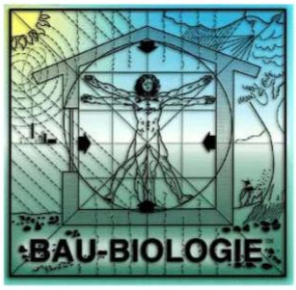
International Institute for Bau-biologie® & Ecology

IBE 206.2

IBE 206.2 Electrical Home Wiring

BRINGING TOGETHER TECHNOLOGY AND DESIGN METHODS TO PROVIDE THE INFORMATION NEEDED TO CREATE HEALTHY HOMES AND WORKPLACES



Electrical Home Wiring – IBE 206.2

Welcome

Thank you for choosing IBE for your educational needs. Current environmental realities demand a new approach to ensuring that our homes, schools and office buildings support the health and wellness of all who dwell there. We strive to provide the latest information and cutting edge methodology on the vital, complex relationship between the natural and the built environments. May you find your educational experiences enlightening, and take this knowledge out into your community for the benefit of all. **Michael Conn**, *Executive Director*, Institute for Bau-Biologie & Ecology.

Course Navigation

You will find that it is very easy to navigate through this course.

- Progress through the lessons using intuitive navigation tools. When you study, make sure to be aware of and use all supporting materials, such as pdf files, video and audio clips, links to other websites or relevant articles or papers, as well as the online forum.
- The last lesson will give you the option of downloading an electronic version (PDF) of the course. Please be aware that this information is copyright protected.
- When finished, you will be ready for the test. These tests are "open book" and are designed to help you evaluate your understanding of the subject.
- When you have finished the entire Course Pack, a Certificate of Completion is available on-line.

By using the Forum feature, students can share information and solve problems. We would like to see truly interactive discussions take place.

Please be advised that links to third party information may not reflect or support the Building Biology viewpoint. However, it might be of some interest to see how other people, groups, institutions, etc. argue the same subject.

Copyright

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Lesson 1 – Standards of Building Biology Testing Methods

This unique standard gives an overview of the risk factors encountered in sleeping areas, living spaces, workplaces and properties. It offers guidelines on how to perform specific measurements and assesses possible health risks. All testing results, testing instruments and testing procedures are documented in a final written report. In case potential problems are identified, an effective remediation strategy is presented. The various items of the standard deal with environmental factors, that can pose a health risk to indoor living. It is the goal of the suggested building biology testing methods to offer a professional and holistic testing protocol according to which achievable reduction or elimination strategies can be developed.

The accompanying Building Biology Guidelines for Sleeping Areas were first published by Baubiologie Maes between 1987-1992 in cooperation with the Institut für Baubiologie und Ökologie Neubeuern IBN, and with the support of scientists, medical doctors and building biology consultants. The Standard (SBM 92/5) was issued for the first time in May 1992, the fifth revision followed as SBM-2000 in May 2000. The most current Standard was published as SBM-2003 in May 2003. Since 1999 an expert panel is responsible for maintaining and updating the Standard including the Guidelines and specific testing protocols. The members of the panel are as follows: Dr. Thomas Haumann, Dipl-Ing. Norbert Honisch, Wolfgang Maes, Dipl.-Ing. Helmut Merkel, Dr. Manfred Mierau, Uwe Münzenberg, Peter Sierck, Dipl.-Chem. Jörg Thumulla and Dr. Martin Virnich.

