Regulatory Guide

How to determine whether a radiofrequency source is a controlled apparatus
This document is provided to assist controlled persons determine whether a radiofrequency (RF) source is classed as a controlled apparatus under the Australian Radiation Protection and Nuclear Safety Act 1998. In particular, it clarifies conditions and defines terms used in Section 9 of the Australian Radiation Protection and Nuclear Safety Regulations 2018.
1. Criteria to be satisfied

Section 9 of the Australian Radiation Protection and Nuclear Safety Regulations 2018 (the Regulations) consists of three separate criteria, all of which must be fulfilled for the apparatus to be classed as controlled apparatus.

Paragraph 9(1)(a) has to do with the type of apparatus; this criterion is met if the apparatus is:

- a magnetic field non-destructive testing device
- an induction heater or induction furnace
- an industrial radiofrequency heater or welder
- a radiofrequency plasma tube
- microwave or radiofrequency diathermy equipment
- an industrial microwave or radiofrequency processing system
- an optical source, other than a laser product, emitting ultraviolet radiation, infrared or visible light
- a laser product with an accessible emission level more than the accessible emission limit of a Class 3R laser product, as set out in Australian/New Zealand Standard AS/NZS IEC 60825.1:2014 Safety of laser products Part 1: Equipment classification and requirements

The items marked in bold in this list are apparatus that emit RF. A definition of the listed RF emitting apparatus can be found in Appendix 1.

The second criterion, paragraph 9(2)(b) concerns source emission. It is fulfilled if the apparatus produces non-ionising radiation that could lead to a person being exposed to radiation levels exceeding the non-ionizing radiation exposure limits. For RF the relevant standard referred to in Section 4 is Radiation Protection Standard for Maximum Exposure Levels to Radiofrequency Fields – 3 kHz to 300 GHz (RPS 3). This document specifies reference levels which have been derived from the basic restriction levels. The reference levels have been chosen as they are based on quantities that are easy to measure and compliance with the reference levels will ensure compliance with the basic restrictions. See Appendix 2 for more details and extracts from RPS 3.

Some of the apparatus (for example induction heaters) also generate electric and magnetic fields at 50/60 Hz. In this case the exposure limits referred to in Section 4 are in the ICNIRP Guidelines for Limiting Exposure to Time-Varying Electric and Magnetic Fields (1 Hz – 100 kHz). See Appendix 3 for more details and extracts from the ICNIRP Guidelines.

The third criterion, paragraph 9(2)(c) is based on the accessibility of the source. Factors determining whether radiation above the exposure limits is accessible to persons have to be evaluated. The condition is fulfilled if excess levels of radiation are readily accessible to persons in any of the following situations:

- in the course of intended operations or procedures of the apparatus
- as a result of a reasonably foreseeable abnormal event involving the apparatus
as a result of a reasonably foreseeable single element failure of the apparatus
without the use of tools or other specialised equipment required to remove protective barriers or access panels.

The procedure in the next section describes how to go through these three criteria to determine whether an RF emitting device is classed as controlled or not.

**Radiofrequency (high frequency) and low frequency radiation**

The part of the electromagnetic spectrum with high frequencies is in the range 3 kHz to 300 GHz and is referred to as radiofrequency (RF). The low frequency is in the range of 1 Hz to 100 kHz which include the 50/60 Hz electric and magnetic fields. The diagram below shows the divisions of the electromagnetic spectrum that are commonly accepted and will be used in this guide. Microwave (MW) frequency radiation is commonly used to denote a subset of RF radiation, typically at frequencies from 300 MHz to 300 GHz.

RF and MW radiation are forms of non-ionising radiation where individual photons are not energetic enough to break chemical bonds or remove electrons (ionisation). Ultraviolet, visible and infrared light are other forms of non-ionising radiation.

![Electromagnetic spectrum with frequencies of some RF applications shown](image-url)

**Figure 1**: Electromagnetic spectrum with frequencies of some RF applications shown.
Reference documents

Radiation Protection Standard for Maximum Exposure Levels to Radiofrequency Fields—3 kHz to 300 GHz (2002), ARPANSA Radiation Protection Series No 3 (RPS 3).

