TECHNICAL STANDARD ON RF EMISSION CONTROL OF CELLULAR RADIO SITES

MTSFB 004 : 2005 Revision 1

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Committee representation

The Working Committee for the RF emission control of mobile radio cellular sites named as the Wireless Industry Emission Working Group comprises representatives from the following Telecommunication Service Provider and Manufacturer Associations.

Celcom Malaysia Berhad
DiGi Telecommunications Sdn Bhd
MAXIS Communications Sdn Bhd
Rohde & Schwarz Malaysia Sdn. Bhd.

FOREWORD

This “Technical Standards (TS)” is a recommendation by the Wireless Industry Emission Working Group (WIEWG) to MCMC as a guideline to administer the RF emission levels of cellular radio sites with respect to the general public and workers.

This TS is intended as a reference for Network Service Providers (NSP), Network Facilities Provider (NFP), property owners, general public, government authorities and other concerned parties for the control of RF emissions of cellular radio sites.

The implementation of the recommendations in this document is applicable for new sites and later the existing sites will be covered in stages.

Other forms of radio transmission equipment such as broadcasting (TV, Radio), paging, wireless broadband access, 3G, etc. will be reviewed and reflected in this TSRFEC at a later stage.

TECHNICAL STANDARD ON RF EMISSION CONTROL OF CELLULAR RADIO SITES

1. Scope

This Technical Standard termed as Technical Standard on RF Emission Control of Cellular Radio Sites (TSRFEC), is a guideline for the network service provider and network facilities provider in ensuring that the RF levels emitted are within safe levels during operations of cellular radio sites.

The standard defines the following guidelines and recommendations:

a) Permissible RF levels and the associated exclusion zones for general public and workers.

b) Warning signs type and placement for general public and workers.

c) Guidelines on the administration of RF emission of cellular sites for the network operator.

d) Permissible SAR (Specific Absorption Rate) limits for transmitting devices.

The current scope of this document covers the RF emission of cellular radio sites for GSM 900, GSM 1800, ETACS, AMPS/D-AMPS and 3G technologies.

2. Reference documents

The following reference documents contain provisions, which through reference in this text constitute provision of this Technical Standard. For dated references, where there are subsequent amendments to, or revisions of, any of these publications of the Technical Standard shall be amended or revised accordingly.

This standard is based on the following references:

a) Regulatory Framework on the Sharing of Telecommunications Infrastructure (ISSN 15511 – 2829) – Reg-R002 published by Jabatan Telekom Malaysia (JTM).

b) Guidelines for Limiting Exposure to Time-Varying Electric, Magnetic, and Electromagnetic Fields (up to 300 GHz), 1998 published by International Commission on Non-Ionizing Radiation Protection (ICNIRP).

c) Malaysia Institute for Nuclear Technology Research (MINT) Radio Frequency and Microwave Radiation Safety Assessments of Radio Stations - report number UPP/BPK/NIR2004 (09).

d) MINT Radio Frequency and Microwave Radiation Safety Assessments of Radio Stations – report numbers UPP/2001/03/15(7), UPP/2002/03/15(5), UPP/2002/03/15(8), UPP/2002/03/15(9), UPP/BPK/NIR/2004 (10).

e) Specification for Safety Signs and Colours – SIRIM – MS 981:1985.

f) Communications and Multimedia Act 1998 (Act 588) & Regulations and Malaysian Communications and Multimedia commission Act 1998 (act 589) as at 1st November 2003.

g) Occupational Safety and Health Act 1994 - Department of Occupational Safety and Health (DOSH), Ministry of Human Resources Malaysia.

h) IEEE Standard for Safety Levels with Respect to Human Exposure to Radiofrequency Electromagnetic Fields, 3 kHz to 300GHz, IEEE C95.3-1991/ANSI.

i) World Health Organization: Electromagnetic Fields and Public Health, Fact Sheet No. 193, May 1998.

j) Limits of Human Exposure to Radiofrequency Electromagnetic Fields in the Frequency Range from 3 kHz to 300 GHz, Safety Code 6, Canada.

k) IEC 62209 Part I, Procedure to Measure the Specific Absorption Rate (SAR) in the Frequency Range 300MHz to 3GHz: Hand Held Mobile Wireless Devices.

l) ES59005 October 1998 - Considerations for the evaluation of human exposure to Electromagnetic Fields (EMFs) from Mobile Telecommunication Equipment (MTE) in the frequency range 30 MHz - 6 GHz.

