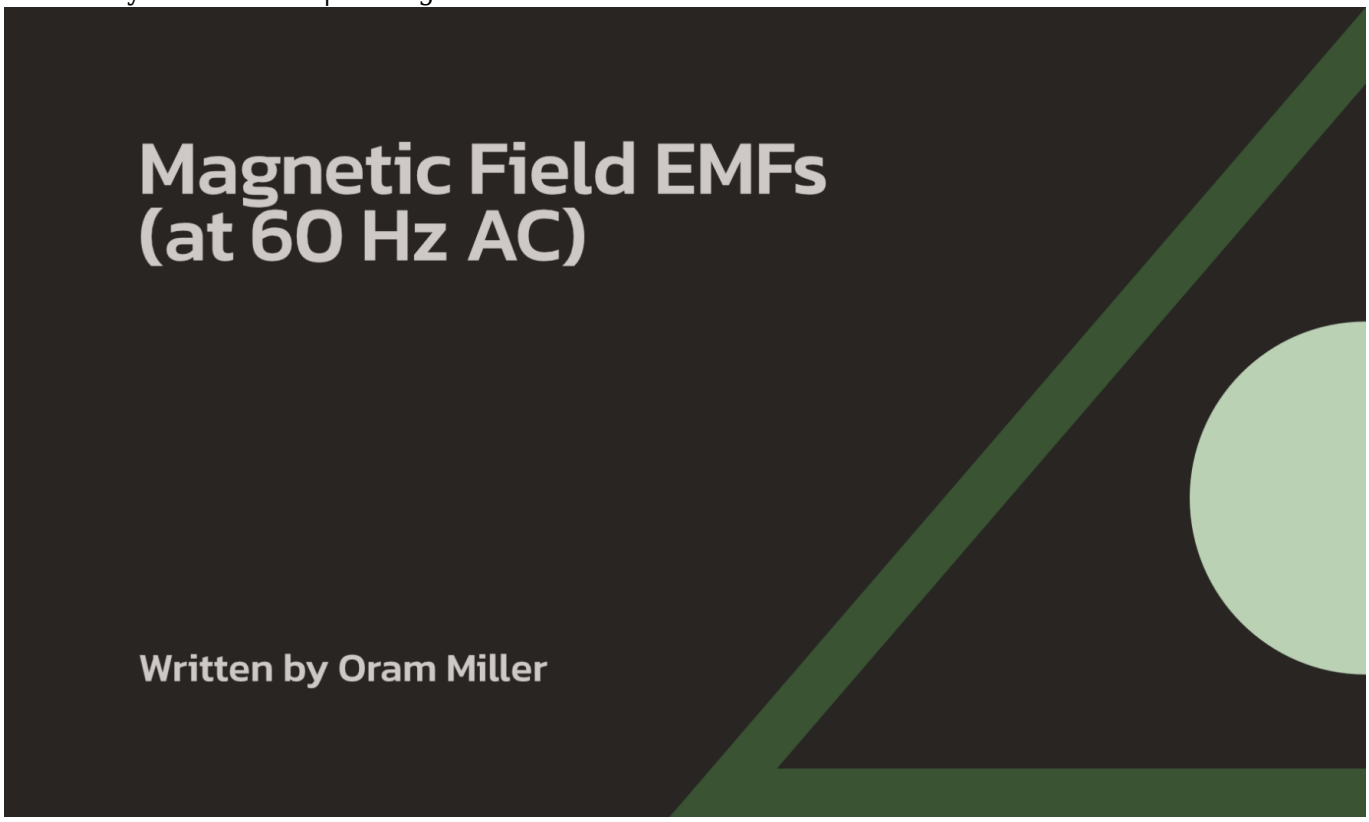
Magnetic Field EMFs (at 60 Hz AC)

written by Oram Miller | 30 August 2026



Magnetic Field Exposure

Introduction

In general, while electric field exposure in homes creates an agitating influence on the body that does not allow deep, restful sleep, magnetic field exposure, on the other hand, creates what some consider to be a more harmful influence by depressing the immune system and vitality.

Magnetic fields, particularly from 60 Hz AC building wiring, are a known cancer risk, and when magnetic and electric fields are *both* present in sleeping areas, the cancer risk is reported to be eleven times higher than with either alone. Electric field exposure can prevent a deep, restful sleep, while magnetic field exposure essentially wears down your immune system and causes a host of symptoms in clients.

The Four Sources of AC Magnetic Field EMF Exposure

The building biology profession recognizes four potential sources of unhealthy magnetic field exposure in homes. They include:

- Outside overhead powerlines
- “Point sources” within the home (such as motors, transformers, and electric breaker panels and meters)
- Wiring errors, and
- Electric current running on metal water pipes and the grounding system

These potential sources of magnetic field exposure are measured either coming in from outside or at various “hot spots” from various sources during healthy home evaluations. I use a Magnii Technologies DSP-523 True-RMS 3-Axis Gauss Meter to measure magnetic fields, as well as a Tri-Field Gauss Meter as a magnetic field “detector”. (I do not recommend that you purchase a Tri-Field Meter, unless you choose the Flat Response model, for reasons explained in the magnetic field EMF section of my page, EMF Meters and Instruments, linked to here.

How AC Magnetic Field EMFs Are Created

Magnetic fields are created by the flow of electricity through a wire or other metallic path (water pipe, gas line). These create “flux” lines of measurable magnetic field exposure that extend out around the wire like a tube. The flux field runs parallel to the wire source. The field strength diminishes by a straight one:to:one ratio, whereby at half the distance to zero field strength, the level is half.

For example, if the wire has a magnetic field strength of 100 milliGauss (mg) and it drops off to near 0 milliGauss at ten feet, then at five feet the level would be 50 mG. This is what happens with magnetic fields from outside power lines, from wiring errors on inside circuits, and from electric current on water pipes and grounding conductors. These are all discussed separately below.

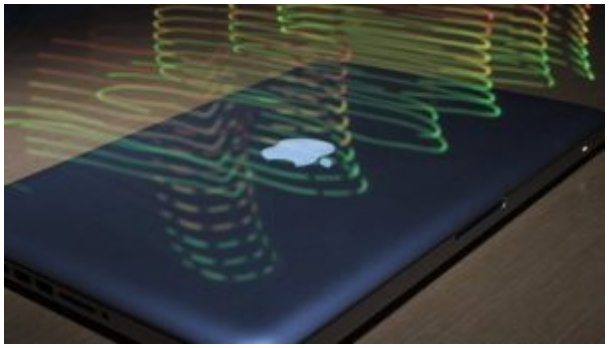
The most common sources of magnetic field exposure, however, are from so-called “point sources.” These include transformers, electric motors and your breaker panel and electric meter (whether it is a digital smart meter or older analog mechanical meter). Point sources do have high magnetic field exposure levels, however the good news is the field strength drops off rather quickly.

