Draft Radiation Protection Standard for Exposure Limits to Electric and Magnetic Fields 0 Hz – 3 kHz

Questions and Answers

7 December 2006

1. Why is ARPANSA preparing a Standard?

In 1989 the National Health and Medical Research Council (NHMRC) published *Interim guidelines on limits of exposure to 50/60 Hz electric and magnetic fields*, Radiation Health Series No. 30, which were based on the current scientific knowledge of the time. Although the NHMRC guidelines have since been rescinded, the document has remained the only Australian guidance on limits of exposure to power frequency electric and magnetic fields.

ARPANSA is now responsible for management and review of the NHMRC's Radiation Health Series publications. In order to protect community health, ARPANSA has concluded that with the large body of scientific research on possible health effects of electromagnetic fields undertaken since 1989, a new Standard to limit human exposure to electric and magnetic fields was required to replace the NHMRC Interim Guidelines.

In addition there is a need for a standard to cover electric and magnetic fields for the entire Extremely Low Frequency (ELF) range from 0 Hz to 3 kHz, as the NHMRC publication only covered 50/60 Hz.

2. What are the sources of ELF electric and magnetic fields?

ELF electric and magnetic fields are produced by both natural and artificial sources. Naturally occurring ELF fields are associated with atmospheric processes such as thunderstorms and lightning. However, artificial sources are the dominant sources of ELF fields and are usually associated with the generation, distribution and use of electricity at the frequency of 50 Hz. Powerlines, electrical wiring and common appliances (electric blankets, televisions, hair-dryers, computers, etc) all produce ELF electric and magnetic fields.

3. What does the ARPANSA draft Standard contain?

The draft Standard contains limits of human exposure to ELF electric and magnetic fields in the frequency range 0 Hz to 3 kHz. In addition to the limits it specifies risk management practices that should also be applied.

The Basic Restrictions are the fundamental limits designed to ensure that known adverse health effects do not arise from exposure to ELF fields. The Basic Restrictions refer to electric fields found within the tissues of the human body and are not readily measurable. Therefore the draft Standard also provides indicative Reference Levels which are more easily measured quantities.

For frequencies below 0.1 Hz because of limited data the draft Standard provides guidance levels rather than exposure limits.

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The draft Standard also includes:

- approaches to verification of compliance with the Standard (Section 4);
- requirements for management of risk in occupational exposure and measures for protection of the general public (Section 5);
- a comprehensive rationale, ie. statement of the underlying reasoning employed in the development of the Standard (Schedule 1) ;
- a review of epidemiological (human health) studies (Annex 3);
- a review of bio-effects research at low levels of exposure (Annex 4);
- a public health precautionary approach to ELF fields (Annex 6); and
- the contact details of relevant regulatory and radiation protection authorities (Annex 8);

4. What are Basic Restrictions?

'Basic Restrictions' are fundamental limits of exposure to ELF electric and magnetic fields. These are specified in Section 2 of the ARPANSA draft Standard. . If Basic Restrictions are not exceeded there will be protection against established bioeffects which could lead to adverse health outcomes. The Basic Restrictions also include appropriate safety factors to allow for uncertainties in where the thresholds for established bioeffects actually lie.

In the frequency range 0.1 - 3 kHz the physical quantity used to specify the Basic Restrictions is the tissue induced electric field E_{int}. At the different frequency ranges relevant to these adverse physical effects, these Basic Restrictions are designed to prevent the occurrence of magnetophosphenes in the sensitive retinal tissue (0.1 Hz – 400 Hz) and electrostimulation of excitable tissue (400 Hz – 3 kHz).

5. Why are magnetophosphenes so important?

In the frequency range 0.1 - 400 Hz, Basic Restrictions are provided to prevent the occurrence of magnetophosphenes in the retina. Since this phenomenon is related to effects in the connections of specialised nerves, and since similar effects could possibly occur elsewhere in the central nervous system, particularly the brain, any exposure involving the head should be below this level. Although, the occurrence of magnetophosphenes is considered annoying rather than hazardous it could represent a threshold for less well defined phenomena in nerves.

6. What are Reference Levels?

Because direct assessment against the Basic Restrictions can be difficult, time consuming and costly, Reference Levels are specified to provide a simpler way of demonstrating that the Basic Restrictions are not exceeded.

