Australian Government
Australian Radiation Protection and Nuclear Safety Agency

arpansa

Standard for Limiting Exposure to Radiofrequency Fields — 100 kHz to 300 GHz

Radiation Protection Series S-1 (Rev. 1)

Radiation Protection Series

The Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) publishes Fundamentals, Codes, Standards and Guides in the Radiation Protection Series (RPS), which promote national policies and practices that protect human health and the environment from harmful effects of radiation. ARPANSA develops these publications jointly with state and territory regulators through the Radiation Health Committee (RHC), which oversees the preparation of draft policies and standards with the view of their uniform implementation in all Australian jurisdictions. Following agreement and, as relevant, approvals at the Ministerial level, the RHC recommends publication to the Radiation Health and Safety Advisory Council, which endorses documents and recommends their publication by the CEO of ARPANSA.

To the extent possible and relevant for Australian circumstances, the RPS publications give effect in Australia to international standards and guidance. The sources of such standards and guidance are varied and include the International Commission on Radiological Protection (ICRP); the International Commission on Non-Ionizing Radiation Protection (ICNIRP); the International Atomic Energy Agency (IAEA); and the World Health Organization (WHO).

Fundamentals set the fundamental principles for radiation protection and describe the fundamental radiation protection, safety and security objectives. They are written in an explanatory and non-regulatory style and describe the basic concepts and objectives of international best practice.

Codes are regulatory in style and may be referenced by regulations or conditions of licence. They contain either general safety or security requirements which may be applicable for all dealings with radiation, or practice-specific requirements. They provide overarching requirements and are expressed as 'must' statements which are to be satisfied to ensure an acceptable level of safety and/or security.

Standards provide a national reference point for radiation protection and safety. They mainly provide quantitative requirements, such as exposure limits and key procedural guidance regarded as essential for best practice in radiation protection. They may be referenced by regulators, authorities, industry and other stakeholders in State, Territory or Commonwealth jurisdictions.

Guides provide recommendations and guidance on how to comply with the Codes and Standards or apply the principles of the Fundamentals. They are written in an explanatory and non-regulatory style and indicate the measures recommended to provide good practice. They are generally expressed as 'should' statements.

These four categories of publications are informed by public comment during drafting and are subject to a process of assessment of regulatory impact.

All ARPANSA publications (including earlier editions of codes and guides for which ARPANSA is now responsible) are available in electronic format, and can be downloaded free of charge by visiting ARPANSA's website at https://www.arpansa.gov.au/regulation-and-licensing/regulatory-publications/radiation-protection-series.

Further information can be obtained by telephoning ARPANSA on 1800 022 333 (free call within Australia) or +61 (03) 9433 2211.

Standard for Limiting Exposure to Radiofrequency Fields – 100 kHz to 300 GHz

Radiation Protection Series S-1

February 2021

This publication was prepared jointly with the *Radiation Health Committee*. The *Radiation Health and Safety Advisory Council* advised the CEO to adopt the Standard.

ARPANSA
619 Lower Plenty Road
YALLAMBIE VIC 3085
Tel: 1800 022 333 (Freecall) or +61 3 9433 2211

Email: info@arpansa.gov.au
Website: www.arpansa.gov.au

The mission of ARPANSA is to protect people and the environment from the harmful effects of radiation.

Published by the Chief Executive Officer of ARPANSA in February 2021.

Acknowledgement of Country

ARPANSA respectfully acknowledges Australia's Aboriginal and Torres Strait Islander communities and their rich culture and pays respect to their Elders past and present. We acknowledge Aboriginal and Torres Strait Islander people as Australia's first peoples and as the Traditional Owners and custodians of the land and water on which we rely.

We recognise and value the ongoing contribution of Aboriginal and Torres Strait Islander people and communities to Australian life and how this enriches us. We embrace the spirit of reconciliation, working towards the equality of outcomes and ensuring an equal voice

Foreword

This *Standard for Limiting Exposure to Radiofrequency Fields – 100 kHz to 300 GHz* (hereafter referred to as 'the Standard') sets limits for human exposure to radiofrequency (RF) electromagnetic fields in the frequency range 100 kHz to 300 GHz. The Standard includes:

- Mandatory basic restrictions for both occupational and general public exposure involving all or part of the human body.
- Corresponding reference levels for measurable quantities derived from the basic restrictions.
- Approaches for verification of compliance with the Standard.
- Requirements for management of risk in occupational exposure and measures for protection of the general public.

This Standard supersedes the 2002 *Radiation Protection Standard for Maximum Exposure Levels to Radiofrequency Fields — 3 kHz to 300 GHz* (Radiation Protection Series No. 3). This Standard is based on the 2020 guidelines of the International Commission on Non-Ionizing Radiation Protection (ICNIRP) for RF electromagnetic fields. ICNIRP is the peak international body developing and disseminating science-based advice on health protection in relation to exposure to non-ionising radiation and is recognised by the World Health Organization for its independence and expertise in this area. The ICNIRP guidelines reflect international best practice on what constitutes a high level of protection for all people against substantiated adverse health effects from exposures to both short- and long-term, continuous and discontinuous RF fields. Further, the principles for protection against adverse health effects of exposure to RF fields in this Standard are based on the ICNIRP Principles for Non-Ionising Radiation Protection, published in 2020.

Research is continuing in many countries into possible effects on health arising from RF exposure. In recognition of this, the Radiation Health Committee will continue to monitor the results of this research and, where necessary, issue amendments to this document.

It is recognised that the Standard does not operate in isolation from the legal framework within Australia. Relevant Australian occupational, health, safety, and environmental laws provide obligations on employers, and the designers, manufacturers and suppliers of plant or equipment, to ensure that their activities, or their plant and equipment, do not represent a risk to the health and safety of their employees or third parties who may be affected by them. In effect, such laws require relevant parties to continually assess and improve the safety and health impact of their activities.

This Standard is intended to complement the requirements of the relevant Work Health and Safety legislation in each jurisdiction. The relevant regulatory authority should be contacted should any conflict of interpretation arise. A listing of such authorities is provided at www.arpansa.gov.au/Regulation/Regulators.

Dr Carl-Magnus Larsson
CEO of ARPANSA

Table of Contents

1. Introduction

1.1 Citation

This publication may be cited as the Radiation Protection Standard for Limiting Exposure to Radiofrequency Fields —100 kHz to 300 GHz (2021).

1.2 Background

Historically, several standards issued by Standards Australia provided the basis for limiting exposure to **radiofrequency (RF) electromagnetic fields** in Australia (Standards Australia, 1985, 1990; Standards Australia/Standards New Zealand, 1998). ARPANSA published the Radiation Protection Standard '*Maximum Exposure Levels to Radiofrequency Fields - 3 kHz to 300 GHz*' in May 2002 (ARPANSA 2002). The 2002 Standard was prepared by a working group established under the auspices of the ARPANSA Radiation Health Committee (RHC). While the International Commission on Non-Ionizing Radiation Protection (ICNIRP) 1998 exposure guidelines provided the initial basis for the 2002 Standard, further material was considered, including all relevant literature up to a cut-off date (about 2000) prior to the publication of the Standard. Overall harmonisation with ICNIRP was considered important and the exposure limits in the ARPANSA 2002 Standard differed only in small detail from those in the ICNIRP 1998 guidelines.

Since the ARPANSA 2002 Standard was published research on RF and health has grown rapidly and several major research programs and reviews have been undertaken internationally. In March 2014 ARPANSA published a report by the ARPANSA Radiofrequency Expert Panel on Review of Radiofrequency Health Effects Research – Scientific Literature 2000 – 2012 (ARPANSA 2014). The report concluded that the science behind the ARPANSA RF Standard remains sound and that the exposure limits in the Standard continue to provide a high degree of protection against the known health effects of exposure to RF. The report also identified areas where the ARPANSA 2002 Standard could be updated to take account of increased knowledge and to better harmonise with international guidelines.

Given the scientific advances surrounding the effects of RF fields since 1998, ICNIRP revised its RF guidelines for limiting exposure to electromagnetic fields (100 kHz to 300 GHz) in March 2020 (ICNIRP 2020a). For effects below 100 kHz ICNIRP revised its guidelines for static (0 Hz) and low **frequency** (1 Hz to 100 kHz) fields in 2009 and 2010, respectively (ICNIRP 2009; 2010).

It is Australian Government Policy to implement international best practice and to adopt international standards where they exist and can be applied to the Australian regulatory environment. This Standard is based on the ICNIRP (2020) recommendations for RF fields (ICNIRP 2020a).

1.3 Purpose

This Standard specifies limits of human **exposure** to RF fields in the frequency range 100 kHz to 300 GHz, to prevent adverse health effects. These exposure limits are defined in terms of **basic restrictions** for occupational and general public exposure of all or a part of the human body. Relevant derived **reference levels** are also provided as a practical means of showing compliance with the basic restrictions.

The exposure limits specified in this Standard are intended to be used as a basis for planning work procedures, designing protective facilities, the assessment of the efficacy of protective measures and practices, and guidance on medical assessment.

This Standard supersedes the 2002 Radiation Protection Standard for *Maximum Exposure Levels to Radiofrequency Fields — 3 kHz to 300 GHz* (Radiation Protection Series No. 3).

1.4 Scope

This Standard is applicable:

- Wherever the general public (including persons of any age or health status) may be exposed to RF fields and whenever employees may be exposed in the course of their work.
- To continuous and discontinuous RF electromagnetic fields exposure at single or multiple frequencies within the range 100 kHz to 300 GHz.
- To situations where RF fields are produced, either deliberately or incidentally, by the operation of equipment or devices. It is the responsibility of the manufacturer/supplier, installer, employer/service provider and user to ensure that all devices and installations are operated in such a way as to achieve compliance with the requirements of this Standard.

This Standard does not apply where patients are exposed to RF fields during **medical exposure**, but does apply to persons operating the radiating equipment and others who are in the vicinity during the procedure. The Standard also applies to people exposed to RF fields during cosmetic treatments without control by a qualified medical practitioner.

The exposure limits specified in this Standard do not apply to other potential hazards of RF fields such as the ignition of explosives or flammable gases, or with interference to electronic equipment, which are the province of other Standards.

The exposure limits represent acceptable levels of RF exposure to the body. Compliance with the exposure limits may not eliminate the possibility of RF burns or shock arising from contact currents. The Standard provides guidance on minimising the potential hazards posed by contact currents. For certain occupational tasks that may involve a possibility of accidental exposure to higher levels, specific additional precautions against RF burns or shock arising from contact currents may be required.

1.5 Principles for protection

The principles for protection against adverse health effects of exposure to RF fields in this Standard are based on the ICNIRP principles for non-ionising radiation protection (ICNIRP 2020b). These principles have been adapted from those recommended by the International Commission on Radiological Protection for ionising radiation protection (ICRP 2007), in order to establish a comprehensive system of radiation protection over the entire electromagnetic spectrum and for infra- and ultrasound.

1.6 Structure

This Standard is structured as follows:

- Section 1 provides introductory and background material for the Standard.
- Section 2 specifies the basic restrictions and reference levels for different parts of the RF spectrum.
- Section 3 describes how to handle simultaneous exposure to multiple frequency fields.
- Section 4 sets out the procedures to be followed for verification of compliance with the basic restrictions and reference levels.
- Section 5 specifies appropriate risk management practice in relation to both occupational and general public exposure.
- Schedule 1 provides figures of reference levels.
- Schedules 2 and 3 provide look-up tables of reference levels.
- Appendix 1 provides information on quantities and units.
- Appendix 2 provides contact information for relevant radiation protection and regulatory authorities.

1.7 Interpretation

In interpreting the provisions of the Standard, the words ‘must’ and ‘should’ have particular meanings. The presence of the word ‘must’ indicates that the requirement to which it refers is mandatory. The presence of the word ‘should’ indicates a recommendation - that is, a requirement that is to be applied as far as is practicable in the interests of reducing risk.

Each of the terms in bold type on first use has the meaning given in the Glossary.

2. Basic restrictions and reference levels for exposure to RF fields between 100 kHz and 300 GHz

2.1 Application

This Section specifies limits of exposure for both 'occupational' and 'general public' groups. These groups are distinguished by their potential level of exposure and are defined by the degree of control and the level of awareness and training they have, as distinct from whether or not an exposure is likely to occur in the workplace (see Section 5).

