UNDERSTANDING ELECTRIC AND MAGNETIC FIELDS OF HVDC LINES

High voltage direct current (HVDC) transmission lines offer significant electrical, economic, and environmental advantages for the transport of electricity over long distances. HVDC is a well-established technology with decades of safe and reliable operation across the world. HVDC is particularly well-suited to transport large amounts of renewable power generated in remote areas over long distances to demand centers. Currently, there are more than 20 HVDC transmission facilities in the United States and more than 35 across the North American electric grid.

STATIC ELECTRIC AND MAGNETIC FIELDS

The electric and magnetic fields produced by direct current (DC) lines are referred to as static fields because their sources, voltage and current, do not alternate over time. Thus, DC fields are qualitatively different in nature than the alternating current (AC) electric and magnetic fields (often called EMF) produced by AC transmission lines. While AC EMF can cause the induction of currents or voltages in nearby objects, this does not occur with DC fields. DC electric and magnetic fields are identical to those found in the natural environment.[1,*]

Static Electric Fields

Static electric fields occur as a result of voltage. Natural sources of static electric fields include the electric fields produced by the charge on a body after shuffling across a carpet or the "static cling" found on clothing.[2]

Static Magnetic Fields

Static magnetic fields result from the flow of DC electricity. The steady flow of currents in the Earth's core produces the static "geomagnetic" field that causes a compass to point north. Common sources of static magnetic fields much stronger than those associated with DC transmission lines include permanent magnets, battery-powered appliances (e.g., telephones, electric tooth brushes, hearing aids, laptops, etc.) and some electrified railway systems.[2]

Static electric and magnetic field levels close to common sources.

ELECTRIC FIELDS	
Source	**Electric Field Level**
Friction from walking across carpet (at body surface)	Up to 500 kV/m
Computer screen (at 30 centimeters)	10-20 kV/m
± 500 kV DC transmission line (standing beneath conductors)	20–30 kV/m
MAGNETIC FIELDS	
Source	**Magnetic Field Level**
MRI machines	15,000,000–40,000,000 mG
Refrigerator magnets	10,000-50,000 mG
Battery-operated appliances	3,000–10,000 mG
Electrified railways	<10,000 mG
The Earth	300–700 mG
± 500 kV DC transmission line (standing beneath conductors)	300–600 mG

mG – milligauss
kV/m – kilovolt per meter (1 kV/m = 1,000 volts/m)

RESEARCH ON THE IMPACT OF STATIC FIELDS

Much of the research on static fields has focused on the strong magnetic fields associated with certain occupational exposures and the operation of MRI machines. The International Agency for Research on Cancer (IARC)[3], the World Health Organization (WHO)[2], and others[1,4,5] have all concluded that the current body of research does not indicate that strong static electric or magnetic fields cause long-term health effects.

Research has also been conducted to assess the impact of DC transmission lines on farm and ranching operations. Noteworthy findings from this research include:

- A ±400 kV DC line did not affect crops, vegetation, or nearby wildlife; nor were the fields perceived by persons walking on the right-of-way[6]
- No differences were found between cattle and crops raised under ±500 kV DC transmission lines and those raised away from the lines[7]
- Multiple indicators of herd health did not differ between periods before and after a nearby ±400 kV DC line was energized or with distance from the line in a study of over 500 herds of dairy cattle[8]

* DC transmission lines are not connected to AC distribution systems. Therefore, they are not sources of AC voltages on farm or building equipment that can cause disturbances to livestock (i.e., stray voltage).

CORONA PHENOMENA

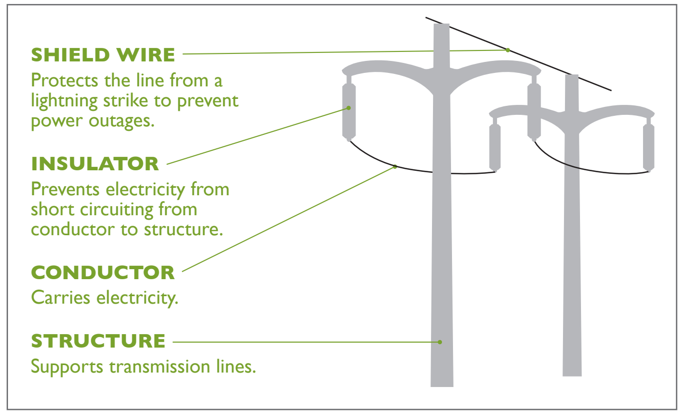
Corona refers to the partial electrical breakdown of the air surrounding points on the transmission line conductor surface by the electric field. This breakdown results in the release of small amounts of energy that may be detected near the line as audible noise and "static" on radio and analog television receivers. The US Environmental Protection Agency (EPA) and the Institute of Electrical and Electronic Engineers (IEEE) have established guidelines for the production of such noise and static, which are met in the design and construction of a HVDC transmission line.

Corona also creates air ions, which are molecules that have temporarily gained or lost electrons. Air ions also occur as a result of geologic, atmospheric, weather-related and combustion phenomena. Some air ions from DC transmission lines remain in the air for seconds before contacting an opposite charge or transferring charge to aerosol particles. Air ions and charges on aerosols collectively are called "space charge," and their presence adds to the static electric field of a DC transmission line. Space charge has been studied for over one hundred years.

No health agencies have proposed exposure limits for space charge or confirmed any health risks from this natural phenomenon.

ELECTRONIC DEVICES

The static fields of DC transmission lines are too weak to affect the operation of implanted medical devices such as cardiac pacemakers. As already noted, the corona from DC transmission lines can produce AM radio and analog TV picture signal interference. This interference is typically limited to within approximately 100 feet of the transmission line. Due to right-of-way requirements, such noise interference has not been a significant issue for most landowners. Cellular telephones, GPS receivers and other electronic equipment are used near existing DC transmission lines without issue. Thus, the possibility of interference with the operation of such devices is unlikely.



A DC transmission line has two conductor bundles called "poles." Conductors are the wires that hang from the towers and are often bundled in groups of two or three. Like a car battery, the two bundles of DC conductors have opposite polarity, one positive and one negative. The voltage of a DC transmission line, therefore, is usually referred to as ± (plus-minus) voltage. For example, a 500 kilovolt (kV) DC transmission line is referred to as a ±500 kV DC transmission line.

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