The ARPANSA RF Standard sets limits for human exposure to RF EMR in the frequency range 3 kHz to 300 GHz. The Standard also includes requirements for protection of the general public and the management of risk in occupational exposure, together with additional information on measurement and assessment of compliance. Extracts from this document can be found in Appendix 2.

ICNIRP Guidelines For Limiting Exposure to Time-Varying Electric and Magnetic Fields 1Hz-100 kHz (2010), Health Physics 99(6):818-836.

The International Commission on Non-Ionizing Radiation Protection (ICNIRP) guidelines are aimed at preventing the established health effects resulting from exposure to ELF EMF. The ICNIRP ELF guidelines are consistent with ARPANSA’s understanding of the scientific basis for the protection of the general public and workers from exposure to ELF EMF. Extracts from this document can be found in Appendix 3.

Definitions

Maximum exposure level – ELmax: the maximum exposure limit as specified in RPS 3 and the ICNIRP Guidelines. Different limits apply for occupational exposure and exposure to the general public.

Controlled apparatus (non-ionising): an apparatus prescribed by the Regulations that produces harmful non-ionising radiation when energised.

Procedure for determining controlled apparatus

This procedure (as illustrated by the flow chart below) will assist you to determine whether your apparatus is controlled or not.

1. Determine if the apparatus is one of the following as defined in Appendix 1:
   - an induction heater or induction furnace
   - an industrial radiofrequency heater or welder
   - a radiofrequency plasma tube
   - microwave or radiofrequency diathermy equipment
   - an industrial microwave or radiofrequency processing system.

2. If there is a reasonably foreseeable abnormal event that could lead to a person being exposed to radiation levels in excess of the maximum exposure level, as specified in RPS 3 or the ICNIRP Guidelines and reproduced in Appendix 2 and Appendix 3, the apparatus is classed as controlled apparatus. Examples of reasonably foreseeable abnormal events are possible exposure during normal maintenance, easy overriding of an interlock, entry into exclusion zones etc.

3. If there is a reasonably foreseeable single element failure of the apparatus that would lead to a person being exposed to levels above the maximum exposure level, then the apparatus is classed as controlled apparatus. An example of this is a malfunctioning interlock.
4. If the apparatus is enclosed, the possibility of removal of the access panels has to be assessed. If there is no enclosure, choose no, and go to the next step. If a person can be exposed to levels above the maximum exposure level when removing protective barriers or access panels that do not require the use of tools or other specialized equipment, the apparatus is classed as controlled apparatus.

5. Estimate the exposure level that a person could receive in the course of intended operations and procedures, $E_{L_{op}}$. The distance to the unit during intended operations should be estimated and the expected exposure level calculated or measured. The attenuation provided by any fixed shields should be taken into account.

Compare with the maximum exposure level ($E_{L_{max}}$) as specified in RPS 3 or ICNIRP Guidelines.

If $E_{L_{op}} > E_{L_{max}}$ then the apparatus is classed as controlled apparatus.

If $E_{L_{op}} < E_{L_{max}}$ then the apparatus is not classed as controlled apparatus.
Determining whether your apparatus is a controlled

- Is the RF source a:
  - induction heater or induction furnace
  - industrial RF heater or welder
  - RF plasma tube

  **YES**

  Is there a reasonably foreseeable abnormal event that would expose the person to levels above the exposure limits?

  **YES**

  Is there a reasonably foreseeable single element failure of the apparatus that would expose the person to levels above the exposure limits?

  **NO**

  Can a person receive excess levels of radiation when removing protective barriers or access panels without the use of tools or specialised equipment?

  **NO**

  Estimate the exposure that a person could receive in the course of intended operations and procedures, $E_{ref}$.

  **NO**

  Compare with the maximum exposure level.

  **NO**

  Not controlled

  **YES**

  Controlled
Appendix 1: Definition of RF emitting apparatus

1. Induction heater

**Definition:** A heater that uses an induced electric current to produce heat.

**Description:** In an induction heater a conducting material is heated by induction of an electric current in the object to be heated. The resistance of the metal leads to Joule heating. An induction heater consists of an electromagnet through which a high-frequency alternating current is passed. Heat can also be generated by magnetic hysteresis losses.

Induction heating provides a controllable and localized method of heating without contact between the heater and the components. Typical used for induction heaters are: heat treatment of metals, hardening of steel, annealing, bonding, curing and forging. A typical induction heater is shown below in Figure 2 and induction heating of a metal bar is shown in Figure 3.

