

RF safety at base station sites



**Mobile Manufacturers
Forum**



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1 PURPOSE AND SCOPE

This document gives practical guidance for personnel working at base station and antenna sites on how to take exposure to radio frequency (RF) electromagnetic fields (EMFs) into account in order to make sure applicable exposure guidelines are not exceeded. It is primarily directed at RF workers but some content will be relevant to other workers (for example, rooftop workers) who may have reason to come close to transmitting equipment.

This document is not intended to replace existing company procedures or regulatory requirements for RF workers, which should always take precedence. This document may be used to develop such procedures or requirements.

This guidance should be integrated into the overall management of health and safety at base station sites as part of a risk assessment approach.

For general information on the topic of EMF safety you can browse the website for the “International EMF Project” published by the World Health Organization (WHO, www.who.int/peh-emf).

2 INTRODUCTION

Wireless communication is based on radio wave propagation, similar to other commonly known forms of radio communication such as broadcast radio and television. These systems operate in designated frequency bands within the electromagnetic spectrum and health effects have been extensively studied for over 50 years. The international scientific committee ICNIRP (International Commission on Non-Ionizing Radiation Protection) has set guidelines for human exposure to EMF [1]. The guidelines include a substantial safety margin to assure that no adverse health effects are experienced when EMF levels are within the established limits.

This document gives generic safety instructions which ensure, when followed that the worker's exposure to RF fields will be within the applicable safety limit. Where local guidelines already exist they should be followed.

Other workers, such as building maintenance personnel, may also need to access areas near transmitting equipment. In many cases these persons would be regarded as members of the public for RF safety purposes. Clear procedures should be in place for such workers.

Before entering a base station or antenna site, personnel must acquaint themselves with the up-to-date technical and safety information provided by their employer, the site management company, and any relevant local safety requirement. A risk assessment approach should be applied looking at all risks at the site. As far as EMF is concerned, due regard shall be taken to consider all RF sources in the immediate vicinity of the work location and access routes.

More information on EMF and health can be found on the Mobile Manufacturers Forum website (www.mmfa.org) and that of the GSM Association (www.gsmworld.com/health/).

3 BASIC INFORMATION

3.1 EMF limits for workers and the general public

Most countries have adopted the limits developed by ICNIRP which include safety margins designed to assure protection for EMF workers and the general public. The level of absorption is expressed as SAR (Specific Absorption Rate) with the unit W/kg (watts/kilogram of body tissue).

Exposure guideline limits for EMF workers are higher than for the general public because workers are adults who are generally exposed under known conditions and are trained to be aware of potential risk and to take appropriate precautions. Sufficient information or warning signs should be provided to ensure that other workers who have not received specific EMF training can take measures to avoid exposure above the relevant limit. Anyone who is not at work would be regarded as a member of the public and the public exposure guideline limits apply.

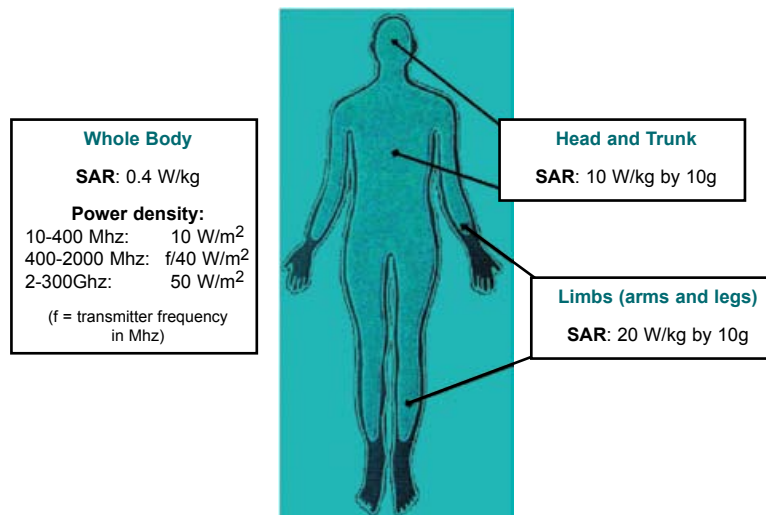
In the frequency range from 10 MHz to 10 GHz, the EMF limits are expressed as SAR values, see 3.1.1 below. For practical assessments, e.g., using the field monitors described in section 3.5, ICNIRP also specifies frequency dependent reference levels, expressed as power density (S), electric field strength (E) and magnetic field strength (H). The reference levels can be used to show compliance with SAR limits but exceeding the reference levels does not necessarily mean that the SAR limits are exceeded. Reference levels for power density are shown in section 3.1.2.

