Article on Electromagnetic Fields published in Medical Electronics:

A Survey of present knowledge concerning low-frequency electromagnetic radiation from power lines, home wiring, appliances, televisions and computer displays

EMFs Linked to health problems

Can electromagnetic fields (EMF) from power lines, distribution lines, home wiring and appliances cause brain tumors, leukemia, birth defects, and other health problems? Numerous studies have produced contradictory results, yet some experts are convinced the threat is real. Dr. David Carpenter, Dean at the School of Public Health, State University of New York, says "This is really harming people."

According to Dr. Carpenter, it is likely that 10% to 15% of all childhood cancers come from exposure to residential power lines. The Environmental Protection Agency warns "There is reason for concern" and advises "prudent avoidance." Martin Halper, the EPA's Director of Analysis and Support, goes even further. "I have never seen a set of epidemiological studies that remotely approached the weight of evidence that we're seeing with ELF [extremely low frequency] electromagnetic fields. Clearly there is something here."

Concern over electromagnetic radiation began to explode after Paul Brodeur wrote a series of lengthy articles in the New Yorker Magazine. When the articles were published in June, 1989, Brodeur had already established renown by bringing the previously unknown hazards of asbestos into public view. In this new revelation, Brodeur described how Louis Slesin, editor and publisher of VDT News, had pieced together a fascinating puzzle. For nearly a decade, Slesin had compiled details on studies which linked magnetic fields with cancer. Most experts thought that the results were erroneous because it seemed inconceivable that such low levels of non-ionizing radiation could cause harm. Consequently the studies were branded biased, and instead of praise for their pioneering work, the researchers who conducted these studies were ridiculed and their concerns ignored.

Because of Paul Brodeur's reputation, his New Yorker articles had a catalytic effect on scientists, reporters and concerned people throughout the world. In 1989 and 1990, the EMF issue gained mainstream publicity, with alarming reports appearing in Time, the Wall Street Journal, Business Week, and popular computer publications such as MacWorld. ABC's Ted Koppel aired a full 30 minute show and interviewed Paul Brodeur, while CBS' Dan Rather aired a special segment on an ominous EPA report.

In October, 1989, an article in Business Week quoted a leading scientist as saying that low frequency magnetic fields were biologically active. This acceptance of EMF as having a measurable impact on living cells and organisms represented a major shift in the scientific community from debating whether EMF could cause biological effects to debating, instead, the level of harm caused by the radiation. "It is now clear that 60-hertz and other low-frequency electromagnetic fields can interact with individual cells and organs to produce biological changes," says a 1989 Office of Technology Assessment report. "The nature of these interactions is subtle and complex. The implications of these interactions for public health remain unclear, but there are legitimate reasons for concern."

The word "epidemiology" is often used in conjunction with studies of EMF. "Epidemiology" comes from "epidemic" meaning common to or affecting a great number of people in a community at the same time. An epidemiologist studies the statistical relationship between health problems and suspected causes, but even when a positive relationship is found, such studies do not prove cause and effect, even if it seems obvious. To see why this is important, consider that a rooster will crow at sunrise, and on most mornings the temperature starts to rise. An epidemiological study of roosters crowing would show a positive correlation with subsequent temperature increases that day, but it would be invalid to conclude that the crowing causes the temperature rise. Similarly, there may be a factor other than EMF from power lines which causes cancer, such as traffic density. With so many variables, the cause-and-effect relationship is difficult to establish.

In late 1989, the Wall Street Journal reported that electromagnetic radiation was linked to cancer and leukemia. Even more alarming, the Electric Power Research Institute, the leading arm of the electric utility companies, had "only praise" for the methodology used in a power line study that linked leukemia, prostate and other cancers in young men with chronic exposure to magnetic fields. In November of 1989, the Department of Energy reported that "It has now become generally accepted that there are, indeed, biological effects due to field exposure."

EPA SAYS THREAT IS REAL

By 1990, over one hundred studies had been conducted worldwide. Of these, at least two dozen epidemiological studies on humans indicated a linkage between electromagnetic radiation and serious health problems. In response to public pressure, the Environmental Protection Agency (EPA) began reviewing and evaluating the available literature. In a draft report issued in March, 1990, the staff of the EPA recommended that magnetic fields be classified as a Class B carcinogen. This category is for "probable human carcinogens," and includes formaldehyde, DDT, dioxins and PCBs. However, in a later watered-down revision, the reference to Class B was deleted, and the following explanation was added:

"At this time such a characterization regarding the link between cancer and exposure to EM fields is not appropriate because the basic nature of the interaction between EM fields and biological processes leading to cancer is not understood."

Curiously, this rather unusual logic appears on the very same page as the following: "In conclusion, several studies showing leukemia, lymphoma, and cancer of the nervous system in children exposed to magnetic fields from residential 60 Hz electrical distribution systems, supported by similar findings in adults in several occupational studies also involving electrical power frequency exposures, show a consistent pattern of response that suggests a causal link."

RECENT STUDIES RAISE CONCERN

Until a few years ago, the electric and magnetic fields around power lines, electric motors and household appliances were thought to be harmless. However, on the basis of new studies, scientists are changing their opinions. As reported in the Wall Street Journal, "recent research with human cells and laboratory animals, plus epidemiological studies, all have suggested that the fields do have biological effects, and that they may foster a number of medical problems, including cancer and miscarriage. Leonard Sagan, the radiation expert at the Electric Power Research Institute, says that the latest experiment is important because 'this is humans, not rats, who are apparently showing an effect'."

As early as 1976, scientists in Loma Linda demonstrated that exposure to weak levels of EMF could slow the outflow of calcium in cells from chicken brains. A major study of chicken embryos, sponsored by the Environmental Protection Agency and the U.S. Navy, found a

significant increase in abnormal embryos of chickens when exposed to pulsed magnetic fields similar to the type of magnetic fields emitted by VDTs. Of six laboratories, two found a statistically significant increase in abnormal embryos, and three found non-statistically significant increases. Such abnormalities included lower birth weights and birth defects.

One of the earliest studies on the human health effects of EMF was conducted in the greater Denver, Colorado area by epidemiologist Nancy Wertheimer and physicist Ed Leeper. Using data on children who had died before age 19 of cancer between 1950 and 1979, this study found significant excess risks among children who resided in homes close to heavy duty distribution lines. Other studies indicate that these lines typically produce strong magnetic fields.

In 1982, the New England Journal of Medicine published a letter from Dr. Samuel Milham, Jr. describing his study of leukemia deaths in Washington state. His comprehensive study, which examined the data for 438,000 deaths occurring between 1950 and 1979, found that leukemia deaths were elevated in 10 out of 11 occupations involving exposure to EMF. In 1988, epidemiologist Dr. David Savitz set out to disprove the results of the earlier Denver study using a different group of children. Instead, his findings were nearly identical with the first study F indicating elevated risk for all cancers among children living in homes near power lines with magnetic fields at or above 2 milliGauss (mG).

Perhaps the most publicized study was conducted in 1988 by the Kaiser Permanente HMO in Oakland, California, one of the largest health care facilities in the country. Kaiser's researchers tracked 1,583 pregnancies to find out whether pregnant women had been affected by the widespread use of aerial spray to kill medflies. No problem was found with the spraying, but the researchers were surprised to find a statistically significant 73% increase in miscarriages in working women using CRT-style VDTs (cathode ray tube style video display terminals), compared to other working women. The study also found an increase in birth defects, although the result was not statistically significant due to the sample size.

The National Institute for Occupational Safety and Health (NIOSH) captured world-wide headlines in the spring of 1991 when it released the results of its study on the health effects of CRT-style VDTs and miscarriages. The study found no link between VDT use and miscarriages, after studying 730 pregnant directory assistance and general telephone operators. The study concluded that "the use of VDTs and exposure to the accompanying electromagnetic fields were not associated with an increased risk of spontaneous abortion in this study" (emphasis added). The media's immediate interpretation was:

"[the new study] settles a question that has worried women of childbearing age for more than a decade: Can using a video display terminal cause miscarriage? The answer is clearly no..."

Unfortunately, a close examination of the NIOSH report (published March 14, 1991, in The New England Journal of Medicine) shows that the media's interpretation was incorrect, and that the study's conclusions were limited. One group (the study population) of operators used CRT-style VDTs, and another group (the control group) of operators used a different type of video display, with either LEDs (light emitting diodes) or neon glow tubes. Interestingly, measurements of abdominal exposure to ELF magnetic fields were similar for both groups. Hence, the study reached no conclusions about health risks to pregnant women from the ELF radiation emitted by VDTs, although NIOSH attempted to minimize this major flaw by stating that the levels of abdominal exposure to ELF for both groups were in the same range as exposures in the home (i.e., .5 mG to 2.5 mG).

Moreover, the study only dealt with two monochrome models of VDTs manufactured by IBM and Computer Controls, Inc. These VDTs emitted very low frequencies (VLF) in the range of

15 kHz, while a large percentage of video displays sold today produce VLF emissions in the 30 kHz to 85 kHz range. Furthermore, the researchers found that among the same model VDT, VLF levels varied by as much as 1500% (a fifteenfold difference), but the study made no attempt to determine if the higher levels were associated with increased risks. Finally, the study did not deal with other health risks, such as cancer, from VDTs.

Other studies have yielded alarming results. A Johns Hopkins study showed that the incidence of leukemia among telephone cable workers was 7 times greater than among other telephone company employees. A subsequent study of 1.5 million past and present employees of AT&T found that men working as cable splicers and central office technicians had 1.7 times the risk of dying from leukemia than men working at jobs with less exposure to EMF. This is startling, considering that the field these men are exposed to is, on the average, relatively low (4.3 milliGauss.) As John Monahan of the Food and Drug Administration explains, "the effect is real. It is produced by a low-level magnetic field, but we don't yet know what the important parameters of the field are."

Studies of cells and laboratory animals exposed to EMF show biological effects, including: changes in levels of neurotransmitters F the chemicals which send signals between nerves, changes in levels of calcium found inside or on the surface of cells, embryo abnormalities in chickens, mice and pigs, malignant lymphomas in mice exposed to very high-intensity EMF, slowing of repetitive learning and reduced testical weight in rats, changes in brain chemistry, heightened stress, and changes in the rate of growth and cell division of some cells. The latter effects have implications for the offspring of pregnant women and growing children.
In some experiments, human cancer cells exposed to EMF exhibit increased resistance to attack by the body's cancer fighting white blood cells and the body's immune system. Further, a drop in the levels of melatonin have been reported in people sleeping with electric blankets. Melatonin is a hormone which controls the monthly female cycle and inhibits the growth of certain cancers. Other experiments on humans indicate that EMF can cause fatigue, headache, slower reaction times, slower heart rates and altered brain waves.

A study released in February, 1991 by the University of Southern California (USC) Los Angeles unexpectedly found an increased rate of leukemia among children who watch black and white televisions. While the study is the first to make this link, it is a reminder to keep children as far back from a television as possible. This study also found that exposure to hair dryers, curling irons and electric blankets increased the risk of getting leukemia.

In addition to leukemia in children, more recent studies have linked EMFs with new diseases. Loomis and Savitz of the University of North Carolina reported a doubling of the expected breast cancer rates for women in electrical trades aged 45-54. (Microwave News, Nov/Dec 1993). More recently, a major study linked EMFs with Alzeimer's. Results from two studies conducted in Finland and one in Los Angeles indicate that people with a high occupational exposure to EMF's are at least three times as likely to develop Alzeimer's disease a those without significant exposure. (Network News, Aug/Sep 1994).