In fact, magnetic fields from transformers, motors and your breaker panel and meter drop off exponentially or logarithmically by what is known as the “one over r cubed” law. Thus, at half the distance to zero, the field strength is already only 1/8th the strength that it is right at the source. The field is high but compact, and rarely extends more than two to three feet from these types of sources. The magnetic field from your refrigerator motor, when running, and your breaker panel and meter might extend closer to three feet, but again, the field does drop off rather quickly.

Magnetic fields from linear sources, on the other hand, like power lines and current on a water pipe or grounding conductor under your floor drop off much more slowly. The magnetic field from current on a water pipe or grounding conductor can extend several feet into the room from under the floor, and the magnetic field from an outside power line, especially transmission lines, can extend for half a city block, gradually dropping off by a direct inverse “one over r” relationship, where “r” is distance.

To help you visualize this, please view diagrams of EMFs prepared by Oram’s mentor and fellow building biologist, Spark Burmaster, EE, BBEC, EMRS of Chaseburg, Wisconsin. Click here to view a diagram of magnetic fields (and notice the comparison to and contrast with electric fields).

To also help “make the invisible visible,” a team of designers, Luke Sturgeon of Denmark and his colleague, Shamik Ray, set out to capture magnetic fields on film and video footage. James Holloway wrote about this in a July 3, 2013 post on the online blog, Gizmag, linked to here.



The photo to the right shows what they came up with for the magnetic field emerging up from the hard drive motor of a laptop computer. This is not the exact configuration of the field itself but more a result of their photographing technique, however, bear in mind that the same field also emerges downwards by the same distance, right into your lap.

To see more photos of their work, showing magnetic fields around air purifiers and a cellphone, click here and click on "7 Pictures" or "Image Gallery." To see a two-minute video of how they took these photos, click here.

Safe Exposure Levels for AC Magnetic Field EMFs

Before we discuss how to protect protect oneself from these types of EMFs, we need to ask what are the safe exposure limits for human exposure to magnetic fields? While the regulatory agencies in this country feel that what we consider to be high levels of magnetic field exposure are, in their opinion, perfectly safe, our profession has adopted the more stringent standards used in Europe and elsewhere around the world. As a result, magnetic field exposure levels during the daytime above 1 to 2 milliGauss (mG) are considered by our profession to be relatively unhealthy. At night, when we take our rest, we prefer to see levels below 0.5 mG. This is documented by research that is linked to from my website on the page entitled, EMF Research Citations.

The building biology guidelines are given below, but first we need to review what governmental and non-governmental regulatory agencies say about this topic in this country and around the world:

The US Environmental Protection Agency states, "In the U.S., there are no federal standards limiting occupational or residential exposure to power line EMF." Others, however, including electrical engineer and building biologist Vicki Warren writing on Dr. Mercola's website, emf.mercola.com, state that the EPA does recommend magnetic field safe exposure limits as follows: "The EPA has proposed a safety standard of 1 mG."

The World Health Organization's International Agency for Research on Cancer (IARC) finds that human exposure to levels of 300-400 nT (3-4 mG) and up are considered to be potentially carcinogenic. The BioInitiative Report, published by the University of Albany in New York, found biological effects occurring at 10 mG, and stated that, "other researchers used a cut-point of around 2-3 mG, or sometimes even less, as a 'high' average". (References provided here.)

The California EMF Program was created by the California Public Utilities Commission (CPUC) and is administered by the California Department of Health Services (CDHS). It sets no safe exposure levels for exposure to magnetic fields, however they do comment on whether EMFs are a health hazard. From the Executive Summary of the California EMF Risk Evaluation for policymakers and

the public:

“On behalf of the California Public Utilities Commission (CPUC), three scientists who work for the California Department of Health Services (DHS) were asked to review the studies about possible health problems from electric and magnetic fields (EMFs) from power lines, wiring in buildings, some jobs, and appliances. The CPUC request for review did not include radio frequency EMFs from cell phones and radio towers…

THE CONCLUSIONS AFTER REVIEWING ALL THE EVIDENCE:

- To one degree or another, all three of the DHS scientists are inclined to believe that EMFs can cause some degree of increased risk of childhood leukemia, adult brain cancer, Lou Gehrig’s Disease, and miscarriage.
- They strongly believe that EMFs do not increase the risk of birth defects, or low birth weight.
- They strongly believe that EMFs are not universal carcinogens, since there are a number of cancer types that are not associated with EMF exposure.
- To one degree or another they are inclined to believe that EMFs do not cause an increased risk of breast cancer, heart disease, Alzheimer’s Disease, depression, or symptoms attributed by some to a sensitivity to EMFs. However,
- All three scientists had judgments that were “close to the dividing line between believing and not believing” that EMFs cause some degree of increased risk of suicide, or
- For adult leukemia, two of the scientists are “close to the dividing line between believing or not believing” and one was “prone to believe” that EMFs cause some degree of increased risk.

“HOW AND WHY THE CONCLUSIONS DIFFER FROM THOSE OF OTHER RECENT REVIEWS: While there are important differences between the three DHS reviewers’ conclusions, the DHS scientists are **more inclined to believe that EMF exposure increased the risk of the above health problems than the majority of the members of scientific committees convened to evaluate the scientific literature by the National Institutes of Environmental Health Sciences Working Group (NIEHS) in 1998, the International Agency for Research on Cancer (IARC) in 2001, and British National Radiological Protection Board (NRPB) in 2001.**” (emphasis added)

What Local Southern California Electric Utilities Say About Magnetic Field EMFs

Two local electric utilities in Southern California have weighed in on the subject.

The Los Angeles County Department of Water and Power (LA DWP) states:

“Given the uncertainty of the issue, the medical and scientific communities have been unable to determine that EMF causes health effects or to establish any standard or level of exposure that is known to be either safe or harmful.”

DWP says the Magnetic Fields Outside under Distribution Lines can range from 1-80 mG under the line, and under Transmission Lines can range from 1 to 300 mG at the edge of the right-of-way.

LA DWP concludes by saying, “Until more is known, your best strategy is to stay informed and, if you think it’s necessary, to limit your exposure. You may be able to reduce your exposure by identifying EMF sources, changing the way you use electric appliances, and increasing your distance from EMF

sources."

The file path for information on EMFs on the LA DWP website is: Los Angeles County Department of Water and Power's (DWP) main website, then Services, then Residential Services in the drop down menu, then Electric Safety, then scroll down to "Related Links" and click on "Understanding Electric & Magnetic Fields". The direct link is here.

