THE PLANETARY ASSOCIATION FOR CLEAN ENERGY, INC.

SAFE BUILDING ELECTROMAGNETIC FIELD DESIGN GUIDELINES

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Introduction to guideline norms

In the last 3 decades, the scientific community has begun to study the various effects on living organisms of both magnetic and electric fields.

From this research we know that, generally speaking, long-term exposure to weak magnetic fields (from around 1 milliGauss or 0.1 *micro*Tesla) affects cells, tissue, glands, genes and muscles, both in positive and in negative ways, depending on such factors as frequency, intensity, randomness of emission, duration and waveform. We also know that long-term exposure to weak electric fields (from around 6 Volt/metre) tends to affect the nerve system, including our skin. As the waves become shorter in length in accordance with the increase in frequency, so the electric and magnetic fields become less important – as separate vectors - for the study of biological effects and so scientists focus on their *combined* effect – that is, their *total power* – to determine the rate of absorption by the human body. This is reason why standards associated with cellular phones and microwave ovens, for example, discuss the level of power. Their effects are for both tissues, nerves and systemic.

Unabated concern by the public has resulted in major health assessments by several governments, such as the major US **National Institute of Environmental Health** review (also known as the ***US EMF RAPID***) and which have led to spin-offs, including from the **World Health Organization**. After reviewing more than 2,000 reports, an international working group of scientists, researchers and public health policy professionals (***BioInitiative***) has released its comprehensive report on August 27, 2007 as an alternative to the ICNIRP/WHO guidelines. The *BioInitiative* recommends 1 mG for inhabitable space adjacent to all new or upgraded power lines and 2 mG for all other new constructions. (www.bionitiative.org).

The **European Parliament**, following up on the *BioInitiative* report on EMFs, has voted 522 to 16 to recommend tighter safety standards, stating, “The limits on exposure to electromagnetic fields which have been set for the general public are obsolete.” In February 2009, the European Parliament **Committee on the Environment, Public Health and Food Safety** voted 43 - 1 to recognize this objection [i]

Addressing the question of radiofrequency/microwave wireless technology emissions, **Dennis Kucinich**, US Domestic Policy Committee Chairman wrote to **Kevin Martin**, FCC Chairman on Nov. 3, 2008, “The NAS Report support the NTP’s conclusion that the research record upon which FCC’s RF Safety Guidelines are based does not adequately safeguard the public from non-thermal chronic exposures” *The Bamberg Appeal,* sent to President Obama February 12, 2009 states, *“*Since immediately, after digital television stations had started transmitting, adverse health effects have occurred, the review of the Guidelines announced by the ICNIRP is imperative.”

There are 2 recent landmark rulings**:** in France, a power company was ordered to compensate cattle farmers for EMF damages to animals. On November 14, 2008, **Agence France Presse** reported*,* "In ordering the management of **RTE** (responsible for the distribution of electricity) to pay almost 400,000 Euros to cattle farmers, the courts have established for the first time that there is a link between the effects of electromagnetic radiation from a very high voltage power line and symptoms of diseases among animals" Similarly*,* telephone company **Bouygues Telecom** was ordered on February 4, 2009 by a Versailles appeals court to dismantle cellphone towers in the Lyons area on the basis of the ***Precautionary Principle*** and the potential health risk for nearby residents. The ruling is significant because it draws on research such as the *BioInitiative report* as well as doctors' Appeals of Salzburg (Austria), Freiburg and Bamberg (Germany) and Helsinki (Finland). (http://www.powerwatch.org.uk).

For the 60Hz powerfrequency, an exposure to 0.60 milliGauss results in no known deleterious effect in contrast with general population statistics. Yet hypersensitive individuals, who now account for almost 20% of the population in Canada can accurately identify and describe the sensation of field of lower intensities, whether consciously or to physically respond to such unconsciously. Epidemiological studies indicate at long-term and chronic exposure of 1 mG (experienced during sleep, at work and in schoolrooms), serious health risks commence. Risk appears to escalate proportionally with higher intensity to the degree that the **WHO** determined that 4mG is a too high level, while the standard-setting authority, the US **National Council on Radiation Protection and Measurement** proposed in 1995 that eventually no federally funded day-care centre, school, playground and housing should have fields higher than 2mG. Individuals who are more susceptible to adverse health effects from continuous exposure to levels ranging from 1 to 2mG are the foetus, young children, pregnant women, those who are already ill, the elderly and the hypersensitive.