![Figure 2: Induction heater](https://www.superiorinduction.com/index.php?cPath=22_28&cPath=hfseries)

![Figure 3: Induction heating of a metal bar](https://www.superiorinduction.com/index.php?cPath=22_28&cPath=hfseries)


Operating frequencies range from 50/60 Hz to over 1 MHz. Induction welders and induction solders are types of induction heaters and are included in the above category.
2. **Induction furnace**

**Definition:** A furnace that uses an induced electric current to heat a metal to its melting point.

**Description:** An induction furnace uses induction to heat a metal to its melting point. The heating mechanism is the same as in the induction heater. Common metals that are melted are iron, steel, copper, aluminum and precious metals. Melting and mixing rates can be controlled by selecting and varying the frequency and power. A picture of an induction furnace is shown in Figure 4.

![Induction furnace](figure4.jpg)

(Source: [www.exportersindia.com/amritsarmachine/](http://www.exportersindia.com/amritsarmachine/))

3. **Industrial radiofrequency heater**

**Definition:** A heating device in which heat is generated through a radiofrequency field. Industrial signifies that the apparatus is not used for domestic applications.

**Description:** The frequency of operation of RF heaters is in the range 10 MHz – 100 MHz, with output powers up to 100 kW. Common frequencies are 13.56 MHz, 27.12 MHz and 40.68 MHz. These frequencies have been designated to prevent interference with communications equipment.

RF heaters are used to heat, melt, dry or cure dielectric materials (insulators or poor conductors that can be polarized by an applied electric field). Plastic, glue and rubber are electrical and thermal insulators and consequently difficult to heat using conventional methods. These materials are well suited for heating with an RF heater. This is in contrast to induction heaters (defined in the previous section) which operate at lower frequencies and are used to heat materials which are good conductors of electricity. RF heaters can be used in industrial drying processes and are then often called RF dryers.

4. **Industrial radiofrequency welder**

**Definition:** A heating device in which heat is generated through a radiofrequency field and the heat is used to weld the material. Industrial signifies that the apparatus is not used for domestic applications.

**Description:** The heating mechanism is the same in an RF welder as in an RF heater. The material (often plastic) is heated to its melting point and the work pieces are joined together. RF welders are sometimes called RF sealers. An example of a RF welder is shown in Figure 5.

![Industrial RF welder](figure5.jpg)

(Source: [www.cosmos-kabar.com/machinery-automated.asp](http://www.cosmos-kabar.com/machinery-automated.asp))
5. Radiofrequency plasma tube

**Definition:** A tube containing plasma which is created by a radiofrequency field.

**Description:** An RF generator is attached to the RF tube and is used to generate the plasma. The tube typically contains a gas or a mixture of gases. As the gas is ionized, free electrons are accelerated in the field and collide with the atoms thereby exciting the atoms. As the atoms are de-excited photons are emitted resulting in visible or ultraviolet emission. A picture of an RF plasma tube is shown in Figure 6.

6. Microwave or Radiofrequency (RF) diathermy equipment

**Definition:** Microwave diathermy equipment uses electromagnetic energy in the microwave frequency range (300 MHz to 300 GHz) for therapeutic purposes.

RF diathermy equipment uses electromagnetic energy in the frequency range (3-30 MHz) for therapeutic purposes.

In Australia the only approved frequency for microwave diathermy treatment is 2450 MHz.

RF diathermy is sometimes referred to as shortwave diathermy. In Australia the only approved frequency for RF diathermy is 27.12 MHz. A picture of a diathermy unit can be seen below.

**Note:** Microwave and RF diathermy are not used very much nowadays and very few licence holders have this apparatus. In both microwave diathermy and RF diathermy heating of muscular tissue is performed for therapeutic reasons. In surgical diathermy a high-frequency electric current is made to pass through the body between two contact electrodes. The frequency is lower than for RF diathermy, typically 0.5–3 MHz. Surgical diathermy is not included in the above definition for microwave and radiofrequency diathermy equipment.

7. Industrial microwave processing system

**Definition:** A system where energy in the form of microwaves is used for heating or drying. Industrial signifies that the apparatus is not used for domestic applications.