3. Definitions

For the purposes of this TSRFEC, the following definitions apply.

Cellular Site	:	In wireless telephony, a cell is the geographical area covered by a cellular telephone transmitter. The transmitter facility itself is called the cell site. The cell provided by a cell site can be from a few meters to a couple of kilometers in diameter, depending on terrain and transmission power.
Cellular Radio	:	The transmitter facility that is installed in the cell site.
Electrical Field	:	In physics, an electric field or E-field is an effect produced by an electric charge that exerts a force on charged objects in its vicinity. The units of the electric field are newtons per coulomb or volts per meter (both are equivalent). Electric fields are composed of photons and contain electrical energy with energy density proportional to the square of the field intensity. In the static case, an electric field is composed of virtual photons being exchanged by the charged particle(s) creating the field. In the dynamic case the electric field is accompanied by a magnetic field, by a flow of energy, and by real photons.
Electromagnetic Field	:	An electromagnetic field, sometimes referred to as an EM field, is generated when charged particles, such as electrons, are accelerated. All electrically charged particles are surrounded by electric fields. Charged particles in motion produce magnetic fields. When the velocity of a charged particle changes, an EM field is produced.
Exclusion Zone		The area where either the public or the worker shall not be permitted to be physically present due to the presence of RF emissions
Far Field Zone		The region where the distance from a radiating antenna exceeds the wavelength of the radiated EMF; in the far-field, field components (E and H) and the direction of propagation are mutually perpendicular, and the shape of the field pattern is independent of the distance from the source at which it is taken.
Field Strength Meter	:	An instrument used to give relative measurements of the radiation fields close to an operating transmitter
Frequency	:	The number of repetitions per unit time of the oscillations of an electromagnetic wave (or other wave). The higher the frequency, the

		greater the energy of the radiation and the smaller the wavelength. Frequency is measured in Hertz (Hz).
Isotropic Probe	:	A probe, which is used with a field strength meter/frequency wave analyzer, by being connected to it to capture and measure the surrounding RF field strength.
Magnetic Field	:	A magnetic field is generated when electric charge carriers such as electrons move through space or within an electrical conductor.
Microwave System	:	A transmission system providing high-capacity access connection between network elements in a particular network utilizing the air interface.
Microwave Antenna/Dish	:	A transmitting antenna to provide the connection between 2 points in a Microwave network.
Near Field Zone		The region where the distance from a radiating antenna is less than the wavelength of the radiated EMF. Note: The magnetic field strength (multiplied by the impedance of space) and the electric field strength are unequal and, at distances less than one-tenth of a wavelength from an antenna, vary inversely as the square or cube of the distance if the antenna is small compared with this distance.
Power Density	:	The energy flowing from an antenna through a unit area normal to the direction of propagation in a unit time. This is measured in watts per square meter (W/m^2)
Property Owner	:	The actual proprietor of a property (building, billboard, land, lamp posts, etc.) or its agents or its authorized personnel.
RF Antenna		An antenna is a specialized transducer that converts radio-frequency (RF) fields into alternating current (AC) or vice-versa. There are two basic types: the receiving antenna, which intercepts RF energy and delivers AC to electronic equipment, and the transmitting antenna, which is fed with AC from electronic equipment and generates an RF field. (*This document solely refers to the transmitting antenna, as this being the source of RF emission*)
Specific Absorption Rate (SAR)	:	Specific absorption rate or SAR is the time derivative of the incremental energy absorbed by or dissipated in an incremental mass contained in a volume of a given density. SAR values are usually expressed in units of watts per kilogram (W/kg) in either 1g or 10g of tissue.

4. Abbreviations

For the purposes of this TSRFEC, the followings abbreviations apply.

3G	Third Generation Mobile Telephony
A/m	Ampere per metre
ETACS	Extended Total Access Communication System
FF	Far Field
GHz	Giga Hertz

GSM	Global System for Mobile Communications
JTM	Jabatan Telekom Malaysia
MCMC	Malaysian Communications and Multimedia Commission
MHz	Mega Hertz
MINT	Malaysian Institute for Nuclear Technology Research
RF	Radio Frequency
SAR	Specific Absorption Rate
SIRIM	Standards and Industrial Research Institute of Malaysia
V/m	Volt per meter
W/m^2	Watt per square meter

5. Guidelines on Permissible RF Levels and Safe Distances for General Public and Workers

5.1 Exposure Limits

This TSRFEC shall refer to the standards for RF emission levels, which are defined in the ICNIRP guidelines.