Fortunately, for the powerfrequency, good architectural design practice & observance of the ***Electrical Code*** makes it possible to achieve magnetic fields lower than 1mG in most zones of long-term human occupancy. Unfortunately, few designers and fewer electricians know how to apply judicious wiring and localization protocols. These errors by omission or by lack of training have cause Canadian buildings to have generally the most elevated powerfrequency magnetic fields in the world, often higher than the 4 mG barrier proposed by the **WHO**, twice the US indoor environment and about 10 times that of the European Union, as determined by both 1996 **Canada Mortgage and Housing Corporation** and 2008 Montreal ***Protégez-Vous*** studies (Appendix).

Electric fields in Canadian buildings are generally lower than the safe level of 6 Volt/metre. But there is an exception to this rule, and this exception affects probably three-quarters of Canadians. It is the site of our pillow on which we rest our precious heads everything we sleep! This oversight is the result of the frequent placement of wiring in the wall at the head of bed sites, in addition to the generally inadequately wire gauge insulation in most lighting fixtures usually chosen near our beds. Already at 10V/m, electric fields aggravate sleeping patterns, leading to chronic fatigue and general weakening of the body's defence.

This problem is easy and inexpensive to solve – either by re-arrangement of the wiring, or by shielding with appropriate plastic, rubber, metal sheeting next to the head of the bed. According allergy specialists, chemically sensitive individuals are usually electrosensitive, whether they are aware of it or not; they may demonstrate greater irritability/hyperactivity when exposed to even very low electric field intensities and associated “noise”.

Though radiofrequency and microwaves are very easy and inexpensive to shield – any appropriate meshing adapted to the size of the wavelength in question – from non-plastic chicken coop mesh to mosquito meshing, much like the devices used in microwave oven doors - these fields also present unique design considerations. For example, metallic frames of doors and windows act as condensing lenses for incoming microwave signals. Such focusing can easily magnify an altogether safe microwave front into a concentrated beam that may exceed ***Canada’s Safety Code 6*** standards for this bandwidth. This phenomenon is particularly relevant in buildings near cellular phone antennae, radar installations and police and taxi radio transmitters. That is not so rare these days as many hospitals and apartment blocks, because their prominence in the urban skyline lease their roofs for such microwave transmitting devices. Though it is true that one of the safest places is to be directly underneath a transmitter, it is also true that the most dangerous may be right next to it, especially with the optical magnification into a bed, or into a seat! Satellite dishes, by the very nature of their parabolic magnification design and their antenna function, capture and focus bands of electromagnetic emissions within line of sight and then dump this broadband spectrum field directly underneath. If the satellite embraces an electric distribution line, for example, this powerfrequency will be focused directly below, sometimes with a 10-fold magnification. It is not a good idea to occupy such a location for extended periods of time.

About 2/3 of elevated fields found indoors are caused by errors with indoor wiring and the electrical grounding system we employ in Canada. Only when outdoor fields are prevalently over 2 mG (e.g.: where a transmission/distribution line overwhelms the environment surrounding a building - from above, sideways, and in a certain degree, even at ground level), there is basically nothing one can do inside the structure to reduce fields to less than 2mG, except the distance factor - not necessarily an option.

Electromagnetic Field
Intensity guidelines
(for long-term exposure)

	50/60 Hz magnetic	**50/60 Hz electric**	**Radio- & microwave**
no known symptoms *some individuals sensitive to these intensities)*	0.65 milliGauss	6 Volt/metre	0.01milliWatt/cm^2
health problems increase *(epidemiological studies indicate risk of cancer and other diseases begin to increase 2 to 3 times at this range)*	1.00	10	0.025
adverse health problems start *(hazard to health increases proportionately -- up to 35 times greater risk to cancer and other diseases reported)*	2.00 +	15 +	0.065 +

Guidelines were developed in 1989 by Dr. **Jerzy Kulczycki** in *Basis of electromagnetic hygiene* after a review of international medical research. Grading is based on epidemiological correlation between the incidence of cancer, leukemia and tumours in children and adults and power lines as well as effects on cell tissues subjected to powerline (50 / 60Hz) frequency characteristics and to radiofrequency/microwave emissions.

