ELECTROMAGNETIC FIELDS EXPOSURE GUIDELINES

ELECTROMAGNETIC FIELDS EXPOSURE GUIDELINES	Review Version	01
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Contents

Definitions

In these ELECTROMAGNETIC FIELDS EXPOSURE GUIDELINES, unless the context otherwise requires, the following expressions or words bear the meanings assigned to them as follows:

"Act" or "CRA Act of 2012"

means the Communications Regulatory Act of 2012.

"The Authority"

means the Botswana Communications Regulatory Authority established under the CRA Act.

"Electromagnetic Fields or EMF"

means waves of Electric and Magnetic energy moving together through space.

"General Public"

means all non-workers, including individuals within the community who are not occupationally exposed to EMF but may encounter it in their daily environment, including residential, recreational, and public settings.

"Occupational Exposure"

means situations where the persons are exposed because of their employment, and in which those persons who are exposed have been made fully aware of the potential for exposure and can exercise control over their exposure.

"Licensee"

means a Service Provider or Operator Licenced under the Act by the Authority.

"Standards"

means a document approved by a recognised body that provides for common and repeated use, rules, guidelines, or characteristics for products or related processes and production methods, with which compliance is mandatory.

Abbreviation of Terms

In these ELECTROMAGNETIC FIELDS EXPOSURE GUIDELINES, unless otherwise required, the following abbreviations are used:

EMF	Electromagnetic Fields
ICNIRP	International Commission on Non-Ionizing Radiation Protection
IEC	International Electrotechnical Commission
ITU	International Telecommunication Union
ISO	International Standardization Organization
DNA	Deoxyribonucleic Acid
RF	Radio Frequency
SAR	Specific Absorption Rate (W/kg)
WHO	World Health Organization

1. Introduction

1.1. The Botswana Communications Regulatory Authority (BOCRA or The Authority) is mandated by the Communications Regulatory Authority Act of 2012 (CRA Act) section 6 (1) to ensure that communications services which are safe, reliable, efficient, and affordable are provided in all sectors.

1.2. The rapid growth of the telecommunications sector has led to increased deployment of telecommunications infrastructure. Telecommunication installations are a major source of Electromagnetic Fields (EMF). The effects of EMF exposure on human health can be unsafe and detrimental if not monitored effectively.

1.3. Botswana is a member state of the International Telecommunication Union (ITU). The ITU recommends that its member states should establish an appropriate regulatory framework to protect people and the environment from Non-Ionizing radiation. The ITU further recommends that member states should develop standards for monitoring and measuring EMF exposure levels and follow the International Commission on Non-Ionizing Radiation Protection (ICNIRP) Guidelines to ensure compliance.

1.4. In pursuit of this mandate, the Authority has enacted the Electromagnetic Fields Exposure Guidelines. These Guidelines provide the processes and steps to be followed by any organisation seeking to deploy wireless communication services within Botswana. The Guidelines describe the minimum requirements for measuring and monitoring EMF from sites.

2. Objectives

2.1. The objectives of these guidelines are to:
2.1.1. Protect consumers against adverse health effects from exposure to radiofrequency EMFs.
2.1.2. Provide procedures on how radiation compliance assessments will be conducted.
2.1.3. Define technical parameters and/or standards to ensure compliance with radiation limits.

3. Background

3.1. Wireless communication services are becoming widespread in both urban and rural areas due to high user demands, competition, and the need for improved Quality of Service and coverage. However, prolonged exposure to EMF emissions from these technologies may negatively affect public health and the environment.

3.2. Noting that many organisations in the communications field struggle with communicating the risks associated with EMF to the public. Misinformation about EMF could create distrust, just as it has with previous generations of International Mobile Technologies (IMT). Therefore, it is important to address these potential risks and communicate them clearly to the public, especially with the introduction of new technologies that provide enticing services.

3.3. EMFs are a form of energy consisting of Electric and Magnetic waves that move together through space. They are generally split into two main categories: Ionizing and Non-Ionizing EMF.

3.3.1. Ionizing EMF, such as X-rays and gamma rays, have higher energy levels. Because of their characteristics, they can cause damage to biological tissues and DNA.

3.3.2. Non-Ionizing EMF, on the other hand, has lower energy levels compared to Ionizing EMF. Therefore, they are considered safe at typical exposure levels. However, prolonged and intense exposure to Non-Ionizing EMF at close range could cause tissue heating.