3.1.1 SAR limits

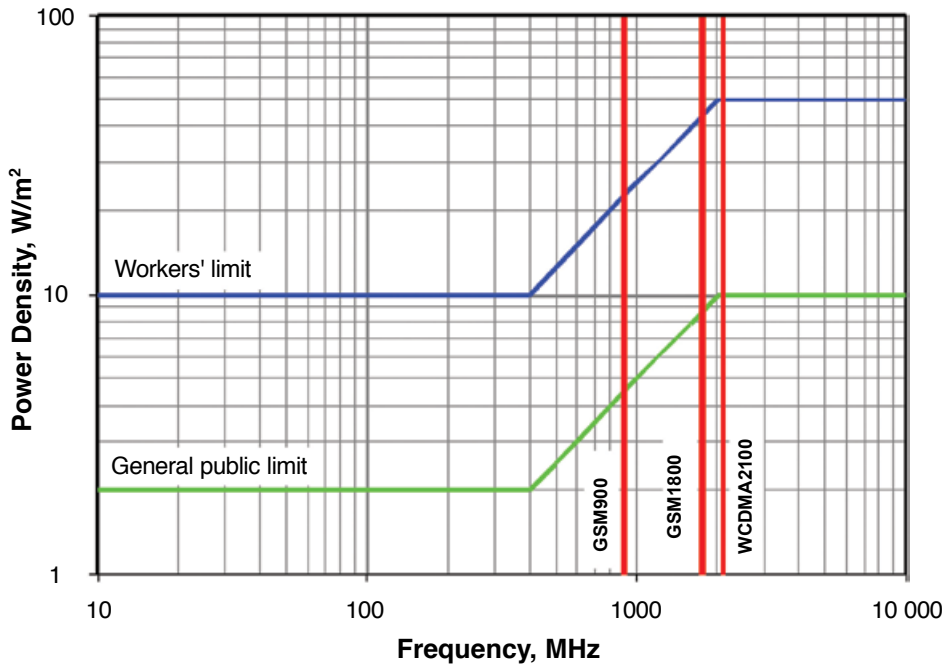
Exposure Characteristics	ICNIRP limits		
	Whole Body Averaged SAR	Local SAR Averaged over 10 g of tissue	
Workers' exposure limits	0.4 W/kg	10 W/kg	20 W/kg
General Public exposure limits	0.08 W/kg	2 W/kg	4 W/kg

Note: These limits apply to exposure averaged over a 6 minute period

ICNIRP Exposure Limits for Workers

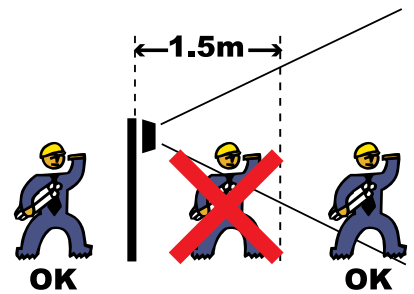


3.1.2 Power Density Limits



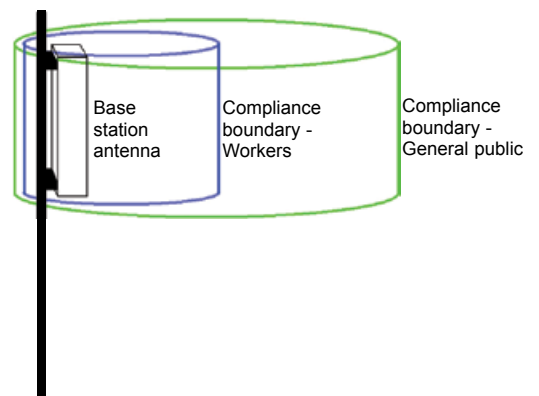
3.2 Compliance distance

In principle, RF levels decrease rapidly when a person moves further away from the source, e.g., a transmitting antenna. For each antenna, the RF level can be calculated based on its electrical characteristics or measured. The distance at which the RF level is always below the RF limit is called the compliance distance. The compliance distance may be based on the reference levels or an SAR evaluation, in either case it incorporates a substantial safety margin. The figure shows an example of a sign used to inform about the compliance distance for RF workers.