****

Update: See Appendix 1 below for the latest press announcements regarding electromagnetic fields. Here is a brief summary:

The Latest News:

Excerpts from: MICROWAVE NEWS -- A Report on Non-Ionizing Radiation

August 2002
California EMF Program to issue Strongest Health Warning Yet

After spending more than $7 million over the last eight years, the California Department of Health Services (DHS) will soon issue the strongest warning to date on the potential health risks from exposure to power-frequency electromagnetic fields (EMFs).

Drs. Raymond Neutra, Vrncent DelPizzo and Geraldine Lee, who wrote the report, conclude that they "are inclined to believe" that EMFs are a cause of childhood leukemia, adult brain cancer, amyotrophic lateral sclerosis (ALS) and miscarriages.

July/August 2001

ELF EMFs (electromagnetic fields) are now classified in the same category as DDT, lead, Carbon Tetrachloride and Chloroform, Category 2B possible carcinogens.

IARC Finds ELF EMFs Are Possible Human Carcinogens

A working group assembled by the International Agency for Research on Cancer (IARC) has unanimously concluded that power-frequency magnetic fields are possible human carcinogens. This finding, announced on June 27 in Lyon, France, is based on the consistent association between childhood leukemia and residential exposure to extremely-low-frequency electromagnetic fields (ELF EMFs).

The makeup of the IARC panel spanned all sides of the EMF controversy, from those who openly believe that EMFs promote cancer to industry consultants who are skeptical of any such connection. "We all agreed," said Dr. Larry Anderson. EMFs have now been formal1y designated "2B Possible Carcinogens." (For a list of the members of the working group and their affiliations, and examples of each type of IARC carcinogens, see below.
"There was a unanimous feeling about it," said Dr. Jan Stolwijk. Dr. Maria
The childhood leukemia studies have had a major impact on all of these prior assessments. The Doll report was heavily influenced by the two recent pooled analyses: one led by Dr. Anders Ahlbom and the other by Dr. Sander Greenland. The IARC panel was similarly swayed, according to both Stolwijk and Dr. Elizabeth Hatch. “The Ahlbom analysis was found to be most impressive," noted Stolwijk. Much more surprising was the IARC panel members' view of the animal data. They came close to finding "limited" support for a cancer association based on the animal exposure experiments.

IARC Carcinogens: Definitions and Examples:
Category 2B: Possible Carcinogen
Evidence: limited in humans and less than sufficient in animals
Chemical and physical agents:
Carbon tetrachloride, chloroform, DDT, ELF EMFs, lead, PBBs. Total number of agents: 236

June, 2001

Maximum EMF Exposure EmergesAs Strong Miscarriage Risk

A new and innovative epidemiological study has found an up to six fold increased risk of spontaneous abortions among women exposed to magnetic fields of 16 mG or greater. The

results “should have wide implications,” concludes Dr. DeKun Li, who led the study team at Kaiser Permanente’s research division in Oakland, CA.

September 2001

WHO EMF Project Now Endorses Policy of Prudent Avoidance

In a major policy shift, the World Health Organization’s (WHO) International EMF Project has endorsed prudent avoidance.

On October 3, the WHO advised that decisions on siting power lines should “consider ways to reduce people’s exposures.” The WHO also recommended that governments and industry should offer the public “suggestions for safe and low-cost ways to reduce exposures.” The advice is contained in a fact sheet on extremely low frequency electromagnetic fields (ELF EMFs) and cancer.

The project’s new outlook follows the decision by an expert panel convened by the International Agency for Research on Cancer (IARC) to classify ELF EMFs as “possible human carcinogens” (see *MWN*, J/A01). IARC, which is based in Lyon, France, is part of the WHO.

German Radiation Commission Endorses Prudent Avoidance

Germany’s Radiation Protection Commission is recommending a policy of prudent avoidance. In a report released on September 14, the panel—known by its German acronym SSK—states that it has confidence in the ICNIRP standards. But it calls for “minimizing” exposures to both ELF and RF/MW EMFs to the extent “technically and economically reasonable,” especially in locations where people spend extended periods of time.

The SSK recommends that emissions from consumer appliances, including mobile phones, be kept as low as possible and that product labels indicate emission levels.

On July 31, the radiation office’s current director, Wolfram König, advised against the use of mobile phones by children and called for restrictions on base station antennas near schools and hospitals (see *MWN*, J/A01).

JUNE 2000

Strong Electric Fields Implicated in Major Leukemia Risk for Workers

Long term employees of Ontario Hydro who worked in strong electric fields had much higher risks of leukemia, Canadian researchers have found. Significant risks were also found for non Hodgkin’s lymphoma (NHL) in a related study.

The elevated risks were seen among workers who spent the most time in electric fields above certain thresholds, in the range of 10 to 40 V/m. The largest increases occurred among those with more than 20 years on the job. Senior workers with the greatest time above the thresholds had an eight to tenfold increase in the risk of leukemia—much higher than in past epidemiological studies of electromagnetic fields (EMFs).

U.K. Panel Discourages Use of Mobile Phones by Children

A high level panel appointed by the U.K. government has recommended that children be discouraged from using mobile phones and that the industry not market phones to children.

Although the Independent Expert Group on Mobile Phones, chaired by Sir William Stewart, found that there was no evidence of a health risk, it favored a “precautionary approach” given current “gaps in knowledge.”

“I have got a grandchild of four and a grandchild of two and I would not be recommending that they have mobile phones,” Stewart told the BBC, noting that he would continue to use his own phone. Stewart was science advisor to the prime minister from 1990 to 1995.

Electromagnetic radiation in the news!

Concerning power lines and appliances:

USA Today conducted a survey of 4,567 readers and reported that electromagnetic fields, or EMF's, are the number one environmental concern in America. "EMF's - always present near power lines and working electrical appliances - are linked to such diseases as leukemia and breast cancer."

"The National Council on Radiation Protection and Measurements (NCRP) committee charged with evaluating the potential health effects of electromagnetic fields (EMFs) has completed a draft report that calls for strong action to curtail the exposure of the U.S. population. "It took us nine years but we finally reached agreement," committee chair **Dr. Ross Adey**, of the Veterans Administration Hospital in Loma Linda, CA, told ***Microwave News***.

A draft report prepared for the Environmental Protection Agency (EPA) generally endorses a 2 mG exposure limit. It would take effect immediately for new day care centers, schools and playgrounds, as well as for new transmission lines near existing housing. The report was funded by the EPA. Dr. Joe Elder, EPA's program officer for the NCRP study in Research Triangle Park, NC, called the committee's report "the first comprehensive review of the world's literature on EMF health effects." ***Microwave News***, July/August, 1995

"I have never seen a set of epidemiological studies that remotely approached the weight of evidence that we're seeing with ELF [extremely low frequency] electromagnetic fields. Clearly there is something here." **Martin Halper**, EPA Director of Analysis and Support.

"Electromagnetic fields are associated with the development of leukemia, brain cancer and other serious diseases."

> **Paul Brodeur**, writer, ***The New Yorker Magazine***, author of ***Currents of Death*** (Simon and Schuster), and ***The Great Power Line Coverup*** (Little, Brown).

"...studies on cats, rats, and chick brain cells have shown that low frequency electromagnetic radiation interacts with brain activity and could cause a host of negative symptoms from heightened stress and depression, slowed reaction time, and learning disabilities to miscarriages, fetal deformities, and cancer."
Business Week, Oct. 30, 1989.

"This is really harming people."

> **Dr. David Carpenter**, Dean, School of Public Health, State University of New York, Albany.

When buying a home, it is important to check for EMF's. Homes "sold...for 30% less" when exposed to EMF's, as reported by the ***Wall Street Journal***, September 8, 1993.
According to a survey conducted by ***Indoor Air Review***, 26% of homes have areas that register EMF fields exceeding 3 milligauss.

"...Sweden has concluded that EMF's do lead to higher rates of cancer...I, frankly was somewhat impressed by the arguments made by the Swedes." - **President Bill Clinton**

Concerning televisions and computer displays (VDTs):

"Most unsettling of all, perhaps, is the fact that the pulsed VLF and ELF magnetic fields found routinely within a radius of about two feet from the average CRT computer terminal can be as strong as, or even stronger than, the sixty-hertz magnetic fields found inside the homes in which Wertheirner and Savitz discovered children to be dying unduly of cancer."

The New Yorker, June, 1989.

"...sit at least ten feet away from the television set."

Time Magazine, July 17,1989.

A Swedish study has found that weak, pulsed magnetic fields similar to those emitted by VDTs can cause fetal abnormalities in the offspring of pregnant mice. According to Tom Brokaw of NBC News, "the findings no longer rule out the possibility that radiation can affect human fetuses." In Sweden, a major Swedish union (the Swedish Confederation of Professional Employees, or TCO) is seeking more stringent limits, and pressure is being put on the Swedish government to change VDT work regulations to protect pregnant women.

A study released in February, 1991, by the University of Southern California (UCS) in Los Angeles has found an increased rate of leukemia among children who watch black and white televisions.

****

As more evidence is compiled, concern about the link between exposure to EMF and human health is growing. Yet the experts agree only on one thing: no one knows the extent, nature and cause of health hazards associated with electromagnetic fields. Should we take comfort in published reports that the evidence is "not conclusive," or should we take steps now to mitigate public exposure to EMF even if the scientific jury is still out? An interesting parallel exists with smoking. In spite of overwhelming evidence, the tobacco industry claims that ". . . it is not known whether smoking has a role in the development of various diseases" (quote from The Smoking Controversy: Why More Research Is Needed, published by the Tobacco Institute, November, 1989). Such statements only prove that there will always be experts who disagree, thereby causing widespread confusion. Intelligent people obviously need to sort through the information and reach their own conclusions.

THE NATURE OF ELECTROMAGNETIC RADIATION

An AC electric current is defined as the movement of electrons in roughly the same direction, usually through a wire. This current, in turn, produces two types of fields: an AC electric field and an AC magnetic field, which together are called an electromagnetic field. The AC electric fields result from the strength of the charge and the AC magnetic fields result from the motion of the charge (i.e., the flow of electrons comprising the electric current). The AC electric field represents the force that electric charges exert on other charges, and this force may either repel (as with two positive charges, for example) or attract. The AC magnetic field forms a closed continuous doughnut-shaped loop around the current and radiates at a right angle to the direction of the current.

People can sense an electric field of more than about 20 kilovolts/meter (kV/m) as a slight tingling sensation on their skin. This level can be found underneath high voltage power lines. On the other hand, most people cannot feel the presence of AC magnetic fields except at extraordinarily strong levels (although some people claim they can sense even low levels of EMF).

Interestingly, while an AC electric current creates an AC magnetic field, it is also true that an AC magnetic field creates an AC electric current in a nearby conductor. This is the principle of induction, and it is how we detect and measure AC EMF fields. Induction is also the principle by which a transformer raises or lowers voltages. In a transformer, an AC electric current flowing through a coil of wire radiates an AC magnetic field, and another adjacent coil of wire picks up the AC magnetic field and converts it back into AC electric current. The number of coils on each side of the transformer determine by how much the voltage is increased or decreased.

In order to distribute electricity economically over long distances, high voltages are used. Between the power plant and your home, a series of transformers reduce the voltage along the way so that by the time it reaches your home, the voltage has been reduced to the 120/240 volt level. It is desirable to use alternating current (AC), since most transformers work only with AC. AC means that the direction of the current alternates back and forth. The frequency of the back and forth cycle is measured in Hertz (Hz), which stands for cycles per second. Hence, when we talk about a 60 Hz current, which is the standard in the United States, this means that the direction of the current is changing back and forth 60 times per second. In Europe and other parts of the world, the frequency of AC electric power is 50 Hz rather than 60 Hz.