Table 1 and ***Table 2*** below show the permissible RF levels for the general public and workers respectively for frequencies related to the current mobile cellular frequencies (900 ETACS, 900/1800 GSM, 3rd Generation Networks – 3G). The RF emission levels recommended here are based on the electrical and magnetic fields levels as defined by ICNIRP. The theoretical calculations and field measurements of RF levels are described in ***Section 5.2***.

Table 1. RF Levels Exposure Limits for Public

FREQUENCY (MHz)	Electric Field Strength (V/m)	Magnetic Field Strength (A/m)	Power Density (W/m^2)
300-2000	$1.375*\sqrt{f}$	$0.0037*\sqrt{f}$	f/200
2000-300000	61	0.16	10

Notes:

1. Frequency f is in Megahertz (MHz)
2. A power density of 10 W/m^2 is equivalent to 1mW/cm^2
3. A magnetic field strength of 1 A/m corresponds to 1.257 microtesla or 12.57 milligauss

Table 2. RF Levels Occupational Exposure Limits

FREQUENCY (MHz)	Electric Field Strength (V/m)	Magnetic Field Strength (A/m)	Power Density (W/m^2)
300-2000	$3*\sqrt{f}$	$0.008*\sqrt{f}$	f/40
2000-300000	137	0.36	50

Notes:

1. Frequency f is in Megahertz (MHz)
2.. A power density of 10 W/m^2 is equivalent to 1mW/cm^2
3. A magnetic field strength of 1 A/m corresponds to 1.257 microtesla or 12.57 milligauss

Based on the above tables, we can derive that allowable emission levels are higher for workers compared to the general public. This is because the exposure to the public is potentially throughout the day and he/she may be unaware of the existence of any RF antenna nearby. Comparatively a worker works only for a specific period of time.

For theoretical calculation of multi-frequency sites, individual calculations are required on each frequency (see ***Section 5.2.2, Item 8***). This differs from on-site measurement, where a broadband meter may be used to ascertain emission levels at any one point. For on-site measurements, please refer to ***Section 5.2.2***.

5.2 Methodology Used in Determining the Limits of RF Levels and Corresponding Distances (Exclusion Zones)

The exclusion zone is defined as the area where either the public or the worker shall not be permitted to be physically present due to the presence of RF emissions as described in ***Section 5.1***.

For the purpose of the calculation to determine the exclusion zone from the RF antenna it is recommended that the maximum transmitted power of the radio installation be used.

The calculations and site measurements shown here are referenced to the limits specified in ***Tables 1*** and ***2*** of ***Section 5.1***.

The document recommends that for practical reasons the exclusion zone distances in all circumstances should be at an equal radial distance in all directions from the radiating RF antenna. However it should be noted that the exclusion zone distances determined here are for the RF emissions in the main beam of the antenna. Therefore by having the exclusion zone at an equal radial distance, an additional safety buffer is created.

5.2.1 Theoretical Calculation

The calculation for determining the exclusion zone is derived from the following:

a) Theoretical formulas

1) Near Field zone formula
2) Far Field zone formula

b) **Tables 1** and **2 of Section 5.1**.

5.2.1.1 Description of Formulas

The formulas to be used are explained below:

a) Near Field (NF) zone formula

$$Wm = \frac{4P_T}{A}$$

where,

Wm is the maximum power density, in watts per square metre (*W/m2*);

P_T is the net power delivered to the antenna, in watts (*W*); and

A is the physical aperture area, in square metres (m^2).

The above formula is used to estimate the power density for distances less than the Far Field distance.

b) Far Field (FF) zone formula

$$FF = 0.5 \times \frac{D^2}{\lambda}$$

where,

FF is the beginning of the FF zone in metres (m);

D is the maximum dimension of antenna in metres (m); and

λ is the wavelength in metres (m) ($\lambda = 300/f$, where *f* is in Megahertz (MHz)).