Common microwave frequencies are 915 MHz, 2.45 GHz and 5.8 GHz. An industrial microwave is considered an industrial microwave processing system.
8. **Industrial radiofrequency processing system**

**Definition:** A system where energy in the form of radiofrequency waves is used for heating or drying. Industrial signifies that the apparatus is not used for domestic applications.

The most common RF frequencies are 13.56 MHz, 27.12 MHz and 40.68 MHz. Note that the definition for an industrial RF processing system is similar to the definition for an industrial RF heater. Typically an industrial RF processing system is a large enclosed unit used for large scale heating or drying (see Figure 9).

Radiofrequency and microwave processing systems are frequently used for heating and drying of materials such as paper, ceramics, food and plastics. Heating through RF and microwave is fast compared with conventional heating mechanisms which makes them a preferred option for pasteurization and sterilization. Microwave heating is a common choice in a laboratory environment. The heating mechanism is the same in RF heating, the only difference being the lower frequency. The selection of RF or microwave heating depends on the physical properties of the process. The penetration depth is greater for RF (longer wavelength) which can therefore be more suited for larger scale systems. RF systems also have a greater uniformity of heating.

![Figure 9: Industrial RF processing system used for drying food](Source: www.radiofrequency.com/products/mac8000h.html)
Appendix 2: Extracts from RPS 3 maximum exposure levels to RF Fields – 3 kHz to 300 GHz (2002)

General information

The standard includes:

- mandatory basic restrictions for both occupational and general public exposure involving all or part of the human body
- indicative 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.

Basic Restrictions

Mandatory limits on exposure to RF fields are based on established health effects and are termed ‘basic restrictions’. Depending on the frequency the physical quantities used to specify the basic restrictions are current density (J), specific absorption rate (SAR), specific absorption (SA) and power flux density (S). These quantities are often impractical to measure. Therefore reference levels are measured.

Reference Levels

Reference levels using quantities that are more practical to measure (for example electric and magnetic fields) have been developed. The reference levels have been conservatively formulated such that compliance with the reference levels will ensure compliance with the basic restrictions. Provided that all basic restrictions are met and adverse effects can be excluded, the reference levels may be exceeded. Hence the reference levels have been conservatively formulated such that compliance with the reference levels will ensure compliance with the basic restrictions.

Reference levels are given for occupational exposure and exposure to the general public. These groups are distinguished by their potential level of exposure and are defined by the degree of control and the level of training they have.

In the extract from RPS 3 below, reference levels are specified:

- Table 7 specifies the reference levels for time averaged exposure to ambient electric (E) and magnetic (H) fields.
- Table 8 specifies the corresponding reference levels for instantaneous field exposure.

These reference levels are illustrated in Figures 1 and 2 in the extract in this appendix.

Reference levels for point contact currents are given in Table 9 and reference levels for limb currents are given in Table 10.

Table 7 - Reference levels for time averaged exposure to RMS electric and magnetic fields (unperturbed fields)

<table>
<thead>
<tr>
<th>Exposure category</th>
<th>Frequency range</th>
<th>E-field strength (V/m rms)</th>
<th>H-field strength (A/m rms)</th>
<th>Equivalent plane wave power flux density $S_{eq}$ (W/m$^2$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Occupational</td>
<td>100 kHz – 1 MHz</td>
<td>614</td>
<td>1.63 / $f$</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>1 MHz – 10 MHz</td>
<td>614 / $f$</td>
<td>1.63 / $f$</td>
<td>1000 / $f^2$ (see note 5)</td>
</tr>
<tr>
<td></td>
<td>10 MHz – 400 MHz</td>
<td>61.4</td>
<td>0.163</td>
<td>10 (see note 5)</td>
</tr>
<tr>
<td></td>
<td>400 MHz – 2 GHz</td>
<td>$3.07 \times f^{0.5}$</td>
<td>$0.00814 \times f^{0.5}$</td>
<td>$f / 40$</td>
</tr>
<tr>
<td></td>
<td>2 GHz – 300 GHz</td>
<td>137</td>
<td>0.364</td>
<td>50</td>
</tr>
<tr>
<td>General public</td>
<td>100 kHz – 150 kHz</td>
<td>86.8</td>
<td>4.86</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>150 kHz – 1 MHz</td>
<td>86.8</td>
<td>0.729 / $f$</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>1 MHz – 10 MHz</td>
<td>86.8 / $f^{0.5}$</td>
<td>0.729 / $f$</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>10 MHz – 400 MHz</td>
<td>27.4</td>
<td>0.0729</td>
<td>2 (see note 6)</td>
</tr>
<tr>
<td></td>
<td>400 MHz – 2 GHz</td>
<td>$1.37 \times f^{0.5}$</td>
<td>$0.00364 \times f^{0.5}$</td>
<td>$f / 200$</td>
</tr>
<tr>
<td></td>
<td>2 GHz – 300 GHz</td>
<td>61.4</td>
<td>0.163</td>
<td>10</td>
</tr>
</tbody>
</table>

