

## ELECTROMAGNETIC FIELDS AND PUBLIC HEALTH

### Health Effects of Radiofrequency Fields

Based on: Environmental Health Criteria 137 "Electromagnetic Fields (300 Hz to 300 GHz), World Health Organization, Geneva, 1993, and the report of the Scientific Review under the auspices of the International EMF Project of the World Health Organization, Munich, Germany, November 1996.

Radiofrequency (RF) fields are part of the electromagnetic spectrum. For the purpose of the International EMF Project, such fields are defined as those within the frequency range 300 Hz (or 0.3 kHz) and 300 GHz. Natural and human-made sources generate RF fields of different frequency.

Common sources of RF fields include: monitors and video display units (3 - 30 kHz), AM radio (30 kHz - 3 MHz), industrial induction heaters (0.3 - 3 MHz), RF heat sealers, medical diathermy (3 - 30 MHz), FM radio (30 - 300 MHz), mobile telephones, television broadcast, microwave ovens, medical diathermy (0.3 - 3 GHz), radar, satellite links, microwave communications (3 -30 GHz) and the sun (3 -300 GHz).

RF fields are non-ionizing radiations (NIR). Unlike X-rays and gamma rays, they are much too weak to break the bonds that hold molecules in cells together and, therefore, produce ionization. RF fields may, however, produce different effects on biological systems such as cells, plants, animals, or human beings. These effects depend on frequency and intensity of the RF field. By no means, will all of these effects result in adverse health effects.

RF fields above 10 GHz are absorbed at the skin surface, with very little of the energy penetrating into the underlying tissues.

- The basic dosimetric quantity for RF fields above 10 GHz is the intensity of the field measured as power density in watts per square metre ( $W/m^2$ ) or for weak fields in milliwatts per square metre ( $mW/m^2$ ) or microwatts per square metre ( $W/m^2$ ).
- For adverse health effects, such as eye cataracts and skin burns, to occur from exposure to RF fields above 10 GHz, power densities above  $1000 W/m^2$  are needed. Such densities are not found in everyday life. They do exist in very close proximity to powerful radars. Current exposure standards preclude human presence in these areas. RF fields between 1 MHz and 10 GHz penetrate exposed tissues and produce heating due to energy absorption in these tissues. The depth of penetration of the RF field into the tissue depends on the frequency of the field and is greater for lower frequencies.
- Energy absorption from RF fields in tissues is measured as a specific absorption rate (SAR) within a given tissue mass. The unit of SAR is watts per kilogram ( $W/kg$ ). SAR is the basic dosimetric quantity for RF fields between about 1 MHz and 10 GHz.
- An SAR of at least  $4 W/kg$  is needed to produce adverse health effects in people exposed to RF fields in this frequency range. Such energies are found tens of meters away from powerful FM antennas at the top of high towers, which makes these areas inaccessible.
- Most adverse health effects that could occur from exposure to RF fields between 1 MHz and 10 GHz are consistent with responses to induced heating, resulting in rises in tissue or body temperatures higher than  $1C$ .
- Induced heating in body tissues may provoke various physiological and thermoregulatory responses, including a decreased ability to perform mental or physical tasks as body temperature increases. Similar effects have been reported in people subject to heat stress: for example, those working in hot environments or suffering a prolonged fever.
- Induced heating may affect the development of a fetus. Birth defects would occur only if the temperature of the fetus is raised by  $2-3C$  for hours. Induced heating can also affect male fertility and lead to the induction of eye opacities (cataracts).
- It is important to emphasize that most RF studies conducted at frequencies exceeding 1 MHz, examined the results of acute exposure to high levels of RF fields - an exposure that is not normally found in everyday life. RF fields below 1 MHz do not produce significant heating. Rather, they induce electric currents and fields in tissues, which are measured as a current density in amperes per

square metre ( $A/m^2$ ). Current density is the basic dosimetric quantity for RF fields with frequencies below about 1 MHz.