The *FF* zone formula is used to check that the safe distance calculated is valid. The validity is dependent on the maximum dimension of the antenna being greater than the wavelength being analysed.

$$W = \frac{EIRP}{(4\pi r^2)}$$
$$= \frac{P_T G}{(4\pi r^2)}$$

where,

EIRP is the effective isotropically radiated power, in watts (W);

r is the distance from the antenna, in metres (m);

P_T is the net power delivered to the antenna, in watts (W);

G is the antenna gain (power ratio) with respect to an isotropic antenna; and

π 3.14

The equation above represents the estimation of the Far Field power density on the main beam axis.

5.2.1.2 Calculation of Exclusion Zone Distance

The example of calculating the exclusion zone is explained below:

An antenna measuring at (1.45 x .28 x .125) metres, operating at 1855 MHz with an EIRP of 50 W is to be installed in an area accessible to the general public. What is the minimum distance from the antenna where the exposure does not exceed the limits for the general public?

Step 1.

Calculate the maximum power density exposure limit for the general public (***Table1***):

$$W_{limit} = f/200$$

$$= \frac{1855}{200}$$
$$= 9.275\ W/m^2$$

Step 2.

Calculate the minimum safe distance by rearranging the equation,

$$W = \frac{EIRP}{(4\pi r^2)}$$
$$= \frac{P_T G}{(4\pi r^2)}$$

for the distance from the antenna r_{min} :

$r_{min} = \sqrt{[EIRP/(4\pi W_{limit})]}$
$= \sqrt{[50.0/(4.0 \times \pi \times 9.275)]}$
$= 0.927$ m

Step 3.

Check to make sure that the minimum distance calculated above is in the far-field zone (where equation W_{limit} is valid):

First calculate the wavelength:

$$\lambda = \frac{300}{f} \qquad (f \text{ in MHz})$$

$$= \frac{300}{1855}$$

$= 0.162$ m

As this antenna maximum dimension is larger than the wavelength (l), it may be considered as a large antenna. Thus, the beginning of the far-field region is calculated using the FF formula:

$$FF = 0.5 \times \frac{D^2}{\lambda}$$

$$= 0.5 \times \frac{(0.5)^2}{0.162}$$

$= 0.773$ m

Since the minimum distance, as calculated above, is in the far-field zone of the antenna, the basis for the calculation is valid. Therefore, members of the general public should not stand closer than 0.927 m directly in front of the antenna.

5.2.1.3 Typical Exclusion Zone Distances for Cellular Sites

In general based on the method just described the typical exclusion zone distances for cellular sites are shown in ***Table 3.1*** below. It should be noted that the distances in ***Table 3.1 and Table 3.2*** are just examples and that proper usage of the formulas described should be used to ascertain the correct exclusion zone distances.

Results of the calculations in this TSRFEC show similar results by applying the formula recommended in the Reg-002 document (*Section 3.6, pg. 35*). As such, the calculations in this TSRFEC are accurate for identifying the correct exclusion zones.

The types of cellular sites are explained in ***Section 5.3*** below.

Table 3.1. Exclusion Zone Distances of Typical Cellular Sites

Type of Cellular Site	Frequency (MHz)	Transmit Power at Antenna/ EIRP (dBm)	Transmit Power at Antenna/ EIRP (Watt)	ICNIRP Limit for Public (W/sq m)	ICNIRP Limit for Occupational Exposure (W/sq m)	Exclusion Zone Distance for Public (m)	Exclusion Zone Distance for Workers (m)
Macrocell	915	50	100	4.575	22.875	1.319	0.590
	1855	50	100	9.275	46.375	0.927	0.414
	2110	50	100	10	50	0.892	0.399
Microcell	915	30	1	4.575	22.875	0.132	0.059
	1855	30	1	9.275	46.375	0.093	0.041
	2110	30	1	10	50	0.089	0.040
Picocell	915	10	0.01	4.575	22.875	0.013	0.006
	1855	10	0.01	9.275	46.375	0.009	0.004
	2110	10	0.01	10	50	0.009	0.004

Table 3.2. Exclusion Zone Distances of Typical Microwave Antennas / Dish

Freq (GHz)	Transmit Power at Antenna/ EIRP (dBm)	Transmit Power at Antenna/ EIRP (Watt)	ICNIRP Limit for Public (W/sq m)	ICNIRP Limit for Occupational Exposure (W/sq m)	Exclusion Zone Distance for Public (m)	Exclusion Zone Distance for Workers (m)
4	55	316	10	50	1.59	0.71
11	54	251	10	50	1.41	0.63

On Microwave sites, the typical emissions are concentrated from the main beam of the antenna/dish in a point-to-point network. As such, the exclusion zones mentioned in Table 3.2 above are purely for the immediate areas in front of the antenna/dish.