Occupational exposure is permitted only after thorough risk analysis has been performed and the appropriate risk management and control regimes are in force (see Section 5). The general public are often unaware of exposure, may be continually exposed, and cannot reasonably be expected to take precautions to minimise or avoid exposure. These considerations underlie the application of more stringent exposure restrictions for the general public than for the occupationally exposed population.

2.2 Basic restrictions and reference Levels

Mandatory limits on exposure to RF fields are based on substantiated health effects and are termed 'basic restrictions'. Protection against substantiated adverse health effects requires that these basic restrictions are not exceeded. Depending on frequency, the physical quantities used to specify the basic restrictions are **induced electric field (E_{ind})**, **specific energy absorption rate (SAR)**, **absorbed power density (S_{ab})**, **specific energy absorption (SA)** and **absorbed energy density (U_{ab})**.

The mandatory basic restrictions are specified as quantities that are often impractical to measure. Therefore, reference levels utilising quantities that are more practical to measure, are provided as an alternative means of showing compliance with the mandatory basic restrictions. The relevant reference level quantities are **incident electric field strength (E_{inc})**, **incident magnetic field strength (H_{inc})**, **incident power density (S_{inc})**, **plane-wave equivalent incident power density (S_{eq})**, **incident energy density (U_{inc})**, and **plane-wave equivalent incident energy density (U_{eq})**, all measured outside the body, and **electric current** inside the body (**I**). To be compliant with the present standard, for each exposure quantity (e.g., E-field, H-field, SAR), and temporal and spatial averaging condition, either the basic restriction or corresponding reference level must be adhered to; compliance with both is not required.

The basic restrictions and reference levels are specified for average exposure over the whole body (whole body average exposure), and also for exposure over localised areas of the body (local exposure). Tables 1 to 7 specify whether the basic restrictions and reference levels applying to local exposure incorporate any spatial averaging and, if so, the volume or area over which the exposure is averaged, or whether they apply to the spatial peak (maximum) exposure.

2.3 Basic restrictions

The basic restrictions are specified in Tables 1-2. A description of their derivation is provided in the ICNIRP guidelines (2020).

Different criteria were used in the development of basic restrictions for various frequency ranges:

(a) Between 100 kHz and 10 MHz, basic restrictions on E_{ind} are provided to prevent electrostimulation of excitable tissue (see Table 3).

(b) Between 100 kHz and 300 GHz, basic restrictions on whole body average SAR are provided to prevent whole-body heat stress (see Table 1).

(c) Between 100 kHz and 6 GHz, basic restrictions on local SAR (head/torso and limbs) are provided to prevent excessive localised temperature rise in tissue (see Table 1).

(d) Between 400 MHz and 6 GHz, basic restrictions on local SA are provided to prevent rapid temperature elevation (see Table 2).

(e) Between 6 GHz and 300 GHz, basic restrictions on local S_{ab} are provided to prevent excessive heating in tissue at or near the body surface (see Table 1).

(f) Between 6 GHz and 300 GHz, basic restrictions on local U_{ab} are provided to prevent rapid temperature elevation (see Table 2).

Table 1. Basic restrictions for RF electromagnetic field exposure from 100 kHz to 300 GHz, for averaging intervals ≥ 6 minutes

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 S_{ab} ($W\ m^{-2}$)
Occupational	100 kHz – 6 GHz	0.4	10	20	NA
	>6 GHz – 300 GHz	0.4	NA	NA	100
General Public	100 kHz – 6 GHz	0.08	2	4	NA
	>6 GHz – 300 GHz	0.08	NA	NA	20

Notes:
1. 'NA' signifies 'not applicable' and does not need to be taken into account when determining compliance.
2. Whole body average SAR is to be averaged over 30 minutes.
3. Local SAR and $\mathbf{S}_{ab}$ exposures are to be averaged over 6 minutes.
4. Local SAR is to be averaged over a 10 g cubic mass.
5. Local $\mathbf{S}_{ab}$ is to be averaged over a square 4-cm^2 surface area of the body. Above 30 GHz, an additional constraint is imposed, such that exposure averaged over a square 1-cm^2 surface area of the body is restricted to two times that of the S_{ab} restriction.

Table 2. Basic restrictions for RF electromagnetic field exposure from 100 kHz to 300 GHz, for integrating intervals >0 to < 6 minutes

Exposure Scenario	Frequency Range	Local Head/Torso SA ($kJ\ kg^{-1}$)	Local Limb SA ($kJ\ kg^{-1}$)	Local U_{ab} ($kJ\ m^{-2}$)
Occupational	100 kHz – 400 MHz	NA	NA	NA
	>400 MHz – 6 GHz	$3.6(0.05+0.95[t/360]^{0.5})$	$7.2(0.025+0.975[t/360]^{0.5})$	NA
	>6 GHz – 300 GHz	NA	NA	$36(0.05+0.95[t/360]^{0.5})$
General Public	100 kHz – 400 MHz	NA	NA	NA
	>400 MHz – 6 GHz	$0.72(0.05+0.95[t/360]^{0.5})$	$1.44(0.025+0.975[t/360]^{0.5})$	NA
	>6 GHz – 300 GHz	NA	NA	$7.2(0.05+0.95[t/360]^{0.5})$

Notes:

1. 'NA' signifies 'not applicable' and does not need to be taken into account when determining compliance.
2. t is the exposure time in seconds, and restrictions must be satisfied for all values of t between >0 and <360 seconds, regardless of the temporal characteristics of the exposure itself.
3. Local SA is to be averaged over a 10-g cubic mass.
4. Local U_{ab} is to be averaged over a square 4-cm^2 surface area of the body. Above 30 GHz, an additional constraint is imposed, such that exposure averaged over a square 1-cm2 surface area of the body is restricted to $72(0.025+0.975(t/360)^{0.5})$ for occupational and $14.4(0.025+0.975(t/360)^{0.5})$ for general public exposure.
5. Exposure from any pulse, group of pulses, or subgroup of pulses in a train, as well as from the summation of exposures (including non-pulsed electromagnetic fields), delivered in t seconds, must not exceed these levels.

Table 3. Basic restrictions for RF electromagnetic field exposure from 100 kHz to 10 MHz, for peak spatial values

Exposure Scenario	Frequency Range	Induced Electric Field E_{ind} ($V\ m^{-1}$)
Occupational	100 kHz – 10 MHz	$2.70 \times 10^{-4} f$
General Public	100 kHz – 10 MHz	$1.35 \times 10^{-4} f$

Notes:

1. f is frequency in Hz.
2. Restriction values relate to any region of the body, and are to be averaged as root mean square (rms) values over 2 mm × 2 mm × 2 mm contiguous tissue (as specified in ICNIRP (2010)).

2.4 Reference levels

Reference levels have been derived from a combination of computational modelling and experimental measurement studies to provide a means of demonstrating compliance using quantities that are more-easily assessed than basic restrictions, but that provide an equivalent level of protection to the basic restrictions for worst-case exposure scenarios. However, as the derivations rely on conservative assumptions, in most exposure scenarios the reference levels will be more conservative than the corresponding basic restrictions. Further detail regarding the reference levels is provided in the ICNIRP guidelines (2020a).

The reference levels are specified in Tables 4-8 and have been set to protect against effects associated with:

- Whole body exposure (averaged over 30 minutes; Table 4)
- Local exposure (averaged over 6 minutes; Table 5)

- Brief local exposure (integrated over intervals between >0 and <6 minutes; Table 6); and
- Instantaneous local exposure (peak instantaneous field strength; Table 7)

Additional **limb current** reference levels have been set to account for effects of grounding near human body resonance frequencies that might otherwise lead to reference levels underestimating exposures within tissue at certain RF electromagnetic field frequencies (averaged over 6 minutes; Table 8). Limb current reference levels are only relevant in exposure scenarios where a person is not electrically isolated from a ground plane.

Tables 4 to 8 specify averaging and integrating times of the relevant exposure quantities to determine whether personal exposure level is compliant with the Standard. These averaging and integrating times are continuous periods. They are not necessarily the same as the measurement times needed to estimate field strengths or other exposure quantities. Actual measurement times used to provide an appropriate estimate of exposure quantities may be shorter than the intervals specified in these tables when the field is substantially constant, or when known characteristics can be used to calculate the average.

The reference levels for whole body and local exposure are illustrated in Figures 2 and 3 provided in Schedule 1 and look-up tables provided in Schedules 2 and 3.

Tables 4-7 specify requirements for demonstrating compliance in the far field, radiating near field and reactive near field. The boundaries between these regions depend on several factors, including the antenna type, antenna dimensions and wavelength of the RF electromagnetic field. Users should consult appropriate exposure assessment standards, such as current editions of AS/NZS 2772.2 and IEC 62232 for further details and definition of the boundaries for specific circumstances.

Table 4. Reference levels for whole body exposure, averaged over 30 minutes, to RF electromagnetic fields from 100 kHz to 300 GHz (**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	0.1-6.943 MHz	ES	$4.9/f_M$	NA
	>6.943-30 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 – 6.27 MHz	ES	$2.2/f_M$	NA
	>6.27-30 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

Notes:
1. 'NA' signifies 'not applicable' and does not need to be taken into account when determining compliance.
2. 'ES' signifies that no reference level is available, as it would be greater than the reference level for spatial peak and temporal peak field strengths based on electrostimulation effects shown in Table 7.
3. f_M is frequency in MHz.
4. S_{inc}, E_{inc} and H_{inc} are to be averaged over 30 minutes, over the whole-body space. Temporal and spatial averaging of each of E_{inc} and H_{inc} must be conducted by averaging over the relevant square values (see ICNIRP 2020a for details).

5. For frequencies of 100 kHz to 30 MHz, regardless of the far-field/near-field zone distinctions, compliance is demonstrated if neither E_{inc} nor H_{inc} exceeds the above reference level values.
6. For frequencies of >30 MHz to 2 GHz: a) within the far-field and radiating near field zones: compliance is demonstrated if either S_{inc}, E_{inc} or H_{inc}, does not exceed the above reference level values (only one is required); S_{eq} derived from either E_{inc} or H_{inc} may be substituted for S_{inc};b) within the reactive near-field zone: compliance is demonstrated if both E_{inc} and H_{inc} do not exceed the above reference level values; S_{inc} cannot be used to demonstrate compliance, and so basic restrictions must be assessed.
7. For frequencies of >2 GHz to 300 GHz: a) within the far-field and radiating near field zones: compliance is demonstrated if S_{inc} does not exceed the above reference level values; S_{eq} derived from either E_{inc} or H_{inc} may be substituted for S_{inc}; b) within the reactive near-field zone, reference levels cannot be used to determine compliance, and so basic restrictions must be assessed.

