GUIDANCE ON ELECTRICAL INSTALLATION PRACTICES TO REDUCE EMF FROM LOW VOLTAGE WIRING

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INTRODUCTION

The following information is provided to raise awareness among electrical installation designers and contractors of *low voltage systems* of measures that may be adopted to reduce the production and effects of electric and magnetic fields associated with electrical installations.

The electricity supply industry in Australia, as an appropriate response to scientific uncertainty and community concern regarding possible health effects associated with low frequency (50 Hz) electric and magnetic fields (EMF), has a policy to design and operate their systems "prudently" and apply "prudent avoidance" when designing and siting new facilities. "Prudent avoidance" for installations recognizes the present lack of full scientific certainty but recommends that low cost precautions be undertaken, where appropriate, to reduce exposure of people to EMF.

This document provides information that could be applied for limiting production of and exposure to EMF from *low voltage* electrical installations and sources which do not belong to the electricity supply industry. This includes designing distribution facilities, switchboards and higher current wiring systems having regard to their capacity to produce magnetic fields, and installing or siting them having regard to proximity and exposure.

There are also well identified problems of magnetic or electric field interference with the operation of some electrical equipment, particularly older style computer monitors, which can be addressed by reducing the production of and exposure to EMFs from low voltage sources.

While the advice below is *not* mandatory, it is provided for consideration by users of electrical equipment and contractors who install wiring and equipment. Measures suggested are consistent with the industry policy of "prudent avoidance" in regard to the possible health effects of electric and magnetic fields. Such measures may be installed for no cost or low cost if done at the time of initial installation or when significant modifications are being considered.

BACKGROUND

An electric field is a region where electric charges experience a force related to the voltage applied to the electrical installation. The higher the voltage, the stronger and more extensive is the electric field.

A magnetic field is a region where magnetic materials experience a force related to the current flowing in the electrical installation. The higher the current, the stronger and more extensive is the magnetic field.

While the term 'EMF' refers to electric and magnetic fields, the focus of this information is on measures to reduce magnetic fields since most research has concentrated on this aspect when investigating adverse health effects and such fields penetrate most materials and are thus difficult to shield. Since the late 1970s, there has been a wealth of scientific research on EMF and possible health effects. While the scientific reviews of the many studies have been reassuring in general, there still remains some uncertainty related to possible adverse health effects, particularly in relation to an increased risk of childhood leukaemia associated with magnetic field exposure.

WHAT IS 'PRUDENT AVOIDANCE'

The policy of *Prudent Avoidance* has been adopted by the electricity supply industry in Australia as an appropriate response to community concern regarding possible health effects associated with low frequency EMFs. This policy, which is applied in the design, construction and operation of new distribution and transmission facilities, recognises the present lack of full scientific certainty but recommends that low cost precautions be undertaken where appropriate. Although there is no precise definition of *prudent avoidance*, it is usually described as:

"doing whatever can be done at modest cost and without undue inconvenience to avoid the possible risk to health"

For low voltage electrical installations, this means limiting exposure from low voltage sources. This includes designing distribution facilities, switchboards and higher current wiring systems having regard to their capacity to produce magnetic fields, and installing or siting them having regard to proximity and exposure. Forethought in planning and design can usually place such equipment in low-occupancy locations or away from potentially sensitive groups such as children in schools, day-care and kindergarten centres. The intention is to apply field reduction techniques which can be achieved safely, without inconvenience and at low or modest cost.

These same techniques can also be applied to a range of other technical/safety issues relating to the location of wiring or switchboards in an installation (e.g. electrical fire, power/telecommunications interaction, interference, and power quality issues).

ELECTRICAL INSTALLATION CONTROL MEASURES

As shown in the following figure each conductor carrying current will produce a magnetic field the strength of which decreases rapidly with distance. Where another conductor, carrying the same current flowing in the opposite direction, is placed adjacent, the resulting two fields will attempt to cancel each other.