A. Fields, Waves and Radiation

1. *AC Electric Fields (ELF):* Measuring the ELF electric field strength (V/m), the human body voltage in the electric field (mV) as well as the dominant frequency (Hz)
   Sources: AC voltage in cable, wiring systems, appliances, walls, floors, beds, high-tension power lines
2. *AC Magnetic Fields (ELF):* Measuring and data logging of the ELF magnetic flux density (nT or mG), the dominant frequency (Hz) as well as the field line distribution
   Sources: AC current in wiring systems, appliances, transformers, motors, overhead or ground cables, railways
3. *Electromagnetic Waves (RF):* Measuring and data logging of the pulsed and non-pulsed high frequency electromagnetic power density (mW/m^2) as well as identifying ELF modulation
   Sources: radio and TV towers, cellular phone technology, wireless networks, cordless phones, radar, military applications, electronic devices
4. *Static Electric Fields (DC):* Measuring the surface potential of static electricity (V) as well as discharge time(s)
   Sources: synthetic carpeting, drapes and textiles, vinyl wallpaper, varnishes, laminates, TV or computer screens
5. *Static Magnetic Fields (DC):* Measuring the static magnetic flux density (mT) and deviation of compass needle (^{o})
   Sources: steel in beds, mattresses, furniture, appliances, building materials, DC current in street cars
6. *Radioactivity (Gamma Radiation & Radon):* Measuring the equivalent dose rate (nSV/h, %) and radon concentration (Bq/m^3)
   Sources: building materials, stones, tiles, cinders, waste products, devices, ventilation, terrestrial radiation, location
7. *Terrestrial Radiation:* Measuring the magnetic field (nT) and radioactivity (ips) of the earth as well as respective disturbances (%)
   Sources: electric currents and radioactive substances in the earth; disturbances caused by faults, fractures, underground water courses
8. *Sound & Vibrations (airborne and sound conducted through solids):* Measuring noise level, infrasound, ultrasound and vibrations (dB, M/s^2)
   Sources: traffic noise, air traffic, train traffic, industry, devices, machines, motors, transformers, sound bridges

B. Environmental Toxins, Poisons, Indoor Climate

1. *Formaldehyde & Other Toxic Gases:* Measuring formaldehyde, ozone and chlorine; industrial pollutants, natural gas, carbon monoxide, nitrogen dioxide and other combustion gases (ppm, mg/m^3)
   Sources: varnishes, glues, particle board, wood products, furnishings, devices, type of heating, gas leaks, exhaust fumes
2. *Solvents & Other Volatile Organic Compounds (VOC):* Measuring volatile organic compounds (ppm, mg/cm^3) such as aldehydes, aliphates, cycloalkanes, alcohols, amines, aromatic compounds, chlorinated hydrocarbons, esters, ethers, glycols, isocyanates, ketones, terpenes
   Sources: paints, varnishes, adhesives, synthetics, particle board, building parts, furniture, cleaners, furnishings
3. *Biocides & Other Semi-volatile Organic Compounds (SVOC's):* Measured are semi-volatile organic compounds (mg/kg, ng/cm^3) such as pesticides, insecticides, fungicides, wood preservatives, fire retardants, plasticizers, pyrethroids, PCBs, PAHs, dioxines
   Sources: wood, leather and carpet protections, adhesives, plastics, sealers, moth-proofing agents, pest-control agents
4. *Heavy Metals and Other Inorganic Toxins:* Measuring inorganic substances (mg/kg) such as heavy metals, metal compounds, salts
   Sources: wood preservatives, building materials, building moisture, PVC, paints, glazes, plumbing pipes, industry, environment
5. *Particles and Fibers (Dust, Suspended Particles, Asbestos, other Mineral Fibers):* Measuring dust, number and size of particles, asbestos, and other fibers (/cm^3, /l)
   Sources: aerosols, smoke, soot, dust, building and insulating materials, heating and air-conditioning and heating systems, insulation, appliances, ventilation, environment
6. *Indoor Climate (Temperature, Humidity, CO_2, Air Ions, Smells):* Measuring air temperature (^oC), air humidity (% r.h., a.h.), oxygen (vol. %), carbon dioxide (ppm), air pressure (mbar), air movement (m/s) as well as small ions (/cm^3) and air electricity (V/m), identification of odors and determination of air exchange rate
   Source: building moisture, ventilation, heating, furnishings, breathing activity, static electricity, electromagnetic radiation, dust, environment

C. Fungi, Bacteria, Allergens

1. *Mold (Spores & Metabolites):* Measuring and identifying of culturable and non culturable fungi, their spores (/m^3, /dm^3, /g) and metabolites (MVOC and mycotoxins)
   Sources: moisture damage, heat bridges, building material, ventilation, air-conditioning, furnishings, environment
2. *Yeast and Their Metabolites:* Measuring and identifying yeast-like fungi (/m^3, /dm^3, /g) and their metabolites
   Sources: moist areas, hygiene problems, food storage, garbage, appliances, furnishings, environment
3. *Bacteria and Their Metabolites:* Measuring and identifying bacteria (/m^3, /dm^3, /g) and their metabolites
   Sources: moisture damage, waste water damage, hygiene problems, food storage, garbage, environment
4. *Dust Mites and Other Allergens:* Measuring number and feces of dust mites, pollen, grasses, animal hair (/m^3, /dm^3, /g)
   Sources: dust mites and their metabolites, hygiene problems, house dust, humidity, ventilation, environment