Table 5. Reference levels for local exposure, averaged over 6 minutes, to RF electromagnetic fields from 100 kHz to 300 GHz (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	0.1-0.135 MHz	ES	ES	NA
	>0.135-10 MHz	ES	$10.8/f_M$	NA
	>10-30 MHz	$1504/f_M^{0.7}$	$10.8/f_M$	NA
	>30-400 MHz	139	0.36	50
	>400-2,000 MHz	$10.58 f_M^{0.43}$	$0.0274 f_M^{0.43}$	$0.29 f_M^{0.86}$
	>2 – 6 GHz	NA	NA	200
	>6 – <300 GHz	NA	NA	$275/f_G^{0.177}$
	300 GHz	NA	NA	100
General Public	0.1-0.233 MHz	ES	ES	NA
	>0.233-10 MHz	ES	$4.9/f_M$	NA
	>10-30 MHz	$671/f_M^{0.7}$	$4.9/f_M$	NA
	>30-400 MHz	62	0.163	10
	>400-2,000 MHz	$4.72 f_M^{0.43}$	$0.0123 f_M^{0.43}$	$0.058 f_M^{0.86}$
	>2 – 6 GHz	NA	NA	40
	>6 – <300 GHz	NA	NA	$55/f_G^{0.177}$
	300 GHz	NA	NA	20

Notes:
1. 'NA' signifies 'not applicable' and does not need to be taken into account when determining compliance.
2. 'ES' signifies that no reference level is available, as it would be greater than the reference level for spatial peak and temporal peak field strengths based on electrostimulation effects shown in Table 7.
3. f_M is frequency in MHz; f_G is frequency in GHz.
4. S_{inc}, E_{inc} and H_{inc} are to be averaged over 6 minutes, and where spatial averaging is specified in Notes 6-8, over the relevant projected body space. Temporal and spatial averaging of each of E_{inc} and H_{inc} must be conducted by averaging over the relevant square values (see ICNIRP 2020a for details).
5. For frequencies of 100 kHz to 30 MHz, regardless of the far-field/near-field zone distinctions, compliance is demonstrated if neither peak spatial E_{inc} nor peak spatial H_{inc}, over the projected whole-body space, exceeds the above reference level values.
6. For frequencies of >30 MHz to 6 GHz: a) within the far-field and radiating near field zones, compliance is demonstrated if one of peak spatial S_{inc}, E_{inc} or H_{inc}, over the projected whole-body space, does not exceed the above reference level values (only one is required); S_{eq} derived from either E_{inc} or H_{inc} may be substituted for S_{inc}; b) within the reactive near-field zone: compliance is demonstrated if both peak spatial E_{inc} and H_{inc} do not exceed the above reference level values; S_{inc} cannot be used to demonstrate compliance; for frequencies >2 GHz, reference levels cannot be used to determine compliance, and so basic restrictions must be assessed.

7. For frequencies of >6 GHz to 300 GHz: a) within the far-field and radiating near field zones, compliance is demonstrated if S_{inc}, averaged over a square 4-cm² projected body surface space, does not exceed the above reference level values; S_{eq} derived from either E_{inc} or H_{inc} may be substituted for S_{inc}; b) within the reactive near-field zone, reference levels cannot be used to determine compliance, and so basic restrictions must be assessed.
8. For frequencies of >30 GHz to 300 GHz, exposure averaged over a square 1-cm² projected body surface space must not exceed twice that of the square 4-cm² S_{inc} restrictions.

Table 6. Reference levels for local exposure, integrated over intervals of between >0 and <6 minutes, to RF electromagnetic fields from 100 kHz to 300 GHz (unperturbed rms values)

Exposure Scenario	Frequency Range	Incident Energy Density U_{inc} (kJ m^{-2})
Occupational	100 kHz – 400 MHz	NA
	>400 – 2000 MHz	$0.29 f_M^{0.86}$ x $0.36(0.05+0.95[t/360]^{0.5})$
	>2 – 6 GHz	200 x $0.36(0.05+0.95[t/360]^{0.5})$
	>6 – <300 GHz	$275/f_G^{0.177}$ x $0.36(0.05+0.95[t/360]^{0.5})$
	300 GHz	100 x $0.36(0.05+0.95[t/360]^{0.5})$
General Public	100 kHz – 400 MHz	NA
	>400 – 2000 MHz	$0.058 f_M^{0.86}$ x $0.36(0.05+0.95[t/360]^{0.5})$
	>2 – 6 GHz	40 x $0.36(0.05+0.95[t/360]^{0.5})$
	>6 – <300 GHz	$55/f_G^{0.177}$ x $0.36(0.05+0.95[t/360]^{0.5})$
	300 GHz	20 x $0.36(0.05+0.95[t/360]^{0.5})$

Notes:
1. 'NA' signifies 'not applicable' and does not need to be taken into account when determining compliance.
2. f_M is frequency in MHz; f_G is frequency in GHz; t is the exposure time interval in seconds, such that exposure from any pulse, group of pulses, or subgroup of pulses in a train, as well as from the summation of exposures (including non-pulsed RF electromagnetic fields), delivered in t seconds, must not exceed these reference level values for any time $0 < t < 360$ s.
3. U_{inc} is to be calculated over time t, and where spatial averaging is specified in Notes 5-7, over the relevant projected body space.
4. For frequencies of 100 kHz to 400 MHz, >0 to <6-minute restrictions are not required and so reference levels have not been set.
5. For frequencies of >400 MHz to 6 GHz: a) within the far-field and radiating near field zones: compliance is demonstrated if peak spatial U_{inc}, over the projected whole-body space, does not exceed the above reference level values; U_{eq} derived from either E_{inc} or H_{inc} may be substituted for U_{inc}; b) within the reactive near-field zone, reference levels cannot be used to determine compliance, and so basic restrictions must be assessed.
6. For frequencies of >6 GHz to 300 GHz: a) within the far-field or radiative near-field zone, compliance is demonstrated if U_{inc}, averaged over a square 4-cm² projected body surface space, does not exceed the above reference level values; U_{eq} derived from either E_{inc} or H_{inc} may be substituted for U_{inc}; b) within the reactive near-field zone, reference levels cannot be used to determine compliance, and so basic restrictions must be assessed.
7. For frequencies of >30 GHz to 300 GHz: exposure averaged over a square 1-cm² projected body surface space must not exceed $275/f_G^{0.177}$ x $0.72(0.025+0.975[t/360]^{0.5})$ kJ m^{-2} for occupational and $55/f_G^{0.177}$ x $0.72(0.025+0.975[t/360]^{0.5})$ kJ m^{-2} for general public exposure.

Table 7. Reference levels for spatial peak and temporal peak field strength, to RF electromagnetic fields from 100 kHz to 10 MHz (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})
Occupational	100 kHz – 10 MHz	170	80
General Public	100 kHz – 10 MHz	83	21

Notes:

1. Regardless of the far-field/near-field zone distinction, compliance is demonstrated if neither the temporal nor spatial peak E_{inc} or H_{inc}, over the space occupied by the body, exceeds the above reference level values.

Table 8. Reference levels for current induced in any limb, averaged over 6 minutes, at frequencies between 100 kHz and 110 MHz

Exposure Scenario	Frequency Range	Current I (mA)
Occupational	100 kHz – 110 MHz	100
General Public	100 kHz – 110 MHz	45

Notes:

1. Current intensity values must be determined by averaging over the relevant square values (see ICNIRP 2020a for details).
2. Limb current intensity must be evaluated separately for each limb.
3. Limb current reference levels are not provided for any other frequency range.
4. Limb current reference levels are only required for cases where the human body is not electrically isolated from a ground plane.

2.5 Guidance for contact currents

Exposure due to **contact currents** is indirect, in that it requires an intermediate conducting object to transduce the field. This makes contact current exposure unpredictable, due to both behavioural factors (e.g. grasping versus touch contact) and environmental conditions (e.g. configuration of conductive objects), and reduces this Standard's ability to protect against them. Accordingly, the ICNIRP guidelines and this Standard do not provide restrictions for contact currents, and instead provide 'guidance' to assist those responsible for transmitting high-power RF fields to understand contact currents, the potential hazards, and how to mitigate such hazards.

In determining the likelihood and nature of the hazard due to potential contact current scenarios, ICNIRP views the following as important for the Responsible Person in managing risk associated with contact currents within the 100 kHz to 110 MHz region.

(a) Available data suggest that contact current thresholds for reversible, mild pain, for adults and children, are likely to be approximately 20 mA and 10 mA respectively (ICNIRP 2020).

(b) Contact current magnitude will increase as a function of field strength and is affected by conducting-object configuration such as the proximity to the original source and the angular alignment to the original source.

(c) Risk of contact current hazards can be minimized by training workers to avoid contact with conducting objects, but where contact is required the following factors are important:
   (i) Large conducting objects should be connected to ground (grounding).
   (ii) Workers should make contact via insulating materials or PPE (e.g. RF protective gloves).
   (iii) Reducing or removing the RF power at the original source can eliminate the risk.
   (iv) Workers should be made aware of the risks, including the possibility of 'surprise', which may impact on safety in ways other than the direct impact of the current on tissue (for example, by causing accidents when working at heights).

This may also be useful for assisting the Responsible Person (see section 5.1.3) in conducting a risk-benefit analysis associated with allowing a person into a RF environment that may result in contact currents.

3. Simultaneous exposure to multiple frequency fields

3.1 General principles

It is important to determine whether, in situations of simultaneous exposure to fields of different frequencies, these exposures are additive in their effects. Additivity should be examined separately for the effects of thermal and electrical stimulation, and restrictions met after accounting for such additivity. The formulae below apply to relevant frequencies under practical exposure situations. As the below reference level summation formulae assume worst-case conditions among the fields from multiple sources, typical exposure situations may in practice result in lower exposure levels than indicated by the formulae for the reference levels.

The following issues are noted. In terms of the reference levels, the largest ratio of the E-field strength, H-field strength or power density, relative to the corresponding reference level values, should be evaluated for each source and used to demonstrate compliance. In the radiating far-field at frequencies above 30 MHz, the E^2, H^2 and S exposure ratios are essentially identical and only one ratio need be determined. Reference levels are defined in terms of external physical quantities and have transitions, in terms of quantities, at specific frequencies. For example, field strengths are used below 30 MHz, whereas both field strength and incident power density are applicable from 30 MHz to 2 GHz. Where the exposure includes frequency components below and above the transition, additivity should be used to account for this. The same principle applies to basic restrictions. Field values entered into the equations below must be derived using the same spatial and temporal constraints referred to in the basic restriction and reference level tables. The summation equations for basic restrictions and reference levels are presented separately below. However, for practical compliance purposes, the evaluation by basic restriction and reference level can be combined. For example, the second term in Eqn. 2 can be replaced by the fourth term in Eqn. 4 for frequency components above 6 GHz.

3.2 Basic restrictions for intervals ≥ 6 minutes

For practical application of the whole-body average basic restrictions, SAR should be added according to;

$$\sum_{i=100\text{ kHz}}^{300\text{ GHz}} \frac{\mathrm{SAR}_i}{\mathrm{SAR}_{\mathrm{BR}}} \leq 1 \qquad \text{(Eqn. 1)},$$

where SAR_i and $\mathrm{SAR}_{\mathrm{BR}}$ are the whole-body average SAR levels at frequency *i* and the whole-body average SAR basic restrictions given in Table 1, respectively.

For practical application of the local SAR and local absorbed power density basic restrictions, values should be added according to;

$$\sum_{i=100\text{ kHz}}^{6\text{ GHz}} \frac{\mathrm{SAR}_i}{\mathrm{SAR}_{\mathrm{BR}}} + \sum_{i>6\text{ GHz}}^{30\text{ GHz}} \frac{S_{\mathrm{ab,4cm},i}}{S_{\mathrm{ab,4cm,BR}}} + \sum_{i>30\text{ GHz}}^{300\text{ GHz}} \mathrm{MAX}\left\{\left(\frac{S_{\mathrm{ab,4cm},i}}{S_{\mathrm{ab,4cm,BR}}}\right),\left(\frac{S_{\mathrm{ab,1cm},i}}{S_{\mathrm{ab,1cm,BR}}}\right)\right\} \leq 1, \qquad \text{(Eqn. 2)},$$

where, SAR_i and SAR_{BR} are the local SAR level at frequency *i* and the local SAR basic restriction given in Table 1, respectively; $S_{ab,4cm,i}$ and $S_{ab,4cm,BR}$ are the 4-cm^2 absorbed power density level at frequency *i* and the 4-cm^2 absorbed power density basic restriction given in Table 1, respectively; $S_{ab,1cm,i}$ and $S_{ab,1cm,BR}$ are the 1-cm^2 absorbed power density level at frequency *i* and the 1-cm^2 absorbed power density basic restriction given in Table 1, respectively; inside the body, S_{ab} terms are to be treated as zero; when evaluating the summation of SAR and S_{ab} over the body surface, the centre of the SAR averaging space is taken to be x,y,z, such that the x,y plane is parallel to the body surface (z = 0) and z = -1.08 cm (approximately half the length of a 10-g cube), and the centre of the S_{ab} averaging area is defined as x,y,0; Eqn. 2 must be satisfied for every position in the human body.