Reference Levels are defined by quantities that are relatively easy to measure directly and in general there is commercial equipment available to make such measurements. The Reference Levels are specified in Section 2 of the ARPANSA draft Standard.

The Reference Levels for electric field (E) or magnetic flux density (B) are based on the assumption of a "worst case" exposure. In general, such "worst case" exposure conditions are

rare and exposure at the maximum allowable E and B field levels will be well below the corresponding Basic Restrictions. Hence exposure to a maximum level consistent with the E or B Reference Levels will usually include significant additional safety margins above those already incorporated in the Basic Restrictions.

7. What is the purpose of the draft Standard?

The ARPANSA draft Standard specifies limits of human exposure to ELF fields in the frequency range 0 Hz to 3 kHz, to prevent adverse health effects. The limits specified in this draft 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 health surveillance. However, the use of ELF fields for medical therapies is not included within the scope of the draft Standard. The ARPANSA draft Standard also does not deal with other potential hazards of ELF fields such as the ignition of explosives or flammable gases, or interference to electronic equipment.

The draft Standard is available to be adopted by Commonwealth, State and Territory authorities responsible for regulation of radiation. This would enable ELF emitting equipment and devices throughout Australia and the associated work practices and public protection arrangements to be controlled in a uniform manner.

ARPANSA has the role of promoting uniformity of radiation safety regulatory practices between jurisdictions the National Directory for Radiation Protection (NDRP). In 2004, the Australian Health Ministers' Conference agreed that Codes and Standards adopted in the Directory would be implemented as soon as possible within each jurisdiction's regulatory framework. ARPANSA will be proposing that, when finalised, the Standard be adopted into the National Directory.

8. How will the Standard be implemented?

The CEO of ARPANSA will recommend that all relevant Australian authorities and regulatory bodies use the ARPANSA Standard, when finalised, as an advisory document.

9. How does the Standard affect employers?

Sections 1 through 5 constitute the main body of the Standard. All of these Sections must be adhered to in order to comply with the draft Standard.

10. How does the draft Standard affect employees?

An employer should evaluate the potential exposure levels from plant and equipment. For workers who could be exposed above the occupational exposure limits, the employer must implement an appropriate risk management strategy as indicated in Section 5 of the ARPANSA draft Standard. If a worker is likely to be exposed at levels above the limits specified for members of the general public, then you must be trained in safe work practices, and provided with appropriate supervision. Workers must also be trained in the methods to manage the potential hazard to ELF fields. Note that occupationally exposed women who are pregnant should advise their employers when they become aware of their pregnancy.

11. How does the draft Standard affect members of the public?
Relevant control measures for public exposure are specified in Section 5.7 of the ARPANSA draft Standard. The text of this clause reads as follows:

"*Measures for the protection of members of the general public who may be exposed to ELF fields due to high ELF 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 warning signs or notices

(d) Notification to the competent authority, as required, in the event of the exposure exceeding the relevant limits.

(e) *Minimising, as appropriate, ELF and/or static electric and magnetic field exposure provided this can be readily achieved without undue inconvenience and at reasonable expense. Any such precautionary measures should follow good engineering and risk minimisation practice. Planning practice and relevant codes of practice should also be followed. Precautionary measures should be proportional to the risk. (e.g. where children are involved). Important principles underlying appropriate precautionary measures are discussed in Annex 6. The incorporation of arbitrary additional prescriptive safety factors beyond the exposure limits of this Standard is not supported.*"

12. How were the exposure limits derived?
In deriving the exposure limits of the draft Standard, the origins and evolution of relevant recommendations and standards of both the International Commission on Non-Ionizing Radiation Protection (ICNIRP) and the Institute of Electrical and Electronics Engineers (IEEE) were reviewed. The Working Group used peer reviewed publications for their assessment of the science. Data for effects of ELF exposure on living organisms was evaluated by considering the evidence of health effects in humans, and the biological effects in humans and other organisms, as well as effects at a cellular level.

The Working Group also relied on reviews conducted by expert groups or panels, including one set up by the Working Group to specifically examine the electrophysiological and neurophysiological bases of the Basic Restrictions. Moreover, the Working Group has reviewed and where necessary revised, relevant spatial and temporal measurement averaging parameters so as to provide an adequate and unambiguous specification of the limits.