Southern California Edison power company answers the question, "What Magnetic Levels Are Found Near Power Lines?" as follows:

For Power transmission lines: "Magnetic fields created by transmission lines vary with power line design, and how much electricity flows through the lines. However, at the edge of rights-of-way near 220 kV and 500 kV transmission lines, magnetic field levels in the 20-30 mG range can often be found. At a distance of 300 feet during average electricity demand, the magnetic fields from many transmission lines can be similar to typical background levels found in most homes."

For Power distribution lines: "Typical voltages for power distribution lines in SCE's service territory range from 4 to 33 kV. Similar to transmission lines, the magnetic fields near distribution lines vary with power flow and design. According to the NIEHS (National Institutes of Environmental Health Sciences), magnetic fields under main feeder distribution lines or over underground lines can create fields around 10 to 20 mG. For smaller distribution lines, field levels are often much less (below 10 mG to under 1 mG). At a distance of 100 feet, the magnetic field levels from distribution lines often drop to values similar to levels found in most homes."

In answer to the question, "Are There Official EMF Exposure Limits?", Edison says, "While there are no federal or state of California established limits for EMF exposure, some nongovernmental organizations have issued advisory limits. Exposure to magnetic fields from power lines, in addition to other common exposures in homes, schools, and offices, are far below the advisory limits."

The file path for information on EMFs on the Southern California Edison website is: Southern California Edison's main website, then Outages & Safety, Stay Safe, Your Family's Safety, and then find the link to Electric & Magnetic Fields on the right under "Related Links". The direct link is here.

How This Compares to Accepted Safe Exposure Levels Around the World and In the Building Biology Profession

The reported magnetic field levels quoted above by Los Angeles Department of Water and Power and Southern California Edison are actually lower than some safe exposure limits accepted around the world for magnetic field exposure, which vary greatly. The high end of the range includes a value of 50,000 mG set by the DKE German Commission for Electrical, Electronic & Information Technologies of DIN and VDE and the German Association of Professional Engineers for occupational workers, as well as a value of 4,000 mG set by the same two agencies for the general public in Germany. Magnetic field levels of 2,000 mG are considered safe by the American Conference of Governmental Industrial Hygienists (1996) for occupational TLV (Total Load Volume). (See Building Biology Evaluation Guidelines here, which give these values in nanoTesla (nT), not milliGauss. To convert, 100 nT equals 1 mG.)

The average magnetic field exposure levels quoted above by LA DWP of 1-300 mG and Southern

California Edison of 10-30 mG are therefore quite a bit less than the acceptable levels of these other agencies around the world, just mentioned.

Compare all of these levels, however, to safe exposure levels of only 10 mG as set by the Swiss and Brazilian Governments, 4 mG as recommended in Israel (see below), 3-4 mG recommended by the World Health Organization as "possibly carcinogenic" (referenced here), 2 mG as recommended by Swedish engineers within the Tjanstemannens Centralorganisation (TCO) as well as the US Congress (1996), and a level of only 1 mG as recommended by the BioInitiative Working Group. Natural background levels of magnetic field exposure are found to be less than 0.02 mG. (References provided here.)

The source of the Israeli safe exposure level is an Israeli television news story mentioned in WEEP News for November 24, 2013 entitled, "Israeli TV investigation: electrical beds 'irradiate and carcinogenic', which can be found here and then by scrolling down to the article.

What Does Building Biology Say About Safe Exposure Levels for Magnetic Field Exposure?

The European and North American building biology professions have adopted rather stringent limits for EMF exposure in sleeping areas, saying that the level of no concern is 0.2 mG or less. Slight concern is between 0.2-1.0 mG, and measured levels between 1.0-5.0 mG are in the severe concern range. Levels above 5.0 mG are considered to be of extreme concern by our profession.

We in the North American building biology profession generally recommend that our clients sit, sleep and stand in living and work environments that are below 1.0 mG in the day and evening time, and below 0.5 mG at night when we sleep. Click here to see the guidelines.

These values are in keeping with the most stringent safe exposure levels recommended by governments (outside the US) as well as organizations within the greater international EMF safety community noted above. The building biology guidelines were originally developed in the early 1990s and last updated in 2015. Our guidelines are based upon European research, the precautionary principle, and the consensus of health agencies on that continent and throughout the world. The North American branch of our profession, which certified me and other building biologists in this country, has adopted the same standards as our European counterparts. I therefore follow and teach these safe exposure guidelines.

Wikipedia defines the Precautionary Principle as follows:

"The precautionary principle or precautionary approach states that if an action or policy has a suspected risk of causing harm to the public or to the environment, in the absence of scientific consensus that the action or policy is harmful, the burden of proof that it is not harmful falls on those taking the action.

"This principle allows policy makers to make discretionary decisions in situations where there is the possibility of harm from taking a particular course or making a certain decision when extensive scientific knowledge on the matter is lacking. The principle implies that there is a social responsibility to protect the public from exposure to harm, when scientific investigation has found a plausible risk. These protections can be relaxed only if further scientific findings emerge that

provide sound evidence that no harm will result.

“In some legal systems, as in the law of the European Union, the application of the precautionary principle has been made a statutory requirement.”

The following information is reprinted from the 2015 Standard of Building Biology Testing Methods, which includes a definition of levels of risk as well as reference citations. The standards can be accessed here.

In the building biology profession, acceptable limits of AC magnetic field exposure in sleeping area are listed as follows:

- Less than 0.2 milliGauss (mG) No anomaly
- 0.2 mG – 1.0 mG Slight anomaly
- 1 – 5 mG Severe anomaly
- More than 5 mG Extreme anomaly

From the guidelines:

- No Anomaly. This category provides the highest degree of precaution. It reflects the unexposed natural conditions or the common and nearly inevitable background level of our modern living environment.
- Slight Anomaly. As a precaution and especially with regard to sensitive and ill people, remediation should be carried out whenever it is possible.
- Severe Anomaly. Values in this category are not acceptable from a building biology point of view, they call for action. Remediation should be carried out soon. In addition to numerous case histories, scientific studies indicate biological effects and health problems within this reference range.
- Extreme Anomaly. These values call for immediate and rigorous action. In this category international guidelines and recommendations for public and occupational exposures may be reached or even exceeded.

In areas of the house or home office that we occupy during the day or evening, we are less stringent than sleeping areas. Generally we are not concerned with daytime magnetic field exposure levels up to 0.5 mG, and only slightly concerned from 0.5 to 2.0 mG for healthy people. We are more concerned when levels exceed 2.0 mG, as that is the level at which harmful biological activity is known to begin to occur. We are most concerned when levels exceed 3.0-5.0 mG.

