. Furthermore, in terms of overall public exposure, mobile phones are a much more significant source of radiofrequency radiation than fixed antennas. If the number of fixed antennas is reduced, mobile phones will need to use higher power to maintain their connection, thereby the exposure of the general public may increase.

For further information about this and possible actions to reduce exposure from mobile phones and other devices, see the web-pages of the national authorities listed below.

References

Mobile Telephony and Health – A common approach for the Nordic competent authorities (Available at http://www.nrpa.no/archive/Internett/div_dokument/IIS/NordicMobile.pdf)

ICNIRP. 1998. Guidelines for limiting exposure to time-varying electric, magnetic, and electromagnetic fields (up to 300 GHz). Health Phys 74:494–522. (Available at http://www.icnirp.de/documents/emfgdl.pdf)

ICNIRP. 2009. ICNIRP Statement on the “Guidelines for Limiting Exposure to Time-Varying Electric, Magnetic, and Electromagnetic Fields (up to 300 GHz)”. Health Phys 97:257–258. (Available at http://www.icnirp.de/documents/StatementEMF.pdf)

World Health Organization (WHO). 2005. Fact sheet 296: Electromagnetic fields and public health - Electromagnetic Hypersensitivity. (Available at http://www.who.int/mediacentre/factsheets/fs296/en/index.html)

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SCENHIR (The European Commission Scientific Committee on Emerging and Newly Identified Health Risks) 2009. Health effects of exposure to EMF, European commission 2009. (Available at http://ec.europa.eu/health/ph_risk/committees/04_scenihr/docs/scenihr_o_022.pdf)

SSI`s independent expert group on Electromagnetic fields. 2007. (Statens strålskyddsinstitut) SSI Rapport 2008:12. Recent Research on EMF and Health Risks. Fifth Annual Report from SSI`s independent expert group on Electromagnetic fields. (Available at http://www.stralsakerhetsmyndigheten.se/Publikationer/Rapport/Stralskydd/2008/200812/)

Further reading:

www.ssm.se

www.stralevernet.no

www.sis.dk
www.gr.is
www.stuk.fi

ANNEX:

Exposure of the general public to radiofrequency fields

1. Introduction

This document presents typical exposure of the general public to radiofrequency (RF) radiation in every-day situations. The lists of RF source technologies/devices (see Table 1 & 2) and exposure scenarios are not complete since there are many applications that can emit radiofrequencies and new sources appear regularly. It is however unlikely, due to general rules governing the design of radio systems, that any new technology will cause significantly higher exposures to the general public in the foreseeable future than the examples introduced here.

Table 1. An overview of the properties of commonly used RF emitting devices that are used close to the individual. The general public's exposure limit for local specific absorption rate (SAR[*]) for the head and trunk regions is 2 W/kg. The limit for occupational exposure (e.g. police radio) is 10 W/kg. The given values are for maximum exposure i.e. direct contact between RF transmitter and affected tissue.

Technology	Related acronyms	Frequency (MHz)	Maximum (time averaged) output power (mW)	Maximum SAR (W/kg)
Mobile phones	GSM 900	900	250	1.4
	GSM 1800 (formerly DCS 1800)	1800	125	1
	UMTS (also 3G)	1950	125	1
Wireless internet terminals of the computers (For base stations, see Table 2)	WLAN (also WiFi)	2450	100	1
	3G	1950[†]	125	1
	WiMAX	3500	160	1
	Flash-OFDM (@450 in Finland)	450	200	0.5
Cordless phones	DECT	1900	10	<0.1
Cordless mouses and keyboards	Bluetooth	2450	1 or 2.5	<0.01
Cordless hands free sets	Bluetooth	2450	1 or 2.5	<0.01
Baby monitors	PMR446	446	500	0.4
	DECT	1900	10	0.03
	+ others	27 (typical)	10	<0.01
Professional mobile radio (police etc.)	TETRA	400	250 (750 also)	1 (3)

[*] Specific absorption rate (SAR) is a measure of the rate at which energy is absorbed by the body when exposed to a radiofrequency electromagnetic field. It is defined as the power absorbed per mass of tissue and has units of watts per kilogram. SAR is usually averaged either over the whole body, or over a smaller sample volume. Recommended exposure limits are set by the International Commission Non-Ionizing Radiation Protection (ICNIRP).