A graph of AC current (voltage vs. time) will form a sine wave, with a positive voltage for half of the time, and a negative voltage for the other half. The same is true of the electric and magnetic fields, which travel in one direction and then the other, corresponding with the changes in direction of the AC current. Since power lines, household wiring and appliances all carry electricity with a 60 Hz cycle, the resulting AC electric and AC magnetic fields also oscillate at 60 Hz. Such frequencies are at the low end of the electromagnetic spectrum, and are referred to as extremely low frequency (ELF) fields. The 60 Hz frequency originates at the power generating station and ends up in our household appliances. Higher voltages change the strength of the fields, but not the 60 Hz frequency.

Radiation is a broad term meaning the transmission of energy in the form of waves through space or through a material medium and also the radiated energy itself. The force field associated with radiation is the region throughout which the radiation is measurable. Sometimes electromagnetic radiation is called EMR, while electromagnetic fields are frequently referred to as EMF. EMR and EMF refer to the entire range of the electromagnetic spectrum, from extremely low frequencies to radio waves. In practice, EMF is used more often than EMR because "radiation" sounds scary and its use may create confusion with more dangerous radiation from X-ray machines and radioactive material. In news reports and articles written for the general public (such as this article), EMF is used loosely to indicate the low frequency electromagnetic fields coming from power lines, home wiring, appliances, TVs and computer displays.

EMF from different sources can either add together or cancel each other out. This is due to the wave characteristics of electromagnetic radiation. If the radiation from two sources are in phase, then the peaks of each cycle will occur together, and the fields will add together. On the other hand, if the two sources are exactly out of phase, then one source will be reaching its greatest strength in one direction at exactly the same time as the other source is peaking in the opposite direction. If the magnitude of the fields is identical, then the fields will cancel each other out, and the magnetic field measurement will be zero. This is why neutral and hot wires in household wiring need to be paired close together. This characteristic also provides a mechanism for configuring power lines and VDTs so that EMF levels are reduced.

EMF can be either man-made or occur naturally. Examples of electromagnetic radiation, in order of increasing frequency, are extremely low frequency (ELF), very low frequency (VLF),

radio waves, microwaves, infrared (heat), visible light, ultraviolet, X-rays, and gamma rays. All electromagnetic radiation travels at the speed of light.

The frequency of the electromagnetic radiation is what determines its character. X-rays (and other forms of ionizing radiation) can strip electrons away from an atom, thereby creating an "ion." When living systems are exposed to such radiation, detrimental effects are caused by breaking apart molecular bonds. Cancer can be caused by such ionizing radiation when DNA (the molecules that make genes) is broken apart. At ELF frequencies, electromagnetic radiation is non-ionizing, meaning it cannot knock electrons away from atoms or alter molecular structures. However, low frequency electromagnetic radiation is nevertheless an energy force, and this energy force can shake atoms and molecules back and forth.

The field strength of electromagnetic fields can be calculated mathematically. Fields from compact sources containing coils or magnets (transformers, appliances, and computer displays, for example) diminish most rapidly with distance F in proportion with the distance cubed (1/d**3; d = distance). Fields from long wire conductors in power lines drop off in proportion with the distance squared (1/d**2), provided the currents flowing in opposite directions are well-balanced. The field strength drops off less quickly with secondary distribution lines, since the currents are frequently unbalanced. In practice, it is easier to measure the field strength than to calculate it, since there are usually multiple EMF sources which interact with each other in complex ways.

THEORIES ON HOW EMF AFFECTS BIOLOGICAL SYSTEMS

For many years some scientists and engineers felt that low frequency EMF could not possibly produce significant biological changes or effects. This reasoning was based upon the fact that low frequency EMF cannot break molecular bonds and it generates only a miniscule amount of heat - not enough to heat body tissue. However, this argument has turned out to be incorrect because there are other ways in which fields can interact with individual cells to produce biological changes.

If we recall that magnetic fields can induce an electric current in a nearby conductor, the implication is that AC magnetic fields will induce electric currents in our bodies (although such currents will be very small). That's because our bodies are mostly comprised of a conductive medium (salty water). Some of these currents are similar to what a salamander uses to regenerate a limb, and therefore the artificial creation of these currents in a human body are of concern.

The way in which electromagnetic radiation affects the body is not fully known. A similar state of knowledge applies to the mechanisms behind how aspirin cures a headache or reduces fever, or why asbestos causes cancer. One theory is that EMF causes the cell walls to vibrate, or to resonate, in the same way you can shake a bowl of jello and observe it oscillate back and forth at a certain frequency.

Resonance is not necessarily harmful. The body is composed of many elements that can resonate at different frequencies. The human ear is an example of a part of the body which resonates in tune with its environment. When we listen to the music of a violin, we are hearing a sound vibration of 5,000 cycles per second. The sound from a violin is transmitted by pressure waves in the air, not magnetic radiation. We know that the human body has no difficulty dealing with this kind of sound-induced resonance (unless, of course, the amplitude is very large, as with the sound of a jet engine).

In the case of EMF, resonance with cells occurs when there is a "match" between the wavelength of the radiation and the physical size of the cell. The resonance maximizes the

transfer of energy into the cell, and can result in observable biological effects which may be harmful. One observable effect is a disruption in the calcium flow through cell walls. Calcium acts as a messenger that penetrates into the cell, conveying important information and triggering proteins to carry out cell functions. Calcium also plays an important role in regulating certain body functions, such as muscle contractions, heartbeat, development of egg cells and cell division. Since cancer growth depends on cell proliferation, these findings seem to explain why EMF sometimes behaves like agents that pro mote, rather than initiate, cancerous growths.

Another theory is that the altered calcium flow to the cell reduces the cell's ability to fight cancer. According to Craig Byus, a biochemist at the University of California at Riverside, just because the fields are very small doesn't mean they are innocuous. Cell membranes appear to have a way of amplifying the fields. Due to the poor conductivity of the thin cell wall, small induced currents produce large voltage potentials across the cell membranes, disrupting the chemical balance.

Are weaker fields safer than stronger ones? Logically, our experience with other pollutants would lead us to answer yes, but scientists say this may not be the case because there are "windows" or ranges of biologically active frequencies and field strength. Some experiments show no effect with a strong field, but when the field strength is reduced an effect appears. Other experiments show that above a certain field strength, effects can be observed but no additional effects occur when the field strength is increased.

The resonance effect between EMF and the surfaces of cells may help explain the strange window effect. To understand why, an analogy may be made with the noisy shaking of water pipes sometimes observed when running water from a faucet. As the faucet is opened, a small flow presents no problem. Then, as the initial low flow is increased, a loud noise may occur due to pipe resonance. When the flow is increased even further, the effect doesn't get worse, and usually it stops.

The shape of the magnetic pulse also seems to play a role, too, as different pulse shapes cause different effects. The strength of a 60 Hz EMF field from power lines and household wiring increases and decreases smoothly, while the VLF field from a VDT has a saw-tooth pattern. All this complicated evidence makes it difficult to reach any conclusions on what level of EMF exposure is safe and what isn't. The consensus is that more research is needed.

ELF AND VLF RADIATION

There are two frequency ranges for magnetic fields which are commonly found around our homes and businesses ELF (extremely low frequency) which radiates from a 60 Hz current, such as power lines, and VLF (very low frequency) which comes from the 15 kHz to 85 kHz scanning frequencies of TVs and cathode ray tube video displays. The full ELF frequency range is between 0 Hz and 1,000 Hz, and the VLF range extends from 1,000 Hz (1 kHz) to 500,000 Hz (500 kHz).

THE GAUSS METER

A Gauss is a common unit of measurement of AC magnetic field strength. A Gauss meter is an instrument which measures the strength of AC magnetic fields. Inside a Gauss meter there is a coil of thin wire, typically with hundreds of turns. As a magnetic field radiates through the coil, it induces a current, which is amplified by the circuitry inside the Gauss meter. If a Gauss meter were to have an induction coil with approximately 40,000 turns, a relatively low magnetic field strength of 1 milliGauss (1,000 milliGauss = 1 Gauss) would induce enough current to be read directly with a voltmeter. It is more practical, however, to build a Gauss

meter with fewer turns and, through operational amplification circuitry, to increase the voltage or current and then calibrate the meter to read in Gauss or milliGauss (mG).
On occasion, you may encounter different units of measurement for magnetic fields, such as a Tesla, a micro-Tesla (uT), a nano-Tesla (nT), and milliamps per meter. These units are related as follows:

1 Tesla = 10,000 Gauss (A Tesla is 10,000 times larger than a Gauss)
1 Gauss = 1,000 milliGauss (mG) (A Gauss is 1,000 times larger than a milliGauss)
1 milliGauss (mG) = .0000001 Tesla = .0001 milliTesla (mT) = .1 microTesla (uT) = 100 nanoTesla (nT)
1 milliGauss (mG) = 80 milliamps/meter

POWER LINES

An enormous amount of electricity is created at power generating stations and sent across the country through wires that carry high voltages. These voltages can be 69,000, 100,000, 161,000, 230,000, 500,000, or even 765,000 volts. All power lines emit magnetic and electric fields. The electric field is proportional to the line voltage, while the magnetic field depends on the load current.

Typically high voltage transmission lines carry high current and therefore give off both high electric and high magnetic fields. The ELF magnetic field emitted by a 500,000 volt transmission line can be as high as several hundred mG directly underneath the power line, and the field can still be measured (at reduced levels) more than a thousand feet away. Unfortunately, the problem of EMF does not end with high power transmission lines. Networks of secondary distribution lines criss cross most cities and towns, and these distribution lines have strong magnetic fields, even if one is 10-50 feet away.

The amount of EMF coming from a high power transmission line depends upon its particular configuration. Power companies know which power line configurations are best for reducing EMF, but most utilities feel that the evidence so far does not support costly changes in the way electricity is delivered.

One of the more common transmission line configurations is called a "vertical double-circuit," where a set of three cables is attached, one on top of each other, to each side of the transmission tower. The three cables in each set comprise the "three phases" of the power network, with each cable carrying current. The current peaks in each cable are intentionally out of phase with each other (i.e., they don't peak at the same time) by 1/3 of a cycle. Electric utilities use the letters A-B-C to denote a three phase circuit, with each letter representing one cable and its phase. EMF can be reduced by 50 percent or more with very little expense by reversing the phase order in one circuit with respect to the other (i.e., C-B-A). This configuration causes both the electric and magnetic fields to partially cancel each other. In early 1989, the Bonneville Power Administration adopted this scheme for implementation on both old and new transmission lines. This configuration is not used by most utilities, however, because it creates interference with nearby TVs and radios, and it causes snapping and buzzing noises.

A single-circuit transmission line still has three cables, one for each phase. Typically the three cables are strung in a flat configuration, with all three cables in the same plane. Significant cancelling can be achieved by merely changing from a flat configuration to a "delta" configuration, with the three cables forming a triangle. Moving the cables closer together also helps to cancel the fields, but it reduces safety for the maintenance workers and degrades the line's performance during lightning.

Sometimes burying electric power lines can reduce EMF, but this is not necessarily the case, as magnetic fields travel through dirt, rocks and cement. Unless the underground lines are configured to reduce EMF, simply hiding the lines out of sight may create a false sense of security. If the underground service is just a single phase wire, radiation levels on the ground directly over the wire will be higher than from overhead lines because you will be closer to the source. On the other hand, some underground lines have several circuits which can be balanced to cancel the magnetic field.

In a 1991 study conducted by the Electrical Systems Division of the Electric Power Research Institute, researchers found that magnetic fields produced by underground cables vary by as much as 10 to 1, depending on the method of installation and cable construction. According to the study, a person standing directly over an underground cable with the worst configuration (from an EMF perspective) will be exposed to the same level of EMF as a person standing at the edge of the right-of-way for an overhead transmission line. Unfortunately, the study also found that the best configurations for the lowest EMF are less efficient for electric power transmission.