All frequencies that exceed 2000 MHz have a fixed Power Density limit based on ICNIRP for Public and Occupational Exposure (W/sq m). This is in reference to Tables 1 and 2 of this document.

5.2.2 Measurement at Site

The measurement at site shall be performed based on the following procedures:

1. The electromagnetic field shall be measured at areas normally occupied by the public and workers.

2. The electromagnetic fields being measured shall use isotropic probes because the electromagnetic fields are usually from multiple sources and from various directions.

3. The electromagnetic fields in the environment are mostly non homogeneous in nature. Therefore measurements of the fields shall be taken at several locations around the antenna. The FF (***Section 5.2.1.1***) is used as an indicator to establish suitable measuring instruments and selection of measuring locations around the antenna.

4. The duration of the readings taken shall be averaged over at least 6 minutes per location.

5. The time of day when the readings are taken is important because during heavy traffic the level of RF radiation from the transmitting antenna naturally increases. Therefore as a guide, readings should be taken at the site's busiest period of the day, which is defined as the site's busy hour. A site's busy hour can be determined from daily traffic recordings commonly obtainable from the operator's mobile switch.

6. Only field strength metres with the specified range and the proper calibration shall be used. The failure to use the correct range will lead to false readings.

7. It should be noted that measured readings at multiple frequency sites using broadband measurements are usually higher than if each frequency had been measured separately and the resultant RF levels combined. Even though the broadband readings were higher, these were always lower than the ICNIRP's specified levels. This observation is documented in the RF emission surveys done by MINT.

8. Sites with multiple frequencies shall apply the following formula:

$$\sum_{f=300MHz}^{300\ GHz} R_f \leq 1 \text{ (Reference: ICNIRP)}$$

For field strength measurements (electrical and magnetic) use,

$R_f = (\text{Measured Field Strength/Exposure Field Strength Limit Value})^2$

For power density measurements use,

$R_f = (\text{Measured Power Density/Exposure Power Density Limit Value})$

Example calculation as follows,

The electromagnetic fields measured at site have electrical field strength values of 0.02V/m at 1840 MHz and 0.07V/m at 952 MHz. Using the formula above and ***Table 1*** for assessing the RF emission with regards to the public,

$$R_f = (R_{f1\ measured}/R_{f1\ ICNIRP})^2 + (R_{f2\ measured}/R_{f2\ ICNIRP})^2$$

$$R_f = (0.02/(1.375^* \sqrt{1840}))^2 + (0.07/(1.375^* \sqrt{952}))^2 < 1$$

The resultant value calculated in the above example is less than unity (1), which means the combined field strength is within limits for the public.
A multiple frequency site which has a resultant value of greater than unity (1), means that the combined field strength of that site at that particular position does not conform to the limits specified in ***Tables 1*** or ***2***.

5.3 Cellular Site Categorization

5.3.1 Cell Site Type

The cellular radio sites are categorized into 3 main types based on the extent of signal coverage. These 3 categories are:

a) In-Building – Pico Cells

b) Outdoor – Macro Cells

c) Outdoor – Micro Cells

Each of the above categories would have various types of sites where the radio equipment and its antenna are installed. ***Table 4*** below summarizes these. ***Annex 1*** shows the sample photos of the cellular sites.

