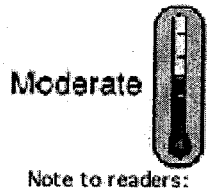
APPENDIX E
QUESTIONS AND ANSWERS ABOUT EMF AND INFORMATION SOURCES

Questions and Answers about EMF
Electric and Magnetic Fields Associated with the Use of Electric Power

Contents

Introduction

Electric power is a fact of life in America, a familiar miracle. Generations have come to take for granted the simple flip of a switch that turns night into day. With electric power, however, come certain pre cautions that are also well known. Electric power lines, household wiring, and appliances can cause serious injury from electric shock if handled improperly. Recently, a new question has emerged about the electric power we all depend on: Does it have anything to do with cancer?



Note to readers: This publication contains a moderate level of technical detail.

Some epidemiological studies have suggested that a link may exist between exposure to power-frequency electric and magnetic fields (EMFs) and certain types of

cancer, primarily leukemia and brain cancer. Other studies have found no such link. Laboratory researchers are studying how such an association is biologically possible. At this point, there is no scientific consensus about the EMF issue-except a general agreement that better information is needed. A national EMF research effort is under way, and major study results are expected in the next few years.

This booklet provides some answers to common questions about the possible health effects of EMFs. First, we define some basic electrical terms, describe EMFs, and discuss recent scientific studies. We then describe what the government is doing to address public concerns about EMFs. Next, we address questions people have about their own exposure to EMFs. Lastly, we tell you how to obtain more detailed information about these issues.

This booklet was prepared by Oak Ridge National Laboratory, under the direction of the National Institute of Environmental Health Sciences and the U.S. Department of Energy, for the EMF Research and Public Information Dissemination (RAPID) Program. It was reviewed by staff from nine federal government agencies and by the National EMF Advisory Committee, which represents public advocacy groups, organized labor, state governments, academia, and industry. Much of this material was originally developed by the Bonneville Power Administration, one of the first federal agencies to recognize the public need for information about the science underlying the EMF issue. Information on EMF sources other than power lines came from the U.S. Environmental Protection Agency. For more information about the EMF RAPID Program, see the Appendix.

On to Electric Power Basics...

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Questions and Answers about EMF
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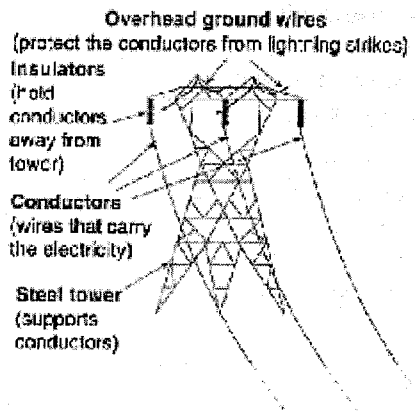
Electric Power Background

Electric Power Basics

This booklet uses six basic electrical terms- conductor, current, voltage, load, power, and circuit. The *conductor* is the wire you see between power poles or towers; it carries the electricity. *Current* is the movement of electrons in the conductor. *Voltage* is the electric force that causes current in a conductor. *Load* is the electric power needed by homes and businesses. When a conductor energized with voltage is connected to a load, a *circuit* is completed, and *current* will flow.



Electric Power Facilities

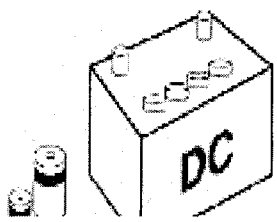
There are two basic types of power lines: transmission lines and distribution lines. *Transmission lines* are high-voltage power lines. The high voltage allows electric power to be carried efficiently over long distances from electrical generation facilities to substations near urban areas. Initftheg United States, most transmission lines use alternating current (AC) and operate at voltages between 50 and 765 kV (lkV or kilovolt = 1000 V).

Utilities use lower-voltage *distribution lines* to bring power from sub-: ;0iV stations to businesses and homes. Distribution lines operate at voltages below 50 kV. For residential customers, these levels are further reduced to 120/240 V once the power reaches its destination.

Electrical *substations* serve many functions in controlling and transferring power on an electrical system. Several different types of equipment may be present, depending on the functions of the particular substation. For example, *transformers* change the high voltages used by transmission lines to the lower voltages used by distribution lines. *Circuit breakers* are used to turn lines on and off.

Alternating Current and Direct Current

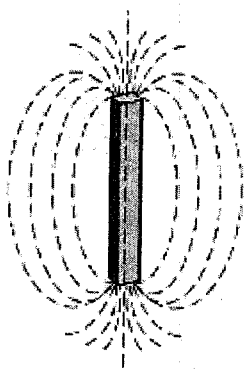
Appliances that operate either with batteries or by plugging into the household wiring usually come equipped with an AC /DC switch. If switched to AC, the appliance uses electric power that flows back and forth or "alternates" at a (U.S.) rate of 60 cycles per second (60 hertz, or Hz). If DC ("direct current") is chosen, current flows one way from the batteries to the appliance. AC fields induce weak electric currents



in conducting objects, including humans; DC fields do not, unless the DC field changes in space or time relative to the person in the field. In most practical situations, a battery-operated appliance is unlikely to induce electric current in the person using the appliance. Induced currents from AC fields have been a focus for research on how EMFs could affect human health.