With concern about EMF in mind, new and different underground cable systems are being developed. The lowest field underground design has three insulated cables lying adjacent to each other in an oil-filled pipe that cools the cables. This configuration can result in magnetic fields 1/10 to 1/20 of the equivalent overhead line. The EMF can be reduced even further, sometimes to near ambient background levels, if the pipe is grounded in a special way.

SUBSTATIONS

A substation is an assemblage of circuit breakers, disconnecting switches, and transformers designed to change and regulate the voltage of electricity. Primary distribution lines, carrying high voltages typically of 115,000 volts to 230,000 volts, bring the current from the power plant to the substation, where the transformers reduce it to lower voltages, typically 4,000 to 13,800 volts. The transformers give off magnetic fields because they depend upon magnetic fields to operate. (See discussion of transformers under "The Nature of Electromagnetic Radiation.") Further compounding the problem, the incoming and outgoing currents at a substation are generally unbalanced. High magnetic fields from substations have been blamed for causing cancer clusters among nearby residents.

Paul Brodeur wrote about several such cancer clusters in the July 9, 1990, issue of the New Yorker. Citing evidence that a cancer cluster had occurred among the residents of Meadow Street in Guilford, Connecticut, Brodeur pointed out that during a twenty year period, seven tumors - four brain tumors, an eye tumor, an ovarian tumor, and a bone tumor - were recorded among the residents. This was particularly extraordinary since the street has only nine houses. The cancer victims lived in five of six adjacent houses located near an electric-power substation and next to a pair of 115,000 volt high-current distribution lines, called feeders, which carry current to the substation. Measurements of magnetic fields taken at that time near the peripheral fence around the Meadow Street substation showed magnetic fields ranging from 20 mG to several hundred mG.

NEIGHBORHOOD TRANSFORMERS

A key component of a utility's electrical distribution network depends upon numerous, small transformers mounted on power poles. A transformer looks like a small metal trash can, usually cylindrical. Even when the electrical service is underground, you will often see a metal box (usually square) located on the ground near the street. Many people don't realize that when they see a transformer, the power line feeding the transformer is 4,000 to 13,800 volts. The

transformer then reduces the voltage to the 120/240 volts needed by nearby homes. Since these transformers can be seen in almost every neighborhood, they are a source of popular concern. The ELF magnetic field near a transformer can be high, but due to its small structure, the field strength diminishes rapidly with distance, as it does from a point source. In fact, measurements at street level directly underneath a power pole transformer are no greater than underneath the power lines themselves. Ground level transformers may have readings as high as 200 mG right next to the box, and 50 mG at 4 inches away. Fortunately the fields drop off quite rapidly, with a 3 mG reading at 2 feet, and near ambient levels 10 feet away. For this reason, having a transformer located near your home is not usually a major source of concern, although just to make sure, you should measure the field strength around it.

WIRING INSIDE THE HOME

WARNING: DO NOT TOUCH ELECTRIC WIRES, EVEN IF YOU THINK THE CURRENT IS TURNED OFF. IF YOU NEED TO DISCONNECT ELECTRICAL CIRCUITS TO DETERMINE THE SOURCE OF MAGNETIC FIELDS, YOU SHOULD CALL A LICENSED ELECTRICIAN.

AC magnetic fields can be found inside everyone's home. These fields can come from power lines outside the home, wiring inside the home, and appliances. Some experts feel a background level of less than 1 mG is desirable, but many homes have readings much higher than this level. If your home has high EMF readings, it is important to determine the sources of the magnetic field so that remedial action can be taken, if possible. Often the source of a high AC magnetic field is incorrect wiring, so it is important to understand how you can correct this problem.

Household electric current comes through two hot wires and one neutral. For appliances that require 240 volts, the "hots" are put together; for appliances and outlets that need only 120 volts, just one hot wire is used. Modern homes have electrical outlets with three holes - two rectangles and a smaller half-round hole at the bottom. The rectangle on the right is smaller, and this is for the hot wire. The rectangle on the left is larger, and this is for the neutral wire. The ground is wired to the bottom, half-round hole in each outlet. The most important consideration in wiring a house is that the ground and neutral wires be kept separate and run directly back to the panel box (either a fuse box or a circuit breaker box), where they are grounded. This is a requirement of the National Electrical Code (NEC). Under no circumstances should the neutral or ground wires be grounded to the plumbing or any other ground except at the panel box.

Electric current needs to flow through a closed loop in order to work. This closed loop is referred to as a circuit. To understand how the current is supposed to flow in a correctly wired circuit, let's examine a circuit used to power a refrigerator. From the panel box electricity flows through the hot wire to the refrigerator, where it turns the motor. The electricity then flows back through the neutral wire to the panel box. With the loop closed in this way, the field is canceled out because the hot and neutral wires are close together. A ground wire runs from the panel box to the refrigerator, but if everything is wired correctly then the ground carries no current. The ground is for safety reasons, so that you will not get electrocuted in case the insulation on the hot wire becomes worn and the hot wire comes into contact with the frame of the refrigerator. The frame of the refrigerator is connected to the ground, so that any stray current from a worn or loose wire will flow back through the ground instead of through your body.

If the neutral has been grounded to your plumbing instead of running back to the panel box, your house is wired incorrectly, and this may result in a significant magnetic field. Suppose this is the case. Tracing the flow of the electric current from the panel box to the refrigerator, after the electric current powers the refrigerator it will run to the neutral and, if wired

incorrectly, through the plumbing where it is grounded. Since it is no longer paired with the hot wire, the magnetic field will not cancel out. Instead, there will be a magnetic field around the hot wire that is connected to the refrigerator, and another field may surround all your plumbing. Just one incorrectly grounded appliance can send electricity through all your water pipes, and create a magnetic field throughout your entire house! Changing the plumbing from metal to plastic is not a proper solution, because electric current is not supposed to flow through the plumbing. The only solution is to rewire correctly, with all hot and neutral wires paired closely together, and without any current flowing through the ground wire or through your plumbing.

Ground currents from underground non-electric utility lines have also been implicated in as a major source of EMF in the home. Present regulations in the United States require that utility lines such as gas, cable TV, telephone, and water be connected at each residence to the same ground as used for electric current. This practice "provides an alternate path for the [neutral return] current to flow from your house back to the distribution system," says Gary Johnson, an executive at a General Electric facility doing EMF research for the Electric Power Research Institute. As a result, an imbalance is created which reduces the cancelling effect of the neutral's field on the hot conductor. This little-known fact can be an eye opener for explaining mysterious EMF in some homes. According to Johnson, you could create fields in your neighbor's house when you switch your appliances on and off, and your neighbor could create them in your house, too. This phenomenon can also account for fields outside of the home and in overhead distribution lines.

Still another source of EMF comes from the power line where it enters your home. The area of your home near this feeder line will have a reading even if the rest of the house is properly wired. If your supply line enters your home with an overhead wire, as opposed to underground, you may want to avoid using a corner of your home, or part of a room, for any prolonged period of time.

To test your home for magnetic fields, simply walk through your home with an ELF Gauss meter. If the reading is generally below 1.0 mG except near appliances, your home is wired correctly. If you find extensive zones of higher readings, you need to first determine if the EMF is coming from your own wiring or from a source outside your home. To start, walk outside and see what the readings are around your home. Then turn off your electricity at your panel box and check inside your home. The results will tell you if you need to go further and check your wiring.

If you suspect that your home is wired improperly, obtain the services of a licensed electrician. Ask the electrician to disconnect all circuits at the panel box and test one circuit at a time. If your home has circuit breakers, you can just turn off all the circuit breakers and turn on one at a time. Then take a reading throughout the house with the Gauss meter. As an alternative, your electrician can test for the presence of unwanted ground currents with a clamp-on ammeter attached to your plumbing (it should read zero), but a Gauss meter is still recommended as it is generally more sensitive and doesn't require open access to the plumbing. This way, you'll be able to determine which circuits or appliances are causing the problem. Hopefully only a single circuit will be responsible for most of the trouble, but sometimes the house is in need of complete rewiring.

Automatic ice makers in refrigerators and in-sink disposal units are often the source of unwanted EMF since these devices are usually connected through copper piping to your plumbing. It is important that these devices be wired so that no current flows through the ground.

COMPUTER DISPLAYS

A video display terminal (VDT) is used to display information from a computer, either in the form of text or graphics. A VDT can be one of several different types: cathode ray tube (CRT), liquid crystal display (LCD), gas plasma display, and electroluminescent display. By far the greatest percentage of video displays are of the CRT type, and for this reason the term "VDT" is generally used to mean the CRT-style VDT.

CRT-STYLE VDTs

A CRT-style VDT uses the same type of picture tube as a television set. The cathode ray tube is a large vacuum tube made of glass, and coated with phosphor on the inside. An electron gun shoots a beam of electrons from the back of the tube toward the front of the screen (i.e., toward the computer operator) until it hits the phosphor. The phosphor gives off visible light when it is excited by the electrons. A full screen image is comprised of thousands of dots, each one of which is refreshed (re-excited by a burst of electrons) between 50 and 80 times per second. A CRT's resolution is expressed as two numbers, such as 640 X 480, 800 X 600, 1024 X 768, 1280 X 1024, 1600 X 1200, or more. The first number is the number of horizontal dots, or pixels, between the left and right sides of the screen, and the second number is the number of vertical dots between the top and bottom of the screen. The electron beam starts in the upper left corner of the screen, and then scans each horizontal line from left to right, one at a time, lighting up whatever pixels are required to comprise the picture. At the end of each line, the electron beam is pushed back to the beginning of the next line, where it begins another horizontal scan. The deflection coils, which are wound around the yoke (the rear, narrow part of the tube) of the CRT, control the movement of the electron beam as it sweeps across the screen. The horizontal deflection coils push the electron beam from side to side between 15,000 and 85,000 times a second or more (corresponding with a scan rate of 15 to 85 kHz), and the vertical deflection coils push the electron beam from the bottom line back to the top line 50 to 80 times a second or more (corresponding with a refresh rate of 50 to 80 Hz). CRT-style VDTs give off all sorts of electromagnetic radiation: radio waves, infrared radiation (heat), visible light, ultraviolet light, microwaves, X-rays, ELF and VLF radiation. The radio waves are typically shielded with a layer of conductive material in order to meet the limits set by the Federal Communications Commission. The infrared radiation in the form of heat is not a health hazard, and of course the visible light is necessary in order to see the screen. The levels of ultraviolet light are substantially less than indoor fluorescent lights or outdoor sunlight, and the amount of microwaves is so small that it is almost undetectable. X-rays were once a problem, but strict guidelines in effect since 1970 have reduced the level of X-rays to less than what is naturally present in the environment. Most experts now agree that X-rays from CRT-style VDTs pose no problem unless the display is defective.

It is the ELF and VLF electromagnetic radiation from CRT-style VDTs which is presently raising concern. The ELF radiation (50 Hz to 80 Hz) comes from the vertical deflection coils, and the VLF radiation (15 kHz to 85 kHz) results from the horizontal deflection coils. CRT-style VDTs also have a power transformer which creates a 60 Hz field, and a flyback transformer which steps up the CRT's voltage to tens of thousands of volts and emits VLF electromagnetic radiation.

The levels of EMF emitted by a VDT can be quite high, but the measurements drop off rapidly with distance. That's why it is important to sit back at least an arm's length from the front of the screen. Measurements taken from a typical color VDT (a popular 13 inch color display was used for this test) show 37 mG of ELF at 6 inches, 12.6 mG at 12 inches and 4.5 mG at 20 inches. The VLF field (which contains several hundred times more energy than an ELF field at the same mG reading) is 6.3 mG at 6 inches, 2.0 mG at 12 inches, and .66 mG at 20 inches. At

6 to 7 feet the ELF level drops to background, but the VLF level is still measurable 10 feet away.