3.4. Radiation from telecommunication systems has a very low energy level and cannot ionize biological tissues. These Guidelines shall focus on EMF radiation caused by Non-Ionizing EMF which ranges between the 100KHz and 300GHz frequency bands that are used by wireless communication systems, which the Authority is mandated to regulate.

3.5. Ionizing EMF radiation is governed by the Radiation Protection Inspectorate of Botswana.

3.6. It is paramount to monitor and measure EMF exposure levels emitted by wireless communication systems to ensure compliance with prescribed limits, such that the environment and members of the public are protected from potential harmful effects associated with exposure to EMF.

3.7. The Authority has adopted the limits prescribed by the International Commission on Non-Ionizing Radiation Protection (ICNIRP) in the Guidelines for Limiting Exposure to Electromagnetic Fields (100KHz – 300GHz) to assess the compliance of wireless communications systems.

3.8. Compliance with the ICNIRP Limits shall be assessed in alignment with methods prescribed by international standardisation bodies, such as the International Communications Union (ITU), International Electrotechnical Commission (IEC), and Institute of Electrical and Electronics Engineers (IEEE).

4. Scope

4.1. The scope focuses on the elements of the ICNIRP Guidelines that are most relevant to EMF exposure from communications network equipment and devices operating in the frequency range of 100kHz to 300 GHz. Licensees that are subject to the Health & Safety condition in their Radio Spectrum Licence shall comply.

5. International Commission on Non-Ionizing Radiation Protection (ICNIRP)

5.1. The International Commission on Non-Ionizing Radiation Protection (ICNIRP) was formed to address concerns and facilitate international cooperation in assessing and providing guidance on the potential health risks associated with exposure to Non-Ionizing radiation. It works with other government agencies and international standards development organisations to develop guidelines for limiting EMF exposure.

5.2. ICNIRP guidelines aim to ensure that human exposure to non-ionizing radiation remains within safe limits. The guidelines prescribe exposure limit values that should be adhered to in order to prevent EMF exposure levels that are high for two main exposure scenarios, Occupational and the General Public, as outlined below:

5.2.1. Occupational Exposure: Refers to situations in which individuals are subjected to certain substances or hazards due to their employment. In these instances, it is imperative that exposed individuals are informed about the potential risks associated with their exposure. Moreover, they should possess the authority and means to regulate and mitigate their exposure levels; and

5.2.2. General Public Exposure: This provision extends to all non-workers and encompasses individuals across diverse demographics, regardless of age or health condition. It notably includes vulnerable populations that may lack awareness or agency in managing their exposure to EMF.

6. EMF Exposure Guidelines

6.1. As indicated, the Botswana EMF Guidelines are based on ICNIRP levels.

6.2. Botswana adopts the Basic Restrictions as part of its Guidelines to provide exposure limits for protection against adverse health effects associated with Non-Ionizing radiation. Basic Restrictions are quantitative limits on exposure to Non-Ionizing radiation and are expressed as the Specific Absorption Rate (SAR).

6.3. SAR is a measure of the rate at which energy is absorbed by the human body when exposed to Electromagnetic Fields. These Guidelines set basic restrictions on SAR to limit the amount of energy absorbed by tissues, especially in the head and body, during exposure to EMF. Table 1 below shows the SAR Basic Restrictions are as follows.

Table 1: Basic restrictions for electromagnetic field exposure from 100 kHz to 300 GHz, for averaging intervals ≥6 min

Exposure scenario	Frequency Range	Whole-body average SAR (W kg^{-1})	Local Head/ Torso SAR (W kg^{-1})	Local Limb SAR (W kg^{-1})	Local Sab (W m^{-2})
Occupational	100 kHz to 6 GHz	0.4	10	20	NA
	>6 to 300 GHz	0.4	NA	NA	100
General Public	100 kHz to 6 GHz	0.08	2	4	NA
	>6 to 300 GHz	0.08	NA	NA	20

6.4. Considering that SAR is a physical process inside the body, the ICNIRP Guidelines provide Reference Levels which are field values outside the body. These Reference Levels are derived from the Basic Restrictions by means of computational and measurement studies and are more practical to measure.

6.5. The Reference Levels shall be used for monitoring EMF and enforcing compliance in Botswana. ICNIRP provides another set of Reference Levels averaged over the whole body or local exposure (head and torso) over six (6) or thirty (30) minute time intervals. Tables 2 and 3 show the Reference Levels prescribed by ICNIRP.