In June 1995 the United States ***National Council on Radiation Protection and Measurement*** *(**NCRP**) released a draft report, after 9 years of deliberation that provides a guideline of 2 mG (200 nT) exposure limit for the U.S. population. It would take immediate effect for new federally-funded day-care centres, schools and playgrounds as well as for new transmission lines near existing housing.*

Electromagnetic Field
Symptoms guide

50 / 60 Hz magnetic fields:
Weakened immune system, endocrine disorders, unrefreshing sleep, leukemia, accelerated cancer.

50 / 60 Hz electric fields:
Multiple allergies (and "electrosensitivity"), skin and nervous system disorders, decrease in lymphocytes.

Radiofrequency & microwave:
Mental disorientation, speech difficulties, reflex and reaction-time alterations, accelerated visual loss and cataracts, neurovegetative disturbances.

Should you note such symptoms and cannot find a plausible cause-effect relationship for the individual involved, consider the possibility of an electromagnetic origin. A proper electromagnetic survey may confirm the source of the difficulty by matching lifestyle with exposure conditions. Sometimes the dealing with the electromagnetic source(s) may remove the symptom.

Safe building electromagnetic field design considerations

There exist design considerations and challenges for specific type of structures. It is possible to address potential electromagnetic field exposure issues at the building design stage in order to significantly reduce and minimise occupant exposure at relatively little cost, especially during the planning and design stage. Designers and contractors should ensure that at each stage of construction or remediation, the actual powerfrequency magnetic, electric levels be verified as well as radiofrequency/microwave power density situation before proceeding next step of implementation, to avoid and distinguish different emission and interference issues before they require significantly more costly corrective measures.

If a 4-wire 3-phase circuit (service feeder/riser distribution conduits) is unbalanced and has net currents, then magnetic field levels become elevated and even an electromagnetic interference menace issue. This is usually resolved when the 4 conductors are bundled close together within the same conduit. Typically, there are complex harmonic and transient components on the return neutral that generate noisy *net currents*. Stray grounding currents in building steel structure and rebars, HVAC ducts, and metal conduits, water pipes also generate elevated levels. A simple grounded-neutral short in several single-phase 120 V receptacles out of thousands in a commercial building is commonplace; its electric short provides an alternative path via the grounded conduits and building steel for some (if not all) of branch circuit neutral current to travel back to the grounded-neutral Wye of the 208/120 V distribution transformer (electrical source). Net currents produce high magnetic fields, and may indicate wiring violations or undetected, potentially lethal electrical shorts in grounded equipment (receptacles, computers, motors, heater coils, compressors, neon signs, dimmers, etc.).

Schools

Schools tend to be linear in shape, necessitating bundling in the wiring configuration. Wires of considerable amperage are often extended (adversely affecting at least for 20% of pupils, according to a **California Department of Health Services** study) within classrooms, often diagonally. Thus a child's seat, located directly above a cable can have a field as high as 9 mG while 2 pupils away can have a field of under 1mG. A pupil may be rebuked, punished for learning incompetence and even medicated for hyperactivity when the cause lies with designers and electricians who are not been trained to understand the consequences of their installations. Aligning these cables along corridor walls or other lesser-occupied zones could eliminate such a situation. Another error, usually sourced by re-wiring, renovations, etc, results in improper wiring between the main electric panel and subpanels, resulting in massive un-cancelled magnetic fields, in violation of the *Electrical Code* (but permitted in earlier codes at the time of construction). Schools may also have adverse microwave environments, due to wireless services. Students use wireless devices *en masse* during inter-class periods, often generating power densities indoors higher than allowed by safety codes. Computer classrooms present a special condition due to the high density of appliances, with positioning, electrostatics, air ionization characteristics which may subject certain groups to hazardous exposure – even when each device alone may actually be "safe". For example, a large number of computers, whose screens act as positive ion generators, can rapidly extinguish available negative ions and present undesirable physiological effects, including listlessness and decreased ability to learn – especially when the building is airtight or windows are not allowed to be opened so that no fresh negative ions may be introduced from the outdoors.