Notes:

1. $f$ is the frequency in MHz
2. For frequencies between 100 kHz and 10 GHz, $S_{eq}$, $E^2$ and $H^2$ must be averaged over any 6 minute period.
3. For frequencies exceeding 10 GHz, $S_{eq}$, $E^2$ and $H^2$ must be averaged over any $9.6 \times 10^4 / f^{1.05}$ minute period (see note 1).
4. Spatial averaging of the time averaged reference levels of Table 7 should be performed according to the requirements of clause 2.7.
5. For occupational exposure, E and H reference levels of Table 7 are given in plane wave ratio at frequencies greater than or equal to 1 MHz. However, for many occupational exposure situations, equivalent plane wave power flux density is not an appropriate metric if ‘far-field’ exposure conditions do not apply. Survey meters may be calibrated in terms of W/m$^2$, but both E and H will generally require independent measurement and evaluation if measured in the near-field.
6. For general public exposure E and H reference levels of Table 7 are given in plane wave ratio at frequencies greater than or equal to 10 MHz. However, equivalent plane wave power flux density is not an appropriate metric if ‘far-field’ exposure conditions do not apply. Survey meters may be calibrated in terms of W/m$^2$, but both E and H will generally require independent measurement and evaluation if measured in the near-field.
Table 8 - Reference levels for exposure to instantaneous RMS electric and magnetic fields (unperturbed fields)

<table>
<thead>
<tr>
<th>Exposure category</th>
<th>Frequency range</th>
<th>E-field strength (V/m rms)</th>
<th>H-field strength (A/m rms)</th>
<th>Equivalent plane wave power flux density $S_{eq}$ (W/m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Occupational</td>
<td>3 KHz – 65 kHz</td>
<td>614</td>
<td>25.0</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>65 kHz – 100 kHz</td>
<td>614</td>
<td>1.63 / $f$</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>100 kHz – 1 MHz</td>
<td>3452 × $f^{0.75}$</td>
<td>9.16 / $f^{0.25}$</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>1 MHz – 10 MHz</td>
<td>3452 / $f^{0.25}$</td>
<td>9.16 / $f^{0.25}$</td>
<td>(10³ / $f^{0.5}$ (see note 4)</td>
</tr>
<tr>
<td></td>
<td>10 MHz – 400 MHz</td>
<td>1941</td>
<td>5.15</td>
<td>10 000 (see note 4)</td>
</tr>
<tr>
<td></td>
<td>400 MHz – 2 GHz</td>
<td>97 × $f^{0.5}$</td>
<td>0.258 × $f^{0.5}$</td>
<td>25 × $f$</td>
</tr>
<tr>
<td></td>
<td>2 GHz – 300 GHz</td>
<td>4340</td>
<td>11.5</td>
<td>50 000</td>
</tr>
<tr>
<td>General public</td>
<td>3 kHz – 100 kHz</td>
<td>86.8</td>
<td>4.86</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>100 kHz – 150 kHz</td>
<td>488 × $f^{0.75}$</td>
<td>4.86</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>150 kHz – 1 MHz</td>
<td>488 × $f^{0.75}$</td>
<td>3.47 / $f^{0.178}$</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>1 MHz – 10 MHz</td>
<td>488 × $f^{0.25}$</td>
<td>3.47 / $f^{0.178}$</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>10 MHz – 400 MHz</td>
<td>868</td>
<td>2.30</td>
<td>2 000 (see note 5)</td>
</tr>
<tr>
<td></td>
<td>400 MHz – 2 GHz</td>
<td>43.4 × $f^{0.5}$</td>
<td>0.115 × $f^{0.5}$</td>
<td>5 × $f$</td>
</tr>
<tr>
<td></td>
<td>2 GHz – 300 GHz</td>
<td>1941</td>
<td>5.15</td>
<td>10 000</td>
</tr>
</tbody>
</table>