We must bear in mind that EMF consultants like myself deal with two groups of people in our work. The first is those who are known to be electro-hypersensitive, or EHS. This group is conservatively estimated to be 3-5% of the current population (Levallois, Neutra, Lee and Hristova, 2002; Schreirer, Huss and Roosli, 2006). EHS is a recognized, compensable disability in the Swedish health care system. Studies by medical researchers show that electrical hypersensitivity has a biological basis, however the syndrome is much more studied and accepted by researchers and doctors in Europe than in this country.

The Parliamentary Assembly of the Council of Europe, a branch of the European Parliament, passed Committee Resolution 1815 in May of 2011. Entitled, “The potential dangers of electromagnetic fields and their effect on the environment,” the resolution strongly urges sweeping reforms in the way governments, science, medicine, media and industry approach the issue of the adverse impact of electromagnetic fields on the health of all people from appliances, wireless devices and power lines that we are all exposed to in modern society.

The Council of Europe resolution sheds new light on the degree to which research and clinical experience is showing that long-term use of devices and appliances in common use as well as exposure to power lines do have adverse health effects even at exposure levels considered by governmental regulatory agencies to be safe. This is particularly true for the growing number of people in the world who are termed “electro-hypersensitve.” As an example with cell towers, the resolution urges recognition of these people and creation of areas within each country that are “wavefree.” Here is the actual passage in the resolution pertaining to the EHS:

“8.1.4. pay particular attention to ‘electrosensitive’ people who suffer from a syndrome of intolerance to electromagnetic fields and introduce special measures to protect them, including the creation of wave-free areas not covered by the wireless network;”

The full Council of Europe document can be accessed here.

Potential Health Effects from Long Term Exposure to Elevated AC Magnetic Field EMFs

Research showing adverse health effects from long term exposure to ELF, or Extra Low Frequency, Magnetic Fields from AC electric power lines at 60 Hz does exist, although it is not well known. Much doubt is cast upon research that does exist, that doubt coming in an orchestrated manner from the electric power industry (see links below for a discussion of this).

In our professional opinion and in the opinion of non-industry sponsored, independent researchers, primarily outside the United States, the evidence is sufficient to warrant prudent avoidance when possible with regards to long term exposure to AC magnetic fields and to all the types of EMFs that we evaluate and mitigate in our profession. That is the position adopted by the European Union, as demonstrated in the Council of Europe’s Committee Resolution 1815 noted above, and by other countries outside the United States.

The concept of long term exposure is important because many of these adverse health effects do not manifest immediately on the gross level, even though there are cellular changes right from the start. Many of us have clients within our practice who have actually contracted cancer from living in homes with elevated AC magnetic field levels in the Severe and Extreme Concern levels of 1-5 milliGauss (mG) and above 5 mG, respectively.

Most importantly, for all clients we deal with, the overarching consideration is for you to decide to what extent are you willing to risk your health by living in a home that has AC magnetic field EMF levels, or levels of any other type of EMF for that matter, within the Severe or Extreme Concern level. If you already have a chronic illness or are electrically hypersensitive (EHS), then you need to exercise caution and not choose to live in a home with anything but Slight or No Concern levels of EMFs (below 1.0 mG), virtually at all times. The same is true, in our opinion, if you have young children or the elderly living in your home or you are an expectant mother.

If, on the other hand, you are healthy to begin with and do not have any of the conditions listed above, then you have more latitude to choose to live in a home with EMF levels in the low end of the Severs Concern range (essentially in the 1.0-2.0 mG range), at least some of the time. You would be well advised, however, to reduce and eliminate all other EMFs that you do have control over so that you reduce your overall toxic load.

I would not, however, ever advocate that even a healthy person live in a home with EMF levels in the middle or upper end of the Severe Concern level (above 2.0-3.0 mG), and never in a home with EMFs in the Extreme Concern range (over 5.0 mG).

Using the Concept of Risk Ratio

It all comes down to risk ratio, or RR. This is the concept in medical research that an exposed group has an adverse health effect when exposed to a potentially harmful influence compared to a control group. If the exposed group shows no illness compared to the control group, the RR is 1.0. If the exposed group shows 50% more illness than the control group, the RR is 1.5. It is possible to have RRs even higher than 2, which means more than double the risk. The science of sampling is complex, and is explained on Wikipedia here.

You will see in articles linked to below that the risk ratio for exposure to AC magnetic fields above 1.0 milliGauss is above 1.0, based upon research not generally reported, known or accepted in the United States. As the EMF level increases, so does the risk radio. This means that your chances of developing cancer or some other disease goes up when living in these environments.

Of course, millions of people live in homes with elevated magnetic field levels who never develop outright disease, just as a certain percentage of people who chain-smoked in the 1950s, 60s and 70s did not go on to develop emphysema or die of lung cancer. However, the percentage of those who did was not 1-3%. It was substantially higher, and as the general public and health officials finally accepted the link between smoking and lung cancer over the decades, people stopped smoking and smoke-free public places came into being, despite the tobacco industry making claims to the contrary.

You have the same situation today with magnetic fields from power lines and exposure to radio frequencies from wireless devices and transmitters. You must decide how high you are comfortable having your risk ratio be for you and your family. That depends upon your general health and sensitivity to EMFs in the first place, and how healthy you want yourself and your family to be going forward.

Links to Websites with Research on the Adverse Health Effects from EMFs

To help you make that decision, I present links below to research on the proven adverse health effects of long term exposure to EMFs:

The first is links to information already presented above in this article, particularly including my explanation of the safe exposure guidelines for my profession and for governmental agencies around the world. You will see how much accepted safe levels vary from country to country. I discussed how these guidelines came into being and what my profession describes as possible health consequences from prolonged exposure to various EMFs at the exposure levels given.

Secondly, here are 17 research studies linked to on the page, “Evidence of Risk: Studies and Articles” written by Rob Metzinger on the website for his company, Safe Living Technologies (www.safelivingtechnologies.com). Rob is an Electronics Engineering Technologist, Building Biology Environmental Consultant, Electromagnetic Radiation Specialist based in Ontario, Canada, and principle co-teacher of the Institute for Building Biology and Ecology’s Basic and Advanced EMR

(electromagnetic radiation) seminars that I help teach. The links to research on the health effects of EMFs are found in the section entitled, “Extremely Low Frequency (ELF) Radiation”, accessed directly by clicking here. Rob teaches our students to follow the Building Biology Safe Evaluation Guidelines that I link to above and which can also be accessed here.