3.3 Reference levels for intervals ≥ 6 minutes

For practical application of the whole-body average reference levels, incident electric field strength, incident magnetic field strength and incident power density values should be added according to;

$$\sum_{i=100\text{ kHz}}^{30\text{ MHz}} \text{MAX}\left\{\left(\frac{E_{inc,i}}{E_{inc,RL,i}}\right)^2, \left(\frac{H_{inc,i}}{H_{inc,RL,i}}\right)^2\right\} + \sum_{i>30\text{ MHz}}^{2\text{ GHz}} \text{MAX}\left\{\left(\frac{E_{inc,i}}{E_{inc,RL,i}}\right)^2, \left(\frac{H_{inc,i}}{H_{inc,RL,i}}\right)^2, \left(\frac{S_{inc,i}}{S_{inc,RL,i}}\right)\right\} + \sum_{i>2\text{ GHz}}^{300\text{ GHz}} \left(\frac{S_{inc,i}}{S_{inc,RL}}\right) \leq 1, \qquad \text{(Eqn. 3)},$$

where, $E_{inc,i}$ and $E_{inc,RL,i}$ are the whole-body average incident electric field strength and whole-body average incident electric field strength reference level given in Table 4, at frequency *i*, respectively; $H_{inc,i}$ and $H_{inc,RL,i}$ are the whole-body average incident magnetic field strength and whole-body average incident magnetic field strength reference level given in Table 4, at frequency *i*, respectively; S_{inc} and $S_{inc,RL}$ are the whole-body average incident power density and whole-body average incident power density reference level given in Table 4, respectively; $S_{inc,i}$ and $S_{inc,RL,i}$ are the whole-body average incident power density and whole-body average incident power density reference level given in Table 4, at frequency *i*, respectively. Note that in the radiating far-field the three exposure ratios in the second term of Eqn. 3 are essentially identical and therefore only one ratio need be determined at each frequency. Note that the third term of Eqn. 3 is not appropriate and cannot be used for the reactive near-field zone. In this circumstance, the equivalent terms from Eqn. 1 for basic restrictions must be used instead.

For practical application of the local reference levels, incident electric field strength, incident magnetic field strength and incident power density values should be added according to;

$$\sum_{i=100\text{ kHz}}^{30\text{ MHz}} \text{MAX}\left\{\left(\frac{E_{inc,i}}{E_{inc,RL,i}}\right)^2, \left(\frac{H_{inc,i}}{H_{inc,RL,i}}\right)^2\right\} + \sum_{i>30\text{ MHz}}^{2\text{ GHz}} \text{MAX}\left\{\left(\frac{E_{inc,i}}{E_{inc,RL,i}}\right)^2, \left(\frac{H_{inc,i}}{H_{inc,RL,i}}\right)^2, \left(\frac{S_{inc,i}}{S_{inc,RL,i}}\right)\right\} + \sum_{i>2\text{ GHz}}^{6\text{ GHz}} \left(\frac{S_{inc,i}}{S_{inc,RL,i}}\right)$$

$$+\sum_{i>6\ \mathrm{GHz}}^{30\ \mathrm{GHz}}\left(\frac{\mathrm{S}_{\mathrm{inc,4cm},i}}{\mathrm{S}_{\mathrm{inc,4cm,RL},i}}\right)$$

$$+\sum_{i>30\ \mathrm{GHz}}^{300\ \mathrm{GHz}}\mathrm{MAX}\left\{\left(\frac{\mathrm{S}_{\mathrm{inc,4cm},i}}{\mathrm{S}_{\mathrm{inc,4cm,RL},i}}\right),\left(\frac{\mathrm{S}_{\mathrm{inc,1cm},i}}{\mathrm{S}_{\mathrm{inc,1cm,RL},i}}\right)\right\}\quad\leq 1, \qquad \text{(Eqn. 4)},$$

where, $E_{inc,i}$ and $E_{inc,RL,i}$ are the local incident electric field strength and local incident electric field strength reference level given in Table 5, at frequency *i*, respectively; $H_{inc,i}$ and $H_{inc,RL,i}$ are the local incident magnetic field strength and local incident magnetic field strength reference level given in Table 5, at frequency *i*, respectively; $S_{inc,i}$ and $S_{inc,RL,i}$ are the local incident power density and local incident power density reference level given in Table 5, at frequency *i*, respectively; inside the body above 6 GHz, S_{inc} terms are to be treated as zero; Eqn. 4 must be satisfied for every position in the human body. Note that within the reactive near-field zone for frequencies above 2 GHz, reference levels cannot be used to determine compliance, and so basic restrictions must be assessed (refer to Eqn 2). Note that in the radiating far-field the three exposure ratios in the second term of Eqn. 4 are essentially identical and therefore only one ratio need be determined at each frequency. Note that the third term of Eqn. 4 is not appropriate and cannot be used for the reactive near-field zone. In this circumstance, the equivalent terms from Eqn. 1 for basic restrictions must be used instead.

For practical application of the limb current reference levels, limb current values should be added according to;

$$\sum_{i=100\ \mathrm{kHz}}^{110\ \mathrm{MHz}}\left(\frac{\mathrm{I}_i}{\mathrm{I}_{\mathrm{RL}}}\right)^2\quad\leq 1 \qquad \text{(Eqn. 5)},$$

where I_i is the limb current component at frequency *i*; and I_{RL} is the limb current reference level value from Table 8. If there are non-negligible contributions to the local SAR around limbs over 110 MHz, these need to be considered by combining corresponding terms in Equations 2 or 4.

3.4 Basic restrictions for intervals < 6 minutes

For practical application of the local basic restrictions for time intervals (*t*) <6 minutes, SAR, SA and absorbed energy density values should be added according to:

$$\sum_{i=100\ \mathrm{kHz}}^{400\ \mathrm{MHz}}\int_t\frac{\mathrm{SAR}_i(t)}{360*\mathrm{SAR}_{\mathrm{BR}}}dt$$

$$+\sum_{i>400\ \mathrm{MHz}}^{6\ \mathrm{GHz}}\frac{\mathrm{SA}_i(t)}{\mathrm{SA}_{\mathrm{BR}}(t)}$$

$$+\sum_{i>6\ \mathrm{GHz}}^{30\ \mathrm{GHz}}\frac{\mathrm{U}_{\mathrm{ab,4cm},i}(t)}{\mathrm{U}_{\mathrm{ab,4cm,BR}}(t)}$$

$$+\sum_{i>30\ \mathrm{GHz}}^{300\ \mathrm{GHz}}\mathrm{MAX}\left\{\left(\frac{\mathrm{U}_{\mathrm{ab,4cm},i}(t)}{\mathrm{U}_{\mathrm{ab,4cm,BR}}(t)}\right),\left(\frac{\mathrm{U}_{\mathrm{ab,1cm},i}(t)}{\mathrm{U}_{\mathrm{ab,1cm,BR}}(t)}\right)\right\}\quad\leq 1 \qquad \text{(Eqn. 6)},$$

where, $SAR_i(t)$ and $SAR_{BR}(t)$ are the local SAR level at frequency *i* and the local SAR basic restriction given in Table 1, over time *t*, respectively; $SA_i(t)$ and $SA_{BR}(t)$ are the local SA level at frequency *i* and the local SA basic restriction given in Table 2, over time *t*, respectively; $U_{ab,4cm,i}(t)$ and $U_{ab,4cm,BR}(t)$ are the 4-cm^2 absorbed energy density level at frequency *i* and the 4-cm² absorbed energy density basic restriction given in Table 2, over time *t*, respectively; $U_{ab,1cm,i}(t)$ and $U_{ab,1cm,BR}(t)$ are the 1-cm² absorbed energy density level at frequency *i* and the 1-cm² absorbed energy density basic restriction given in Table 2, over time *t*, respectively; inside the body, U_{ab} terms are to be treated as zero; when evaluating the summation of SAR and/or SA, and U_{ab}, over the body surface, the centre of the SAR and/or SA averaging space is taken to be x,y,z, such that the x,y plane is parallel to the body surface (z = 0) and z = -1.08 cm (approximately half the length of a 10 g cube), and the centre of the U_{ab} averaging area is defined as x,y,0; Eqn. 6 must be satisfied for every position in the human body; for simultaneous exposure of brief and extended exposures, SAR, SA and U_{ab} must all be accounted for in this equation.

3.5 Reference levels for intervals < 6 minutes

For practical application of the local reference levels for time intervals (*t*) <6 minutes, incident electric field strength, incident magnetic field strength, incident power density and incident energy density values should be added according to:

$$\sum_{i>100\text{ kHz}}^{30\text{ MHz}} \text{MAX}\left\{\left(\int_t \frac{E_{inc,i}^2(t)}{360 * E_{inc,RL,i}^2} dt\right), \left(\int_t \frac{H_{inc,i}^2(t)}{360 * H_{inc,RL,i}^2} dt\right)\right\}$$

$$+ \sum_{i>30\text{ MHz}}^{400\text{ MHz}} \text{MAX}\left\{\left(\int_t \frac{E_{inc,i}^2(t)}{360 * E_{inc,RL,i}^2} dt\right), \left(\int_t \frac{H_{inc,i}^2(t)}{360 * H_{inc,RL,i}^2} dt\right), \left(\int_t \frac{S_{inc,i}(t)}{360 * S_{inc,RL,i}} dt\right)\right\}$$

$$+ \sum_{i>400\text{ MHz}}^{6\text{ GHz}} \frac{U_{inc,i}(t)}{U_{inc,RL,i}(t)}$$

$$+ \sum_{i=6\text{ GHz}}^{30\text{ GHz}} \frac{U_{inc,4cm,i}(t)}{U_{inc,4cm,RL,i}(t)}$$

$$+ \sum_{i>30\text{ GHz}}^{300\text{ GHz}} \text{MAX}\left\{\left(\frac{U_{inc,4cm,i}(t)}{U_{inc,4cm,RL,i}(t)}\right), \left(\frac{U_{inc,1cm,i}(t)}{U_{inc,1cm,RL,i}(t)}\right)\right\} \leq 1 \qquad \text{(Eqn. 7)},$$

where, $E_{inc,i}(t)$ and $E_{inc,RL,i}$ are the local E_{inc} level over time *t* and the local E_{inc} reference level given in Table 5, at frequency *i*, respectively; $H_{inc,i}(t)$ and $H_{inc,RL,i}$ are the local H_{inc} level over time *t* and the local H_{inc} reference level given in Table 5, at frequency *i*, respectively; $S_{inc,i}(t)$ and $S_{inc,RL,i}$ are the local S_{inc} level over time *t* and the local S_{inc} reference level given in Table 5, at frequency *i*, respectively; $U_{inc,i}(t)$ and $U_{inc,RL}(t)$ are the incident energy density level and the incident energy density reference level, over time *t*, at frequency *i*, given in Table 6, respectively; $U_{inc,4cm,i}(t)$ and $U_{inc,4cm,RL}(t)$ are the 4-cm² incident energy density level and the 4-cm² incident energy density reference level, over time *t*, at frequency *i*, given in Table 6, respectively; $U_{inc,1cm,i}(t)$ and $U_{inc,1cm,RL}(t)$ are the 1-cm² incident energy density level and the 1-cm² incident energy density reference level, over time *t*, at frequency *i*, given in Table 6, respectively; inside the body, U_{inc} terms are to be treated as zero; Eqn. 7 must be satisfied for every position in the human body. Note that in the radiating far-field the three exposure ratios in the second term of Eqn. 7 are essentially identical and therefore only one ratio need be determined at each frequency. Note that within the reactive near-field zone for frequencies above 400 MHz, reference levels cannot be used to determine compliance. In this circumstance, the equivalent terms from Eqn. 6 for basic restrictions must be used instead.

3.6 Basic restrictions for electrostimulation effects

For practical application of the basic restrictions to prevent electrostimulation of excitable tissue, the instantaneous spatial peak rms induced electric field values should be added according to:

$$\sum_{i=100\ \text{kHz}}^{10\ \text{MHz}} \frac{\mathrm{E}_{\text{ind},i}}{\mathrm{E}_{\text{ind,BR},i}} \leq 1, \qquad \text{(Eqn. 8)},$$

where, $\mathrm{E}_{\text{ind},i}$ is the induced electric field at frequency *i* and $\mathrm{E}_{\text{ind,BR},i}$ is the basic restriction evaluated at frequency *i* given in Table 3.