Notes:

1. $f$ is the frequency in MHz
2. For the specific case of occupational exposure to frequencies below 100 kHz, and where adverse effects from contact with passively or actively energised conductive objects can be excluded such that Table 9 would not apply (refer Note 3 Table 9), the derived electric field strength can be increased by a factor of 2.
3. The E and H reference levels in Table 8 are instantaneous rms values and for purposes of compliance determination, measurements are to be rms averaged over any 1 µs period. However, at frequencies below 100 kHz, measurements may be rms averaged over any 100 µs period or, below 10 kHz, at least one single cycle of the carrier frequency.
4. For occupational exposure, E and H reference levels of Table 8 are given in plane wave ratio at frequencies greater than or equal to 1 MHz. However, for many occupational exposure situations, equivalent plane wave power flux density is not an appropriate metric if ‘far-field’ exposure conditions do not apply. Survey meters may be calibrated in terms of W/m², but both E and H will generally require independent measurement and evaluation if measured in the near-field.
5. For general public exposure E and H reference levels of Table 8 are given in plane wave ratio at frequencies greater than or equal to 10 MHz. However, equivalent plane wave power flux density is not an appropriate metric if ‘far-field’ exposure conditions do not apply. Survey meters may be calibrated in terms of W/m², but both E and H will generally require independent measurement and evaluation if measured in the near-field.
Figure 1: Reference levels for instantaneous and time averaged rms exposure to electric fields (refer Tables 7 & 8 and look-up tables in Schedules 2 and 3). [See RPS 3 for look-up tables in Schedules 2 and 3]

Figure 2: Reference levels for instantaneous and time averaged rms exposure to magnetic fields (refer Tables 7 & 8 and look-up tables in Schedules 2 and 3). [See RPS 3 for look-up tables in Schedules 2 and 3]
**Reference levels for contact currents**

For frequencies up to 110MHz, reference levels for point contact current are given in Table 9. Above these levels caution must be exercised to avoid shock and burn hazards arising from high spatial peak current densities during point contact with energised or passively charged conductive objects. For further information, refer American National Standards Institute C 95.3 Standard (ANSI 1991).

**Table 9 - Reference levels for instantaneous rms contact currents from point contact with conductive objects**

<table>
<thead>
<tr>
<th>Exposure category</th>
<th>Frequency range</th>
<th>Maximum contact current (mA rms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Occupational</td>
<td>3 kHz – 100 kHz</td>
<td>$0.4 \times f$</td>
</tr>
<tr>
<td></td>
<td>100 kHz – 110 MHz</td>
<td>40</td>
</tr>
<tr>
<td>General public</td>
<td>3 kHz – 100 kHz</td>
<td>$0.2 \times f$</td>
</tr>
<tr>
<td></td>
<td>100 kHz – 110 MHz</td>
<td>20</td>
</tr>
</tbody>
</table>

Notes:
- $f$ is the frequency in kHz.
- For frequencies greater than or equal to 100 kHz, instantaneous contact currents must be rms averaged over any 1 µs period. However, at frequencies below 100 kHz, measurements must be rms averaged over any 100 µs period or, below 10 kHz, over at least one single cycle of the carrier frequency.
- The reference levels of Table 9 are applicable only where there is a possibility of point contact with passively or actively energised conductive objects such that significant instantaneous spatial peak current densities are likely (e.g. where current is drawn through a finger rather than induced in an arm).

**Reference levels for limb currents**

For the frequency range 10 MHz – 110 MHz, reference levels for time averaged rms limb currents are provided in Table 10, to ensure compliance with the basic restrictions for spatial peak SAR in the limbs (see Table 2 in RPS 3).