13. What is a 'controlled circumstance'?
(a) Occupational exposure:
It is an activity or circumstance in which exposure to ELF electric or magnetic fields may reasonably be expected to exceed the occupational exposure Reference Levels but not to exceed higher specified levels called "Controlled Activity/Circumstance Reference Levels" (Occupational exposure).

Such exposure is permissible only if the persons being exposed:

- are made aware of the probable exposure and given information about possible biological effects and risk of adverse health effects;
- give informed consent to such exposures;
- are given sufficient training and information so they may minimise their exposure consistent with operational requirements and may avoid accidents or injuries if biological effects do occur; and
- are suitably screened for the presence of electronic or metallic medical implants that may put them at risk in the range of fields expected.

Such activity or circumstance must also be:

- under the supervision of a competent person who must ensure that exposures cannot exceed the Controlled Activity/Circumstance (Occupational Exposure) Reference Levels;
- be subject to appropriate access controls and signage to prevent inadvertent entry and exposure; and
- be documented and signed so that areas exceeding normal occupational Reference Levels are clearly indicated.

(a) General public exposure:
It is an activity or circumstance in which exposure to ELF electric or magnetic fields may reasonably be expected to exceed the general public exposure Reference Levels but not to exceed higher specified levels called "Controlled Activity/Circumstance Reference Levels" (General public exposure).

Such exposure is permissible only if:

- signage at all entry points is present to inform all likely visitors/occupants that the fields exceeding the general public limits may be present and that visitors/occupants may wish to minimise the duration of their stay;
- that such signage includes reference by telephone number (available at least during normal business hours) and internet URL to a source of more comprehensive information about the likely exposure levels, and possible risks to health;
- that where exposures are highly localised, the signage clearly indicates which locations are effected; and
- documentation is prepared and maintained explaining why such exposures are practically necessary.

14. What is the scientific basis of the limits?

The exposure limits are based on a large body of scientific research data. In brief, they are designed to protect against all adverse effects and to prevent unwanted nuisance effects that may arise through the occurrence of magnetophosphenes in the sensitive retinal tissue and electrostimulation of excitable tissue.

15. How does the draft Standard deal with the question of childhood leukaemia?

The draft Standard contains Annexes on the Epidemiological evidence of ELF fields and bio-effects research at low levels of exposure which review studies relevant to the childhood leukaemia issue. The draft Standard concurs with every major review on the subject that there is some epidemiological evidence that prolonged exposure to power frequency magnetic fields at levels higher than what is normally encountered is associated with a small increased risk of leukaemia in children. However it has not been established that this relationship is causal. Other scientific evidence, including cell and animal studies, does not support this finding, and many of the epidemiological studies themselves suffer from problems, including inadequate exposure assessment. Based on the epidemiological findings of childhood leukaemia, the International Agency for Research on Cancer (IARC) has classified power frequency magnetic fields as a 2B or "possible" carcinogen.

Since causality has not been established the epidemiological results cannot be used as a basis for the derivation of quantitative restrictions at this stage. Although the childhood leukaemia results do not lend themselves to setting quantitative limits of exposure the draft Standard recommends a precautionary approach (Section 5. Protection - occupational and general public exposure). Cautionary policies are reviewed in Annex 6.

16. Does the draft Standard include a precautionary approach for exposure of members of the public?

Yes - the exposure limits in the ARPANSA draft Standard include significant safety margins below exposures known to cause adverse effects. The general public exposure limits include additional safety margins over and above those incorporated into the occupational limits. There is also a requirement [sub-clause 5.7 (e) of the draft Standard] for:

"Minimising, as appropriate, ELF and/or static electric and magnetic field exposure provided this can be readily achieved without undue inconvenience and at reasonable expense. Any such precautionary measures should follow good engineering and risk minimisation practice. Planning practice and relevant codes of practice should also be followed. Precautionary measures should be proportional to the risk. (e.g. where children are involved). Important principles underlying appropriate precautionary measures are discussed in Annex 6. The incorporation of arbitrary additional prescriptive safety factors beyond the exposure limits of this Standard is not supported.