Table 4. Categorization of cellular sites

Site Type	Location 1	Location 2	Location 3
In-Building – Pico Cells	**Corridor/Hall / Room** Wall Mounted Ceiling Mounted Leaky feeder / cable	**Parking Area** Wall Mounted Ceiling Mounted Leaky feeder / cable	**Tunnel** Wall Mounted Ceiling Mounted Leaky feeder / cable
Outdoor - Micro Cells	**Street Level** Lamp Post Traffic Light Wall Mounted (2 / 3 storey building)		
Outdoor - Macro Cells	**Rooftop** Mini Structure Boom Pole Wall Mounted (Tall Buildings)	**Land** Guyed Mast Cellular Tower Broadcast / Transmission Tower Monopole Stand Alone Mast Aesthetic Monopole	**Others** Billboard Water Tank Signboard Minaret

5.3.2 Power Levels of Cellular Sites

The typical power levels of cellular sites vary from around 2 dBm to 52 dBm as shown in ***Table 5*** below. The power levels stated here is the transmitted power from the antenna of the radio equipment, which is the subject matter of this document. The sole purpose of the aforesaid transmission is for the mobile device connectivity to and from the core network.

Table 5. Cellular sites typical EiRP Power Levels (verify output power for 4 Trx)

Site Type	Power Levels EIRP (dBm)	Power Levels EIRP (Watt)	TX Output Power - 1TX	TX Output Power - 1TX	TX Output Power - 4TX	TX Output Power - 4TX	Antenna height (m)
Macrocell	50.5 - 51.5	112 - 141	41 dBm	12.6 watt	38dBm	6.3 watt	>10
Microcell	35 - 36	3.1 - 3.9	33 dBm	2 watt	30 dBm	1 watt	4 - 6
Picocell	2.6 - 21.13	0.002 - 0.13	33 dbm	2 watt	30 dBm	1 watt	ceiling height

The table above are typical power values for cellular BTS / Node Bs networks, mainly GSM and 3G.

6. Guidelines on Warning Signs for General Public and Workers

The warning sign is used to inform the public and workers on the existence of an exclusion zone.

The exclusion zone is defined as an area where the general public and worker shall not be present because the RF emission could probably be higher than those specified by this TSRFEC, refer to ***Tables 1*** and ***2*** of ***Section 5***. The RF levels are dependent on the frequency and the level of RF power transmitted. Therefore in order to prevent undue exposure, access to these areas need to be restricted.

A radio site's exclusion zone is determined based on theoretical calculations (see ***Section 5.2.1***). However actual site measurements using field strength and power density meters (see ***Section 5.2.2***) could be used to verify the accuracy of the theoretical calculation.

6.1 Signage Design

The signage type recommended in this TSRFEC is based on SIRIM's MS 981 1985.

The signage shall be used to warn the public and workers on the existence of a nearby operating radio antenna and the appearance recommended is illustrated below:

Diagram 1. Worker Boundary Signage

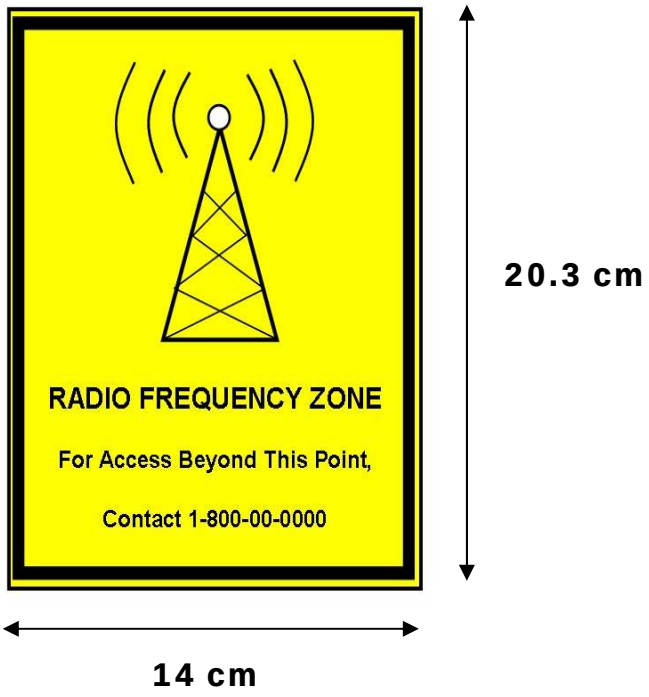

Diagram 2. General Public Boundary Signage

The signages are for the cell sites categorized in ***Section 5.3*** above. The signage in ***Diagram 1*** is for places where public access is restricted but not to workers such as in the rooftops. However for areas where the public can access with an antenna placed nearby, ***Diagram 2*** is recommended.

Further explanation on signage placement is described in ***Section 6.2***.