Office / Apartment buildings

Transformers and network protectors are placed in secured vaults usually located within buildings; but in the suburbs, utilities mount the transformers on outside pads. High-current, low- voltage (less than 600 V) feeder wires supply the main switchgears rated between 1,000 and 4,000 A, per phase. In multi-story buildings, substations (transformers, network protectors & feeders), electrical rooms and high-current (1,000-2,500 A) distribution electric risers are necessary every 10 to 12 floors. Occupied areas above, below, and adjacent to the substations and risers are subjected to very high (10 to 1,000 mG) and extremely high (1,000 - 100,000 mG) levels. Besides current load, conductor spacing is a critical factor affecting levels. Closely stacked, solid bus bars, compacted conduits minimize phase conductor spacing, and thus promote self-cancellation and lower levels. Electric riser rooms can be problematic, and preferably not adjacent to lived-in spaces. If necessary, these can be laid out next to storage areas, but their offending sides may be shielded with appropriate mechanisms such as *mu*Metal sheets (sometimes layered with soft metal sheets and aluminium), 2-hour fire door panels, etc. to acceptable and safe exposure levels.

The office environment is one scattered with a large variety of potential "hotspots" from appliances, with fields of quite short ranges. The reason is that most appliances use transformers, whose field dissipation ratio is 0 times greater than that from wiring. Anomalies can also be caused by heavy-duty cable layouts, horizontally and vertically – as in the school classroom situation. Office and apartment buildings have electric riser areas and care should be taken to isolate long-term occupancy zones at a distance that is adequate to ensure exposures that are acceptable (usually 2 meters). For example, storage, filing, equipment / appliances, bathrooms can be designated for such proximity zones. Otherwise, magnetic & electric fields and transients shielding can be installed against the walls, floors and ceilings that cause concerns. Cable conduits supplying power to large equipment, such as elevators and roof top air conditioners carry large loads and therefore have high EMF levels nearby. Ensure as much as practicable that such cable runs follow hallways and other areas as to minimize close proximity to where people work.

Workstation and sleeping areas should be carefully planned to avoid unnecessary fields. A common error involves a transformer in a power bar placed too close to the user. Layouts should be designed to minimize exposure to EMFs from equipment. Power-conditioning outlet strips (those specified to reduce "EMI" or electro-magnetic interference) are recommended to avoid radio waves being picked up from the power line by the computer. In working environments, separate ventilation ducts for office equipment may be included for copy machines, faxes and printers to reduce exposure to chemical emissions. In multiple apartments, bedroom bed-head walls should be placed in such a way as to ensure that electrical appliances such as refrigerators, stoves, microwave ovens, television and entertainment equipment are not placed on the other side of the wall in an adjacent areas, preferably against external walls.

Residences

On the average, residences have the most elevated fields, higher than power generation stations, most factories and offices. This situation indicates the socio-economics of not encouraging design and installation professionalism that people deserve! Electricians may not have an understanding of electrical principles behind *Electrical Code*; they are not electrical engineers. Electrical engineers, architects and construction people usually are not familiar with wiring practices. The tendency to save time or materials and to misunderstand grounding ("the more grounding the better") lead to disallowed neutral/ground connections, new fire and shock hazards as well as compromise circuit breaker response.

Often the electric service and the water service are separated by significant distances, sometimes at opposite ends of the building. This configuration can result with the grounding wire – a single wire – carries the un-cancelled current that exists at both at the electric panel and throughout the municipal water distribution system, right through the living zones of residences. A single wire with 1 Ampere of current has a magnetic field of 2mG, one (1) metre away. In urban areas, it is altogether common to have sustained currents in the grounding wire of near 3A, with spikes of up to 30A during high electric consumption periods, just when residents dine, study, or recreate. That passage of current amounts to fields of around 6 mG, which circulate in the residence even if all appliances are turned "off" (and even while residents enjoy a candlelit meal). This situation can be remediated by designing configurations in which the electrical panel and the water service are located at very close range so that such currents travel in some isolated, uninhabited zone of the house. If the house has been built, this problem can be tackled by grounding the main panel to grounding rods rather than to the water mains, a protocol permitted by the current *Electrical Code* and accepted by authorities and utility companies across Canada. Current from municipal pipes may also travel in conducting indoor water pipes; such current can be removed with a dielectric coupler or any non-conducting material (e.g.: plastic or rubber tubing) between the water main and indoor plumbing. (See: Question of net current.) At least a dozen typical electrical wiring errors lead to excessive electric or magnetic fields indoors – all violations of the *Electrical Code* – and they can be traced and corrected *(see Appendix - net current protocol)*.