Third, here is a link to an excellent review article on research supporting our profession’s stringent EMF safe exposure guidelines written by the other principle teacher of our basic and advanced EMR seminars, Larry Gust (www.gustenviro.com). Larry is an Electrical Engineer, Building Biology Environmental Consultant, Electromagnetic Radiation Specialist, and president of the Institute’s board of directors. He is based in Ventura, California, west of Los Angeles. Larry specifically mentions research that indicate adverse health effects from long term exposure to AC magnetic fields at levels as low as 1-3 milliGauss. The adverse effects are discussed in terms of elevated risk ratio levels that range from 2 to 3.8 (double or more then triple). Click here to see Larry’s article.

Fourth, a good review of the potential adverse effects from living in proximity to power lines is written by an electrically sensitive person in England, Lloyd Burrell, on his website, (www.electricsense.com). Lloyd is a prominent EMF blogger who conducts numerous interviews with experts in the field of EMFs. The article contains links to research on the subject, accessed here.

Fifth, links to articles and studies on magnetic field EMFs from the website of The Swedish Association for the Electrosensitive can be accessed here.

Sixth, Microwave News posted an article on August 27, 2017 entitled, “Hiding in Plain Sight, Neglected Low-Level EM (Electromagnetic) Effects”. The article reports on the unsung work of researcher Abe Liboff, PhD, formerly of the Naval Medical Research Institute, New York University and Oakland University in Rochester, Michigan. Dr. Liboff proved that weak magnetic fields below 1.0 milliGauss (mG) interfere with DNA synthesis. The article says, “The results raised questions about the safety of power lines.” Dr. Liboff subsequently went on to show that cellular harm occurs from low level exposure to magnetic fields from a biological mechanism, not a thermal (heating) mechanism. Read the article here.

Lastly, a page on my own website, EMF Research Citations, lists links to articles on non-cell phone EMF issues, including magnetic fields from power lines. In particular, there are links to newspaper articles published in 2006 and 2007 on the controversy in England, when Oxford University studies showed a link between children living within 240 feet of power lines and an increased risk in the development of cancer. Link to the page here.

Presentation of Lectures on the Physiological Basis for Harm to Human Health from Exposure to EMFs

The building biology profession has held several conference in the past few years. We have had presentations by nationally renowned physicians and researchers on the health impacts of EMFs on the electro-hypersensitive population and on the public in general. Presenters have included Martin Blank, PhD and Martin Pall, PhD, among others. To view videos of presentations by these experts, click on the Building Biology YouTube channel here. You can also view videos on EMFs on the website for the Building Biology Institute, by clicking here.

A Physiological Basis for Electrical Hypersensitivity

Many people who suffer from a sensitivity to one or more types of EMFs have a hard time getting their family, friends and doctors to understand that their symptoms are real. Fortunately, researchers have established a physiological basis for electro-hypersensitivity as documented in the following publications:

- "Electromagnetic Hypersensitivity: Evidence for a Novel Neurological Syndrome," by Andrew Marino, PhD and his team at the Department of Neurology, LSU Health Sciences Center, Louisiana State University, Shreveport, Louisiana
- "The Biological Effects of Weak Electromagnetic Fields," by Andrew Goldsworthy

More recently, Martin Pall, PhD has conducted extensive research on voltage gated calcium channels, or VGCCs, as a mechanism for explaining why certain people are sensitive to EMFs while others are not. Dr. Pall discussed this in a lecture presented to the Building Biology profession at our gathering on Bainbridge Island, outside Seattle in 2015. That lecture is available on the Building Biology Institute YouTube channel. The direct link to the lecture is found here.

These electrically sensitive people all require a higher standard or threshold when deciding what a safe exposure level should be for any type of EMF. That also goes for anyone with chronic illness or those who are at high risk, including children, the elderly, and pregnant women. Electrically sensitive people cannot tolerate what otherwise healthy people can. They are at much higher risk for adverse biological effects according to extensive research and their own experience. For those reasons, we adhere more strictly to the safe exposure guidelines recommended by my profession for electrically sensitive people.

The other population we deal with is everyone else who is normally healthy and asymptomatic around EMFs. What is a safe exposure level for them? We generally recommend the same safe exposure limits we do for electrically sensitive individuals as a precautionary measure. Our goal is to protect people from possible harm if at all possible. The standards can be relaxed under certain circumstances, but as long as the individual is made aware of what the research shows and what the potential risks are shown to be, they can take their own measurements and consider those taken by building biologists and other EMF experts and decide for themselves what level of potential risk they are willing to expose themselves to on a long-term basis. Precaution is our primary goal.

Next we turn to how we protect ourselves from each of the specific types of magnetic fields.

Magnetic Fields from Outside Overhead or Underground Powerlines

Overhead transmission and distribution lines produce potentially significant magnetic fields due to the distance between conductors. There is no cancellation possible when conductors are separated several feet apart. Magnetic fields therefore extend in concentric rings equally in all directions for dozens of feet around each wire like a tube or tunnel.

These flux fields pass through virtually all building materials. The only materials capable of effectively shielding against magnetic field exposure are expensive nickel alloys used in the

aerospace industry and available from such retailers as Less EMF. Such materials do not eliminate lines of flux. They just compress them, and if the shielding is not wide enough, the lines of flux simply bend around the edges, so to speak, by propagating towards you from the edges of the shielding material.

Overhead or underground distribution lines carrying lower voltage can likewise emit strong magnetic fields throughout a neighborhood due to imbalances between loads carried on the hot and neutral conductors from so-called “pipe current,” discussed below. Governments around the world differ in how they are handling this issue. England has been grappling with implementing a moratorium on residential construction around existing powerlines and trying to issue a ban on constructing new powerlines near existing residences. Russia has reportedly banned powerlines in close proximity to residences for decades.

The best way in my profession’s opinion to protect yourself against magnetic fields from any source is to reduce or eliminate that source, if possible, or increase your distance, if reduction is not possible. With outside overhead or underground powerlines, the obvious solution is to increase your distance. When I measure virtually the same elevated magnetic field strength throughout a home, with only slight reduction as I move, for instance, from the front of the house to the back, the cause will be an outside overhead or buried powerline. I will find the same magnetic field strength levels outside the house, gradually increasing as I walk towards the source, just as is the case inside.

There is really nothing we can do about magnetic field levels above 1-2 milliGauss that come inside your home from powerlines. Having magnetic fields on the property that extend into the home forces you to make a decision as to whether or not you are safe from these elevated levels and whether that means you need to relocate. One always needs to consider the balance between constant exposure to what many experts, including my profession, consider to be a known source of biological harm versus your body’s particular ability to repair any cellular damage potentially caused by such a source. Many in the alternative medical community say this should include consideration of one’s heredity and family history of illness as well as your lifestyle, most importantly diet. Of course, you primarily need to consider whether you are healthy or already symptomatic in making your decision.