6.2 Signage Placement

The signage is recommended to be placed at a visible position at close proximity of the radio antenna.

Placement of the signage should be at the antenna's mounting structure. This signage is specifically meant for the attention of the worker who will be working within the exclusion zone of the transmitting radio antenna (exclusion zone distance see ***Section 5.2***).

Ideally the signage should be placed at the boundary of the exclusion zone to warn the worker and public of a nearby RF antenna.

In certain places such as where mobile antennas are installed inside a building for in-building coverage, signage is not necessary. As shown in the calculation in ***Table 3, Section 5.2.1*** the RF safe level distance does not normally exceed 0.01 metres from the antenna and is moreover installed at ceiling height.

In summary the signage placement rules shall be as follows:

a) At the boundary of the exclusion zone (defined as per calculation, ***Section 5.2.1***).

b) If signage is placed on an antenna mounting structure, the signage needs to be clearly readable at the boundary of the exclusion zone.

c) The recommended signage to be used to warn workers and the public are as per ***Diagrams 1 and 2*** respectively.

d) The operators can, at their own discretion, implement additional measures as necessary for the safety of workers and public at the site.

7. Administration of RF Emission of Cellular Radio Sites

7.1 Site Record Keeping

The site radio equipment installation record shall be kept at the site. A copy of the record of the installation may be given to the property owner for reference.

The network operator shall make information on the site RF emission database available to the relevant authorities, property owners and the public upon their request.

The network operator is responsible to update its site records if any changes are made to the RF emission levels and the corresponding exclusion zones due to modifications done on the radio system by the operator.

The content of the information on the site RF emission database shall contain the following items:

a) Radio equipment layout plan.

b) Antenna layout plan.

c) Radio equipment technical specification (to include SIRIM certification and AA reference numbers)

d) Antenna technical specification.

e) RF emission levels showing the exclusion zone relative to the site make up.

f) Operator's contact number contactable 24 hours 7 days a week.

g) Date of last update of Site Record book.

8 Specific Absorption Rate (SAR)

SAR (Specific Absorption Rate) is an indication of the amount of radiation that is absorbed into a head whilst using a cellular phone or any other similar transmitting equipment, the higher the SAR rating the more radiation that is absorbed into the human body.

Specific absorption rate or SAR is the time derivative of the incremental energy (dW) absorbed by or dissipated in an incremental mass (dm) contained in a volume (dV) of a given density (ρ):

$$\mathrm{SAR} = \frac{\mathrm{d}}{\mathrm{dt}}\left(\frac{\mathrm{dW}}{\mathrm{dm}}\right) = \frac{\mathrm{d}}{\mathrm{dt}}\left(\frac{\mathrm{dW}}{\rho \mathrm{dV}}\right)$$

SAR should be considered as an "absorbed dose rate" and is related to electric fields at a point by:

$$\mathrm{SAR} = \frac{\sigma |\mathrm{E}|^2}{\rho}$$

Where:

σ is the conductivity of the tissue (S/m)
ρ is the mass density of the tissue (kg/m3)
E is the rms electric field strength (V/m)

SAR can also be a calculated rate of temperature rise at a given point. However, for commercial testing of radiating devices, electric field measurements are normally used.

8.1 SAR Measurement System

According to IEC 62209 Para 5.1 - Human exposure to radio frequency fields from hand-held and body-mounted wireless communication devices - Human models, instrumentation, and procedures - Part 1: Procedure to determine the specific absorption rate (SAR) for hand-held devices used in close proximity to the ear (frequency range of 300 MHz to 3 GHz) :

“The test shall be performed using a miniature probe that is automatically positioned to measure the internal E-field distribution in a phantom model representing the human head exposed to the electromagnetic fields produced by wireless devices. From the measured E-field values, the SAR distribution and the maximum mass averaged SAR value shall be calculated.”

8.2 Measurement Protocol and Exposure limits

European Specification ES 59005 (1998) shall be used for SAR measurement protocol and Guidelines for Limiting Exposure to Time-Varying Electric, Magnetic, and Electromagnetic Fields (up to 300 GHz), 1998 published by ICNIRP shall be the Reference to the SAR Limits.

The SAR of a wireless product can be measured in two ways. It can be measured directly using body phantoms, robot arms, and associated test equipment, or it can be mathematically modeled.