Safe residences may be organized to be "wireless free" with artificial lighting avoided when possible.

Health care

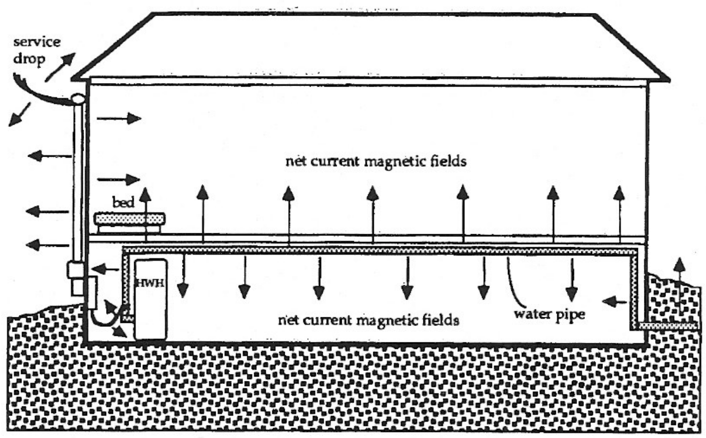
Hospitals and health care centres are budding grounds for all sorts of technically-generated fields, both in powerfrequency range as well as in the radiofrequency & microwave ranges. The fields are elevated: current Canadian unofficial guidelines, based on inducing body currents and shock limits, (833 mG magnetic fields) quasi-legalize such equipment as CT Scanners, now illegal in Europe. Hospitals have many wireless microwave systems, polluting bedside fixtures that can produce “hot spots” often next to patients (with potential for even genetically-modifying microbes). Hospitals also lease their roofs and perimeter walls for wireless transmitters to increase revenues. Professionals designing hospitals should take extra care to ensure the lowest possible electromagnetic field levels. Certain pathologies worsen in the presence of powerfrequency magnetic field levels higher than 1 mG; even genes can change their expression starting at this intensity. Many drugs interact with wireless fields, causing unsafe synergisms. Distance protects both patient and health server; layout is critical, including judicious wiring and lighting configurations.

Question of net currents

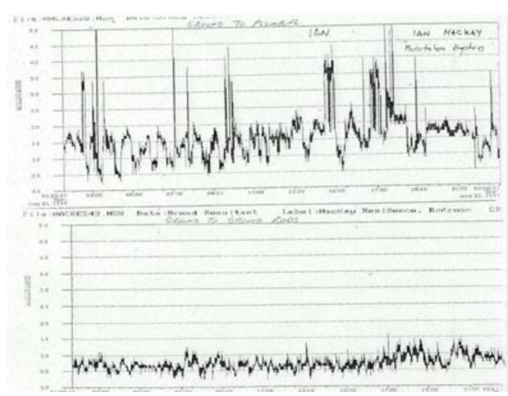
When substantial current returns to a distribution transformer *via* the ground - instead of the neutral conductor of the line, ***net current*** develops. It contains 60Hz and such harmonics as 90, 180, 300, 420 Hz and even variable oscillating crescendos of extremely low frequencies. The currents also can include cablevision, telephone, radiofrequency / microwave, as grounding return “noise”. The magnetic field produced by this net current is not cancelled. It is usually a major source of magnetic fields nearby. **Ontario Hydro Research** (**D. L. Mader**, *et al,* 1990) noted that the main contribution to residential 60 Hz magnetic fields is from grounding or "water-pipe" currents caused by local imbalance, higher in summer, and highest daily between 6 PM and midnight. Residential low-voltage grounding connections - neutral wire to ground contacts in houses are crucial since they protect against shock and fire from fault currents. The multi-grounding problem exists in both overhead and underground electrical distribution systems.

If wiring is installed according to the ***Electrical Code***, indoor net currents and their associated un-cancelled magnetic fields will not occur. A net current is defined as the resultant current in amperes when part of the current in a circuit is shunted to another path. The shunted current is usually the “neutral” return current. The code is written to prohibit this kind of circuit imbalance. Conductors of a circuit are required to be run together to allow the hot and neutral conductors to cancel out each other’s magnetic fields. The concerns are that they may result in induced currents on nearby metal and, therefore, circuit heating of the, and that they may travel in unexpected pathways, resulting in shock, arcing, as well as leading to fire. Neutral current should not flow on gas pipes, water pipes, HVAC ducts, building steel, etc. Magnetic fields as low as 3 mG may cause computer screen jitter, corrosion and interfere with electronic devices.

