ELECTRIC AND MAGNETIC FIELDS

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What is EMF?

EMF refers to electric and magnetic fields. Natural sources of EMF include the earth's static (0 Hz) magnetic field, which we use for compass navigation, and the electric and magnetic fields occurring within our own bodies as a result of the normal electrical activity of our heart, nerves, and brain. The frequency of EMF that is produced by most everything connected to our electrical system – including most power lines that carry electricity, the electric wiring in our homes and offices, and the appliances that use electricity – is 60 Hertz (Hz).

Electric fields result from the electric charge (or voltage) applied to electrical conductors and equipment and are measured in units of volts per meter (V/m) or kilovolts per meter (kV/m). Magnetic fields are produced by the movement of electricity (or current) such as through a wire or object. Magnetic field levels are measured as magnetic flux density in units called gauss (G), or in milligauss (mG).

Both electric fields and magnetic fields diminish quickly in strength as distance from the source increases. Electric fields are easily blocked by conductive objects such as buildings, walls, trees, and fences. Magnetic fields, unlike electric fields, are not easily blocked; as a result, most research on EMF and human health has focused on exposure to magnetic fields.

Common Sources of EMF in Our Homes

Because electricity is used to do so many things in modern society, EMF are present throughout our daily lives while at home, work, school, out shopping, during travel, and other places. Our daily exposure depends on where we spend time and the sources we encounter in those locations.

Indoors, the primary sources of EMF in most homes and buildings are the electrical wiring and the electrical appliances and equipment we use, such as vacuum cleaners, electric shavers, and hair dryers. The highest magnetic field levels are found close to appliances and can be as high as several hundreds of mG, as shown in **Table 1**. Other residential EMF sources include nearby transmission and distribution lines and currents on water pipes. EMF levels from all of these sources diminish quickly with distance. An example of this is illustrated in **Figure 1**, which shows the decrease in measured magnetic field levels at increasing distances from a vacuum cleaner.

Table 1. Magnetic field levels* (in mG) measured near household appliances

	Distance from Source		
Source	**6 inches**	**1 foot**	**2 feet**
Hair dryer	300	1	—
Electric shaver	100	20	—
Blender	70	10	2
Can opener	600	150	20
Toaster	10	3	—
Vacuum cleaner	300	60	10
Power saw	200	40	5

* Values represent median magnetic field levels (i.e., half of the appliances tested had higher levels and half had lower levels than those shown).

Source: Electric and Magnetic Fields Associated with the Use of Electric Power, National Institute of Environmental Health Sciences (NIEHS) and National Institutes of Health, June 2002

Research on EMF and Human Health

Research on the possible health effects of EMF exposure has been on-going since the late 1970s. Scientists around the world have conducted thousands of studies that have looked for relationships between EMF in our homes and workplaces and possible adverse health outcomes. This research includes studies that observe human populations and characteristics about their lives (called epidemiologic studies), as well as studies of biological processes in animals and in cells and tissues.

The large body of research on EMF has been evaluated by numerous international health and scientific organizations, including the World Health Organization (WHO), the U.S. National Institute of Environmental Health Sciences (NIEHS), and the Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR). These organizations have assembled panels of scientists with multidisciplinary expertise to review the scientific research and arrive at conclusions about the possible risks associated with EMF. The scientific panels weigh the strengths and weaknesses of each individual study and consider all the evidence together when developing their overall evaluations and recommendations.

To date, none of these health and scientific agencies have concluded that EMF from transmission lines or other sources is a cause of any adverse health effects in humans or animals. The WHO, which in 2007 released one of the most extensive reviews of EMF health research ever conducted, concluded that the research does not establish that exposure to EMF causes or contributes to any disease or illness, including cancer. The findings of the 2015 report released by SCENIHR, which represents the most recent comprehensive review, are consistent with those of other agencies, including the WHO.