Because the EMF comes from the internal components, the EMF levels on the back and sides of a VDT are higher than in front, often by a factor of 2. This means you must distance yourself further away from the back and sides of a VDT (at least 3 to 4 feet, respectively) in order to achieve the same level of exposure. Smaller VDTs are not necessarily better, either. A 15 inch VDT might well generate a stronger magnetic field than a 21 inch one, because the field's strength depends more on the internal design of the deflection coils and electronic components than on the screen size.

The electric components of a VDT consist of an electrostatic potential and alternating electric fields at ELF, VLF and radio frequencies. The electrostatic potential results from a build-up of an electric charge on the surface of the screen. Its effect is similar to what most of us have experienced when we get a static shock by walking across a carpet and touching a metal object in a dry environment. This static may attract dust on your screen and cause eye irritation. On some occasions, skin irritations have been reported, although this is infrequent and the cause has not been proven. Fortunately, no long-term or serious health effects have been attributed to the electrostatic or alternating electric fields. Moreover, the electric fields can easily be blocked by incorporating a grounded conductive layer into an anti-glare shield.

On the other hand, ELF and VLF magnetic radiation is not easy to block. Low frequency magnetic fields can easily travel through layers of solid aluminum, copper or steel with little reduction in strength. Further, unlike an electric field which travels in a straight line, a magnetic field loops outward in curves, forming an irregular, rounded envelope of energy. Adding to the problem is the source of the EMF, which is not the front of the screen but the deflection coils, flyback transformer, and power supply inside the VDT. The EMF travels up and over the top of the screen, around the sides, and underneath in all directions.

"Screen savers" designed to blank out the screen after a short period of inactivity are useful to prevent "burn in" or damage to the VDT's phosphor coating from constant use, but even if the image is blank, the components which generate ELF and VLF emissions are still active. Similarly dimming the display will do nothing to reduce the fields.

Shields placed in front of a VDT's screen do not block ELF magnetic fields. They do block electric fields, but the ELF magnetic field is the main concern.

Some well-meaning people, when they hear the word radiation, think that lead shielding is a solution. It isn't. Unlike X-rays, ELF and VLF magnetic fields can penetrate right through lead. One shielding method which has shown partial success is to install a Mu metal barrier around the deflection coils and flyback transformer inside the cabinet of the VDT. Mu metal is an alloy of nickel, iron, and various other trace metals which is magnetically permeable, meaning that it is a good conductor of magnetic lines of force. The percentage of each element in the Mu metal affects its performance, as does the thickness and the method of manufacture. While Mu metal can reduce magnetic radiation if installed properly, it cannot block all the radiation in the same way that lead blocks out X-rays.

Mu metal is not recommended as a do-it-yourself solution for several reasons. The configuration and placement of the Mu metal will vary with each different model of VDT, sometimes requiring many hours of experimentation to determine the optimum configuration. Frequently its use may cause distortion in the image, requiring retuning by a service technician. Moreover, because the Mu metal redirects the magnetic fields, it is possible to actually increase fields, rather than reduce them. And last but not least, CRT-style VDTs can provide a dangerous electric shock if you don't know what not to touch, since the tube stores up

thousands of volts, even when it is not plugged into the wall. In short, using Mu metal is an art rather than a science.

In response to users' concerns, many display manufacturers have modified their VDTs to produce lower levels of magnetic radiation. Some low radiation models use a compensating coil adjacent to the deflection coils to create an opposite magnetic field. When the two opposing fields meet, most of the radiation is canceled out. Low radiation displays may also incorporate extra shielding around the yoke and flyback transformer.

HEALTH CONCERNS RELATING TO CRT-STYLE VDTs

According to a study by The Mount Sinai School of Medicine and the 9 to 5 National Association of Working Women organization, there are now 36 million VDTs in the United States. Of those, 67%, or 24 million, are being used by women. Out of that subset, approximately 3 million are used by women who are either pregnant or likely to become pregnant in a short period of time. Is there reason this very large group of VDT workers should be more concerned than others?

Based upon the results of a number of studies, the answer is uncertain (see section on "RECENT STUDIES CAUSE CONCERN"). Manufacturers such as IBM cite studies and reports by reputable organizations such as the American Medical Association to back their position that there is no evidence that VDTs are harmful to pregnant women or to anyone else. In May, 1991, IBM wrote:

"Based on our examination of available scientific evidence and on the conclusions of national and international health organizations, we believe our VDTs are safe. . . . We concur with the International Radiation Protection Association which, in conjunction with the World Health Organization, stated that available epidemiological data 'do not provide any basis for health risk assessment useful for the development of exposure limits.'"

Meanwhile IBM has obtained a patent on a device which reduces VDT radiation and the company is using this technology to reduce the EMF coming from its displays.

Other studies concerning the effects of EMF on embryos show reason for concern. According to Dr. Ezra Berman of the Environmental Protection Agency, "the Henhouse Study [of chicken embryos exposed to low frequency magnetic fields] performed in four countries has contributed significantly to the growing database implicating an association of [EMF with an] increase of abnormalities in chick embryos." Expert Louis Slesin, publisher of VDT News, says "the new results should help convince skeptics that magnetic fields can be biologically active at very low levels."

However, pregnant women and their unborn fetuses are not the only ones at risk. CRT-style VDTs can emit levels of ELF magnetic radiation which is far higher than 2 to 3 mG (the level associated with higher risks of brain tumors, leukemia and other cancers). A link between VDT use and cancer has not been established, but this does not mean there is no danger. Consider the fact that the vast majority of VDT operators in the U.S. are women and that the incidence of female breast cancer has been rising steadily along with VDT use. Breast cancer now accounts for 29% of all cancers among women, and an astounding 1 out of 9 women will contract the disease.

Because of the relatively short period of time computers have been used, more studies are needed before there is conclusive evidence regarding adverse long-term effects. However, with the extremely strong evidence that ELF magnetic radiation increases the incidence of leukemia and brain cancer, some experts fear that long-term VDT use will also be shown to increase the

likelihood of contracting cancer, and/or inhibit the ability of the computer operator to fight off cancer that might otherwise be held in check or destroyed by the body's immune system. Remember that power lines have been around for one hundred years and the cancer link is just now being established. It took over 40 years of research to conclusively establish the dangers of smoking. VDTs have only been widely used for the past twenty years.

Other less severe problems sometimes associated with VDTs are headaches, fatigue, nausea, dizziness, irritability, skin redness or rashes, and eye strain.

THE SWEDISH STANDARD

Sweden has been a leader in developing recommended visual ergonomic and electromagnetic emission standards for computer displays. In 1987 the Swedish National Board for Measurement and Testing (MPR) introduced the first, non-mandatory testing procedures for VDTs. The test methods, called MPR 1, specified a maximum of 50 nT (.5 mG) of peak VLF magnetic field strength in the 1 kHz to 400 kHz range at 50 cm (19.7 inches) from the front of the screen. The full test procedure called for 16 measurements taken on 5 horizontal planes at 22.5 degree intervals all around the display F for a total of 80 measurements in all. No ELF requirements were included in the MPR 1 standard, because widespread concern over ELF radiation was just developing.

On July 1, 1991, new guidelines became effective. The new test methods, called MPR 2, specify less than 2.5 mG rms (root mean square) of ELF magnetic emissions in the 5 Hz to 2 kHz range (Band 1) and less than .25 mG rms of VLF magnetic emissions in the 2 kHz to 400 kHz range (Band 2). The number of measurements was reduced to 48 for each band F taken at 50 cm (19.7 inches) starting from the front of the screen and every 22.5 degrees all around the display (16 points) on each of three horizontal planes 25 cm apart.

The change in the VLF standard from the previous .5 mG peak to .25 mG rms, as explained by Lars-Erik Paulsson of Sweden's National Institute of Radiation Protection, is not a tightening of the standard, but rather a change in the method of measurement. "The two limits are essentially the same," Paulsson stated, because "the peak value is the maximum reading during each cycle, while the rms value is a time-weighted average." Commenting on this, electrical engineer Mark Kettering says that "using an oscilloscope to study the wave forms from VDTs shows that the two limits are not 'essentially the same.' The shape of the wave form (mG vs time) varies, depending upon the manufacturer. Some VDTs have sharp spikes in their wave form, but the rms value essentially ignores these spikes." Based on current knowledge, it is not known which method of measurement is most appropriate.

MPR 2 also includes guidelines for visual ergonomics (such as focus, jitter and character distortion), X-ray radiation (which is not a problem), electrostatic potential, electrostatic discharge, and AC electric fields. The source of the electric fields are the power supply and deflection coils. These components can also create a surface potential of several kilovolts, depending upon humidity, temperature, air velocity and ion concentration in the air. Reduction of the electrostatic potential and the electric fields is normally achieved by a conductive surface coating on the screen, which is connected to the power ground, together with metallic shielding of the power supply. Sometimes a CRT-style VDT will include a metal cage around all the components, or metal foil on the inside of the cabinet, to help shield the electric field. The Swedish guidelines have received a formal embrace from many major manufacturers of computer displays. Yet even in Sweden there is not a complete consensus on the limits. A major Swedish union (the Swedish Confederation of Professional Employees, or TCO) is seeking more stringent limits and test protocols F as low as 2 mG for ELF magnetic fields at 30 cm (12 inches) from the front of the screen. Their reasoning is that levels above 2 mG have been linked to increased risks of cancer, and that many VDT users' heads, hands and/or breasts

are often closer than 50 cm from the screen. Some experts have also questioned the validity of .25 mG for VLF, pointing out that the higher frequency VLF field contains more energy than ELF. These experts say that if induction levels are used to measure the amount of energy in the radiation, then 2.5 mG of ELF is equal to .01 mG of VLF. MPR's response is that "there are no proven biological reasons" for limiting VDT EMFs, and that the guidelines are not based on health risks. Rather, the recommended limits are based on what is technically feasible to measure and on what is achievable "today or within the near future."

This presents a dilemma for VDT users: If a computer display meets the Swedish guidelines, is it safe? No one can say for sure, since there are no conclusive studies which quantify the danger. On the other hand, there is no harm in being cautious. This means when buying a VDT you should know whether it meets just MPR 1 (in which case the ELF fields could still be quite high), or whether it complies with MPR 2, which includes ELF measurements. Purchase your low radiation VDT from a reputable company, or bring along a Gauss meter and buy the display with the lowest emission levels, not just the one which claims it meets the Swedish standard.

The United States does not have any regulations governing ELF and VLF emissions from VDTs. FCC requirements deal only with radio frequency emissions.

For health enthusiasts, Technology Alternatives Corporation offers CRTs certified at 0.1 milligauss. All experts agree that fields under 0.5 milligauss are safe.
(See www.safelevel.com)

NON-CRT DISPLAYS

LCDs (liquid crystal displays) are commonly used in portable laptop and notebook computers. Many experts consider LCDs safe, believing that they have lower EMF levels. Since LCDs are backlit or sidelit with fluorescent lights, they emit magnetic fields in the ELF and VLF range. The strength of the ELF and VLF magnetic fields coming from an LCD vary greatly, depending upon the manufacturer. Although LCD magnetic fields are less than those produced by CRT-style VDTs at comparable distances, at 6 inches some laptops emit up to 22 mG of ELF magnetic fields, and 2 mG of VLF fields and that far exceeds the levels set under the Swedish MPR 2 guidelines at 20 inches. This is significant because a laptop may actually be placed on a person's lap.

Technology Alternatives offers LCDs that have been certified at 0.0 milligauss.
(See www.safelevel.com)

TELEVISIONS

TVs emit the same assortment of radiation as computer displays, since both devices incorporate a cathode ray tube (CRT). Fortunately, a viewer doesn't have to sit right next to a television set to still see the image. Sitting ten feet away from a 19 inch TV distances the viewer from any measurable ELF or VLF fields. Some televisions, though, are particularly strong, so it makes sense to test your TV with a Gauss meter. A Gauss meter is also useful when buying a TV, since sets can vary quite a bit from one another.