Conditions for demonstrating compliance with the requirements of the ARPANSA draft Standard, including this mandatory precautionary requirement, will be established by the

relevant regulatory body and/or through agreed protocols and codes of practice. The philosophy and application of various precautionary approaches is discussed in Annex 6 of the draft Standard.

17. How does the draft Standard compare to other standards and Guidelines?

The draft Standard has Basic Restrictions very different from the ICNIRP Guidelines, being formulated in terms of induced electric field rather than current density. However, a comparison is possible by using a mean value of 0.2 S/m for the conductivity of tissue.

The Basic Restrictions in the ARPANSA draft Standard are more conservative than ICNIRP in the frequency range up to 100 Hz and then less conservative above this frequency. Below 300 Hz, the Basic Restrictions are similar to the IEEE Basic Restrictions but 1.8-fold lower for the occupational restrictions and 3-fold lower for general public restrictions. Above 300 Hz the Basic Restrictions are progressively more conservative (up to 17-fold lower at 3 kHz), in comparison to IEEE.

Magnetic field Reference Levels have been derived in a different way from that employed by ICNIRP. The Reference Levels in this standard are more conservative than ICNIRP for the lower range of frequencies and less conservative at the higher range. At the extremes and around 50/60 Hz they are almost identical. They are more conservative than the IEEE Reference Levels throughout the range, but follow a similar characteristic shape because of a similarity in their mode of derivation.

18. How can exposure to ELF electric and magnetic fields be reduced?

The widespread use of electricity means that ELF electric and magnetic fields are present in most situations where people live and work. The magnitudes of both electric and magnetic fields decrease rapidly with increasing distance from the source. The easiest way to reduce exposure to these fields may simply be to move areas where people spend a lot of time (for example, chairs, beds) away from electrical appliances and facilities by re-arranging room layouts.

Electric fields can be easily shielded, but the shielding of magnetic fields is technically difficult and therefore very expensive.

Other things that can be done to reduce residential exposure include:

- using an electric blanket to warm the bed and then switching off before going to bed will virtually eliminate what could be a significant exposure;
- locating bedrooms towards the rear of the house will usually reduce the exposure due to distribution lines in front of the house;
- moving a bed away from an external wall which has the power meter or an electric hot water service on the other side will also reduce exposures;
- moving to a distance of about 50 cm away from a video screen.

19. How can I reduce my exposure to ELF electric and magnetic fields at work?
With regard to occupational exposure there may be localized sources of magnetic fields in the workplace such as electrical substations in the basement, power cables in the walls or floor and distribution lines close to the building. The field levels close to these sources will be relatively high and may cause computer screens to shimmer, for example.

The only remedies currently available to reduce these fields, and the resultant exposure, is a combination of shielding and relocating the source (both very costly), or relocating the employees. The general aim of any field reduction program is to minimize the exposure level for all staff. However, particular situations may require particular solutions and advice should be sought from consultants that deal with mitigation techniques.

20. What options are available in the regulation of ELF electric and magnetic fields?
Three regulatory options have been identified by ARPANSA in the regulation of ELF electric and magnetic fields:

Option One — status quo — this entails doing nothing and leaving the *Interim Guidelines on Limits of Exposure to 50/60 Hz Electric and Magnetic Fields* in place;

Option Two — regulatory adoption of the Standard — this option entails re-writing the guidelines, updating it to be consistent with international guidelines and standards, and taking into account more recent literature. The proposed Standard would provide a set of requirements to be adopted by State/Territory regulators as part of their regulatory frameworks; or

Option Three — publishing the Standard without incorporating it into regulation — this option entails re-writing the guidelines, updating it to be consistent with international guidelines and standards, and taking into account more recent literature. State/Territory regulators and industry would use the Standard as an advisory document.

21. What did the Regulatory Impact Statement conclude?
The benefits of Options Two and Three have been assessed in comparison to the *status quo* (i.e. Option One). The analysis indicates that there is little chance of a positive net present value from adopting the draft Standard in legislation. Option Three, on the other hand, is likely to result in a net benefit, and so is the preferred option.

The difference between Options Two and Three is largely driven by the likelihood that capital investments worth over $1 billion that the electricity industry perceives would be required nder Option Two would not need to be undertaken under Option Three.