3.7 Reference levels for electrostimulation effects

For practical application of the reference levels to prevent electrostimulation of excitable tissue, the peak instantaneous field strength values should be added according to:

$$\sum_{i=100\ \text{kHz}}^{10\ \text{MHz}} \text{MAX}\left\{\frac{\mathrm{E}_{\text{inc},i}}{\mathrm{E}_{\text{inc,RL}}}, \frac{\mathrm{H}_{\text{inc},i}}{\mathrm{H}_{\text{inc,RL}}}\right\} \leq 1, \qquad \text{(Eqn. 9)},$$

where, $\mathrm{E}_{\text{inc},i}$ is the incident electric field strength at frequency *i* and $\mathrm{E}_{\text{inc,RL}}$ is the reference level given in Table 7; $\mathrm{H}_{\text{inc},i}$ is the incident magnetic field strength at frequency *i* and $\mathrm{H}_{\text{inc,RL}}$ is the reference level given in Table 7.

4. Verification of compliance with the basic restrictions and reference levels

4.1 General

The mandatory basic restrictions in this Standard are specified through quantities that are often difficult and, in many cases, impractical to measure. Therefore, reference levels of exposure, which are simpler to measure or calculate, are provided as an alternative means of showing compliance with the mandatory basic restrictions. The reference levels have been conservatively formulated such that compliance with the reference levels given in this Standard will ensure compliance with the basic restrictions. If measured exposures are higher than reference levels, it does not necessarily follow that the basic restrictions have been exceeded, but a more detailed analysis is necessary to show compliance with the basic restrictions.

Compliance with the requirements in Sections 2 and 3 must be verified by direct measurements or by computation in accordance with AS/NZS 2772.2 or relevant International Electrotechnical Commission (IEC) or Institute of Electrical and Electronics Engineers (IEEE) standards. In case of any differences in limit values or requirements for evaluation (for example, time or spatial averaging) the requirements specified in RPS S-1 shall have priority. The only exception is for devices that are not capable of exceeding the exposure limits under any conditions of use; supplementary guidance on how this is determined is provided in the *RPS S-1 Advisory Note: Compliance of mobile or portable transmitting equipment (100 kHz to 300 GHz)*.

Measurements or computations to prove compliance with this Standard must be made by an appropriately qualified and experienced person or organisation (testing authority) in accordance with relevant AS/NZS, IEC or IEEE standards. It is at the discretion of the testing authority whether direct measurement or computation is the appropriate methodology to be used. Following such measurements or computations, and where exposure levels are not increased, the results will remain valid for a period set by the testing authority.

Verification of compliance must be based on conditions leading to the highest RF field exposure emitted under normal operating conditions. Further assessment must be made after any modification that may increase the level of human exposure.

Measurements or computations of occupational exposure must be made in areas accessible to workers to ensure that the relevant basic restrictions of Section 2 are not exceeded. Where the field level is variable from day to day and may exceed the occupational basic restrictions, a measurement or computation must be performed under those conditions which are most likely to represent the maximum exposures. As necessary, additional protective measures described in Section 5 must be implemented.

In areas that are accessible to the general public, measurements or computations of exposure must be undertaken to ensure compliance with the general public basic restrictions of Section 2.

4.2 Type testing/RF site evaluation

Type testing of RF sources or RF site evaluation may be used to demonstrate compliance with Sections 2 and 3, provided that a minimum of three similar sources or sites have been measured and the relevant levels shown to be comparable within 3 dB of incident power density.

Type testing or RF site evaluation must not be used where the RF levels are unpredictable e.g.

(a) Industrial RF heaters and plastic welders where the RF levels vary depending on the weld die or the material to be welded.

(b) Antenna structures where the RF field pattern is likely to be significantly influenced by the local ground plane conditions or 'environmental clutter'. Environmental clutter refers to buildings, vehicles, trees/vegetation or other structures that have an influence on the measured levels of RF by introducing reflections, scattering or absorption that is difficult to predict.

4.3 Records

An up-to-date log of measurements or computations for the site configuration must be kept by the site owner and be available for inspection by relevant radiation protection authorities (see Appendix 2) and/or persons authorised to access the site or their representatives.

5. Protection—occupational and general public exposure

This section prescribes processes to ensure that:

(a) No occupationally exposed person (as defined below), is exposed to RF fields that exceed the occupational exposure limits; and

(b) No member of the general public is exposed to RF fields in excess of the general public exposure limits.

The occupational and general public exposure limits are specified in Section 2. Occupational exposure is only permitted under controlled conditions. In particular, a thorough risk analysis must be performed, and an appropriate risk management regimen implemented, prior to the exposure occurring.

More stringent conditions are applied to the exposure of members of the general public. Individual members of the public may be continually exposed and cannot reasonably be expected to take precautions to minimise or avoid exposure. Indeed in most circumstances members of the public may not be aware that the exposure is occurring.

Guidance on the application of this section is provided in Figure 1.

5.1 Definitions

5.1.1 Occupational exposure

Occupational exposure is the exposure of workers incurred in the course of their work. For the purposes of this Standard, occupational exposure is defined as potential exposure above the general public exposure limits in a workplace. This includes the following groups of persons:

(a) RF Worker: A person who may be occupationally exposed to RF fields in the course of and intrinsic to the nature of their work.

(b) Controlled Area Worker: A person, other than an RF Worker, who may be required to work in a Controlled Area (see 5.1.2).

(c) Aware User: A person who is appropriately trained to use two-way radios and other portable wireless devices which expose the user to levels likely to exceed the basic restrictions for general public exposure. Appropriate training includes awareness of the potential for exposure and measures that can be taken to control that exposure. Persons in the Aware User group may include, but are not limited to, the following categories:

  (i) emergency service personnel
  (ii) amateur radio operators
  (iii) voluntary civil defence personnel
  (iv) military personnel.

(d) Supervised Visitor: Supervised Visitors to RF sites who are under the direct supervision of a Responsible Person/RF Worker/Controlled Area Worker and may be exposed above general public limits but below occupational limits while transiting Controlled Areas.

Management of radio frequency (RF) exposure

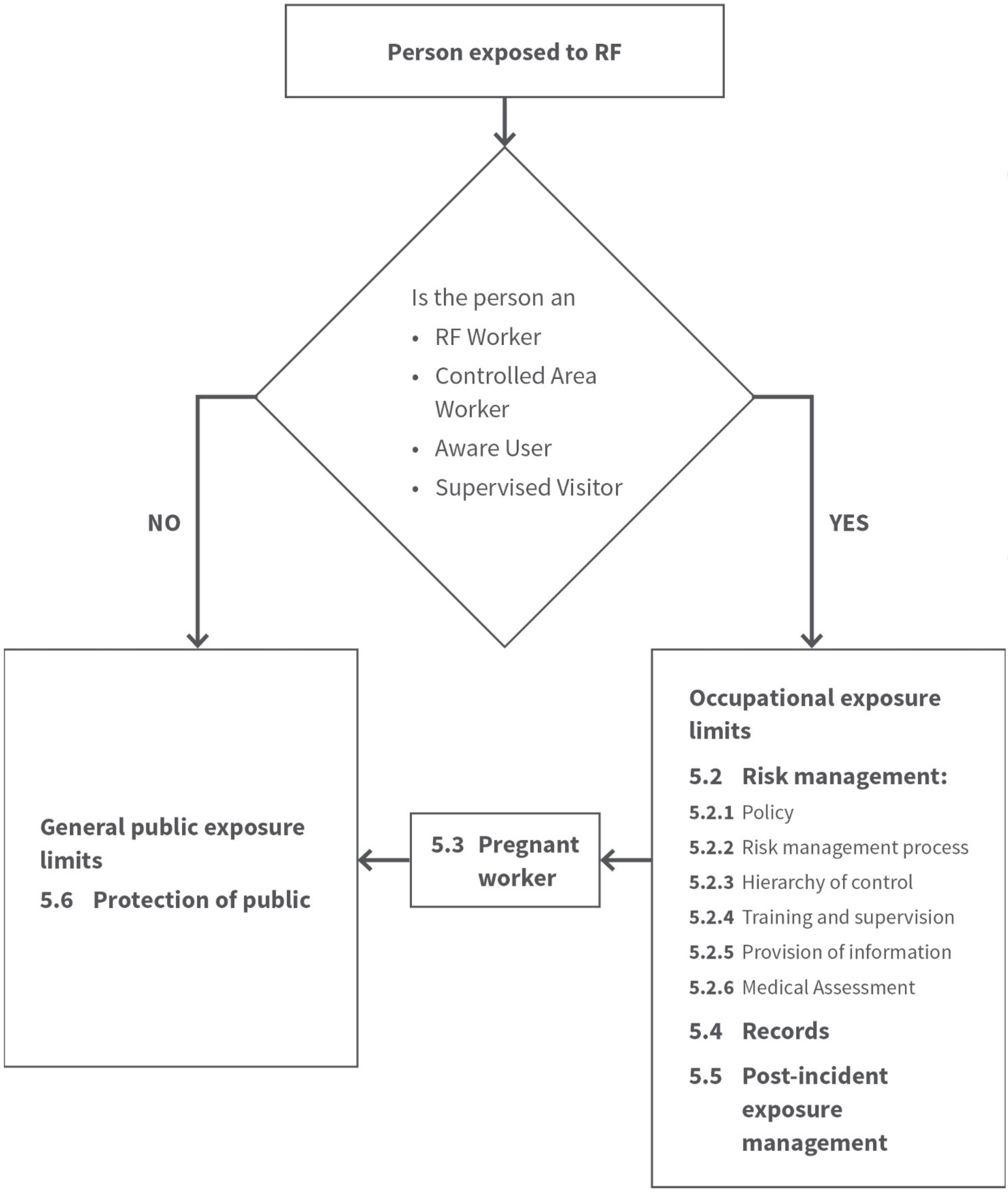

Figure 1. Application of Section 5 in the management of exposure to RF fields

5.1.2 Controlled Area

A Controlled Area is an area or place in which exposure to RF fields may reasonably be expected to exceed general public exposure limits, and with the following characteristics:

(a) The area is under the management of a Responsible Person (see 5.1.3) who must ensure that exposures do not exceed occupational exposure limits.

(b) The area is only to be entered by persons who have been provided with information, training and instruction on RF safety appropriate to the nature of their proposed activity within the Controlled Area.

(c) There is documentation or signage to clearly indicate:
  (i) areas above occupational exposure limits
  (ii) areas above general public exposure limits
  (iii) the Responsible Person and contact details.

5.1.3 Responsible Person

A Responsible Person is responsible for the overall management of a Controlled Area with respect to persons who need to work in or transit the area.

A Responsible Person is to be appointed by the person conducting a business or undertaking, manager or owner of the facility containing the relevant RF sources. The name and contact details of the Responsible Person are to be readily available to persons seeking access to the Controlled Area.

The Responsible Person is responsible for the following:

(a) Ensure up to date documentation regarding exposures associated with all RF sources affecting the work area is available.
(b) Ensure signage and markings or other measures delineate areas exceeding public and occupational exposure limits.
(c) Ensure persons are familiarized with any RF sources and the associated public and occupational access areas, relevant to their activity.
(d) Ensure persons are aware of appropriate safe working practices.
(e) Ensure security of access to the Controlled Area.

To enable the Responsible Person to meet their obligations the following parties are required to consult, cooperate and co-ordinate with the Responsible Person:

(a) The person conducting a business or undertaking, owner or operator of the RF sources, and

(b) Visitors, contractors or other workers who need to access the area.

The appointment of a Responsible Person does not replace or lessen the duty of care required of a person conducting a business or undertaking, facility manager or facility owner under the relevant work health and safety (WHS) or occupational health and safety (OHS) laws.

5.1.4 General public exposure

All exposure to RF fields received by members of the general public. This definition excludes occupational exposure as defined in 5.1.1.

5.2 Managing risk in occupational exposure

The management of risks in occupational exposure must comply with the relevant Commonwealth or State/Territory Work Health and Safety legislation[1].

The following duty holders must ensure that the hazards associated with exposure to RF fields are managed: persons conducting a business or undertaking (for example, employers, people in control of workplaces; designers, manufacturers and suppliers of RF generating equipment; self-employed persons); owners and operators of RF generating equipment.