Table 2: Reference levels for local exposure to electromagnetic fields from 100 kHz to 300 GHz, averaged over 6 min (unperturbed rms values)

Exposure scenario	Frequency Range	Incident E-field strength; E_{inc} (V m^{-1})	Incident H-field strength; H_{inc} (A m^{-1})	Incident power density; S_{inc} (W m^{-2})
Occupational	0.1 – 30 MHz	$1504/f_M^{0.7}$	$10.8/f_M$	NA
	>30 – 400 MHz	139	0.36	50
	>400 – 2000 MHz	$10.58f_M^{0.43}$	$0.0274f_M^{0.43}$	$0.29f_M^{0.86}$
	>2 – 6 GHz	NA	NA	200
	>6 - <300 GHz	NA	NA	$275/f_G^{0.177}$
	300 GHz	NA	NA	100
General Public	0.1 – 30 MHz	$671/f_M^{0.7}$	$4.9/f_M$	NA
	>30 – 400 MHz	62	0.163	10
	>400 – 2000 MHz	$4.72f_M^{0.43}$	$0.0123f_M^{0.43}$	$0.058f_M^{0.86}$
	>2 – 6 GHz	NA	NA	40
	>6 - 300 GHz	NA	NA	$55/f_G^{0.177}$
	300 GHz	NA	NA	20

Table 3: Reference levels for exposure to electromagnetic fields from 100 kHz to 300 GHz, averaged over 30 min and the whole body (unperturbed rms values)

Exposure scenario	Frequency Range	Incident E-field strength; E_{inc} (V m^{-1})	Incident H-field strength; H_{inc} (A m^{-1})	Incident power density; S_{inc} (W m^{-2})
Occupational	0.1 – 30 MHz	$660/f_M^{0.7}$	$4.9/f_M$	NA
	>30 – 400 MHz	61	0.16	10
	>400 – 2000 MHz	$3f_M^{0.5}$	$0.008f_M^{0.5}$	$f_M/40$
	>2 – 300 GHz	NA	NA	50
General Public	0.1 – 30 MHz	$300/f_M^{0.7}$	$2.2/f_M$	NA
	>30 – 400 MHz	27.7	0.073	2
	>400 – 2000 MHz	$1.375f_M^{0.5}$	$0.0037f_M^{0.5}$	$f_M/200$
	>2 – 300 GHz	NA	NA	10

7. Roles and Responsibilities

7.1. This section outlines the roles and responsibilities of key stakeholders within the wireless communications ecosystem, including the Government, the Authority, Licensees, Manufacturers or Assemblers, and the General Public.

7.2. The Government

The Government shall:

7.2.1. Adopt health-based standards and ensure compliance;

7.2.2. Promote public information programmes and dialogue with all stakeholders; and

7.2.3. Enable further research to reduce scientific uncertainty.

7.3. The Authority

The Authority shall:

7.3.1. Conduct periodic independent EMF monitoring surveillance at various locations across the country to ensure compliance with ICNIRP Reference Levels;

7.3.2. Notify the relevant Licensees where there is non-compliance to ICNIRP Reference Levels and ensure corrective measures are taken by the Licensees to achieve compliance;

7.3.3. Publish the EMF measurement campaign and licensees' results on the Authority's website (https://www.bocra.org.bw) for public consumption;

7.3.4. Conduct public education campaigns and raise awareness of EMF-related issues to the General Public in collaboration with Licensees;

7.3.5. Ensure that all communications equipment Type Approved by the Authority is compliant with Health and Safety requirements in relation to EMF exposure limits, and

7.3.6. Resolve disputes that may arise between Licensees regarding EMF compliance.

7.4. Licensees

All Licensees shall:

7.4.1. Conduct pre- and post-installation EMF assessments of the newly deployed radio communications systems to ensure that the ICNIRP Reference Levels are not exceeded and comply with other relevant standards.