The following measurements can also be part of a *Building Biology Survey* : light quality, lighting intensity and UV exposure, potable water quality, testing of building materials, furniture and other furnishings, as well as for home and wood pests.

May we direct your attention to the accompanying **Building Biology Guidelines for Sleeping Areas**, which have been developed especially for monitoring long-term risk and the delicate time of regeneration. The focus in the evaluation process is based on experience, prevention and the achievable.

Lesson 2 – Overview of Electrical Home Wiring

In most of the Western world, homes not only offer the convenience of running water but also the luxury of electricity. Electric kitchen aids help us prepare our daily food, electronic office equipment assists us in managing the ever-increasing load of information, and communication tools give us the opportunity to stay in touch with the rest of the world. Electricity is a hallmark of industrialized societies. We cannot and will not imagine life today without electricity.

It all began with a small, first-power distribution system in New York back in 1884, but now the entire country is covered with a network of power lines and steeped in its buzzing sound – mostly inaudible to the human ear. Today we have so many users that the broad electromagnetic spectrum seems to have run out of space. In order to ensure that all the different electrical appliances and electronic devices can run simultaneously without impeding each other's function, the Federal Communication Commission (FCC) issues rules and regulations regarding their electromagnetic compatibility (EMC).

Unfortunately, the thinking stops there. Biological systems were never included in this equation. Current textbooks on electricity and electrical installations always cover extensively the issue of electromagnetic interference (EMI) among devices, but they hardly touch on the biological compatibility of those technologies.

Since the overall electromagnetic background noise is steadily increasing, it is not unusual to find shielded and isolated ground systems in, for example, sensitive data processing applications to ensure an uncorrupted data transfer. But it seems to be quite a novelty to ask for the same kind of protection for humans. Residential homes in the immediate vicinity of a huge radio telescope in Penticton (Canada), for instance, are required to use armored cable (BX) so that the functioning of this sensitive research tool is not interfered with by ambient electromagnetic noise. Nobody seems to care about the inhabitants themselves.

Thus it does not come as a surprise that only very few electricians consider a shielded, low-EMR wiring system for homes. In most cases, the functionality of the wiring system and its compliance with official rules and regulations are given priority.

On average, a modern home wiring system consists of about 20 electric circuits and 80 outlets (without electric heating) plus the myriad of electric appliances and electronic devices used on a daily basis. The belief that low-level electric, magnetic and other electromagnetic fields, such as those emanating from electric home wiring systems and common appliances, have biological effects is an established scientific fact . The “only” question that remains is how great and how harmful those health effects are, especially in the long run. Since technical advancements tend to develop much faster than the scientific research proving their safety or harmfulness, the following discussion is based on the motto: Prevention is better than a cure!

Footnotes

Auctions of licenses for the use of the electromagnetic spectrum are facilitated by the Federal Communications Commission (see Auctions of licenses)
FCC Rules & Regulations
National Library of Medicine

Physics of Electromagnetic Radiation

In this Course, we will discuss the essential components of a low-EMR electric home wiring system:

- proper earthing system
- low-EMR wiring layout design
- shielded and twisted cables
- wiring-free walls
- demand or cut-off switches
- low-emission electric appliances and electronic devices

All modern homes have at least one room with either elevated AC electric or magnetic fields. Alternating magnetic fields are not easily shielded. And the shielding of alternating electric fields is not given any attention. The actual field strength and spatial distribution of the various alternating electric and magnetic fields associated with home wiring systems depend on the intensity of the voltage, the current flow, the type of cables and appliances, as well as the building materials.

The combined experience of a qualified electrician and a building biology testing specialist provides the necessary knowledge for a low-EMR home wiring system. When all concerned parties work together as a team, it is possible to create a wiring system that not only meets all electrical code requirements, but even exceeds them as it offers a healthy indoor environment with low-level electromagnetic radiation.