SAR limits are expressed for two different classes of people: workers (occupational/controlled exposure) and the general population (uncontrolled exposure). Because the general-population exposure is considered to be uncontrolled, the limit for this group is five times more stringent than the limit for the workers, whose environment and exposure can be monitored and controlled.

The limits, which apply in general for mobile telephones and other similar transmitting apparatus, are drawn directly from the applicable source documents published by ICNIRP for Europe and most parts of the world. Two limits are used: a lower value for exposure averaged over the whole body and a higher value which is applicable to local exposure to parts of the body (e.g. the head). This partial-body SAR is averaged over a volume of tissue defined as a tissue volume in the shape of a cube.

Table 3 shows the Basic SAR Limits for time varying electric and magnetic fields for frequencies up to 10 GHz.

Table 6. SAR Limits for Occupational and General Public

Exposure Characteristics	**Frequency Range**	**Current density for head and trunk (mA/sqm) (rms)**	**Whole-body average SAR (W/kg)**	**Localized SAR (head and trunk) (W/kg)**	**Localized SAR (limbs) (W/kg)**
Occupational Exposure	100 kHz–10 MHz	f / 100	0.4	10	20
	10 MHz–10GHz	-	0.4	10	20
Exposure for General Public	100 kHz–10 MHz	f / 500	0.08	2	4

Notes:

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 cm2 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 u2 (;1.414). For pulses of duration *t*p the equivalent frequency to apply in the basic restrictions should be calculated as *f* 5 1/(2*t*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* 5 1/(2*t*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 kg21 for workers and 2mJ kg21 for the general public, averaged over 10 g tissue.

9. Conclusion and Recommendations

Actual site measurements may be done to investigate complains by the authorities, property owner or public. Theoretical calculations should be acceptable without conducting site measurements provided the data available is sufficient for doing theoretical calculations.

If after the investigation has been done and the RF emission level is still unsafe, meaning that safe RF levels and the associated exclusion zone are found to be unsuitable for the site's requirement, the following corrective action should be done in the following order:

1. Reduce the power of the transmitter (refer also to ***Reg-R002, pg 34***, last paragraph) and re-measure the RF level to ascertain the safe emission level.

2. Realign the antenna if the power reduction that was done as above is insufficient.

If a worker is required to work at close proximity (less than 1 metre) of a transmitting antenna for a period of more than 6 minutes, the affected transmitting antenna should be temporarily shutdown.

To date, the only health effect that has been proven to exist as a result of exposure to RF electromagnetic emissions relates to the heating of human body parts, which is known as thermal effect. The ICNIRP limits (see ***Tables 1, 2*** and ***Table 6 for SAR***) have been set to avoid adverse heating effects caused by exposure to RF & EMF. There are unlikely to be any significant long-term or short-term impacts on the health on individuals with respect to the public exposed to the RF emissions.

The SAR limit as recommended by ICNIRP (***Table 6***) is 2.0 W/kg for localized SAR (Head & Trunk). This limit is the common SAR emission reference limit to mobile phone operation, and as such is adhered to by mobile phone manufacturers. Although the SAR is determined at the highest certified power level, the actual SAR level of the mobile phone while operating can be operating below the maximum value. This is because the phone is designed to operate at various power levels so as to use only the power required to reach the operating network. In general, the closer you are to a base station site, the lower the power output from the mobile phone unit.

Studies that have investigated the RF radiation effects on biological cells are inconclusive. In addition laboratory studies have yet to provide sufficient evidence to show that RF fields cause health effects. In most cases the RF exposure levels used in these studies are often higher than as

specified by international bodies.

This TSRFEC document recommends that the site RF emission control be accomplished through self-regulation by the network operators as follows:

a) Consider careful placement of radio antennas at planning stages to avoid inconveniences to the public, worker and the network service provider.

b) Ensure that site RF emissions are within safe levels.

c) Update site RF emission records (***Section 7.1***).

d) Self regulates itself in ensuring that the RF emissions pose no harm to public and worker safety as defined by international standards as mentioned in this document.

e) Follow the guidelines as recommended in this document.

This document should be reviewed in the future to accommodate any new recommendations by recognized authorities/international bodies on RF electromagnetic field emission safety.

Acknowledgements

The Working Group named the WIEWG that developed this Technical Standard consists of the following representatives:

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