The duty holders listed above are to ensure that the hazards associated with exposure to RF fields and RF-generating plant are identified and managed by a risk management process as listed below.

5.2.1 Workplace policy

The risk management process must be implemented and should be clearly documented in a written workplace policy that expresses the commitment of all parties. The policy should address duties including identifying the hazards and assessing the risks. The workplace policy should specify the procedures that must be implemented to control workplace risks, the monitoring and review schedule of the implemented control measures to ensure effectiveness and identify those responsible for that implementation.

5.2.2 Risk management process

The risk management process should be undertaken in consultation with workers and must include:

(a) Identification of the hazards. This step should include identification of the primary RF source/s and also sources of re-radiation, where currents are induced on conductive objects, and are potential sources of shock and burns.

(b) Assessment of the risk. This step includes assessment of exposure levels, and comparison to the relevant exposure limits. Advice on measurement or calculation of exposures relevant to the limits is given in AS/NZS 2772.2 or relevant IEC and IEEE standards.

(c) Choice of the most appropriate control measures to eliminate or minimise the level of risk (see 5.1.3). The control/s chosen must consider any hazards they may introduce.

(d) Implementation of the chosen control measures. This step must include maintenance requirements to ensure the ongoing effectiveness of the control/s and training on the control measures for workers potentially exposed to RF fields.

(e) Monitoring and reviewing the effectiveness of the control measures. The monitoring and review process must assess whether the chosen controls have been implemented as planned and that the control measures remain effective.

5.2.3 Hierarchy of control measures

Where there is potential for exposure above the limits, the hazard should be managed through application of the most appropriate control priorities as indicated below. The measures higher in the control priorities are usually more effective than those lower, and should be given greater consideration. In order of priority, the Control Priorities are:

[1] Occupational Health and Safety legislation in Victoria, and Occupational Safety and Health legislation in Western Australia

(a) Elimination of the hazard. If this is not reasonably practicable, exposure to the risk, where appropriate, must be minimised by one or a combination of the following control measures.

(b) Substitution with a less hazardous process or less hazardous plant.

(c) Engineering controls including redesign of equipment or work processes. Examples include: barriers to access, building in shielding, fail-safe interlocks, earthing of large metallic objects, built-in leakage detectors and alarms or utilising waveguide below cut-off shielding techniques.

(d) Introduction of administrative controls such as signage restricting access or defining exposure limit boundaries, safe work systems including down-powering or outages. Administrative controls may be used in combination with higher level controls.

(e) Personal issue RF alarms which are designed to alert the worker to the presence of RF fields above the exposure limits. Training is essential for proper use and safety benefits.

(f) Use of other appropriate personal protective equipment (PPE). All users of PPE must be provided with the appropriate PPE and trained and supervised in its use to ensure that they have a clear understanding of its correct usage and limitations and they must use it accordingly. In addition, the PPE must be maintained and replaced as specified by the manufacturer to ensure it is kept in good condition so that its effectiveness as a control is not compromised (For more information on PPE see IEEE C95.7).

5.2.4 Training and supervision

Occupationally exposed persons must be provided with suitable training and supervision taking into account the nature of the work being carried out, the nature of the risk associated with the work and the control measures and safe work practices that have been implemented. They must be trained in the controls implemented to manage the potential RF hazard, including isolation, engineering and administrative controls, personal issue RF alarms and PPE as appropriate. There must be appropriate procedures in place to ensure that the safe systems of work are utilised. Occupationally exposed persons should be supervised when appropriate.

5.2.5 Provision of information to occupationally exposed persons

Occupationally exposed persons must be informed about the following:

(a) The known health effects of RF fields as summarised by the International Commission on Non-Ionizing Radiation Protection (ICNIRP 2020a).

(b) Safe working practices, (see 5.1.3).

(c) The procedures to be followed in the event of any **over-exposure** (see 5.5).

(d) The precautions and procedures to be followed if they are or become pregnant (see 5.3) during the time they are engaged in RF work.

(e) The precautions and procedures to be followed if they have/receive metallic implants or medical devices (see 5.2.6) during the time they are engaged in RF work.

5.2.6 Medical assessment

There must be procedures in place to ensure that persons who are occupationally exposed above basic restrictions for the public and who have medical devices susceptible to RF interference or metallic implants are not put at risk by their exposure. It is advisable that persons who may be occupationally exposed to RF fields are subject to a placement assessment (Hocking and Mild 2008). The IEEE Standard C95.1 (Sections

B.2.2.4 and B.7.8) provides practical advice for the assessment of medical devices and makes comment on metallic implants. This advice should be sufficient for most cases and no further steps would be required such as performing computational analysis, which is unlikely to be an option for many persons.

5.3 Pregnancy

Occupationally exposed women who are pregnant should advise their employers when they become aware of their pregnancy. After such notification, they must not be exposed to RF fields exceeding the general public exposure limits. Pregnancy should lead to implementation of relevant personnel policies. These include, but are not limited to, reasonable accommodation/adjustment or temporary transfer to non-RF work without loss of employment benefits. Additional guidance may be found in the Pregnancy Guidelines produced by the Australian Human Rights and Equal Opportunity Commission (HREOC 2001).

5.4 Records

Records should be kept of the results of all assessments of RF sources and steps to mitigate fields.

The personnel files of workers who are occupationally exposed to RF fields should be maintained and identify that the worker is occupationally exposed to RF fields. Such files should be retained for the full duration of, and after termination of employment as required by law.

5.5 Post incident exposure management

(a) A plan for management of any incident of confirmed or suspected over-exposure should be developed in advance. An over-exposure will not necessarily lead to harm because the exposure limits of the Standard are set well below where harm has been shown to occur. The following plan of action is suggested: First aid treatment should be obtained from the nearest first aider, doctor or hospital as required for burns or other injuries.
(b) Employers should arrange for employees suspected or confirmed as over-exposed to RF fields to be medically assessed as soon as practical after the over-exposure. The employer/site operator should provide information regarding the characteristics of the RF fields. The paper by Hocking and Gobbo (2011) provides information for doctors on the medical management of acute over-exposure.
(c) The incident must be investigated and corrective actions taken. Where confirmed to be an over-exposure incident, it must be reported and managed as per relevant Commonwealth or State/Territory Work Health and Safety legislation. A confirmed incident must be reported by the relevant radiation protection authority to the Australian Radiation Incident Register (see Appendix 2).

5.6 Protection of the general public

Measures for the protection of members of the general public who may be exposed to RF fields due to their proximity to antennas or other RF sources must include the following:

(a) Determination of the boundaries of areas where general public exposure limits levels may be exceeded.

(b) Restriction of public access to those areas where the general public exposure limits may be exceeded.

(c) Appropriate provision of signs or notices complying with AS 1319 (Standards Australia 1994).

(d) In the event of the exposure exceeding the occupational exposure limits the following plan of action is suggested:

(i) First aid treatment should be obtained from the nearest first aider, doctor or hospital as required for burns or other injuries.

(ii) Members of the general public suspected or confirmed as over-exposed to RF fields should be medically assessed as soon as practical after the over-exposure. The site operator should provide information regarding the characteristics of the RF fields. The paper by Hocking and Gobbo (2011) referred to in 5.5(b) provides information for doctors on the medical management of acute over-exposure.

(iii) The incident must be investigated and appropriate corrective actions taken. Where confirmed to be an over-exposure incident, it must be reported to the relevant radiation protection authority (see Appendix 2). A confirmed incident must be reported by the relevant radiation protection authority to the Australian Radiation Incident Register referred to in 5.5(c).

Schedule 1

Figures of Occupational and General Public Reference levels for Whole Body and Local Exposure to RF Electromagnetic Fields as Specified in Tables 4 and 5

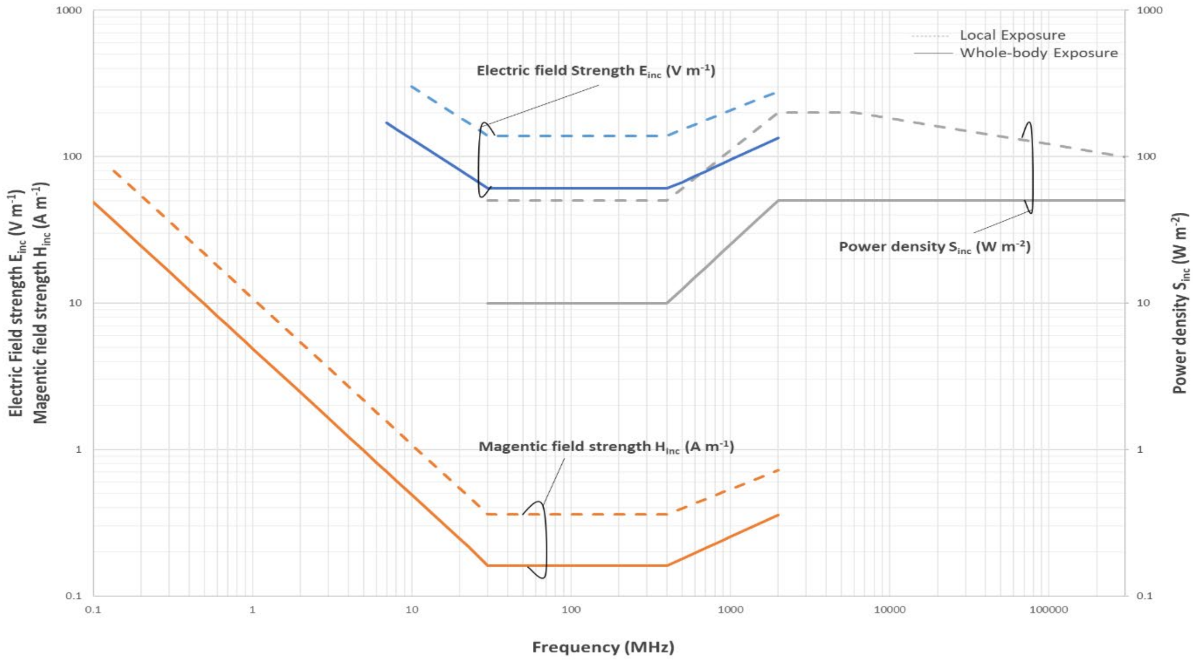

Figure 2. Occupational reference levels for whole body (averaged over 30 min) and local (averaged over 6 min) exposure to incident electric and magnetic field strength (100 kHz - 2 GHz) and incident power density (>30 MHz – 300 GHz) (unperturbed rms values)

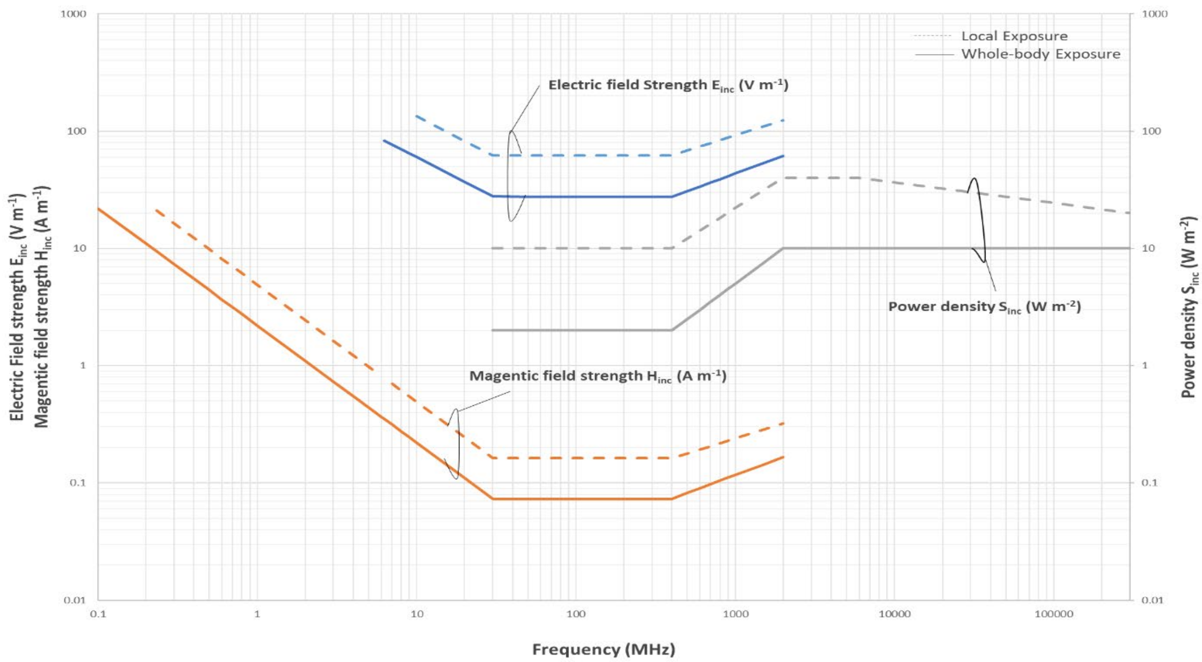

Figure 3. General public reference levels for whole body (averaged over 30 min) and local (averaged over 6 min) exposure to incident electric and magnetic field strength (100 kHz - 2 GHz) and incident power density (>30 MHz – 300 GHz) (unperturbed rms values)

