

Extremely Low Frequency Electric and Magnetic Fields: AC Transmission Lines

Electric and magnetic fields (EMF) are part of both our natural (e.g., the Earth) and electrified (e.g., a microwave) environments, and are present wherever electricity flows. High-voltage direct current (HVDC) and high-voltage alternating current (HVAC) transmission lines produce different types of EMF, though both are also produced by common household appliances and are non-ionizing (i.e., considered harmless due to their lack of potency). The EMF produced by a transmission line are highest directly under the conductors and dissipate dramatically with distance from the line.¹²³

HVAC lines move current and voltage in a wave-like pattern, changing direction 60 times per second (60 Hz). This produces what is known as extremely low frequency EMF (ELF EMF), which is also produced by household appliances such as hair dryers, TVs, and microwaves. Electric fields are produced by voltage, while magnetic fields are produced when current flows through the line. It is highly unlikely that EMF will affect the operation of implanted medical devices, such as pacemakers, due to the low levels of EMF typically measured directly under the line (where EMF would be highest). Below are examples of ELF EMF from common sources as well as the ELF EMF produced by an HVAC transmission line.

Median ELF Magnetic Field Levels from Common Sources	
6 inches from a hair dryer	300 mG
1 foot from a vacuum cleaner	60 mG
1 foot from a microwave	40 mG
Double circuit 345kV AC transmission line (at edge of right-of-way)	25-75 mG
Recommended Limits for Exposure to a 60 Hz Magnetic Field	
ICNIRP limit for general public	2,000 mG
ICES limit for general public	9,040 mG

ELF Electric Field Levels Close to AC Transmission Lines	
Double circuit 345kV AC transmission line (at edge of right-of-way)	<1 kV/m
Recommended Limits for Exposure to a 60 Hz Electric Field	
ICNIRP limit for general public	4.2 kV/m
ICES limit for general public	5 kV/m

The health effects of ELF EMF have been studied closely for decades. The full body of research has been reviewed and summarized by the World Health Organization, the International Agency for Research on Cancer, the International Commission on Electromagnetic Safety (ICES), and the International Commission on Non-ionizing Radiation Protection (ICNIRP). At the edge of the right-of-way, the ELF EMF from a double-circuit 345kV AC line will be below the recommended limits for exposure to low frequency magnetic fields.

More information about ELF EMF can be found at the following websites:

- ICNIRP: <https://www.icnirp.org/>
- Environmental Protection Agency: <https://www.epa.gov/environment-and-you/radiation/emf/>
- Electric Power Research Institute: <https://www.epri.com/research/products/3002006827>

¹ United States Environmental Protection Agency. (1992, December). EMF in Your Environment: Magnetic Field Measurements of Everyday Electrical Devices. EPA. <https://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=000005EP.TXT>

² International Commission on Non-Ionizing Radiation Protection (2010) ICNIRP Guidelines for Limiting Exposure to Time-Varying Electric and Magnetic Fields (1Hz-100Hz). *Health Physics*, 99(6), 818-836

³ "IEEE Standard for Safety Levels with Respect to Human Exposure to Electric, Magnetic, and Electromagnetic Fields, 0 Hz to 300 GHz," in IEEE Std C95.1-2019 (Revision of IEEE Std C95.1-2005/ Incorporates IEEE Std C95.1-2019/Cor 1-2019) , vol., no., pp.1-312, 4 Oct. 2019, doi: 10.1109/IEEESTD.2019.8859679.