Magnetic Fields from Electric Current on Metal Water Service Supply Pipes

The cause of this type of magnetic field is electric current flowing in or out of your house on your incoming water service supply pipe, if it is metal, and/or your cable TV line from the electrical systems in your neighbors’ houses. This causes magnetic fields in certain places in your home, most notably from under the floor above a basement or crawl space. These paths can also run in walls and ceilings.

Ideally all electric current that enters the home on the hot conductors of the electric supply lines should leave the home on the neutral (return) conductor of the same electric supply lines. In actual fact, some of the return current also runs in and out of your home through a metal water service supply pipe and on the sheathing of the cable TV cable. This current then enters the homes of your neighbors via the metal city water main or cable company’s lines. These grounding paths therefore interconnect the electrical systems of each home up and down the street with each other, including yours.

When present, current flowing on these parallel paths results in an unbalanced load between the hot conductors compared to the load on the neutral conductor of the electric drop service line coming

into your house from the electric utility transformer. As noted above, some of this current is carried on the water pipes and the grounding conductor running in the slab or crawl space, and possibly in some of the interior walls and ceilings. It will also be carried on the electric drop service as it runs up the side of your house. All of this can create unhealthy magnetic field exposure in several rooms on the first and possibly second floors.

This is generally not a problem in most houses in Southern California, particularly in Orange County, because the water department usually installs a dielectric union (plastic ring) in the water line at the street to keep surges of electric current in one house from flowing on the metal water pipe to neighboring houses (not to reduce magnetic fields). Electric current on metal water pipes is a problem, however, in some houses in Orange County and many more in Los Angeles County and in other parts of the countryin in virtually every house supplied by city water.

Electric current can be measured as high as 1-2 Amps on the water service supply pipe and this current can potentially spread throughout the building on the water pipes and all other metallic paths, such as metal gas lines and metal air ducts. This can create unhealthy magnetic field exposure in different rooms in the building.

This is not due to improper grounding. Rather, it is a matter of electricity running on parallel paths in addition to the one and only path it should be running on, which is the neutral conductor of the electrical drop service. This results in unbalanced loads, which in turn causes a lack of the cancellation of magnetic flux normally found in circuits and plastic AC power cords where the hot and neutral conductors are side-by-side and have equal current. When that happens, you thus have equal but opposite magnetic flux size that produces no net current and therefore no magnetic fields.

Beyond the health implications, if the amount of electric current on an underground metalic water pipe or other grounding path is high enough, it can, in fact, create a violation of the National Electric Code (NEC). Specifically, electric current of a sufficient amount on grounding paths causes what is called “objectionable current on the grounding system,” which is specifically a violation of NEC Sections 250.6 and 250.142.

You can learn more about this specific code violation from electricians who have commented on this problem for years. Electrician Mike Holt, for example, has written articles on the subject, which you can read by clicking here.

When metal water pipes carry current, however, there is no cancellation because there is no other metal conductor laying right next to the pipe carrying the same amount of current in the opposite direction, as there is in circuits and appliance cords. Hence, you potentially have magnetic fields in amounts that our profession and others consider to be unhealthy.

“Knob and Tube” Wiring

So-called “knob and tube wiring,” used extensively throughout the country until the 1930s and 1940s, consists of individual hot and neutral conductors running through walls, basements and attics that are separated by a few inches. They were wrapped around ceraminc knobs nailed to floor joists when the wire ran along the joist, and fed through ceramic tubes when they ran through joists. This type of wiring, which still carries currents in homes built in that era, has two particular drawbacks. It produces high electric fields at all times, and it also produces high magnetic fields when current is flowing through the wires. This is because it does not allow the magnetic field around the neutral conductor to cancel the magnetic field around the hot conductor because of the separation. I will often measure magnetic field levels in excess of 10 mG within a foot or two of a wall containing

“knob and tube” wiring (when loads are on).

In the short term the solution is to be aware of the magnetic field exposure levels and how far they extend from the floors, walls and ceilings in which they are located so that you can minimize the amount of time you spend near these areas, again when lights and appliances are on. You can also keep the lights off most of the time and therefore not be exposed to this unhealthy influence when you walk by the areas in which the wires are located. The long-term solution, however, is to replace the knob and tube wiring with new wiring, preferably metal-clad. Doing so will also remove a significant source of markedly elevated electric field exposure, which is present whether loads are turned on or not (but disappear when you shut off the breaker). Knob and tube circuits are also ungrounded, so you will be fixing that problem (of not having grounded outlets), too.

Wiring Errors

We recommend that clients have their electric breaker panel and circuits evaluated for wiring errors. Wiring errors are another potential source of magnetic field exposure. They are caused by incorrect wiring practices that are inadvertent but common during the installation of electrical wiring, however long ago that occurred in the past. They also occur when new wiring is added, particularly by homeowners, electricians and handymen over the years who don’t follow proper electrical code.

Wiring errors cause parallel paths for neutral return current to flow, which causes unbalanced loads and therefore, magnetic field exposure along the route of the branch circuit(s) when electric loads are turned on. These fields extend out into occupied rooms from walls, ceilings and floors.

Magnetic fields, whether caused by wiring errors, power lines, current on grounding paths or point sources, create the most serious and detrimental effects on occupant health, in our opinion. These errors need to be traced and fixed to provide a healthy environment for clients, especially if you are EMF-sensitive.

Dirty electricity capacitor filters sold by Stetzer Electric and Greenwave, which we do endorse for the reduction of dirty electricity, are also known within our profession to aggravate the magnetic fields caused by wiring errors and current on grounding paths at the same time that they reduce dirty electricity. See below in the section entitled, “Wiring Errors and Dirty Electricity Capacitor (Stetzer and Greenwave) Filters”, for more information on this important use of dirty electricity filters and how to avoid this problem.

Wiring errors can be tested for at the breaker panel and if discovered, the source can be traced and repaired in the branch circuitry. We work in conjunction with electricians to guide them in implementing a protocol developed by our faculty, who are electrical engineers, to find and fix these errors.

To learn more about the detection and repair of wiring errors, I refer you to an excellent book written by Karl Riley, entitled, “Tracing EMFs in Building Wiring and Grounding.” Karl has also produced a 23-minute DVD for Southern California Edison showing how wiring errors are created and how to repair them. Both the book and DVD/video are available from Amazon by clicking here. You can also see the same video on YouTube by clicking here.

Karl Riley is a retired science teacher in North Carolina who joined a group of electricians who were hired to evaluate and mitigate elevated magnetic fields in schools in Northern California some decades ago. They found wiring errors in branch circuits as well as electric current on grounding

paths as the causes of the magnetic fields. These were violations of the National Electric Code. Tracing and repairing the wiring errors and current on grounding paths removed the magnetic fields.