Schedule 2

Look-up Table of Occupational Reference Levels for Whole Body and Local Exposure to RF Electromagnetic Fields as Specified in Tables 4 and 5

Frequency		Whole Body exposure			Local exposure		
		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})	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})
kHz	100	----	49.00	----	----	----	----
kHz	200	----	24.50	----	----	54.00	----
kHz	300	----	16.33	----	----	36.00	----
kHz	400	----	12.25	----	----	27.00	----
kHz	500	----	9.80	----	----	21.60	----
kHz	600	----	8.17	----	----	18.00	----
kHz	700	----	7.00	----	----	15.43	----
kHz	800	----	6.13	----	----	13.50	----
kHz	900	----	5.44	----	----	12.00	----
MHz	1	----	4.90	----	----	10.80	----
MHz	2	----	2.45	----	----	5.40	----
MHz	3	----	1.63	----	----	3.60	----
MHz	4	----	1.23	----	----	2.70	----
MHz	5	----	0.98	----	----	2.16	----
MHz	6	----	0.82	----	----	1.80	----
MHz	7	169.03	0.70	----	----	1.54	----
MHz	8	153.95	0.61	----	----	1.35	----
MHz	9	141.77	0.54	----	----	1.20	----
MHz	10	131.69	0.49	----	----	1.08	----
MHz	20	81.06	0.25	----	184.73	0.54	----
MHz	30	61.03	0.16	----	139.08	0.36	----
MHz	50	61.00	0.16	10.00	139.00	0.36	50.00
MHz	100	61.00	0.16	10.00	139.00	0.36	50.00
MHz	200	61.00	0.16	10.00	139.00	0.36	50.00
MHz	300	61.00	0.16	10.00	139.00	0.36	50.00

Frequency		Whole Body exposure			Local exposure		
		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})	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})
MHz	400	61.00	0.16	10.00	139.00	0.36	50.00
MHz	500	67.08	0.18	12.50	153.12	0.40	60.75
MHz	600	73.48	0.20	15.00	165.61	0.43	71.06
MHz	700	79.37	0.21	17.50	176.96	0.46	81.13
MHz	800	84.85	0.23	20.00	187.42	0.49	91.00
MHz	900	90.00	0.24	22.50	197.16	0.51	100.70
GHz	1	94.87	0.25	25.00	206.29	0.53	110.25
GHz	1.5	116.19	0.31	37.50	245.59	0.64	156.26
GHz	2	134.16	0.36	50.00	277.93	0.72	200.12
GHz	2.5	----	----	50.00	----	----	200.00
GHz	3	----	----	50.00	----	----	200.00
GHz	3.5	----	----	50.00	----	----	200.00
GHz	4	----	----	50.00	----	----	200.00
GHz	5	----	----	50.00	----	----	200.00
GHz	6	----	----	50.00	----	----	200.00
GHz	10	----	----	50.00	----	----	182.95
GHz	20	----	----	50.00	----	----	161.83
GHz	30	----	----	50.00	----	----	150.62
GHz	40	----	----	50.00	----	----	143.14
GHz	50	----	----	50.00	----	----	137.60
GHz	100	----	----	50.00	----	----	121.71
GHz	200	----	----	50.00	----	----	107.66
GHz	300	----	----	50.00	----	----	100.00

Schedule 3
Look-up Table of General Public Reference Levels for Whole Body and Local Exposure to RF Electromagnetic Fields as Specified in Tables 4 and 5

Frequency		Whole Body exposure			Local exposure		
		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})	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})
kHz	100	----	22.00	----	----	----	----
kHz	200	----	11.00	----	----	----	----
kHz	300	----	7.33	----	----	16.33	----
kHz	400	----	5.50	----	----	12.25	----
kHz	500	----	4.40	----	----	9.80	----
kHz	600	----	3.67	----	----	8.17	----
kHz	700	----	3.14	----	----	7.00	----
kHz	800	----	2.75	----	----	6.13	----
kHz	900	----	2.44	----	----	5.44	----
MHz	1	----	2.20	----	----	4.90	----
MHz	2	----	1.10	----	----	2.45	----
MHz	3	----	0.73	----	----	1.63	----
MHz	4	----	0.55	----	----	1.23	----
MHz	5	----	0.44	----	----	0.98	----
MHz	6	----	0.37	----	----	0.82	----
MHz	7	76.83	0.31	----	----	0.70	----
MHz	8	69.98	0.28	----	----	0.61	----
MHz	9	64.44	0.24	----	----	0.54	----
MHz	10	59.86	0.22	----	----	0.49	----
MHz	20	36.85	0.11	----	82.41	0.25	----
MHz	30	27.74	0.07	----	62.05	0.16	----
MHz	50	27.70	0.07	2.00	62.00	0.16	10.00
MHz	100	27.70	0.07	2.00	62.00	0.16	10.00
MHz	200	27.70	0.07	2.00	62.00	0.16	10.00
MHz	300	27.70	0.07	2.00	62.00	0.16	10.00
MHz	400	27.70	0.07	2.00	62.00	0.16	10.00

Frequency		Whole Body exposure			Local exposure		
		Incident E-field Strength E_{inc} ($V\ m^{-1}$)	Incident H-field Strength H_{inc} ($A\ m^{-1}$)	Incident Power Density S_{inc} ($W\ m^{-2}$)	Incident E-field Strength E_{inc} ($V\ m^{-1}$)	Incident H-field Strength H_{inc} ($A\ m^{-1}$)	Incident Power Density S_{inc} ($W\ m^{-2}$)
MHz	500	30.75	0.08	2.50	68.31	0.18	12.15
MHz	600	33.68	0.09	3.00	73.88	0.19	14.21
MHz	700	36.38	0.10	3.50	78.95	0.21	16.23
MHz	800	38.89	0.10	4.00	83.61	0.22	18.20
MHz	900	41.25	0.11	4.50	87.96	0.23	20.14
GHz	1	43.48	0.12	5.00	92.03	0.24	22.05
GHz	1.5	53.25	0.14	7.50	109.56	0.29	31.25
GHz	2	61.49	0.17	10.00	123.99	0.32	40.02
GHz	2.5	----	----	10.00	----	----	40.00
GHz	3	----	----	10.00	----	----	40.00
GHz	3.5	----	----	10.00	----	----	40.00
GHz	4	----	----	10.00	----	----	40.00
GHz	5	----	----	10.00	----	----	40.00
GHz	6	----	----	10.00	----	----	40.00
GHz	10	----	----	10.00	----	----	36.59
GHz	20	----	----	10.00	----	----	32.37
GHz	30	----	----	10.00	----	----	30.12
GHz	40	----	----	10.00	----	----	28.63
GHz	50	----	----	10.00	----	----	27.52
GHz	100	----	----	10.00	----	----	24.34
GHz	200	----	----	10.00	----	----	21.53
GHz	300	----	----	10.00	----	----	20.00

Appendix 1
Quantities and Units

The electromagnetic quantities and units used in this Standard are shown in Table A1. A detailed description of these is provided in the ICNIRP guidelines (ICNIRP 2020a).

Table A1. Electromagnetic quantities and corresponding SI units

Quantity	Symbol	Unit
Absorbed energy density	U_{ab}	joule per square metre (J m^{-2})
Absorbed power density	S_{ab}	watt per square metre (W m^{-2})
Electric current	I	ampere (A)
Frequency	f	hertz (Hz)
Incident electric field strength	E_{inc}	volt per metre (V m^{-1})
Incident energy density	U_{inc}	joule per square metre (J m^{-2})
Incident magnetic field strength	H_{inc}	ampere per metre (A m^{-1})
Incident power density	S_{inc}	watt per square metre (W m^{-2})
Induced electric field	E_{ind}	volt per metre (V m^{-1})
Plane-wave equivalent incident energy density	U_{eq}	joule per square metre (J m^{-2})
Plane-wave equivalent incident power density	S_{eq}	watt per square metre (W m^{-2})
Specific energy absorption	SA	joule per kilogram (J kg^{-1})
Specific energy absorption rate	SAR	watt per kilogram (W kg^{-1})
Time	t	second (s)
Wavelength	λ	metre (m)

Appendix 2
Radiation Protection and Regulatory Authorities

Radiation Protection Authorities

Where advice or assistance is required from the relevant radiation protection authority, it may be obtained from the following offices (refer to www.arpansa.gov.au for updates):

Commonwealth, State/Territory	Contact	Contact details
Commonwealth	Chief Executive Officer ARPANSA PO Box 655 Miranda NSW 1490 Email: info@arpansa.gov.au	Tel: (02) 9541 8333 Fax: (02) 9541 8314
New South Wales	Manager Hazardous Materials, Chemicals and Radiation Environment Protection Authority PO Box A290 Sydney South NSW 1232 Email: radiation@epa.nsw.gov.au	Tel: (02) 9995 5959 Fax: (02) 9995 6603
Queensland	Director, Radiation Health Department of Health PO Box 2368 Fortitude Valley BC QLD 4006 Email: radiation_health@health.qld.gov.au	Tel: (07) 3328 9310 Fax: (07) 3328 9622
South Australia	Manager, Radiation Protection Environment Protection Authority GPO Box 2607 Adelaide SA 5001 Email: radiationprotection@epa.sa.gov.au	Tel: (08) 8463 7826 Fax: (08) 8124 4671
Tasmania	Senior Health Physicist Radiation Protection Unit Department of Health & Human Services GPO Box 125 Hobart TAS 7001 Email: radiation.protection@dhhs.tas.gov.au	Tel: (03) 6166 7256 Fax: (03) 6222 7257
Victoria	Team Leader, Radiation Safety Department of Health GPO Box 4541 Melbourne VIC 3001 Email: radiation.safety@dhs.vic.gov.au	Tel: 1300 767 469 Fax: 1300 769 274

Commonwealth, State/Territory	Contact	Contact details
Western Australia	Secretary, Radiological Council 189 Royal Street East Perth WA 6004 (Locked Bag 2006 PO Nedlands WA 6009) Email: radiation.health@health.wa.gov.au	Tel: (08) 9222 2000
Australian Capital Territory	Manager Radiation Safety, Health Protection Service ACT Health, Howard Florey Centenary House 25 Mulley Street Holder ACT 2611 Email: hps@act.gov.au	Tel: (02) 5124 9700 Fax: (02) 5124 5554
Northern Territory	Manager Radiation Protection Radiation Protection Section Department of Health GPO Box 40596 Casuarina NT 0811 Email: envirohealth@nt.gov.au	Tel: (08) 8922 7152 Fax: (08) 8922 7334

Regulatory Authorities

The following organisations regulate various aspects of the use of RF fields:

Commonwealth	Contact	Contact Details
(i) for communications	Operations, Services and Technologies Branch Australian Communications and Media Authority PO Box 78 Belconnen ACT 2616 Email: info@acma.gov.au	Tel: (02) 6219 5555 Fax: (02) 6219 5353
(ii) for other than communications	Chief Executive Officer ARPANSA PO Box 655 Miranda NSW 1490 Email: info@arpansa.gov.au	Tel: (02) 9541 8333 Fax: (02) 9541 8314

The Australian Communications and Media Authority (ACMA) is responsible for regulating RF fields for consumer radiocommunications devices (for example, mobile phones) and telecommunications facilities (for example, mobile phone towers). To make sure RF exposure is kept low, the ACMA applies the ARPANSA RF exposure limits contained in this Standard. The ACMA is not an expert body on the possible health effects of human exposure to RF and is not responsible for investigating possible health effects. For more information on how the ACMA regulates RF fields for radiocommunication devices and telecommunications facilities see https://www.acma.gov.au.