Basics

Q. What are EMFs?



DC magnetic field around a bar magnet.

A. Power lines, electrical wiring, and appliances all produce electric and magnetic fields. EMFs are invisible lines of force that surround any electrical device. Electric and magnetic fields have different properties and possibly different ways of causing biological effects. Note that while electric fields are easily shielded or weakened by conducting objects (e.g., trees, buildings, and human skin), magnetic fields are not. However, both electric and magnetic fields weaken with increasing distance from the source.

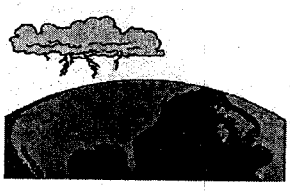
Even though electric and magnetic fields are present around appliances and power lines, more recent interest and research have focused on potential health effects of magnetic fields. This is because epidemiological studies have found associations between increased cancer risk and power-line configurations (p. 34), which are thought to be surrogates for magnetic fields. No such associations have been found with measured electric fields.

Q. What is power-frequency EMF and how does it compare to other types of fields?

A. The electromagnetic spectrum (right) covers an enormous range of frequencies. These frequencies are expressed in cycles per second (i.e., Hz). Electric power (60 Hz in North America, 50 Hz in most other places) is in the extremely-low-frequency range, which includes frequencies below 3000 Hz.

The higher the frequency, the shorter the distance between one wave and the next, and the greater the amount of energy in the field. Microwave frequency fields, with wavelengths of several inches, have enough energy to cause heating in conducting material. Still higher frequencies like X-rays cause ionization-the breaking of molecular bonds, which damages genetic material. In comparison, power frequency fields have wavelengths of more than 3100 miles (5000 km) and consequently have very low energy levels that do not cause heating or ionization. However, AC fields do create weak electric currents in conducting objects, including people and animals.

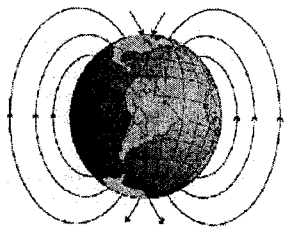
Q. Doesn't the earth produce EMFs?



A. Yes, the earth produces EMFs, mainly in the form of DC (also called static fields). Electric fields are produced by thunderstorm activity in the atmosphere. Near the ground, the DC electric field averages less than 200 volts per meter (V/m). Much stronger fields, typically about 50,000 V/m, occur directly beneath electrical storms.

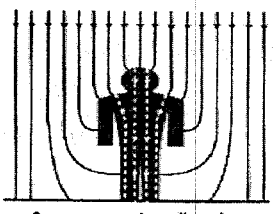
Earth's DC electric field comes from thunderstorms.

Magnetic fields are thought to be produced by electric currents flowing deep within the earth's molten core. The DC magnetic field averages around 500 milligauss (mG). This number is larger than typical AC electric power magnetic fields, but DC fields do not create currents in objects in the way that AC fields do.



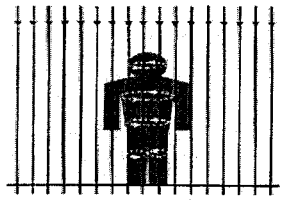
Earth's DC magnetic field comes from currents in the earth.

Q. What happens when I am exposed to EMFs?



A person standing in an electric field (blue lines) showing induced current (white dashed lines).

A. AC fields create weak electric currents in the bodies of people and animals. This is one reason why there is a potential for EMFs to cause biological effects. As shown on the right, currents from electric and magnetic fields are distributed differently within the body. The amount of this current, even if you are directly beneath a large transmission line, is extremely small (millionths of an ampere). The current is too weak to penetrate cell membranes; it is present mostly between the cells.



A person standing in a magnetic field (blue lines) showing induced current (white dashed lines).

Currents from 60-Hz EMFs are weaker than natural currents in the body, such as those from the electrical activity of the brain and heart. Some scientists argue that it is therefore impossible for EMFs to have any important effects. Other scientists argue that, just as a trained ear can pick up a familiar voice or cry in a crowd, so a cell may respond to induced current as a signal, lower in intensity yet detectable even through the background "noise" of the body's natural currents. Numerous laboratory studies have shown that biological effects can be caused by exposure to EMFs (see Biological Studies). In most cases, however, it is not clear how EMFs actually produce these demonstrated effects.

Strong electric fields, such as those found beneath large transmission lines, can cause hair on your exposed head or arms to vibrate slightly at 60 Hz. This is felt by some people as a tingling sensation. EMFs from transmission lines can also in some circumstances cause nuisance shocks from voltages created by EMFs on objects like ungrounded metal fences.

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