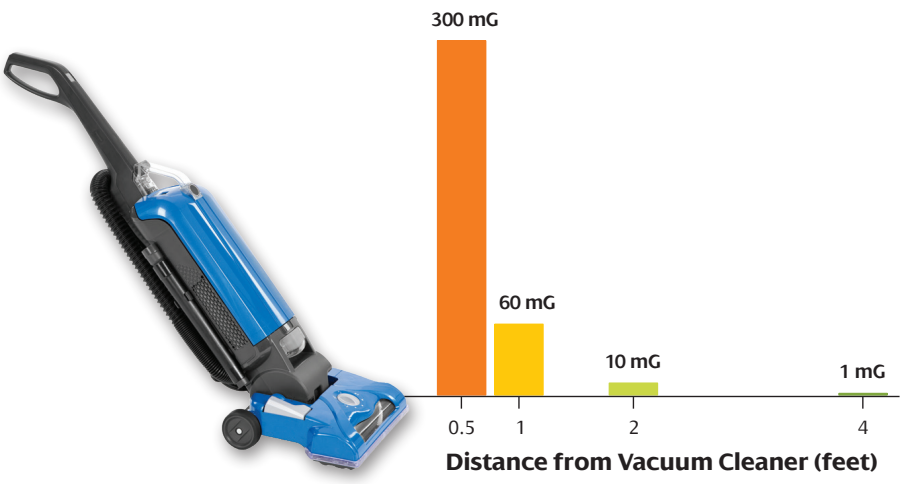
While an association between magnetic fields at high average long-term exposure and childhood leukemia has been reported in some studies, the role of chance, bias (i.e., errors in the studies), and confounding could not be excluded as explanations for this association. Further, this association is not supported by laboratory studies or any known mechanism of action, and no health or scientific agency has concluded that this association reflects a causal relationship.

The WHO's website states:

"Despite extensive research, to date there is no evidence to conclude that exposure to low level electromagnetic fields is harmful to human health."

"Despite the feeling of some people that more research needs to be done, scientific knowledge in this area is now more extensive than for most chemicals."

Figure 1. Magnetic fields decrease with increasing distance



EMF Exposure Standards and Guidelines

State of Connecticut

There are no federal standards or guidance for limiting residential or occupational exposure to EMF. The Connecticut Siting Council (CSC) adopted "EMF Best Management Practices for the Construction of Electric Transmission Lines in Connecticut" in 2007, with a revision in 2014. After reviewing the research on EMF, the CSC concluded that the evidence did not warrant the establishment of magnetic field exposure limits at the edge of the transmission line right-of-way. Nevertheless, the CSC established best practices for the siting of new transmission lines in the state of Connecticut, including "the use of effective no-cost and low-cost technologies and management techniques… to reduce MF [magnetic field] exposure to the public while allowing for the development of efficient and cost-effective electrical transmission projects."

International Guidelines

Two international scientific organizations have published guidelines for limiting exposure to EMF based on their review of the scientific evidence regarding potential effects of exposure. These guideline limits were set to prevent the only known and established health effects of exposure, which are short-term effects, such as stimulation of nerves and muscles and annoyance by spark discharges, that occur at high levels of exposure. Both organizations determined that the scientific evidence does not establish a causal relationship with long-term health effects, including cancer or other diseases. The International Commission on Non-Ionizing Radiation Protection (ICNIRP) recommends exposure limits for the general public of 2,000 mG for magnetic fields and 4.2 kV/m for electric fields. The International Committee for Electromagnetic Safety (ICES) recommends limits for the general public of 9,040 mG for magnetic fields and 5 kV/m for electric fields.

Impact of Power Lines on Residential EMF Exposure

The magnetic field levels associated with transmission and distribution lines vary substantially depending on the voltage, the design of the lines, and the distance from the lines. The strength of magnetic fields diminishes quickly with distance from the source; therefore, the distance of most buildings and homes from power lines typically reduces the magnetic field from these sources within residences and other buildings. Examples of magnetic field levels for transmission lines of different voltages are summarized in **Table 2**. Magnetic field levels from underground cables diminish more quickly with distance from the lines compared to those from overhead transmission lines.