Many appliances generate AC electric and AC magnetic fields, even when they are turned off. For example, televisions with remote controls still have current flowing when not in use. This current generates EMF, although it is less than when the TV is in use. Radios, too, may produce EMF even when turned off.

If you need to watch TV in a confined space, you should consider purchasing a small LCD TV. They have quite a strong electric field at 1 inch, but at the distance of 1 foot, the magnetic fields are negligible.

ELECTRIC BLANKETS

Electric blankets create an AC magnetic field that penetrates about 6 or 7 inches into the body. Thus it is not surprising that an epidemiological study has linked electric blankets with miscarriages and childhood leukemia. This pioneering work was performed by Dr. Nancy Wertheimer and Ed Leeper, who originally discovered that magnetic fields were linked to childhood leukemia.

In response to EMF concerns, the major U.S. electric blanket manufacturers: Fieldcrest, Casco-Belton and Northern Electric (Sunbeam) have come out with "zero magnetic field" blankets. In one design the wires are laid out in pairs so that the magnetic fields are balanced. Another design uses DC electricity, which doesn't emit pulsed EMF. Although these models reduce or eliminate magnetic fields, the blanket may still produce electric fields, even when turned off. This is because current does not have to be flowing for an electric field to exist. If the on/off switch cuts the neutral wire instead of the hot wire, the user would then be subjected to the electric field coming from the hot wire in the blanket. That's why it is best to use an electric blanket only to warm your bed before you get in it. Once you're in bed, the blanket should be unplugged to be absolutely safe. This advice is especially valid for children and pregnant women.

Waterbeds should be warmed during the day, but unplugged before going to bed. However, an unheated water bed can get quite chilly, so you may need a thick mattress pad or quilt to stay warm. Use of heating pads for chronic problems should be discontinued and replaced with hot water bottles.

ELECTRIC CLOCKS

A dial-face (analog) electric clock has a very high AC magnetic field, as much as 5 to 10 mG up to two feet away. If you are using a bedside plug-in dial-face alarm clock, it should not be placed near your head. Studies have linked high rates of brain tumors with chronic exposure to magnetic fields, so it is wise to place all plug-in clocks and other electric appliances at least 5 feet from your bed. Better yet, you may want to use a battery-powered alarm clock. Some travel clocks feature snooze, a digital display and even a radio alarm, yet they work on batteries so they have a negligible magnetic field.

FLUORESCENT LIGHTS

Fluorescent lights have replaced incandescent lights in most offices and schools. Fluorescent lights are cooler, last longer and consume less electricity, so they are more economical to use. A fluorescent bulb has no filament. Instead, the bulb is coated on the inside with a fluorescent material called a phosphor. The bulb is also filled with argon gas and mercury vapor, and a transformer (called a ballast) is used to increase the voltage to the electrodes on each end of the bulb. The high voltage excites electrons in the gas, which give off ultraviolet light. When the ultraviolet light strikes the phosphor coating on the bulb, the phosphor emits visible light which passes through the glass.

Fluorescent lights produce much more EMF than incandescent bulbs. At a distance of two inches from an incandescent bulb, the ELF field is .3 mG, and at six inches it is barely measurable. On the other hand, a typical fluorescent lamp of the type commonly found in office ceilings can have a reading of 160 to 200 mG 1 inch away. At 6 inches the reading drops

to 45 mG, at 12 inches the reading is 14 mG , at 24 inches the level is 1.7 mG, and at 30 inches the level is close to background. Thus rooms with low ceilings and fluorescent lights may have readings above 2 mG at head level. In multi-story schools with fluorescent lights, although young children may be far enough away from the ceiling fixtures, they may still be exposed to EMF from the lights on the floor below.

MICROWAVE OVENS

Microwave ovens are interesting because they emit two types of radiation: microwave and ELF. The microwave radiation, which is very high in frequency (in the billion Hertz range), is produced by an element called a magnetron. Microwaves make water molecules vibrate. It is this vibration that creates the heating process, and stray microwaves can cause serious health problems by heating body tissue. Current regulations require that a microwave oven leak no more than 1 milliwatt per square centimeter when it leaves the factory. We have no idea if this level is safe, and one study has indicated that the level should be less than .5 milliwatt per square centimeter. Since microwave emissions can change with normal use, it is best to have a qualified repairman check your oven each year.

Microwave ovens also create a 60 Hz EMF field because they have a strong power transformer. The 60 Hz component of a microwave oven usually travels five feet, so it is recommended that you stay at least five feet away from a microwave oven while it is in operation.

TELEPHONES

Telephones can emit surprisingly strong EMF, especially from the handset. This is a problem because we hold the phone so close to our heads. Measuring different telephones before you buy is important because the field strength can vary a great deal in just a matter of inches. Place a Gauss meter right against the ear piece and the mouth piece. There are several telephone handsets in the market with no measurable fields, while others emit a relatively strong field that travels several inches. That's the same distance from your ear to your brain! As with most small appliances, the body of the telephone has a magnetic field that extends one or two feet. Because of this it is a good practice to position the phone as far as possible from the user.

ELECTRIC RAZORS AND HAIR DRYERS

An electric razor which plugs into the wall produces an extremely high-strength AC magnetic field, as high as 200 to 400 mG one-half inch away from the cutting edge. This seems alarming, but we don't know if this is worse (or better) than exposure to a 2 to 3 mG field (the level linked to increased risk of cancer). If exposure to such high fields is a problem, the duration of the exposure (the dose-rate concept) might mitigate the effects. To understand the dose-rate concept, consider that we can zip a finger through the flame of a match without burning ourselves. This is evidence that short-term exposure to certain harmful influences can produce dramatically different results than longer exposure. If the dose-rate concept applies to EMF (and we don't know if it does), since an electric razor is used only a few minutes each day, it is probably safe. Keep in mind, however, that the data on short-term exposure to high-strength fields is incomplete, and that the use of non-electric razor blades will eliminate all EMF risks. There are now wind up mechanical razors available, which use a non electrical flywheel for power. A small epidemiological study found a link between electric razor use and higher skin cancer in men. Presumably the fields, being close to the brain, could influence production of melatonin, a cancer fighting hormone. Also, recent reports are pointing to the fact that cells go through the most disturbance at the beginning of field exposure, and later try to compensate. As such, non electrical razors are recommended.

Electric hair dryers are another source of extremely high AC magnetic fields because they require high currents to produce heat. A 1600-watt model will produce 100 to 200 mG near the handle and 10 to 50 mG at normal drying distances (6 to 18 inches). When it is operated on its "high heat" setting, it will draw more current and generate a higher magnetic field than when it is operated on its "low heat" setting. Again, in evaluating the health risks, the dose-rate concept may provide comfort, since a hair dryer is used only a few minutes each day. On the other hand, hairdressers who use a hand-held hair dryer repeatedly each workday may have something to worry about.

PRUDENT AVOIDANCE

Electricity is an inseparable part of our modern day society. This means that electromagnetic radiation will continue to be all around us for the foreseeable future. But, as Discover Magazine postulated, aside from making our lives easier, is electricity also making our lives shorter? Perhaps a more important question is "Until more is known, what can we do to minimize the potential risks?"

Prof. M. Granger Morgan, a well-known expert at Carnegie Mellon University, says it certainly can't hurt to take simple steps. EMF "may pose no risk," he says, "but most experts I have talked with give me odds somewhere between 10 percent and 60 percent that within the next decade it will become clear that they do." Prof. Morgan advocates "prudent avoidance." "Prudence" means to be sensible and to exercise sound judgment in practical matters. Hence, prudent avoidance means that we should avoid exposure to EMF when it is consistent with sound judgment. In other words, learn where EMF comes from and then distance oneself from it whenever such avoidance won't cause too much personal or economic disruption.
Most experts agree that limited, non-chronic exposure to EMF is not a threat. For example, it is probably acceptable to be near a toaster in the morning, but it is not advisable to sleep under an electric blanket operating all night. Certainly the person who works on a computer all day, watches TV close up at night, lives near a power line, and sleeps under an electric blanket, is under an extreme case of chronic exposure. This condition applies to millions of Americans and people throughout the world.

If you wish to practice prudent avoidance, the following advice is offered:
Measure your environment with a Gauss meter, and avoid areas where the field is above 1 mG. Measure the fields both inside and outside your home, and don't let your children play near power lines, transformers and microwave towers.

Measure the magnetic fields from appliances, both when they are operating and when the are turned off. Magnetic fields are created only when current is flowing, but some appliances (such as TVs) are still drawing current even when they are switched off.
Don't sleep under an electric blanket or on a water bed. If you want to warm your bed before go to sleep, when you're ready to get under the cover, unplug the electric blanket (don't just turn it off). Even though there is no magnetic field when the blanket is turned off, there may still be a high electric field.

Don't sit too close to your TV set. Distance yourself at least 6 feet, but keep in mind that EMF from some TV sets can be measured as far away as 10 feet or more. An ELF and VLF Gauss meter can help you decide where to sit.

Don't sit too close to your computer display. Keep at least an arm's length away from the screen, but remember that at this distance you will still be within the magnetic field. Computer monitors vary greatly in the strength of the magnetic fields which they emit.
Rearrange your office work area so that you and your co-workers are not exposed to EMF from the sides and backs of each other's VDTs.

Turn off your VDT when you are not using it.
Consider purchasing a low radiation VDT which contains an active compensating coil, or a zero radiation display based on shielded LCD technology.
Don't stand close to your microwave oven when in use. Even if your microwave oven is not leaking microwaves, it will still give off strong ELF magnetic fields.
Move your electric clock away from your pillow. Several feet away should be sufficient. Better yet, buy a battery-powered digital clock.
Keep other electric appliances away from your pillow, too. Telephones and answering machines generate EMF.
Eliminate dimmers and three-way switches; they create high fields.
Eliminate wires running under your bed.

Be wary of cordless appliances such as electric toothbrushes, which use magnetic induction to charge the battery. Such devices deliberately create a large magnetic field.
Remember that EMF passes right through walls, so check out what's on the other side. It could be a cordless electric toothbrush, or a television set, or a clock-thermostat radiating EMF into your bedroom.

A final note on AC fields: just like medicines have good and bad effects, not all AC electric and magnetic fields are negative influences. Under controlled circumstances, AC fields can be used to help our health. Some AC magnetic fields, for example, are used at hospitals to promote bone growth in the case of fractures. Similarly, Magnetic Resonance Imaging (MRI) machines are very useful in detecting tumors, aneurysms, etc., and are an excellent alternative to X Rays or CAT Scans. Other devices that use AC magnetic fields are also in use, such as AC Tens units to treat pain, as well as other magnetic devices that treat other symptoms and complaints. Static magnets have now been reported in the medical literature as being benefitial for diabetic neuropathy, (tingling and chronic pain in the feet), a condition affecting half of all diabetics, or almost 10 million people. Static magents have also been shown to be effective in many pain complaints.

About Technology Alternatives Corporation

Technology Alternatives Corporation, located in Miami, FL, has been a pioneer in the area of prudent avoidance of EMF. Technology Alternatives manufactures a zero radiation LCD computer display and several models of hand-held, inexpensive Gauss meters for measuring magnetic radiation from power lines, home wiring, appliances, televisions, and computer displays. Technology Alternatives also markets ultra-low radiation CRT-style video displays, and offers a radiation reduction service for retrofitting selected models of existing CRT-style VDTs.