Karl wrote about his experiences in his book, Tracing EMFs in Building Wiring and Grounding. The book is now in it's third edition. Karl was subsequently asked to join the National Electric Code (NEC) review committee. The NEC comes out with an updated version of their code book every three years, and Karl assists in that process. The NEC is followed by all city building departments in the US as the electrical code for new and remodeled construction. Some local jurisdictions add their own additional code requirements.

You can also view a video on identification and repair of wiring errors that Oram Miller recorded at the headquarters of the International Association of Certified Home Inspectors (InterNACHI). To view the video, entitled, "Common Wiring Errors That Imperil Health in Homes", click here and scroll down to Part 5. The video is part of an eight-part series of lectures on EMFs presented by Oram and his colleagues at the Building Biology Institute. To see the other videos, click here.

Wiring errors and electric current traveling on grounding paths that we find in single family homes, apartment buildings and condo buildings are all violations of the NEC.

You can read an article by Karl summarizing the information in his book. It is entitled, What Electricians Should Know About EMF.

That article provides a summary of the justification for how wiring errors are created and how they cause magnetic fields. All electricians and EMF consultants should know this information, as it is essential in detecting and mitigating some of the most common causes of unhealthy magnetic field exposure in homes and offices. Karl not only discusses the health implications of wiring errors, he discusses how they can also impact electronic appliances and possibly overheat conductors (wires in circuits), a potential fire hazard.

You can also see an excellent five-page summary of this topic in an article written by Karl, entitled, "Suggested Protocol for School Electricians for Correcting Wiring Errors Causing Net Current Magnetic Fields," previously published by the California Electric and Magnetic Fields Program (the funding for which unfortunately ended in the mid-2000s), available here.

Wiring Errors as Violations of National Electric Code (NEC)

In these articles Karl discusses how magnetic fields are created due to un-canceled magnetic fields from wiring errors and current flowing on grounding paths, such as water service supply pipes and cable TV cables, all of which are violations of the National Electric Code.

Neutral-to-Neutral Wiring Errors

In particular, neutral-to-neutral wiring errors are, according to Karl, a violation of two specific NEC Code provisions. The first is Section 300-303B, which states, "All conductors of the same circuit and, where used, the grounded conductor (neutral) and all equipment grounding conductors and bonding conductors shall be contained within the same raceway, auxiliary gutter, cable tray, cablebus assembly, trench, cable, or cord."

Furthermore, NEC 310.10(h) and 310.10(g) (in modern code books) states: "Conductors may not be paralleled, that is joined at both ends, so you can't join two neutrals at a junction box because they are also joined at the circuit breaker panel where they terminate at the neutral bus." and "when run

in separate raceways or cables, the physical arrangement must ensure that all phase conductors, neutral conductors, and equipment grounding conductors from each parallel set are grouped in the same raceway or cable enclosure to avoid dangerous inductive heating."

Stated another way, NEC Code Section 310-4 "prohibits connecting a neutral to another neutral such that a parallel return path to the panel is set up, unless the conductors are 1/0 or larger and meet exacting conditions." Circuits in most residential settings are not larger than gauge 1/0, and therefore this provision applies.

Neutral-to-Ground Wiring Errors

Likewise, current flowing on grounding paths are also National Electric Code violations, specifically Sections 250-24(a)(5) — 1999 and 250-61(b). Grounding paths include ground wires within metal-clad or plastic, non-metallic NM (Romex) wiring, or the metallic sheathing surrounding metal-clad circuits. They also include metallic grounding paths such as water pipes, natural gas lines, cable TV sheathing and the like.

In particular, Provision 250-24(a)(5) states, "Neutral wire (grounded conductor) shall not be connected to equipment ground wires or metal parts on the 'load side' at any point after the main service panel (containing the main disconnect switch)." Formerly this was 250-61(b). This is referenced here from the article, "Suggested Protocol for School Electricians for Correcting Wiring Errors Causing Net Current Magnetic Fields", by Karl Riley. Karl says sections 250-23(a) and 250-61(b) both, "prohibit connecting neutrals to ground on the load side of the service entrance".

Mike Holt, an electrician who writes a blog for other electricians, has written a comprehensive article on wiring errors, entitled, "NEC Article 250 — Sections 250.6 through 250.12". Others also include sections 250.142 and 250-24(a)(5). This includes NEC section 250.6, which involves what is referred to as "Objectionable Current Flowing Through The Grounding Path". That article is no longer available on Mike's website as a free-standing article, but likely appears as part of his 2023 Bonding and Grounding Video Program, available here or his 2023 Bonding and Grounding DVD Program, available here.

Unfortunately, many electricians do not follow these provisions because they are not taught that the magnetic fields that wiring errors create are important. Some electricians have created these errors unknowingly out of expediency as a short cut, not knowing they are also creating conditions that could cause adverse health risks for occupants, let alone potentially leading to conditions that in rare circumstances may cause a fire.

I have even been told by electricians that they have never heard of these provisions in the NEC when they went through training. I have asked why these provisions are even in the code book in the first place. I was told they prevent one of the potential causes of fire, albeit, a very obscure cause, way down the list of fire sources that electricians would be concerned about.

Secondly, the magnetic fields caused by wiring errors are known to interfere with the functioning of sensitive electronic equipment, such as computer monitors and servers. To us, it is odd that code inspectors, or whoever wrote these particular provisions in the NEC, would be concerned about the "health" of computer equipment but not the health of human occupants of buildings. However, for reasons discussed elsewhere in this article, it seems there is a tendency by some to not regard magnetic fields as a health risk.

We certainly disagree and feel magnetic fields do pose a significant health risk, even at levels about 1-2 mG. Several of us in the building biology profession have clients (and their pets) who have or

have had cancer who live in homes with high magnetic fields from wiring errors and current on grounding paths. While this is not a scientifically valid survey or sample size, it is nevertheless a correlation we have made in our practices that bears acting upon.

Likewise, electrical and home inspectors do not find these errors because, as Karl points out, junction boxes are not inspected and the consequences of wiring errors, mainly magnetic fields, are not considered important. Wiring errors must be looked for and corrected, if present.

Be aware that modern wiring generally does not have wiring errors since implementation in 2008 of the National Electric Code (NEC) requirement to install ARC-Fault breakers in most circuits.

Electricians understand that ARC-Fault breakers will trip the first time they are turned on if a neutral-to-neutral or neutral-to-ground wiring error exists on that circuit. They are learning to not create these errors in the first place to avoid spending time during an install fixing circuits with errors.