7.4.2. Declare compliance to the Authority by submitting the assessment measurement results comprising all the information outlined in 8.5;

7.4.3. Ensure that their radio equipment is installed in accordance with international standards;

7.4.4. Restrict the General Public from gaining access into the base station's periphery;

7.4.5. Install signage on the restricted areas of communications sites to warn members of the public of the danger associated with EMF Exposure close to the antenna(s);

7.4.6. Implement corrective measures whenever non-compliance has been found on sites where their radio equipment has been installed;

7.4.7. Ensure that all safety measures which guard against potential EMF exposure risks are catered for and adhered to by individuals who are occupationally exposed while performing their duties at the base stations;

7.4.8. Conduct public education on EMF compliance to the General Public to reassure compliance with specified standards with guidance from the Authority;

7.4.9. Regularly have their EMF measuring equipment calibrated by an accredited body to maintain the accuracy of the measured results;

7.4.10. Ensure that the total EMF exposure levels, including those of other Licensees on the shared infrastructure, do not exceed the ICNIRP Reference Levels; and

7.4.11. Collectively take necessary action to ensure that compliance to the ICNIRP Reference Levels is achieved in the event where the cause for non-compliance is unknown in any area covered by any number of sites from different Licensees.

7.5. General Public

Members of the General Public shall:

7.5.1. Avoid unauthorised entry into the periphery of sites where radio equipment has been installed, to ensure their safety from excessive EMF exposure; and

7.5.2. Ensure that they use their terminal equipment correctly, following the instructions prescribed by the Original Equipment Manufacturer, to avoid causing harm to themselves and others.

7.6. Manufacturers/Assemblers

7.6.1. Manufacturers and Assemblers of Information Communication Technology devices shall ensure that their products comply with the ICNIRP Basic Limit Values.

8. Compliance Assessment Procedure

8.1. All EMF compliance assessments shall be done in accordance with the measurement protocol of the IEC 62232:2022 – standard for determination of RF field strength, power density, and SAR in the vicinity of base stations for the purpose of evaluating human exposure. The following shall be considered:

8.2. Measurement Tool Selection

The following shall be considered when selecting the EMF measurement tool:

8.2.1. Probe characteristics

8.2.2. The probe which is selected shall be able to adapt to the frequency margin and the necessary dynamic range of the field strength with consideration of whether the measurement is undertaken in the Near-Field or Far-Field.

8.2.3. Measurement Coordinates: The probe shall have the ability to store the geographic coordinates of each measurement point and produce corresponding maps.

8.3. Measurement Point Selection

The following shall be considered when selecting the EMF measurement point:

8.3.1. Measurement Height

The EMF measurement shall be taken at a height of at least 1.5 meters from the ground, as this is the area of concern.

8.3.2. Antenna Directivity

The EMF probe shall be positioned to accurately reflect the maximum exposure level which a member of the General Public may encounter at each measurement point.

8.3.3. Measuring Near Metal Objects

The EMF measuring probe shall be kept at a significant distance away from metal objects to avoid the coupling effect which could distort the measured values.

8.3.4. Mobile Phones

shall be kept away from the measuring probe, unless when they are specifically used to trigger beamforming or carrier aggregation.

8.3.5. Areas of Interest

Measuring Points shall be selected such that areas which are frequently accessed by the General Public around a site are covered, including schools, health facilities, malls, etc.

9. General Principles (Regulatory and Compliance)

9.1. The general principles of these Guidelines are as follows:

9.1.1. Enforcement

The Authority shall take appropriate measures to ensure enforcement of the requirements of the EMF Guidelines.

9.1.2. Compliance and Investigation

The Authority shall continuously monitor EMF exposure levels across Botswana to ensure that the ICNIRP Guidelines are adhered to by the relevant stakeholders. Additionally, it shall conduct investigations in cases of non-compliance to the ICNIRP Reference Levels or Basic Restrictions and other standards in these Guidelines.

9.1.3. Penalties

9.1.4. The Authority shall invoke the relevant penalties from the Act when the need arises after an assessment of the merits of non-compliance.

9.1.5. The penalties shall be administered according to the Act of 2012, Section 50 (2), which states that "Any person who contravenes Subsection (1) commits an offence and is liable to a fine of not less than P10 000.00 but not more than P2 000 000.00, or to imprisonment for a term of not less than one year but not more than 10 years, or to both."

9.1.6. Equipment that does not comply with the required standards shall be shut down.

10. Review and Amendments

10.1. The Authority shall continually review and implement the Electromagnetic Field Exposure Guidelines to align with best practices, standards, technology trends, and policies from institutions such as the International Telecommunication Union (ITU), International Commission on Non-Ionizing Radiation Protection (ICNIRP), and International Electrotechnical Commission (IEC), among others.