- The many chemical reactions involved in staying alive have associated normal "background" currents of about  $10\text{ mA}/m^2$ .
- Induced current densities that exceed at least  $100\text{ mA}/m^2$  can interfere with normal functioning of the body and cause involuntary muscle contractions. Other effects on the body from exposure to low-intensity RF fields, present in the living environment, have been reported. But, either they have not been confirmed by other laboratory studies, or their health implications are unknown. However, these studies have raised important health concerns about an increased risk of cancer. It is for this reason that they are being monitored and evaluated under the International EMF Project. Exposure to RF fields and cancer: Current scientific evidence indicates that exposure to RF fields is unlikely to induce or promote cancers.
- Cancer studies using animals have not provided convincing evidence for an effect on tumour incidence. A recent study found that RF fields, similar to those used in mobile telecommunications, increased the incidence of cancer among genetically engineered mice that were exposed near (0.65m) an RF transmitting antenna. Further studies will be carried out to determine the relevance of these results to cancer in human beings.
- Many epidemiological (human health) studies have addressed possible links between exposure to RF fields and excess risk of cancer. To date these studies do not provide enough information to allow a proper evaluation of human cancer risk from RF exposure because the results of these studies are inconsistent. This can be explained by differences in the design, execution and interpretation of these studies, including the identification of populations with substantial RF exposure and retrospective assessment of such exposure. The International EMF Project is encouraging coordinated research in this area. Exposure to low-levels of RF fields, too low to produce heating, has been reported to alter the electrical activity of the brain in cats and rabbits by changing calcium ion mobility. This effect has also been reported in isolated tissues and cells. Other studies have suggested that RF fields change the proliferation rate of cells, alter enzyme activity or affect the genes in the DNA of cells. However, these effects are not well established, nor are their implications for human health sufficiently well understood to provide a basis for restricting human exposure. Electromagnetic interference and other effects: Mobile telephones, as well as many other electronic devices in common use, can cause electromagnetic interference in other electrical equipment. Therefore, caution should be exercised when using mobile telephones around sensitive electromedical equipment used in hospital intensive care units. Mobile telephones can, in rare instances, also cause interference in certain other medical devices, such as cardiac pacemakers and hearing aids. Individuals using such devices should contact their doctor to determine the susceptibility of their products to these effects. RF fields from natural sources have very low power densities. RF intensity from the sun -- the primary natural source -- is less than  $0.01\text{ mW}/m^2$ . Human-made sources, which emit the majority of RF fields found in the immediate environment, can be divided into those found in the community, home, and workplace:
- Community: Most RF fields found in the environment are due to commercial radio and TV broadcasting, and from telecommunications facilities. RF exposure from telecommunications facilities is generally less than from radio or TV broadcasting. A study conducted in the United States found that, in large cities, the average background RF levels were about  $50\text{ W}/m^2$ . About 1% of people living in large cities are exposed to RF fields exceeding  $10\text{ mW}/m^2$ . Higher RF field levels can occur in areas located close to transmitter sites or radar systems.
- Home: RF sources in the home include microwave ovens, mobile telephones, burglar alarms, video display units and TV sets. Microwave ovens that could potentially be the source of very high RF levels, are covered by product performance standards which limit the amount of microwave leakage. Overall, the RF field background from household appliances is low, and of the order of a few tens of  $W/m^2$ .
- Workplace: There are a number of industrial processes which use RF fields: dielectric heaters used for wood lamination and the sealing of plastics; industrial induction heaters and microwave ovens; medical diathermy equipment to treat pain and inflammation of body tissues; and electrosurgical devices for cutting and welding tissues. There is the potential for excessive exposure to personnel operating these systems, especially in industries involved in RF heating or sealing, or from the operation of medical diathermy units. RF fields near equipment in the workplace can exceed tens of  $W/m^2$ . All these levels of exposure are regulated nationally and internationally.
- Relatively high levels of exposure to RF fields can occur to workers in the broadcasting, transport and communications industries when they work in close proximity to RF transmitting antennas and radar systems. An important subset of these workers are military personnel. Stringent regulations controlling the civil and military use of RF fields exist in most countries.

- Safety Standards: To ensure that devices emitting RF are safe and their use does not interfere with other devices, international standards are adopted. Exposure limits for RF fields have been developed by the International Commission on Non-Ionizing Radiation Protection (ICNIRP) -- a nongovernmental organization formally recognised by WHO. ICNIRP guidelines were developed following reviews of all the peer-reviewed scientific literature, including thermal and non-thermal effects. The RF field limits are well above the levels found in the living environment. The standards are based on evaluations of biological effects that have been established to have health consequences. The objective of the International EMF Project is to determine if the biological effects reported from exposure to RF fields at low levels have any adverse health consequences. If such consequences were found, this may result in a reevaluation of the limits of human exposure.
- Exposure to RF fields may cause heating or induce electrical currents in body tissues. Heating is the primary interaction of RF fields at high frequencies, above about 1 MHz. Below about 1 MHz, the induction of electrical currents in the body is the dominant action of RF exposure.
- A scientific review by WHO, held under the International EMF Project (Munich, November, 1996), concluded that, from the current scientific literature, there is no convincing evidence that exposure to RF shortens the life span of humans, induces or promotes cancer.
- However, the same review also stressed that further studies are needed to draw a more complete picture of health risks, especially about possible cancer risk from exposure to low-levels of RF exposure.

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