Code violations are frequently practiced by electricians, result in net currents and elevated magnetic fields; and they are rarely detected by the standard electrical inspection - being not easily visible nor within the scope of inspector protocol (and no verification with proper field meters). A common error is the connecting of neutral to ground somewhere in the building. Such connection is allowed by the Code only at the electric service entrance point. But such connections can be deliberate, such as at a subpanel, or as the result of accidental cutting into the neutral insulation by a sharp metal edge, improper screwing of panels. This violation is also frequently seen in the incorrect installation of electric dryers and electric ranges due to failure to follow the manufacturer's instructions. Another error, seen in multi-story buildings is the connection of neutrals from 2 branch circuits that share a junction box (or a switch box used as a junction box). A third error often seen is the mis-wiring of 3-way switch circuits, in which a two-wire traveler is used instead of the necessary 3-wire traveler. This results in high fields from loop circuits.



Net current - ***Splitting between electric service & water system grounding***. *Net current* path as neutral return current splits at service point due to required grounding to water system at other end of house. Indoor pipe has current; service drop has same net current due to a deficit of the neutral.



Net current – ***Variation over 24 hours to water mains compared to grounding rods only – residential setting.*** *Net current* varies according to use of circuits with wiring errors, start-up of appliances located throughout a neighbourhood that is inter-connected with conducting water mains and electrical supply. If grounding rods are used, only a portion of current is typically diverted from the electrical distribution system.

It should also be observed that radiofrequency and microwaves infiltrate water main currents through electric power transmission / distribution systems and grounding wires neutral return net currents. These include the ***BPL*** - Broadband over power line systems, including ***Wi-Fi*** (at 1.7 to 80 MHz – with 10 MHz of Bandwidth used per modem) – which by pass transformers. Computerized, high-amperage assembly line facilities, such as Post Office Sorting centres and factories, Data Centres, foundries, etc. introduce strong Radiofrequency / microwave emissions into neutrals of powerlines and which also create supplementary net current conditions that interface with water mains. Furthermore, remote reading water and utility meters (SMART) apply strong pulsed RF transmissions every 14 seconds with modulated RF carrier wave using a frequency hopping technique). And, finally, the ground returns from building telephone, cablevision, security and computerized systems also affect neutrals, water mains, indoor pipes and even circuits with their frequency characteristics.

Building-level Guidelines

Panel and electric supply

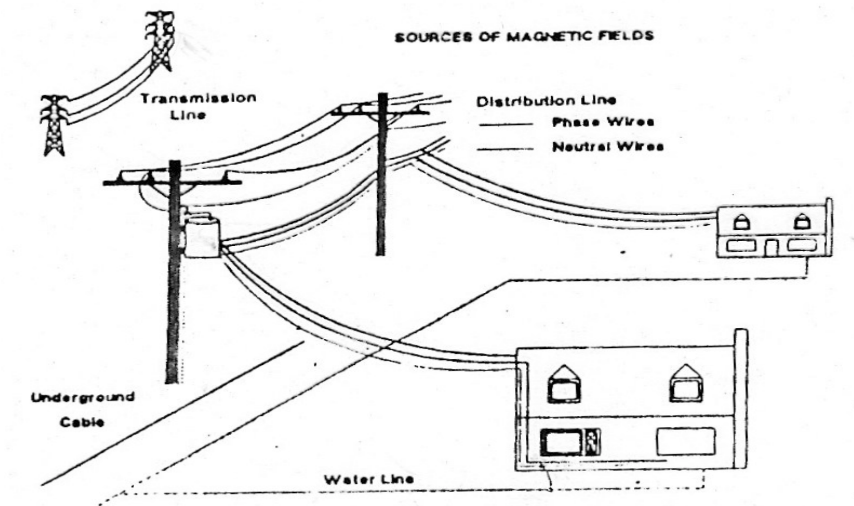
The electrical service supply, meter, main and sub panels should be located on a wall that no one will be spending extended time near to, horizontally or vertically. The electric panel should be as close as possible to the water main or, preferably, to grounding rods as per the ***Electrical Code.*** If a service drop is adjacent to dwelling, place bedrooms on the far side of the building to reduce night time exposure to its fields, or not less than 1meter distance (and then, only if the electric supply from the utility is balanced); otherwise, not less than 2.25 to 3 meters.