3.3 Compliance boundary / exclusion zone

It is also possible to determine a three dimensional (3D) compliance boundary around an antenna. The region inside the compliance boundary is often called the exclusion zone.



The advantage of defining a compliance boundary is that it specifies the compliance distance in all directions. Usually base station antennas are highly directional and therefore the RF level behind the antenna is much smaller than in front of it.

3.4 Averaging time

The ICNIRP guidelines specify an averaging time of 6 minutes for determining the exposure level. Therefore, an RF level exceeding the reference level for a short period does not necessarily mean that the RF limit has been exceeded.

In practice, this means that even if people walk through a compliance boundary zone, they are unlikely to be subject to overexposure. However, the averaging time should only be used with expert advice.

3.5 Field monitor

A field monitor is a device which can measure the instantaneous value of EMF level in real time and over a broad frequency range; the measured value can then be compared to the *reference levels* defined in the ICNIRP guidelines. There are several different models available on the market and these can be categorized into two different types, namely body-worn and hand-held.



Body-worn field monitors allow for hands-free operation and offer continuous monitoring capability. The human body may shadow the monitor from transmissions in

certain directions. For an appropriate reading, the path between the antenna and the monitor must be unobstructed. At times it may be necessary to turn around to obtain the proper reading from a body-worn field monitor. These monitors typically have LED indicators showing fractions of limits, and typically do not provide numerical values of the EMF levels. Due to the measurement tolerances of these devices it is not advisable to use them at the 100% level.



Hand-held field monitors allow for measurement without the shadowing associated with the body-worn type. The measurement accuracy is normally higher with a hand-held monitor than with a body-worn monitor. Hand-held monitors typically give numerical values of the EMF levels.

Most field monitors provide an audible and/or vibration alarm which can usually be set to some fraction of the safety limit. Some hand-held types do not have this alarm function and the result must be read from the display.



When using field monitors to assure compliance to EMF limits, workers must be trained accordingly and the monitors used as recommended by the manufacturer.

4 SAFE WORKING PRACTICES AT A BASE STATION SITE OR ANTENNA SITE

All areas at a base station site or at an antenna site (which is where the antenna is mounted) that meet the EMF limits for the general public are, by definition, safe for workers. When it is necessary to access areas closer to transmitting antennas, there are two alternative safe working practices. These are based on either the knowledge or designation of compliance boundaries or on the use of a field monitor.

4.1 Safety distance / compliance boundary

Prior to arrival or before approaching transmitting antennas at a base station site, the worker must be acquainted with the safety information for all transmitting installations at the site, e.g., compliance boundaries and the locations of the antennas.

When arriving at a base station or antenna site, all transmitting antennas at the site must be identified. If the safety information is not known for every antenna or for the complete installation, the missing information should be requested from the company responsible for the base station or antenna site management.

Alternatively, in some countries safety distances of transmitting antennas are clearly labeled at the antenna.

When the worker has verified that the compliance boundary information is complete, he/she can enter the base station or antenna site.

Without complete compliance boundary information, the worker must either leave the site or use a field monitor to establish the safe working area.

4.2 Field monitor

When complete compliance boundary information is not available, a field monitor must be used during a site visit. It is important that the field monitor cover the frequency range of the radio services at the site.

Manufacturer's instructions supplied with a field monitor must be fully understood prior to use of the field monitor, and followed at all times during the site visit. This is particularly true for body-worn field monitors that may be shadowed by the body in certain directions and have a larger tolerance on the accuracy of field measurements.

Whenever a field monitor gives an alarm, or indicates a value exceeding the applicable threshold, the worker must move away from the transmitting antenna and avoid entering any areas where the exposure limit could be exceeded.