In order to benefit from this Course Pack, a basic understanding of the physics involved, as discussed in the IBE 204.3 Electromagnetic Radiation, (EMR) is necessary.

Load and Voltage of the Electric Power System

Before taking a more detailed look at the major components of the electric home wiring system, it is helpful to understand how electric power is supplied to a residential home. Electric power facilities use various voltage levels to distribute electricity economically.

Transmission Level

(Transmission networks from power plant to sub-transmission level or very large customers)

Extra high voltage 300 - 765 kV
High voltage 100 - 300 kV

Sub-transmission Level

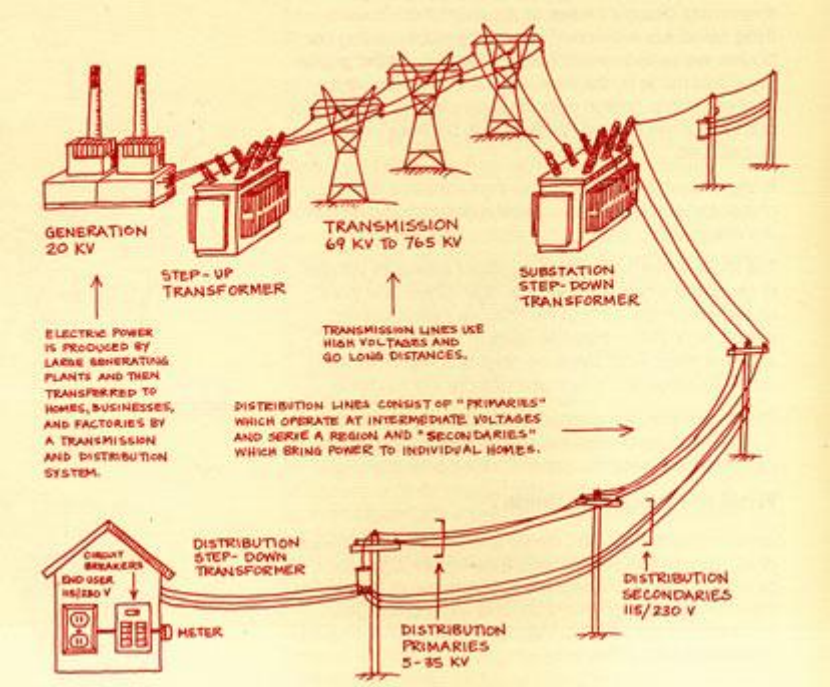
(Sub-transmission networks to substations or large customers)

Some high voltage 100-300 kV
Mostly medium voltage 1-100 kV (but typically only 5-15 kV)

Local Distribution Level

(Distribution networks from substation to small customers and residences)

Medium voltage 1-100 kV
Low voltage 120 or 240 V



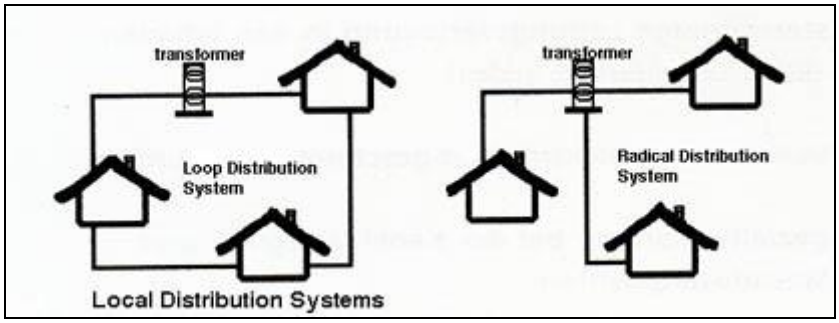
With permission of Professor M. Granger Morgan, Carneigie Mellon University.

The electric power generated in a power plant is transmitted over long distances before it reaches the end user, ideally with as little power loss as possible. This is accomplished by transforming or stepping up the voltage as the power leaves the power station. In North America and some European countries power is stepped up to a high voltage of 765 kV, in Germany usually to 220 kV or 380 kV, and in Russia up to 1,200 kV.