**Table 10 - Reference levels for time averaged Rms current induced in any limb**

<table>
<thead>
<tr>
<th>Exposure category</th>
<th>Frequency range</th>
<th>Current (mA rms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Occupational</td>
<td>10 MHz – 110 MHz</td>
<td>100</td>
</tr>
<tr>
<td>General public</td>
<td>10 MHz – 110 MHz</td>
<td>45</td>
</tr>
</tbody>
</table>

**Note:** For compliance with the basic restriction on spatial peak SAR in limbs, induced limb current measurements are to be rms averaged over any 6-minute period.
Appendix 3: Extracts from the ICNIRP Guidelines for limiting exposure to time-varying electric and magnetic fields 1 Hz–100 kHz (2010)

General information

This publication establishes guidelines for limiting exposure to electric and magnetic fields in the low frequency range of the electromagnetic spectrum. Separate guidance is given for occupational and general public exposures.

Reference Levels

A summary of the reference levels recommended for occupational and general public exposures to electric and a magnetic field is given in Tables 3 and 4.

Table 3 - Reference levels for occupational exposure to time-varying electric and magnetic fields (unperturbed rms fields)

<table>
<thead>
<tr>
<th>Frequency range</th>
<th>E-field strength E (kV/m)</th>
<th>Magnetic-field strength H (A m⁻¹)</th>
<th>Magnetic flux density B (T)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Hz–8 Hz</td>
<td>20</td>
<td>1.63x10⁵/f²</td>
<td>0.2/f²</td>
</tr>
<tr>
<td>8 Hz–25 Hz</td>
<td>20</td>
<td>2x10⁵/f</td>
<td>2.5x10⁻²/f</td>
</tr>
<tr>
<td>25 Hz–300 Hz</td>
<td>5x10²/f</td>
<td>8x10²</td>
<td>1x10⁻³</td>
</tr>
<tr>
<td>300 Hz–3 kHz</td>
<td>5x10²/f</td>
<td>2.4x10⁵/f</td>
<td>0.3/f</td>
</tr>
<tr>
<td>3 kHz–10 MHz</td>
<td>1.7x10⁻¹</td>
<td>80</td>
<td>1x10⁻⁴</td>
</tr>
</tbody>
</table>

Notes:

- f in Hz.
- Refer ICNIRP Guidelines separate sections for advice on non-sinusoidal and multiple frequency exposure.
- To prevent indirect effects especially in high electric fields see section on “Protective measures” in the ICNIRP Guidelines.
- In the frequency range above 100 kHz, RF specific reference levels need to be considered additionally.
Table 4: Reference levels for general public exposure to time-varying electric and magnetic fields (unperturbed rms values)

<table>
<thead>
<tr>
<th>Frequency range</th>
<th>E-field strength E (kV/m)</th>
<th>Magnetic-field strength H (A m⁻¹)</th>
<th>Magnetic flux density B (T)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Hz–8 Hz</td>
<td>5</td>
<td>3.2x10⁴/f²</td>
<td>4x10⁻²/f²</td>
</tr>
<tr>
<td>8 Hz–25 Hz</td>
<td>5</td>
<td>4x10⁷/f</td>
<td>5x10⁻⁹/f</td>
</tr>
<tr>
<td>25 Hz–50 Hz</td>
<td>5</td>
<td>1.6x10²</td>
<td>2x10⁻⁴</td>
</tr>
<tr>
<td>50 Hz–400 Hz</td>
<td>2.5x10³/f</td>
<td>1.6x10²</td>
<td>2x10⁻⁴</td>
</tr>
<tr>
<td>400 Hz–3 kHz</td>
<td>2.5x10³/f</td>
<td>6.4x10⁴/f</td>
<td>8x10⁻³/f</td>
</tr>
<tr>
<td>3 kHz–10 MHz</td>
<td>8.3x10⁻²</td>
<td>21</td>
<td>2.7x10⁻⁵</td>
</tr>
</tbody>
</table>

Notes:

- \( f \) in Hz
- Refer ICNIRP Guidelines separate sections for advice on non-sinusoidal and multiple frequency exposure
- In the frequency range above 100 kHz, RF specific reference levels need to be considered additionally

For further information on the ICNIRP Guidelines for Limiting Exposure to Time-Varying Electric and Magnetic Fields 1Hz-100 kHz the document can be downloaded from the ARPANSA website link (https://www.arpansa.gov.au/regulation-and-licensing/regulation/international-best-practice/non-ionising-radiation-safety) to the ICNIRP website.