It should be noted that RF levels from base station antennas vary in time for several reasons, e.g., the number of calls routed through the base station. The RF levels from antennas for other services may not vary or may vary in quite different patterns. Therefore, the field must be constantly monitored, unless the measured levels are significantly below the limits (for example, more than 10 times) at the location of work.

4.3 Shut-down procedures

If it is necessary to work within the compliance boundary, the worker must use appropriate precautions, which may include switching off RF transmissions from several or all antennas. If none of the practice detailed above can assure compliance to the RF limits, procedures must be used to limit RF exposure so that compliance is assured, or the transmitting antenna must be shut-down.

In some cases, the network operator may need advance notice before allowing a base station or antenna to be switched off. All this should be taken into account when planning a work schedule. On the other hand, contact information of the antenna operator must always be available to workers.

A field monitor is also useful in confirming that a power down has been completed and that the antenna is not radiating RF fields.

4.4 Cabling and waveguides

Defective cabling and connectors can be unwanted sources of RF exposures. Damaged cabling and incorrectly tightened connectors can leak RF energy, which may lead to excessive levels in their immediate vicinity. Never disconnect RF cables or connectors associated with a transmitter in operation since this may result in an RF burn through direct contact with RF conductors.

In addition to RF cabling, some base stations may have fiber-optic distribution systems. Workers shall follow the specific rules dealing with optical emissions.

Other radio transmitters may use waveguides. Workers should avoid putting their eyes near unterminated or damaged waveguides.

4.5 Suspected over-exposures

A suspected over-exposure should be referred to management to determine what investigations are needed. Work practices may also be reviewed. In many cases, even if a worker was within the exclusion zone, they will not have been over-exposed according to the basic restrictions. The vast majority of over-exposures result in no symptoms at all because of the large safety margin in the standards but workers may require reassurance. Where symptoms are present, treatment should be the same as for similar injuries from any other cause.

5 MEDICAL IMPLANTS

A worker with an active medical implant (for example, a cardiac pacemaker) or a personal active medical device, should be directed to management to determine what sort of specific arrangements can be made in order to comply with any safety requirements. Without further analysis, personnel with active medical devices should not enter areas above general public limits.

6 HOW TO RECOGNISE POTENTIALLY NON-COMPLIANT AREAS ON A BASE STATION OR ANTENNA SITE

In order to recognize areas in which safety limits could be exceeded, the worker should immediately on arrival at a base station or antenna site, check for the following:

- any signs, notices, labels, etc.
- types of antennas used
- site safety instructions

6.1 Signs, notices, labels, etc.

This triangular sign indicates active/transmitting RF equipment. Often this sign will be accompanied by instructions or warnings which must be followed.

Any other instruction/warning sign must also be followed at all times.

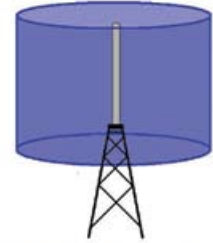


6.2 Types of antennas used for cellular networks

The following typical types of antenna are commonly found at base station or antenna sites. In each case, a photo is given of the antenna(s) as well as a sketch indicating the shape of the compliance boundary (shown in blue). Please note that while the locations described refer to areas directly inline with the antenna, the exclusion zone / compliance boundary in other locations (e.g. above, below, behind) may, though small (in the range of several centimeters), exist.

6.2.1 Omni-directional coverage

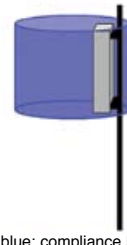
These antennas radiate RF energy equally in all directions in the horizontal plane. The antenna input power is typically 10 – 80 watts, and the compliance boundary for a worker typically extends 0.1 – 1.5 meters from the antenna.



(shown in blue: compliance boundary - workers)

6.2.2 Sector coverage

These antennas restrict most of their radiated RF energy to a narrow angular sector in their forward direction (typically 60 to 120 degrees in the horizontal plane, typically 8 to 14 degrees in the vertical plane). The photograph shows 2 sector antennas, one mounted above the other. The antenna input power is typically 10 – 80 watts, and the compliance boundary for a worker extends typically 0.2 – 3 meters from the front face of the antenna.