There are only two causes of wiring errors in modern wiring, which will not trip an ARC-Fault breaker.

The first is incorrectly wired three-way switches, in which a 12-2 circuit is used for the travelers, meaning, the neutral wire is used as the second hot traveler, with no neutral. The returning load from the switch leg to the lighting load is then connected to the neutral of a completely different circuit at the second three-way switch (not where the power comes to the travelers). This causes a large loop of current in the house and a magnetic field when the lights are turned on, as there is no cancellation of magnetic fields on the hot and neutral wires. The solution is to use a 12-3 circuit in the first place for travelers and keep the return current on the neutral of the travelers, not connecting it to the neutral of another circuit.

If a 12-2 circuit is being used as a traveler, you will have to abandon one of the three-way switches, disconnect the lighting load neutral from the other circuit’s neutral, and turn the lighting circuit into a simple circuit controlled by a single switch.

The second wiring error that can take place in modern wiring with ARC-Fault breakers occurs when the neutral wire of a switch leg is connected to a different neutral than the neutral accompanying the hot wire in the circuit that carries the current to the load in the first place. This, too, will result in a large current loop in the house with no cancellation of magnetic fields between the hot and neutral. The return current must be solely on the neutral that accompanies the hot wire carrying the load and not on any other path, either shared or exclusively.

Wiring Errors and Dirty Electricity Capacitor (Stetzer and Greenwave) Filters

One important final note. If you ever install Stetzer or Greenwave dirty electricity filters, which are capacitors and the use of which we endorse, it is imperative to find and repair all wiring errors first. This is because capacitor filters can unfortunately aggravate the magnetic fields that wiring errors and current on grounding paths create. That means that in the process of reducing one type of EMF, namely dirty electricity (or, as we in the building biology profession now call it, microsurge electrical pollution, or MEP), capacitor filters can also aggravate another type of EMF, namely, magnetic fields if wiring errors are present.

We therefore recommend testing for and repairing any wiring errors before inserting dirty

electricity filters, then continue to use your Stetzer and Greenwave filters for the benefits that they provide, namely reduction of “electro-pollution” caused by harmonic frequencies of 60 Hertz, the frequency of AC electricity in house wiring. (Also, plug-in and in-line whole house dirty electricity-reduction PxDNA and RxDNA technologies such as from Noble Electronics do not use capacitors and therefore do not aggravate magnetic fields caused by wiring errors. However, the magnetic fields from wiring errors are serious enough that you always want to trace and eliminate them regardless of whether or not you also mitigate dirty electricity.)

Current on the Cable TV Grounding Wire

Another potential source of electric current flowing into a house is on the grounded portion of the incoming cable TV wire, and it can also be easily fixed. Even if you don’t have active service at this time, this current path can still exist as long as the cable is still installed and connected outside to the utility at the pole or underground.

This current flows because the cable TV wiring is connected at the utility pole (or ground level green cable box out near the street) to the streetside electric utility grounding system, which also carries current on it. This current then jumps onto the electrical system in your house whenever you plug in a DVD or VCR player that has a grounded (three-pronged) plug on it and it has a cable TV cable connected to it. You will notice that television plugs are never grounded for this reason, so they do not pass on current from electricity on the ground of the cable TV cable.

This current can create magnetic field exposure in the rooms beside and above the route of the circuit from the circuit breaker panel to the outlet in the room that the DVD player is plugged into. It is best to check for the cable TV cable as another path for electric current and magnetic field exposure, particularly after the current has been removed from the water pipe.

The best solution is to install a cable TV ground loop isolator in the cable TV cable on the street side of the ground connector.

Note: All of these Ground Loop Isolators will require one Male-to-Male “F” Cable Coupler, available from Radio Shack by clicking here or from Amazon here.

Purchase a Holland Cable Isolator with Spike Protection (CISP) for $13 from Tech Tool Supply in Michigan, 877-208-6657.

“Point Sources” of Magnetic Field Exposure

Finally, so-called “point sources” of magnetic field exposure also exist throughout most homes, particularly in bedrooms, a home office and kitchen. Elevated magnetic field levels can be measured within one to two feet of all transformers. Transformers are required to step “line voltage” of 120 Volts from electric outlets down to lower voltages, such as 12-14 Volts, to run circuit boards within all electronic appliances. These include printers, laptop computers, modems, computer speaker systems, and LCD (liquid crystal display) electronic clocks.

These transformers are also found inside the cabinet of electronic appliances when the cabinet is big enough to house them, such as a computer tower (central processing unit, or CPU), monitor and even electric clock radios. Therefore, there is a magnetic field extending out one to two feet from the back of these cabinets where the electric power cord attaches to the appliance.

On the other hand, when the cabinet is small enough, the transformer is housed in a small, square box that is plugged directly into an outlet, often on a surge protector or power strip. That power strip, loaded with transformers, is usually located right at people's feet at their computer workstation, and should be moved a few feet away from any part of your body. You may also have an in-line free-standing transformer for some of your electronic devices, such as laptop computers and printers. These, too, should be moved several feet away from your toes. This is also discussed in the section on Safer Use of Computers.

Specifically, you will have magnetic fields created by the transformer in an electric clock radio, although it only extends out about one to two feet at most. Whether you keep the electricity in the bedroom on at night (due to metal-clad wiring in your walls) or shutting off circuits because they are plastic-jacketed, you will need a battery-powered clock, which does not produce harmful magnetic field exposure. You will not want to keep the digital clock radio near the bed with metal-clad wiring in the walls, even if you move the clock away, because you will not want the electric field exposure from the unshielded AC power cord of the clock.

Electrically-powered clocks with analog hands on a clock face, as opposed to digital, have a very large magnetic field, extending three to four feet, well onto your pillow, from the electric motor that moves the clock hands. This type of electric clock should never be on a bedside table.

In your kitchen you will have magnetic field exposure right next to and behind your refrigerator when the electric compressor motor is running. For this reason do not sit or sleep on the other side of the wall from a refrigerator. You will also have smaller magnetic fields from the transformers in digital clocks throughout the kitchen, but they only extend out a foot or so. Avoid standing next to a stovetop that has a digital clock and controls at the front, right in front of your abdomen. This is not healthy and should be avoided.

Click here for recommendations on avoiding point sources of magnetic field exposure at your computer workstation.

*To view an extensive **list of links** to web sites documenting the health effects of exposure to EMFs caused by wireless devices, including cell phones, cordless telephones and wireless Internet (Wi-Fi) routers, click here.*

*To learn about **Smart electric meters**, click here.*

*To view an extensive **list of links** to web sites documenting the health effects of exposure to EMFs in general, click here.*

*To return to the **main Articles on EMFs page,** click here.*