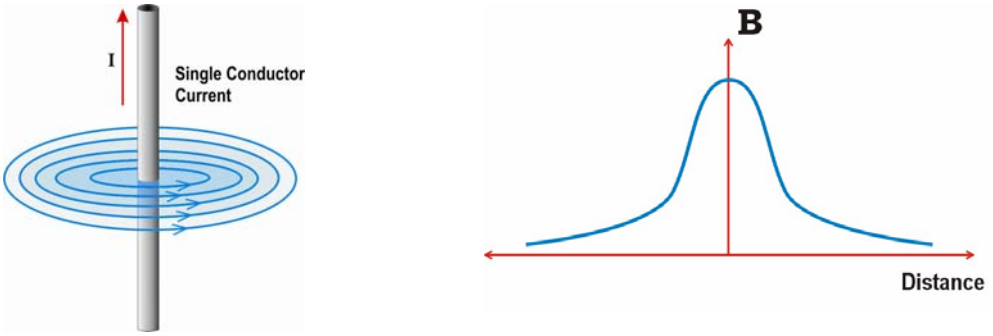

Figure 1. Reduction of magnetic field strength, B, with distance from conductor source

There are five basic techniques that may be used in the design and installation processes to reduce EMF:

- reduce electrical current by using more energy efficient equipment for large electrical loads such as lift motors, air conditioning equipment, industrial motors and manufacturing equipment;
- balance circuits to minimise net magnetic fields;
- cancel magnetic fields by circuit installation arrangements that reduce distance between, or coordinate the relative placement of, all conductors in the same circuit;
- maximise distance between EMF sources and sensitive areas where the level, duration, affected persons or other consequences of exposure may warrant attention; and
- shield sources by containment or dispersal behind specialised barriers.

In many cases these techniques may be applied at little cost provided this is done when the installation is being planned or the equipment is being installed or modified. Shielding measures, which are

considered as a retrofit measure where other precautions are not available, can be expected to incur more considerable design and installation costs to satisfy specific site performance conditions.

The following list contains examples of how the lower cost techniques may be applied.

Circuit Arrangements

Circuits carrying high currents such as mains and submains should be planned to promote cancellation of the magnetic field or to avoid more sensitive locations. Practical measures for consideration include -

- group all cables of the same circuit – active, neutral and earth - in close trefoil or quadrature;
- where circuits comprise parallel groups of single cables, each group should contain phase and neutral conductors. Do not group all conductors of the same phase together;

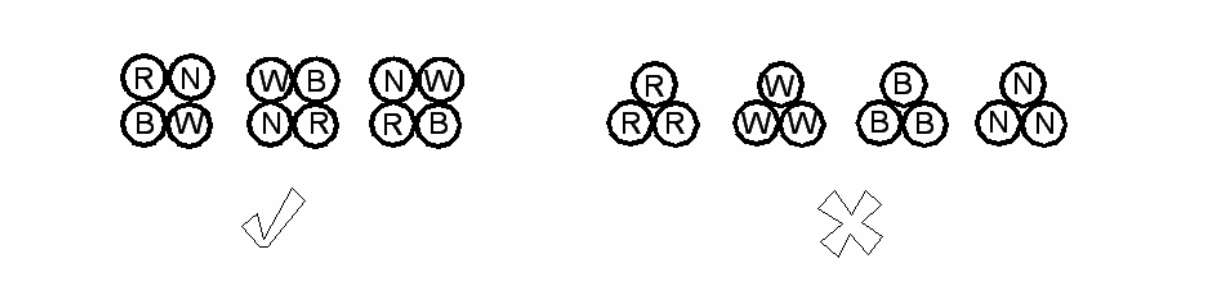

Figure 2. Low EMF cable group arrangement for circuit of parallel single-core conductors

- maintain the same route for active and neutral currents, e.g. parallel circuits, two-way lighting switch straps, or in three-phase circuits where transfer switches are of the 3-pole rather than the 4-pole type, the neutral should still follow the same route as the associated actives;
- avoid the use of separate conduits, trays or wiring enclosures for the active and neutral conductors of the same circuit;
- in domestic premises run higher current circuits, such as ranges and water heaters, as multicore cables in ceilings or other locations away from high use areas such as lounge rooms or long exposure areas such as bedrooms;
- in commercial premises, run high current circuits such as submains some metres (at least 2 to 3) away from high use areas and/or sensitive areas;
- install cables in an underground enclosure as an alternative to bare aerial cables.