[†] also other mobile phone bands, if 3G not available

2. Exposure sources

The exposure to an individual caused by any single RF source is strongly dependent on the distance between the source and the individual, the source output power and duration of RF transmission. Therefore, regarding exposure there are two main types of devices; small devices used close to the individual (hand-held and/or body-worn) and fixed transmitters. Exposure caused by devices used close to the individual is localised and usually occasional, since RF transmission shuts down while not in use, though exposure to RF can be near the ICNIRP exposure limits when such devices are in use. Fixed transmitters often use high output powers and typically transmit RF continuously. Recommended exposure limits can therefore be exceeded in close proximity to such sources. Fixed transmitters are, however, usually installed in places where the general public does not have access, such that the typical exposure caused by fixed transmitters is very low. Table 1 and 2 list some properties of the most common RF technologies in use.

Table 2. An overview of commonly used fixed radio transmitters including information regarding frequency and output power

Technology	Related acronyms	Frequency range (MHz)	Typical output power	Typical power density mW/m^2
Mobile phone base stations	GSM 900	900	20 W	< 0.1
	GSM 1800 (former DCS 1800)	1800		< 0.1
	UMTS (also 3G)	2150		< 0.1
TV broadcasts (digital)	DVB-T	500 - 900	15 kW	< 0.01
Voice radio broadcasts	VHF, FM-radio	87-108	50 kW	< 0.001
Wireless internet connections (base stations)	WLAN (also WiFi)	2450	100 mW	
	3G ♠			
	WiMAX	3500	1 W	
	Flash-OFDM (@450 in Finland)	450	up to 20 W	
Cordless phone (fixed part)	DECT	1900	10 mW (single phone system)	
Professional mobile radio (police etc.)	TETRA	400	up to 100 W	

♠ 3G is based on regular mobile phone base stations (see above)

2.1 Handheld and body worn devices

The highest output powers of hand-held/ body worn devices (e.g., mobile phones, laptops incorporating a WLAN card or other wireless network adapter) are typically in the 100–500 mW range. The output power is therefore relatively low, though a large fraction can be absorbed by the user leading to exposures of the same order of magnitude as recommended exposure limits for localised exposure to the general public (*SAR* limit of 2 W/kg). However, average whole-body exposures will always be small due to the low output power of such devices. In addition, such devices are typically used only

occasionally and transmit RF only when the device is communicating. Moreover, some devices such as mobile phones automatically decrease output power if possible i.e., in areas where reception is good. Hence, typical exposure from these devices is lower than the theoretical maximum; 0.1-0.5 and <0.01 of maximum values for GSM and 3G, respectively. Exposure caused by small-range devices (e.g., cordless DECT phones, Bluetooth devices etc.) is typically only a few percent of exposure limits.

Exposure to RF caused by a small-size low power transmitter generally decreases rapidly with increasing distance from the source. A 30 cm gap between the receiving body and the transmitter typically decreases exposure by a factor 100 when compared to direct contact exposure. Therefore, exposure concerns mainly the user of the device. The individual exposure from such sources is reduced by increasing the distance between user and device. This can be easily done by e.g., using hands-free for voice calls and/or placing baby monitors, WLAN terminals etc such that they are not touching the individual.

2.2. Fixed transmitters

Numerous technologies utilise fixed RF transmitters. Signals from WLAN, WiMAX and mobile phone networks are transmitted by base stations, while TV and voice radio broadcasts are sent via fixed transmitter antennas in high masts. Transmission powers in these devices range from milliwatt (mW) to kilowatts (kW).