10.2. Adequate consultations will be conducted if there is a need to review the Guidelines.

11. Reporting

11.1. Licensees shall produce and submit all EMF measurement reports to the Authority for newly deployed sites/cells that contain the following information:

11.1.1. Standard used for the measurement

11.1.2. Coordinates and altitudes of measurement position(s)

11.1.3. Timestamps of the measurements

11.1.4. Characteristics of the measured site

11.1.5. Description of the measurement points

11.1.6. Photographs of the measurement being conducted

11.1.7. Make, Model, and Serial Number of measuring equipment

11.1.8. Measurement Error/Uncertainty Margins

12. Publication

12.1. EMF measurement results carried out by Licensees or the Authority shall be consolidated and published on the Authority's Annual Report and website (https://www.bocra.org.bw/).

13. Implementation

13.1. These Guidelines shall be enforced and shall come into effect on 1 April 2025.

Appendices

Appendix 1: ITU-T Standards

Table 4 below provides a summary of the key ITU-T Standards that complement the ICNIRP Guidelines for the enforcement of Electromagnetic Field (EMF) Guidelines. All communications sector members are recommended to utilise the most recent issue or published version of these standards.

Table 4: Recommended ITU Standards for Supporting EMF Guidelines

Standard	Link	Title
K.52		Guidance on complying with limits for human exposure to electromagnetic fields.
K.61		Guidance on measurement and numerical prediction of electromagnetic fields for compliance with human exposure limits for communication installations.
K.70		Mitigation techniques to limit human exposure to EMFs in the vicinity of radiocommunication stations.
K.83		Monitoring of electromagnetic field levels.
K.90		Evaluation techniques and working procedures for compliance with exposure limits of network operator personnel to power-frequency electromagnetic fields.
K.91		Guidance for assessment, evaluation, and monitoring of human exposure to radio frequency electromagnetic fields.
K.100		Measurement of radio frequency electromagnetic fields to determine compliance with human exposure limits when a base station is put into service.
K.113		Generation of radiofrequency electromagnetic field level maps.
K.121		Guidance on the environmental management for compliance with radio frequency EMF limits for radiocommunication base stations.
K.122		Exposure levels in close proximity of radiocommunication antennas.

Appendix 2: International Electrotechnical Commission (IEC) Standards

Table 5 summarises the key international standards relevant to Electromagnetic Field (EMF) Guidelines developed by the International Electrotechnical Commission (IEC). These standards offer guidance and methodologies for assessing human exposure to Radio Frequency fields, Power Density, Specific Absorption Rate (SAR), and contact current. The information presented here serves as a reference for organisations and professionals involved in the implementation and enforcement of EMF Exposure Guidelines.

Table 5: Summary of Relevant IEC Standards

Publication	Title
IEC 62232:2022	Determination of RF field strength, power density and SAR in the vicinity of base stations for the purpose of evaluating human exposure
IEC TR 62669:2019	Case studies supporting IEC 62232 - Determination of RF field strength, Power Density and SAR in the vicinity of radiocommunication base stations for the purpose of evaluating human exposure.
IEC TR 63170:2018	Measurement procedure for the evaluation of power density related to human exposure to radio frequency fields from wireless communication devices operating between 6 GHz and 100 GHz.
IEC TR 62905:2018	Exposure assessment methods for wireless power transfer systems.
IEC TR 63167:2018	Assessment of contact current related to human exposure to electric, magnetic, and electromagnetic fields.

Note 1: For dated standards, the latest version applies.

Appendix 3: Institute of Electrical and Electronics Engineers (IEEE) Standard

Table 6 below presents a summary of the IEEE Standard pertaining to Electromagnetic Field (EMF) Guidelines. This standard provides science-based exposure criteria to protect against established adverse health effects in humans associated with exposure to electric, magnetic, and electromagnetic fields, induced and contact currents, and contact voltages over the frequency range of 0 Hz to 300 GHz.

For more detailed information on the IEEE Standard, including its purpose and how it contributes to maintaining safe levels of EMF exposure, the Standard can be accessed from:
https://ieeexplore.ieee.org/document/8859679

It is recommended that the most recent issue or a published version of the IEEE Standard be utilised for comprehensive guidance and compliance.

Table 6: Summary of IEEE Standard

Publication	Title
C95.1-2019	IEEE Standard for Safety Levels with Respect to Human Exposure to Electric, Magnetic, and Electromagnetic Fields, 0 Hz to 300 GHz

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