Because electric fields can be blocked by nearby conductive objects, distribution and transmission lines have little effect on levels of electric fields inside nearby homes. Underground cables do not produce electric fields above ground because electric fields are blocked by the cables' sheaths and the soil covering the cables.

Table 2. Typical Magnetic field levels (in mG) for electric transmission lines*

	Under Structure	50 feet**	100 feet**	200 feet**
115 kV	30	7	2	0.4
230 kV	58	20	7	2
500 kV	87	30	13	3

* Electric and Magnetic Fields Associated with the Use of Electric Power, National Institute of Environmental Health Sciences (NIEHS) and National Institutes of Health, June 2002

** Approximate edge of right-of-way

Does EMF Harm Livestock, Wildlife, and Crops?

Similar to research on human health, a substantial number of studies have been conducted to evaluate the possible effects of EMF exposure on the health of both wildlife and livestock, including cattle, sheep, swine, and poultry. Overall, the research does not conclude that EMF from transmission lines or the presence of power lines and structures result in adverse effects on the health, behavior, or productivity of domestic or wild animals.

Additionally, the results of studies conducted on crops and plants exposed to EMF do not provide any reliable evidence that EMF at levels typically found under transmission lines is harmful to crop yield or production.

Does EMF Interfere with Pacemakers or Other Implanted Cardiac Devices?

Two of the most important classes of implanted cardiac devices are pacemakers and cardioverter defibrillators. Both classes of devices are designed to sense and monitor the electrical activity of the heart in preparation for corrective action if necessary. While electrical signals from outside sources (such as electric appliances, radio communication technologies, or medical equipment), may in principle interfere with the normal operation of implanted cardiac devices, the signals from most of these sources where patients may encounter them are too weak to affect the standard operation of these devices. In addition, modern implanted cardiac devices incorporate many technological and design features (such as shielding through the use of a metallic casing and filters to block 60-Hz fields) to minimize the potential for interference. One organization indicates that EMF levels below the ICNIRP exposure guidelines for the general public would not pose a likely risk (CENELEC EN 50527-1, 2010).

It is theoretically possible but highly unlikely for power lines to have an effect on these devices. The likelihood of an adverse impact to a pacemaker or other implanted cardiac device from power lines is extremely small given the low levels of electric and magnetic fields typically measured even directly under the line where the fields would be highest. Patients should consult with their physicians if they have concerns about the compatibility of their devices with any source of EMF.

UI provides information on EMF produced by any new or upgraded facilities or lines in applications to state agencies. That information is publicly available as part of those filings. UI complies with applicable environmental laws, regulations and standards and is committed to providing safe, reliable and sustainable electric service to meet the needs of our customers both today and well into the future.

More Information on This Topic

World Health Organization (WHO): https://www.who.int/peh-emf/about/en/

U.S. National Institute for Environmental and Health Sciences (NIEHS): https://www.niehs.nih.gov/health/materials/electric_and_magnetic_fields_associated_with_the_use_of_electric_power_questions_and_answers_english_508.pdf

Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR): https://ec.europa.eu/health/scientific_committees/emerging/docs/scenihr_o_041.pdf

Connecticut Siting Council Best Management Practices: https://www.ct.gov/csc/lib/csc/emf_bmp/revisions_updates/754bmpfinal.pdf

European Committee for Electrotechnical Standardization (CENELEC). Procedure for the assessment of the exposure to electromagnetic fields of workers bearing active implantable medical devices - Part 1: General (EN 50527-1).
Brussels, Belgium: CENELEC, 2010.

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This brochure was prepared by Exponent®, a scientific and engineering firm, to present a current summary of the status of EMF research as reflected in reviews by national and international science and health organizations. This brochure is limited to the scientific literature reviewed and may not include all information in the public domain.