The antennas transmitting at the highest power levels (kilowatt-range) are the mast-mounted TV and VHF voice radio transmitters. Power densities measured at ground level are low, however, since the antennas are mounted 100–300 m above ground. The main RF transmission beam is targeted towards the horizon; hence virtually all the RF power surpass people living in the vicinity of the mast (see Fig. 1). Measurements performed around typical broadcasting masts have shown that the field strengths depend more on the terrain (by factor 1000) than on the distance from the source. The highest measured values in a normal living environment have been approximately 0.1 mW/m^2, according to measurements in the Nordic countries, though more typical values are between 0.0001 – 0.001 mW/m^2. The introduction of digital TV broadcasting appears to have decreased overall exposure, due to a lower transmission power being necessary for a single TV program. However, the number of TV channels will increase and presumably all former frequencies of analogous TV will be utilised again for digital broadcasts at some time in the future leading to background RF fields being in the same order of magnitude as before the digitalisation.

Fig.1. Radiowaves from mast-mounted antennas surpasses the people living in the vicinity of the mast.

The largest mobile phone base-stations transmit at approximately 100 W (rms*) and they are also mounted on masts. Lower power levels are used in the antennas that are mounted on roof tops/ building walls (typically 1-20 W). The main transmission RF beams are narrow in the vertical cross-section and targeted towards the horizon or some degrees below it. Hence, they are not transmitting directly towards people living underneath or in the vicinity of the source (as in Fig. 1). Contractors are instructed to install base-stations in places inaccessible from e.g., ventilation windows or balconies. Moreover, high power RF antennas should not be pointed directly towards any neighbouring house, even though the safety distance in the main beam is only a few meters. If these precaution measures are followed, the exposure to the general public caused by such base-stations is very low. Measurements have been conducted in upper floor apartments with base-station antenna either directly above or on the roof of a neighbouring house: typical power densities have been 0.1–10 mW/m^2 with measured maximums in individual cases up to 50–250 mW/m^2. Measured outdoor power densities at street level have been lower, typically well below 0.1 mW/m^2. The reference value given in ICNIRP recommendation is 4 500–10 000 mW/m^2, depending on the frequency.

The TV- and radio broadcasts as well as GSM base-station networks cover most areas of the Nordic countries. According to measurement campaigns, these technologies produce the highest background RF fields in the environment. However, measured values are still typically only 1/10000–1/1000 of the reference levels for power density given in the ICNIRP exposure limits. Many other technologies, such as TETRA base-stations might cause power densities that are in order of magnitude of 1/10000 of the reference levels, but only present in the proximity of such source. As the exposure level decreases rapidly with increasing distance from the source, the exposure caused by small transmitters, such as WLAN base stations, falls below the GSM base-station level if the distance is approximately more than a meter, such that peoples overall exposure does not increase.

The rapid decrease in exposure from RF with increasing distance from the source also leads to the fact that exposure from multiple sources seldom increases the overall exposure when compared to exposure from one or two nearby sources. Moreover, old technologies such as AM-radio or analogous TV broadcasts have been replaced by technologies capable of significantly more efficient use of the radio spectrum. Therefore, the fast development of technologies utilising radio waves has not lead to a similar fast increase of the exposure of the general public; indeed, according to a Swedish measurement campaign the “background” RF field level has remained the same in the period 2001-2007.

In addition to the radio transmitters mentioned here, there exist a large number of short range devices, such as RFID (radio frequency identification) electronic article surveillance gates in e.g. libraries, car keys, wireless thermometers and alarm systems in shops. The power output of these devices is small and hence the additional exposure is expected to be very low. Various high power applications such as radars and satellite links also exist, though according to measurement campaigns and risk assessment studies (e.g. Mulige helseeffekter av yrkesmessig strålingseksponering fra radar, 2007; Riks-Radiumhospitalet HF 05.07)) these do not cause significant exposure to the general public under normal conditions.

More information about background RF fields and exposure of the general public is available on the internet sites of the Nordic radiation safety authorities. The data presented in this document is mainly based on the results of a Swedish background field measurement campaign (reported in SSI rapport 2008:13) and a Finnish study (reported in STUK-TR 5 2008 in Finnish). Both reports are available on the web.

* Root mean square