Technology Alternatives Corporation has received worldwide acclaim for its innovative products. The company has been featured or mentioned by the following news sources: The Boston Globe, the Chicago Sun Times, The Washington Post, Business Week, MIS Week, The Boston Business Journal, UPI, NBC radio, WXEX in Richmond, Virginia, Channel 6 in Providence, RI, Good Morning America, USA Tonight, Channel 7, an ABC affiliate in New York, Glamour Magazine, PC Week Magazine, Lotus Magazine, Compuserve Magazine ("Averting Desktop Cherno-byl"), Adweek's Computer Magazine (Cover story: "Are VDT's Safe?"), Marketing Computers Magazine (Cover story: "Caught in the Crossfire"), PBS TV, WAGA Atlanta TV (a CBS affiliate), Channel 4 WNBC NY TV, and CNN Business News.

For free information, contact:
Technology Alternatives Corporation
1950 NE 208 Terrace
Miami, FL 33179

www.safelevel.com mgauss@netrox.net
Phone 1-800-222-3003
1-305-933-2026

Appendix 1. The Latest News:

The Latest News:

Excerpts from: MICROWAVE NEWS -- A Report on Non-Ionizing Radiation

August 2002
California EMF Program to issue Strongest Health Warning Yet

After spending more than $7 million over the last eight years, the California Department of Health Services (DHS) will soon issue the strongest warning to date on the potential health risks from exposure to power-frequency electromagnetic fields (EMFs).

Drs. Raymond Neutra, Vrncent DelPizzo and Geraldine Lee, who wrote the report, conclude that they "are inclined to believe" that EMFs are a cause of childhood leukemia, adult brain cancer, amyotrophic lateral sclerosis (ALS) and miscarriages.

The final report of the EMF Program, which runs more than 500 pages including appendices, has not yet been released, but *Microwave News* has obtained a copy. It "is slowly working its way through the bureaucracy," said Neutra of the DHS, who led the program. He expects to submit it to the California Public Utilities Commission (PUC) "at the end of the summer."

"We lowered a few of the risk estimates, but overall the conclusions in the final report are very similar to those in the draft," said DelPizzo, who served as research director of the EMF program before retiring recently to Reno, NV.

July/August 2001
ELF EMFs (electromagnetic fields) are now classified in the same category as DDT, lead, Carbon Tetrachloride and Chloroform, Category 2B possible carcinogens.
IARC Finds ELF EMFs Are Possible Human Carcinogens

A working group assembled by the International Agency for Research on Cancer (IARC) has unanimously concluded that power-frequency magnetic fields are possible human carcinogens. This finding, announced on June 27 in Lyon, France, is based on the consistent association between childhood leukemia and residential exposure to extremely-low-frequency electromagnetic fields (ELF EMFs).

The makeup of the IARC panel spanned all sides of the EMF controversy, from those who openly believe that EMFs promote cancer to industry consultants who are skeptical of any such connection. "We all agreed," said Dr. Larry Anderson. EMFs have now been formal1y

designated "2B Possible Carcinogens." (For a list of the members of the working group and their affiliations, and examples of each type of IARC carcinogens, see below.

"There was a unanimous feeling about it," said Dr. Jan Stolwijk. Dr. Maria Stuchly, who remains unconvinced that magnetic fields are responsible for promoting leukemia in children, nevertheless joined the others in voting for the 2B designation. "The epidemiological data are there and it is hard to dismiss them," she said. Dr. Vincent DelPizzo believes that the cancer evidence is stronger that do any of the other panelists. He cast the only vote that there is "sufficient" human evidence for childhood leukemia, which implies that EMFs are known human carcinogens. "I am sure that the childhood leukemia finding cannot be attributed to chance, bias or confounding," he said. (See table below for definitions of "sufficient," "limited" and ”inadequate")

The IARC decision follows similar reviews by panels in the U.S. and the U.K. In 1998, a working group of the National Institute of Environmental Health Sciences (NIEHS), using the same IARC criteria, also classified EMFs as 2B possible human carcinogens, a view that NIEHS Director Kenneth Olden later endorsed in his report to Congress. Earlier this year, an advisory committee to the UK National Radiological Protection Board chaired by Sir Richard Doll, also acknowledged the possible link between EMFs and cancer.

The childhood leukemia studies have had a major impact on all of these prior assessments. The Doll report was heavily influenced by the two recent pooled analyses: one led by Dr. Anders Ahlbom and the other by Dr. Sander Greenland. The IARC panel was similarly swayed, according to both Stolwijk and Dr. Elizabeth Hatch. “The Ahlbom analysis was found to be most impressive," noted Stolwijk. Much more surprising was the IARC panel members' view of the animal data. They came close to finding "limited" support for a cancer association based on the animal exposure experiments.

IARC Carcinogens: Definitions and Examples:
Category 1: Carcinogen
Evidence: Sufficient in humans
Chemical and physical agents:
Asbestos, benzene. dioxin, hepatitis C virus, radon. vinyl chloride. Total number of agents: 87.
Category 2A: Probable Carcinogen
Evidence: limited in humans and sufficient in animals
Chemical and physical agents:
Benzo[a]pyrene, formaldehyde, PCBs, ultraviolet (A,B&C) radiation. Total number of agents: 63.
Category 2B: Possible Carcinogen
Evidence: limited in humans and less than sufficient in animals
Chemical and physical agents:
Carbon tetrachloride, chloroform., coffee, DDT, ELF EMFs, lead, PBBs. Total number of agents: 236

June, 2001
Maximum EMF Exposure Emerges As Strong Miscarriage Risk

A new and innovative epidemiological study has found an up to six fold increased risk of spontaneous abortions among women exposed to magnetic fields of 16 mG or greater. The results “should have wide implications,” concludes Dr. DeKun Li, who led the study team at Kaiser Permanente’s research division in Oakland, CA.

Unlike past efforts, which have essentially all used average fields, Li focused on *maximum* magnetic field (MMF) as the key index of exposure. While Li found miscarriage risks that are significantly higher for women who had an MMF of at least 16 mG, he saw no excess for women with time weighted averages (TWA) of 3mG or more. Nor did he observe any increased risk for elevated spot electromagnetic field (EMF) measurements or with wire codes. "With TWAs you are diluting any possible effect because you are combining relevant and irrelevant exposures," Li told *Microwave News.* In a paper summarizing his results, Li argued that, "It seemed more plausible to us that EMF exposure has a threshold below which any exposure is biologically irrelevant."

Li's paper is an appendix to the as yet unreleased final report of the California EMF Project (see p.2). An advance copy of Li's paper was obtained by *Microwave News.*
"My study convinced me that EMFs probably have a biological effect," Li said. "We are entering a new chapter in the field of EMF epidemiology. There is more evidence that there is an association—the better conducted studies consistently show an association.

A "Robust" Association

"This population based cohort study with prospectively measured EMF exposure level revealed for the first time (based on our search of Medline) an increased SAB risk associated with a MMF exposure level of 16mG. The adverse MMF effect appeared to have a threshold around 16 mG and persisted regardless of the sources/locations of MMF exposure. Prenatal MMF exposure had a greater effect on early spontaneous abortion (< 10 weeks of gestation) when embryos or fetuses are much more sensitive to environmental insults, and among women who may be more susceptible to environmental exposures.

The association was much stronger when women whose 24 hour MF measurements may not reflect their true prenatal MF exposure were excluded. These biologically coherent observations, all based on a priori hypotheses, provide strong evidence that prenatal MF exposure above a certain level (possibly around 16 mG) may increase SAB risk. It is also unlikely that the observed association was due to biases or unmeasured confounders, because any such biases or confounders would have to explain the above observations simultaneously. The robustness of the association against potential confounders was further supported by the evidence that, despite adjusting for more than 30 variables of known or suspected risk factors for SAB, the estimates were barely altered. Moreover, prompted by the findings in this study, Lee et al. reanalyzed the data from the study in which the findings related to TWA exposure led to funding the current study,and confirmed our observed association between MMF and SAB risk. These findings raise the question of the effect of MMF on reproductive outcomes and other health endpoints. The MMF exposure level in our study population was quite comparable to that found in a nationwide survey and our study population was racially / ethnically and socioeconomically diverse. Thus, the findings from our study should have wide implications."

DeKun Li, "A Population Based Prospective Study of Personal Exposure to Magnetic Fields During Pregnancy and the Risk of Spontaneous Abortion," unpublished manuscript, May 2001.

G.M. Lee et al., "A Nested Case Control Study of Residential and Personal Magnetic Field Measures and Spontaneous Abortions," *Epidemiology,* submitted.

Li stressed that 16 mG is not a rare exposure. He noted that approximately 75% of his study population had at least one exposure above this threshold in a 24hour period. Li said that such peak fields are more likely to come from household electrical appliances and transportation sources than from local electrical distribution lines.

The Kaiser Permanente study has cleared peer review and is scheduled to be published in the November issue of *Epidemiology,* Li said. His results were first disclosed at a meeting convened by the California EMF Program on April 25. Kaiser Permanente is the largest and oldest health care provider in the U.S.

"It's quite exciting if it holds up," Dr. Nancy Wertheimer said in an interview. " More work needs to be done on thresholds and short term high exposures." Wertheimer, who lives in Boulder, CO, was a member of Kaiser's internal peer review team. Wertheimer and Ed Leeper have themselves reported associations between miscarriages and EMF xposures from electrically heated beds and home electrical heating systems.

Others have also seen a miscarriage risk due to magnetic fields from video display terminals (see *MWN,* M/J88 and M/A 92) and from power lines (see *MWN,* M/A92).

"Taken together the EMF studies of spontaneous abortions paint a consistent picture," said one epidemiologist, who has read the new Li paper but who asked not to be identified. The new study is the first prospective study ever done for EMF health risks and the first to use maximum magnetic field exposures to gauge risks. A total of 969 women who had been pregnant for less than ten weeks qualified for the study, and the outcomes of their pregnancies were monitored. They wore an EMDEX meter for 24 hours and were then asked if their activities during that particular day were "typical" of the pregnancy.

"One of the strengths of this study was that we measured MF exposure during the relevant period and used personal measurement to capture MF exposure from all sources encountered by a woman," Li wrote.

Li found that women who were exposed to MMFs of 16 mG or more had 80% more miscarriages compared to those exposed to less than 16 mG—a statistically significant increase. But when women who said that they had worn the EMDEX on an atypical day are eliminated from the study population, the miscarriage risk increases to three times that of the less exposed women. And for pregnancies lost during the first ten weeks of gestation, the risk is close to six times that of the less exposed women. All these results are also significant. Of the 159 women who had spontaneous abortions, 132 had exposures above 16 mG, and of these 95 said that they had taken measurements on a typical day.

For women who were judged to be more susceptible to environmental insults—those who had already had two or more miscarriages or who had fertility problems—the miscarriage risk is three times higher when they were exposed to 16 mG or more.

This risk rises to close to five times that of the unexposed women for those pregnancies that were lost before the tenth week of gestation, a time when the fetus is most sensitive to environmental insults. Both these risks are statistically significant.

"All this evidence points to an underlying biological effect of the magnetic field rather than bias or a chance finding," Li said. "If this were a chance finding, you would not expect there to be a difference between typical and atypical exposures and between early and late abortions." In the interview, Li said that he was "a little disappointed" by the recent commentary on EMF epidemiology by Dr. David Savitz A number of researchers have argued for the need to look beyond TWAs to measure biologically relevant EMF exposures.

For instance, in the early 1990s, Drs. Richard Lovely and Bary Wilson of the Battelle Labs in Richland, WA, pointed specifically to MMF exposure as an alternative exposure index (see *MWN,* M/J93). Until Li, no one had followed up their suggestion.

In a previous epidemiological study, Li found that women with fertility problems who used electric blankets during pregnancy had a greater chance of having babies with birth defects (see *MWN,* S/O95). The risk was ten times higher among women who used electric blankets during the first trimester.