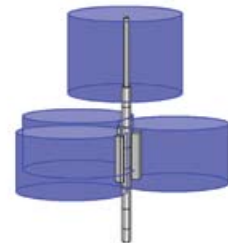


(shown in blue: compliance boundary - workers)

6.2.3 Antenna farms (or clusters)

Antennas are often grouped together on masts. The combination illustrated here is that of an omni-directional antenna mounted above a cluster of 3 sector antennas.

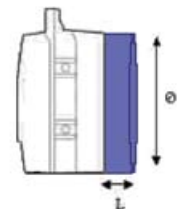
In the case that multiple antennas are present on a site, whenever an additional antenna is installed, the compliance boundary of each antenna should be evaluated again, taking into account the additional exposure of the newly installed antenna.



(shown in blue: compliance boundary - workers)

6.2.4 Radio relay (also known as fixed point-to-point link)

These antennas concentrate their RF energy into a narrow beam in the forward direction e.g., parabolic dish antennas. Since the power levels are typically low, less than 1 watt, the safety distances in this forward direction (L) are often small (in centimeters) and in many cases there is no need of any safety distance for occupational exposure. Areas above, below and to the sides of the antenna, as well as the area behind the antenna, are normally safe at even shorter distances. Thus, the compliance boundary has the shape of the antenna with the diameter D and the length L in the forward direction. However, workers should never step in front of these antennas because it will interrupt radio link.



(shown in blue: compliance boundary - workers)

6.2.5 Accessible areas in which RF limits are not exceeded

Outdoor base station site:

Areas which are intended to be accessed by the general public will not exceed the RF limits for either the general public or workers. For example, at outdoor base station sites as illustrated in the photo on the right, the RF limits will not be exceeded at ground level for either the general public or workers.

If there is a need to climb the mast, the instructions given in Section 4 above (Safe working practices at a base station site) have to be followed.

Indoor base stations and antennas:

Indoor base stations and antennas typically transmit at very low output power levels (less than 1 watt) and the corresponding compliance boundary typically extends a few centimeters or less. It is possible to work close to the operating antenna without exceeding the safety limits. RF exposure information is provided with the product.



7 REFERENCE

International Commission on Non-Ionising Radiation Protection: "Guidelines for Limiting Exposure to Time-varying Electric, Magnetic and Electromagnetic Fields (up to 300 GHz)." Health Physics, April 1998, vol. 74, number 4, pp. 494-522.

World Health Organisation, Fact Sheet N°304 "Base Stations and Wireless Networks" (May 2006), www.who.int/peh-emf/publications/facts/factsheets/en/index.html

Product standard to demonstrate the compliance of radio base stations and fixed terminal stations for wireless telecommunication systems with the basic restrictions or the reference levels related to human exposure to radio frequency electromagnetic fields (110 MHz - 40 GHz) – Occupational, EN 50384:2002.

IEEE Recommended Practice for Radio Frequency Safety Programs, 3 kHz to 300 GHz, C95.7-2005, 2006.

Fixed radio transmitter sites; Exposure to non-ionising electromagnetic fields; Guidelines for working conditions, ETSI Technical Report 101 870 V1.1.1, November 2001.

DISCLAIMER

Where reference is made to a company, or a specific commercial product or service howsoever referred, no endorsement or recommendation is implied or intended.



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The Mobile Manufacturers Forum is an international association of radio communications equipment manufacturers.

For more information, please visit the MMF's website at www.mmfai.org.

Diamant Building
Boulevard Auguste Reyers 80
1030 Brussels Belgium
Tel: + 32 2 706 8567
Fax: + 32 2 706 8569

Av. Paulista, 2300 – Piso Pilotis
CEP 01310-300 São Paulo/SP Brazil
Tel: +55 11 6847-4610
Fax: +55 11 6847-4550

15th Floor, 100 Queen's Road Central,
Central, Hong Kong
Tel: +852 3180 9375
Fax: +852 3180 9399



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1st Floor, Mid City Place, 71 High
Holborn, London, WC1V 6EA, UK
Tel: +44 20 7759 2300
Fax: +44 20 7759 2301

400 Northpark, 1000 Abernathy Road,
Suite 450, Atlanta, GA 30328, USA
Tel: +1 678 281 6600
Fax: +1 678 281 6601