Once the power has reached its target area, the voltage is stepped down to a medium voltage between 33 or 66 kV for the sub-transmission network. These lines finally terminate into a substation.

At the substation the electric power is transformed even further, down to about 11 to 16 kV. From there the local distribution network sends the power to the end user, mainly overhead, but also underground. However, before it reaches the residential consumer, it is stepped down one final time to a low voltage of 120/240 V.

The local distribution network comes in two major configurations: the network forms either a loop or a radial pattern. Unfortunately, loop distribution systems can contribute to quite high AC magnetic fields in large areas of a subdivision.



In European countries, railway systems run with a voltage of 15 kV at 16.7 Hz and the accompanying distribution system operates with 110 kV at 16.7 Hz.

Lesson 3 – Design Criteria for Low Radiation

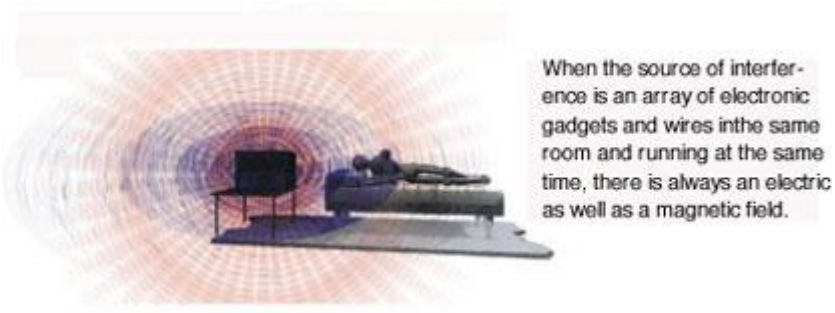
Homes and Workplaces

The goal of a low-EMR wiring system is to keep the exposure to undesirable human-made electromagnetic radiation as low as possible. In building biology, the smart use of power is not limited to making energy-efficient choices. It extends to eliminating or reducing unnecessary electromagnetic stress by following smart wiring practices. The construction of a new home offers the unique opportunity to incorporate building biology principles for a low-EMR design right from the start. Any renovation or alteration always has the potential for major improvements.

Home wiring systems are designed to protect users from electric shock and fire hazards. The National Electrical Code and local code requirements are written to achieve this end. Since those rules are not concerned with the biological effects of exposure to electric, magnetic and radio frequency fields, it is worthwhile to go beyond them. With rather little effort, simple precautionary steps (for example, cutting-off power and shielding wires and paying attention to detail during installation) can be implemented to protect you from permanent exposure to low-level radiation. The following points should be considered in electric home wiring systems:

- Hook-up to a suitable electric service (preferably to a TT or TN-S Power System)
- Proper equipotential bonding
- Proper grounding system (less than 5 ohm resistance to ground)
- Star-like or radial wiring pattern throughout the house (no ground loops)
- Installation of electrically-shielded cables
- Strategic design of wiring layout and outlet arrangement
- Power cut-off options for the entire house or selected rooms
- Installation of switchable circuits and outlets
- Creation of field-free zones for dining, rest and sleep
- No permanent RF transmitters within one's home
- Conscious placement of electric appliances, preferably with low-emission rating
- Testing of the system after installation to assure correct performance

In those places where we spend most of our time, we should avoid exposure to power frequency fields. This is especially desirable for sleeping areas, desk spaces and workplaces. All wiring, lighting and electronic equipment in close proximity to a person should be shielded – especially in the bedroom. If this is not feasible, it is highly recommended to cut off as many electric circuits and devices affecting the selected area as possible. During sleep the human body is particularly vulnerable to stressors of external electromagnetic origin.



When the source of interference is an array of electronic gadgets and wires inthe same room and running at the same time, there is always an electric as well as a magnetic field.

Yet most frequently it is the sleeping area where people unknowingly try to rest their tired heads against highly radiating walls. This all too common scenario can be caused by a single source, or a combination of the following: an electric water heater, freezer or stereo system right behind the wall of the bedroom; an electric main panel in the same room or on the other side of the wall; unshielded wiring inside the walls; two-conductor wiring for three-way switches; bundles of extension cords underneath the bed; and/or wiring errors causing unintended current flows.