The Commonwealth regulates a limited number of RF emitting sources (e.g. RF welding, diathermy equipment and industrial microwaves) used by Commonwealth entities. In the state and territory jurisdictions, while there is no special regulation of RF exposure, Work Health & Safety Legislation applies. Karipidis et al (2019) provides a description of RF regulation across all Australian jurisdictions.

The Australian Radiation Incident Register (ARIR) is Australia's national database of incidents and events, where radiation was implicated. The purpose of the ARIR is to raise awareness on where, how and why incidents and events occur, and how they can be best prevented. Reports are provided by Commonwealth, state and territory radiation protection authorities. For more information see https://www.arpansa.gov.au/regulation-and-licensing/safety-security-transport/australian-radiation-incidents-register

The information on radiation protection and regulatory authorities was correct at the time of publication but is subject to change from time to time. For the most up to date list the reader is advised to consult the ARPANSA web site at www.arpansa.gov.au.

Glossary

Further information on many of the quantities defined in the Glossary is provided in the ICNIRP (2020) guidelines.

Absorbed energy density (U_{ab})

For frequencies above 6 GHz, the RF energy absorbed per unit area within very superficial regions of the body, expressed as joule per square metre (J/m^2).

Absorbed power density (S_{ab})

For frequencies above 6 GHz, the RF power absorbed per unit area within very superficial regions of the body, expressed as watt per square metre (W/m^2).

Basic restrictions

The mandatory limiting values of exposure expressed in terms of selected quantities that closely match all known biophysical interaction mechanisms that may lead to health effects.

Contact current

The resulting current produced by touching an electrically charged conductive surface or object within an electromagnetic field.

Electric current (I)

Flow of electrical charge, expressed in ampere (A).

Electric field (E)

Region around an electric charge in which an electric force is exerted on another charge. The strength of the electric field is expressed in units of volt per metre (V/m).

Electromagnetic field

A time and space varying field associated with electric and magnetic forces on electric charges as described by Maxwell's equations. It can be characterized at any instant by electric (E) and magnetic (H) field vectors.

Exposure

That which occurs whenever a person is subject to the influence of an RF field or contact current.

Far-field

Region sufficiently far from the source that the phase and amplitude relationships of the waves arriving from different areas of the antenna do not change appreciably with distance. The antenna gain and angular pattern are essentially independent of distance, and the power density (in free-space paths) is inversely proportional to the square of the distance from the source.

Frequency

The number of sinusoidal cycles completed by electromagnetic waves in 1 second, expressed in hertz (Hz).

Incident electric field strength (E_{inc})

Electric field incident on the body surface, expressed in volt per metre (V/m).

Incident energy density (U_{inc})

The amount of RF energy through a unit area incident on the body surface, expressed in joule per square metre (J/m^2).

Incident magnetic field strength (H_{inc})

Magnetic field incident on the body surface, expressed in ampere per metre (A/m).

Incident power density (S_{inc})

The rate of RF energy through a unit area incident on the body surface, expressed in watt per square metre (W/m^2).

Induced electric field (E_{ind})

Electric field inside the body as a result of exposure to an external electromagnetic field, expressed in volt per metre (V/m).

Limb current

Current flowing through the limbs, such as through an ankle or wrist

Magnetic field (H)

Region where a force is produced by electric currents. The strength of the magnetic field is expressed in ampere per metre (A/m).

Medical exposure

Exposure of a person to RF fields received as a patient undergoing medical diagnosis or recognised medical treatment, or as a volunteer in medical research. Medical exposure also applies to carers and comforters of patients.

Near-field

Region of an electromagnetic field that is between the transmitting source and the far field. It is subdivided into the reactive and radiating near field regions.

Over-exposure

Exposure exceeding the relevant local or whole-body basic restrictions taking into account the appropriate averaging time (e.g. 6 minutes or 30 minutes). A short-term exposure to a level exceeding the basic restriction typically does not lead to an over-exposure unless the time-averaged level is above the relevant limit.

Plane wave

An electromagnetic wave in which the electric and magnetic field vectors lie in a plane perpendicular to the direction of wave propagation.

Plane-wave equivalent incident power density (S_{eq})

RF power per unit area, equal in magnitude to the power density of a plane wave having the same electric or magnetic field strength, expressed in watt per square metre (W/m^2).

Plane-wave equivalent incident energy density (U_{eq})

RF energy per unit area, equal in magnitude to the energy density of a plane wave having the same electric or magnetic field strength, expressed in joule per square metre (J/m^2).

Radiating near-field

The region between the reactive near field and the far field. Reactive components of the electric and magnetic fields are insignificant, and the relationships between the electric and magnetic fields are approximately the same as in the far field.

Radiofrequency (RF)

Electromagnetic field with frequencies in the range 100 kHz to 300 GHz.

Reactive near-field

The region immediately surrounding an antenna or source where the non-radiating (reactive) components of the electric and magnetic fields are significant and essentially unrelated to each other.

Reference levels

Practical or 'surrogate' parameters that may be used for determining compliance with the basic restrictions.

RMS

The root mean square which is derived by first squaring a set of numbers and then determining the mean value of the squares obtained, and taking the square root of that mean value.

Specific energy absorption (SA)

The RF energy absorbed per unit mass of biological tissue, expressed in joule per kilogram (J/kg).

Specific energy absorption rate (SAR)

The rate at which RF energy is absorbed in body tissues, expressed in watt per kilogram (W/kg).

Unperturbed values

Electromagnetic field quantity values in the absence of the human body.

References/ Bibliography

Australian Radiation Protection and Nuclear Safety Agency (ARPANSA), 2002. *Maximum Exposure Levels to Radiofrequency Fields - 3 kHz to 300 GHz*, Radiation Protection Series; No. 3. [https://www.arpansa.gov.au/sites/g/files/net3086/f/legacy/pubs/rps/rps3.pdf]

Australian Radiation Protection and Nuclear Safety Agency (ARPANSA), 2014. *Review of Radiofrequency Health Effects Research – Scientific Literature 2000–2012*, Technical Report Series; No. 164. [https://www.arpansa.gov.au/sites/g/files/net3086/f/legacy/pubs/technicalreports/tr164.pdf]

Australian Standard, 1994. *Safety signs for the occupational environment*, Standards Australia, AS 1319:1994. [https://www.standards.org.au/standards-catalogue/sa-snz/publicsafety/sf-005/as--1319-1994]

Australian/New Zealand Standard (AS/NZS), 2016. *Radiofrequency fields Principles and methods of measurement and computation - 3 kHz to 300 GHz,* Standards Australia, AS/NZS 2772.2:2016. [https://shop.standards.govt.nz/catalog/2772.2:2016(AS%7CNZS)/scope?]

Hocking B, and Gobbo F, 2011. *Medical aspects of overexposures to electromagnetic fields*, J Health Saf Environ, 27(3):185-195. [https://www.arpansa.gov.au/sites/g/files/net3086/f/legacy/pubs/rps/rps3_hocking.pdf]

Hocking, B., Mild, K, H, 2008. *Guidance note: risk management of workers with medical electronic devices and metallic implants in electromagnetic fields,* Int J Occup Saf Ergon, 14(2):217-22. [https://www.ncbi.nlm.nih.gov/pubmed/18534156]

Human Rights & Equal Opportunity Commission (HREOC), 2001. *Pregnancy guidelines.* Commonwealth of Australia, ISBN 0 642 26976 9. [https://www.humanrights.gov.au/our-work/sex-discrimination/publications/pregnancy-guidelines-2001]

International Commission on Non-Ionizing Radiation Protection (ICNIRP), 1998. *Guidelines for limiting exposure to time-varying electric, magnetic and electromagnetic fields (up to 300 GHz)*, Health Physics, 74(4):494-522. [http://www.icnirp.org/cms/upload/publications/ICNIRPemfgdl.pdf]

International Commission on Non-Ionizing Radiation Protection (ICNIRP), 2009. *Guidelines on limits of exposure to static magnetic fields*, Health Physics, 96(4):504-514. [http://www.icnirp.org/cms/upload/publications/ICNIRPstatgdl.pdf]

International Commission on Non-Ionizing Radiation Protection (ICNIRP), 2010. *Guidelines for limiting exposure to time-varying electric and magnetic fields (1 HZ – 100 kHz),* Health Physics, 99(6):818-836. [http://www.icnirp.org/cms/upload/publications/ICNIRPLFgdl.pdf]

International Commission on Non-Ionizing Radiation Protection (ICNIRP), 2020a. *ICNIRP guidelines for limiting exposure to electromagnetic fields (100 KHz to 300 GHz),* Health Physics, 118(5):483–524. [https://www.icnirp.org/cms/upload/publications/ICNIRPrfgdl2020.pdf]

International Commission on Non-Ionizing Radiation Protection (ICNIRP), 2020b. *ICNIRP Statement Principles for Non-ionizing Radiation Protection*, Health Physics, 118(5):477–482. [https://www.icnirp.org/cms/upload/publications/ICNIRPprinciples2020.pdf]

International Commission on Radiological Protection (ICRP), 2007. *The 2007 recommendations of the International Commission on Radiological Protection*, ICRP Publication, 103. [https://journals.sagepub.com/doi/pdf/10.1177/ANIB_37_2-4]

International Electro-technical Commission (IEC), 2018. *Determination of RF field strength, power density and SAR in the vicinity of radiocommunication base stations for the purpose of evaluating human exposure*, AS IEC 62232:2018. [https://www.standards.org.au/standards-catalogue/sa-snz/communication/te-007/as--iec--62232-colon-2018]

Institute of Electrical and Electronics Engineers (IEEE), 2014. *Recommended Practice for Radio Frequency Safety Programs, 3 kHz to 300 GHz,* IEEE Std, C95.1. [https://ieeexplore.ieee.org/document/6874474]

Karipidis K, Urban D, Mate R and Tinker R, 2019. *Non-Ionising Radiation Protection in Australia: Technical Report 182*, ARPANSA TR, 182. [https://www.arpansa.gov.au/sites/default/files/tr182.pdf]

Standards Australia, 1985. *Radiofrequency radiation. Part 1: Maximum exposure levels—100 kHz to 300 GHz*. Standards Australia, AS 2772.1:1985. [https://infostore.saiglobal.com/preview/as/as2000/2700/2772-1985.pdf?sku=1699444]

Standards Australia 1990. *Radiofrequency radiation. Part 1: Maximum exposure levels—100 kHz to 300 GHz*. Standards Australia, AS/NZS 2772.1:1990.

Standards Australia/Standards New Zealand, 1998. *Radiofrequency fields. Part 1: Maximum exposure levels—3kHz to 300 GHz*, Standards Australia AS/NZS 2772.1(Int):1998. [https://www.saiglobal.com/PDFTemp/Previews/OSH/as/as2000/2700/27721.pdf]

Contributors to drafting and review

Dr Ken Karipidis	Radiation Health Services Branch
Dr Rick Tinker	Radiation Health Services Branch
Dr Bruce Hocking	Consulting Specialist in Occupational Medicine
Mr Martin Gledhill	Technical adviser to the New Zealand Ministry of Health
Mr Rohan Mate	Radiation Health Services Branch
Mr David Urban	Radiation Health Services Branch
Dr Stuart Henderson	Radiation Health Services Branch
Mr Don Wijayasinghe	Radiation Health Services Branch

Section 5 Working Group

Dr Ken Karipidis	Radiation Health Services Branch
Dr Bruce Hocking	Consulting Specialist in Occupational Medicine
Mr Ray McKenzie	Australlian Mobile Telecommunications Association