September 2001

WHO EMF Project Now Endorses

Policy of Prudent Avoidance

In a major policy shift, the World Health Organization's (WHO) International EMF Project has endorsed prudent avoidance.

On October 3, the WHO advised that decisions on siting power lines should "consider ways to reduce people's exposures." The WHO also recommended that governments and industry should offer the public "suggestions for safe and low-cost ways to reduce exposures." The advice is contained in a fact sheet on extremely low frequency electromagnetic fields (ELF EMFs) and cancer.

The project's new outlook follows the decision by an expert panel convened by the International Agency for Research on Cancer (IARC) to classify ELF EMFs as "possible human carcinogens" (see *MWN,* J/A01). IARC, which is based in Lyon, France, is part of the WHO.

Three years ago, in its last fact sheet on ELF EMFs and cancer, the WHO project took a very different view. "There is no need for any specific protective measures for members of the general public," it stated —beyond meeting the exposure limits recommended by the International Commission on NonIonizing Radiation Protection (ICNIRP). This standard protects against acute health hazards, such as shocks and burns, but does not address cancer risks.

At that time, Dr. Michael Repacholi, who oversees WHO's work on EMFs, told *Microwave New*s: "It is not WHO's job to be recommending 'prudent avoidance' to national governments" (see *MWN,* N/D98).

As late as last year, the EMF project advised that prudent avoidance "may be justified," but warned that "such actions should not be recommended by national authorities on health grounds."

Rather, they may be appropriate to deal with individual perceptions of risks (see *MWN,* M/J00).

German Radiation Commission

Endorses Prudent Avoidance

Germany's Radiation Protection Commission is recommending a policy of prudent avoidance. In a report released on September 14, the panel—known by its German acronym SSK—states that it has confidence in the ICNIRP standards. But it calls for "minimizing" exposures to both

ELF and RF/MW EMFs to the extent "technically and economically reasonable," especially in locations where people spend extended periods of time.

The SSK recommends that emissions from consumer appliances, including mobile phones, be kept as low as possible and that product labels indicate emission levels.

The SSK also argues for more health effects research. The Federal Environment Ministry, which is revising Germany's EMF safety rules, requested the report (see *MWN*, S/O97). In July, the ministry announced that it was weighing precautionary exposure limits for mobile phone base stations, but would wait for SSK's advice (see *MWN*, J/A01).

The SSK's principal expert on non ionizing radiation is Dr. Jürgen Bernhardt, who is the vice chair—and a past chair—of ICNIRP and a former head of Germany's Radiation Protection Office.

On July 31, the radiation office's current director, Wolfram König, advised against the se of mobile phones by children and called for restrictions on base station antennas near schools and hospitals (see *MWN*, J/A01).

JUNE 2000

Strong Electric Fields Implicated in

Major Leukemia Risk for Workers

Long term employees of Ontario Hydro who worked in strong electric fields had much higher risks of leukemia, Canadian researchers have found. Significant risks were also found for non Hodgkin's lymphoma (NHL) in a related study.

The elevated risks were seen among workers who spent the most time in electric fields above certain thresholds, in the range of 10 to 40 V/m. The largest increases occurred among those with more than 20 years on the job. Senior workers with the greatest time above the thresholds had an eight to tenfold increase in the risk of leukemia—much higher than in past epidemiological studies of electromagnetic fields (EMFs).

"It's very interesting that there seems to be a threshold effect," Dr. Anthony Miller, a coauthor of the study, told *Microwave News*. " These studies confirm that electric fields are very important, if not dominant," Miller said. "I think that's a very important essage." Both studies were based on data from Miller's 1996 study of Ontario Hydro employees, which put a spotlight on cancer risks and electric fields (see *MWN*, J/A 96). Formerly at the University of Toronto, Miller is now with the German Cancer Research Center in Heidelberg.

Paul Villeneuve of the University of Ottawa, who led the studies as part of his doctoral dissertation, said, "It's remarkable that we saw similar threshold effects for both leukemia and NHL."

The threshold levels were "relatively consistent" in the two studies, he noted.

In an interview, Dr. Lois Green of Ontario Power Generation (formerly part of Ontario Hydro) in Toronto described this work as the first of its kind. "No one has ever taken a systematic look at threshold effects before," she said. Most previous studies have focused on cumulative effects or time weighted averages, which Green called "a very limited way to view EMF exposures."

The new work by Villeneuve, Miller and colleagues "shows that there are other important ways of looking at exposure," she said. "We can't close the door on this question."

The new Canadian results stand in sharp contrast with past EMF epidemiological studies, most of which have focused almost exclusively on magnetic fields. Dr. David Savitz of the University of North Carolina, Chapel Hill, told *Microwave News* that the new findings "suggest that those doing future studies reconsider the pessimism about the value of electric field data."

"Our results suggest that there is no association between exposure to magnetic fields and NHL," Villeneuve and colleagues write in the April issue of *Occupational and Environmental Medicine,* and no threshold effects were seen with magnetic fields ineither study. In the leukemia study, some nonsignificant elevations in risk were observed for workers with higher average magnetic field exposure.

Miller's 1996 study also described electric fields as the main source of risk, but indicated that the highest risks came from combined electric and magnetic exposure. While the two new studies "tend to confirm the dominance of electric fields," he said, "I'm not sure they remove any effect for magnetic fields."

For electric fields, however, Miller now believes that the threshold analysis in the new papers is a more precise way of measuring their impact.

The leukemia study, published in the June issue of the *American Journal of Industrial Medicine,* found that the amount of time spent above these thresholds was a "significant predictor of leukemia risk." While average exposure was also linked to an increase in risk, Villeneuve and colleagues write, their results indicate "that leukemia risk is more sensitive to exposures above a threshold."

For workers employed for more than 20 years, the findingswere especially striking. Of these, the one third who spent the most time above 10 V/m were ten times more likely than others to develop leukemia, a significant increase. The one third with the most time above 20 V/m had a risk eight times higher than others. These odds ratios, however, had very wide confidence intervals.

The case control study was based on 50 cases of leukemia and 200 controls, drawn from a cohort of over 31,000 male Ontario Hydro employees and retirees. Employment data were linked to a job exposure matrix based on both job title and work site, with personal measurements from over 800 workers, and to incidence data from the Ontario Cancer registry. These data were the basis of Miller's 1996 study, which was part of a three utility study that included workers at Hydro Quebec (HQ) and Electricité de France (EDF) (see *MWN*, M/A94). The Ontario research used a more detailed exposure assessment—taking into account job location as well as title—than was used for the other utilities.

The NHL study was based on 51 cases and 203 controls from the same study population. It found that the one third of workers who spent the most time in electric fields above 10 V/m had triple the risk of NHL. Those with the most time above 40 V/mwere 3.6 times more likely to get the disease.

"Many of us, starting with Genevieve Matanoski around 1986, have long held that we need to look at alternative indices of exposure," Dr. Indira Nair of Carnegie Mellon University in Pittsburgh told *Microwave News.* Confirmation of this point is "the central importance of these papers," said Nair. "Until we are able to elucidate a mechanism, studies that include these

alternate indices can provide us with understanding which may help us eventually to ‘back into’ the mechanisms.”

Field Exposure in the Electric Utility Work Environment,” *Bioelectromagnetics, 18,* pp.365375, 1997.

Trevor Dawson, Kris Caputa and Maria Stuchly, “A Comparison of 60 Hz Uniform Magnetic and Electric Induction in the Human Body,” *Physics in Medicine and Biology, 42,* pp.23192329, December 1997.

U.K. Panel Discourages Use of Mobile Phones by Children

A high level panel appointed by the U.K. government has recommended that children be discouraged from using mobile phones and that the industry not market phones to children. Although the Independent Expert Group on Mobile Phones, chaired by Sir William Stewart, found that there was no evidence of a health risk, it favored a “precautionary approach” given current “gaps in knowledge.”

“I have got a grandchild of four and a grandchild of two and I would not be recommending that they have mobile phones,” Stewart told the BBC, noting that he would continue to use his own phone. Stewart was science advisor to the prime minister from 1990 to 1995.

The 12 members of the expert group issued their report on May 11. They asked that radiation exposure data for different phones—specific absorptionrates (SARs)—be “readily accessible to consumers” and that there be no shortcutsin the planning process for the siting of mobile phone base stations.

Electromagnetic radiation in the news!

Concerning power lines and appliances:

USA Today conducted a survey of 4,567 readers and reported that electromagnetic fields, or EMF's, are the number one environmental concern in America. "EMF's - always present near power lines and working electrical appliances - are linked to such diseases as leukemia and breast cancer."

"The National Council on Radiation Protection and Measurements (NCRP) committee charged with evaluating the potential health effects of electromagnetic fields (EMFs) has completed a draft report that calls for strong action to curtail the exposure of the U.S. population. "It took us nine years but we finally reached agreement," committee chair **Dr. Ross Adey**, of the Veterans Administration Hospital in Loma Linda, CA, told ***Microwave News***.

A draft report prepared for the Environmental Protection Agency (EPA) generally endorses a 2 mG exposure limit. It would take effect immediately for new day care centers, schools and playgrounds, as well as for new transmission lines near existing housing. The report was funded by the EPA. Dr. Joe Elder, EPA's program officer for the NCRP study in Research Triangle Park, NC, called the committee's report "the first comprehensive review of the world's literature on EMF health effects."

Microwave News, July/August, 1995

"I have never seen a set of epidemiological studies that remotely approached the weight of evidence that we're seeing with ELF [extremely low frequency] electromagnetic fields. Clearly there is something here."

Martin Halper, EPA Director of Analysis and Support.

"Electromagnetic fields are associated with the development of leukemia, brain cancer and other serious diseases."

Paul Brodeur, writer, ***The New Yorker Magazine***, author of ***Currents of Death*** (Simon and Schuster), and ***The Great Power Line Coverup*** (Little, Brown).

"...studies on cats, rats, and chick brain cells have shown that low frequency electromagnetic radiation interacts with brain activity and could cause a host of negative symptoms from heightened stress and depression, slowed reaction time, and learning disabilities to miscarriages, fetal deformities, and cancer."
Business Week, Oct. 30, 1989.

"This is really harming people."

Dr. David Carpenter, Dean, School of Public Health, State University of New York, Albany.

When buying a home, it is important to check for EMF's. Homes "sold...for 30% less" when exposed to EMF's, as reported by the ***Wall Street Journal***, September 8, 1993.
According to a survey conducted by ***Indoor Air Review***, 26% of homes have areas that register EMF fields exceeding 3 milligauss.

"...Sweden has concluded that EMF's do lead to higher rates of cancer...I, frankly was somewhat impressed by the arguments made by the Swedes." - **President Bill Clinton**

Concerning televisions and computer displays (VDTs):

"Most unsettling of all, perhaps, is the fact that the pulsed VLF and ELF magnetic fields found routinely within a radius of about two feet from the average CRT computer terminal can be as strong as, or even stronger than, the sixty-hertz magnetic fields found inside the homes in which Wertheirner and Savitz discovered children to be dying unduly of cancer."

The New Yorker, June, 1989.

"...sit at least ten feet away from the television set."

Time Magazine, July 17,1989.

A Swedish study has found that weak, pulsed magnetic fields similar to those emitted by VDTs can cause fetal abnormalities in the offspring of pregnant mice. According to Tom Brokaw of NBC News, "the findings no longer rule out the possibility that radiation can affect human fetuses." In Sweden, a major Swedish union (the Swedish Confederation of Professional Employees, or TCO) is seeking more stringent limits, and pressure is being put on the Swedish government to change VDT work regulations to protect pregnant women.
A study released in February, 1991, by the University of Southern California (UCS) in Los Angeles has found an increased rate of leukemia among children who watch black and white televisions.

****

For information on products to help protect ourselves from electromagnetic fields, visit www.safelevel.com (source of this document)