Earthing Arrangements

The Multiple Earthed Neutral (MEN) system requires the connection of the incoming neutral from the electricity distribution system to the main earthing conductor and neutral conductor of the customer's installation. The connection of the main earthing conductor to the mass of earth is by means of an earth electrode, usually in conjunction with a metallic water pipe and other parts of the building structure.

The neutral return current from the installation is primarily intended to flow back to the distribution system through the incoming neutral but some fraction, as determined by the relative impedance of the neutral and earth paths, will flow through the earthing system. If this happens, then the main earth conductor or water pipe can become a source of magnetic field, as can the incoming service or mains service, as the magnitudes of the active and neutral currents are not equal.

The following measures can be considered to assist in reducing the potential EMF impact:

- check that incoming service or mains neutral connections are secure particularly at aerial and underground service connection points and at main switchboard terminations;
- select size of neutral conductor to be not smaller than associated active conductors to provide a lower impedance path than earthing system;
- install the main earth conductor and water pipe bond away from high use or sensitive areas.

Switchboard Arrangements

The size and configuration of busbars, cabling and switchgear in switchboards and meter panels present a significant source of EMF that can extend outside the immediate switchboard area. Plan the layout of meters, switchboard and associated wiring to provide separation from areas of high use or sensitive occupancy where possible.

- Keep plant rooms containing large electrical loads such as motors, pumps, heating, ventilation and air cooling equipment, fans, and associated switchboards and wiring systems, away from heavily occupied or sensitive areas. Basement and roof top locations are typical and desirable.
- In office premises, install switchboards in switchrooms, riser cupboards or similar less frequented locations away from high use areas. When laying out new or reorganised office equipment such as workstations, a distance of 4 to 5 metres from switchrooms is suggested to provide the additional benefit of avoiding computer monitor interference for old style CRT monitors.
- In schools, childcare facilities or similar sensitive premises, install switchboards well away from classrooms and areas that may be used by children for extended periods.
- In domestic premises, locate the switchboard and metering panel to reduce fields in active use areas. Preferred locations for switchboards would include the garage or laundry cupboards. The location of meter panels is restricted to external locations by meter access requirements but should avoid living room walls or bedroom walls adjacent to bed heads – as shown in the following illustration.

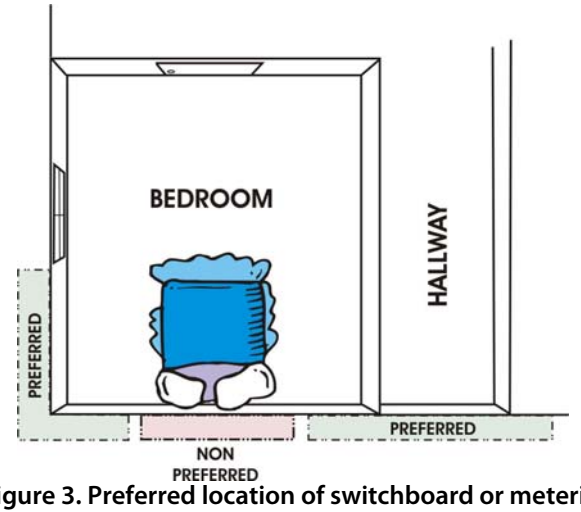

Figure 3. Preferred location of switchboard or metering panel

Other measures

Other measures which may be applied include:

- Design computer training rooms in schools so that students avoid sitting close to the back (the higher-field end) of computer monitors. A separation distance of some two metres is suggested.
- Use or specify energy efficient equipment to reduce the electrical load on the installation thereby reducing magnetic fields. This includes domestic appliances as well as services such as lifts, air conditioning, and hydraulic and manufacturing equipment.

FURTHER INFORMATION

Further information on EMF can be found on this ENA web site www.ena.asn.au/emf including:

- the industry EMF Policy; and
- the public information brochure "EMF What we know".

Further general information and references on EMF and health effects can be found on the Australian Radiation Protection and Nuclear Safety Agency web site www.arpansa.gov.au