SMART meters should be installed together - in one location, away from lived-in zones, including corridors. No net current should be allowed to be generated from them into building wiring by ensuring no opportunity of bonding and contact. Panels and distribution boxes generate magnetic fields due to the separation of conductors, which are routed to busses as well as the busses themselves. Due to their short lengths, the fields weaken more rapidly than net currents from lengthy conductor runs; and, these decrease as the square of the distance. A radius of 1.5 to 2 m will generally see the field below 2 mG. Where power transformers are located inside buildings a radius of 2.25m is normally sufficient to achieve a field of 2 mG or less.

Water service

The water service should enter the building as close as possible to the electric service entry. This way, the common bonding of the electric service entrance neutral to the water pipe will not allow neutral current to go across the building as net current, should the indoor water service be metallic. Instead, what current may still flow on the water pipe outdoors will then flow outside the building. However, such flow will still cause net current on the service drop cable, so if the drop is from overhead lines, its routing along the building should also be away from living areas, particularly bedrooms. In the case of underground service (service laterals) there will be no effect on the upper floors from any net current.

The illustration below indicates how current in water lines can be shared between buildings. By way example, if in one of the houses, 20% the neutral wire's current is deviated into the water line, then only 80% of the return current will be directed back to the electric company's distribution line's neutral wires. This means that water line has current which produces magnetic fields (as described in the preceding images, above) with all their variations, including "noise" from harmonics, radiofrequencies and microwave technologies in the neighbourhood), without cancellation effects. It also means that the electric service drop has at least 20% current that is not being cancelled by the "hot" phase wires, and there any space near the service drop, or along the electric power distribution line is subject to near-field magnetic field pollution at a higher rate than if the distribution and supply were totally (100%) cancelled by the returning "cold" current from the neutral conductor at the electric panel.



Net current – Current in electric supply is shared with water service lines between buildings. Part of the return, "spent" current travels between buildings through conducting water pipes. Electric distribution lines are not balanced because the neutral wires no longer have equal (and cancelling-effect) current to "hot" phase wires – and comparatively generate higher magnetic fields. The water pipes also become emitters of magnetic fields.

Grounding and grounding wires

One may electrically isolate any metal water piping between a structure and street main with a 2 metre plastic water pipe inserted in the line between the street supply and building, or with a dielectric coupler, 2 metres from building. This conductivity break eliminates an alternative low-impedance path for the return current. An alternative is to install a dielectric coupler at the water main indoors and have the building's grounding wire attached to grounding rods, as per *Electrical Code.* It is not recommended to ground into the foundation rebars due to foundation water main bond corrosion issues. Indoor grounding wires must not be in contact with ventilation ducts and any other conductor. If they cross path, they can be separated mechanically with non-conductive inserts. Grounding fault interrupters should be electromagnetic- field- interference (EMI) free.

Appliances

Selection of appliances, including electric heating systems, should be made also on the basis of whether they produce magnetic fields higher than 0.65 to1 mG at working / long-term exposure range when operating. Note that transformer-equipped accessories such as clocks, some lighting systems and appliances with variable speed drives, such as Jacuzzi & whirlpool baths, fans, heaters, front-loading washing machines and some furnaces can produce higher fields and that these can simply be not installed or removed in order to reduce exposure. Microwave ovens should be avoided. Appliances with clocks should be avoided if these come with clocks, which may come with transformers and produce elevated magnetic fields at working/operating distance. In hot water heaters, ensure that the wires between the elements are not separated (creating a loop current) and replace with a new circuit wire through the insulation if so.

Wiring

Those who conduct surveys in residences note that about 20% of sources of elevated indoor magnetic fields - 3 mG and above - come from electric power lines (about 5% transmission lines, 12 % primary distribution and about 3 % secondary distribution). Wiring and grounding problems account for about 2/3 of the observed high fields. In about 43 %, wiring errors are the identified source of emissions and the water supply pipes are responsible for about 15 %. Appliances account for about 3 % of high fields. About one North American residence out of twenty: 5 % - will have no field higher than 1 mG throughout. Clearly wiring errors and currents along water pipes are a major electromagnetic field issue in safe buildings.

There should be no wiring and outlets routed across and behind bed heads nor behind long-term occupancy working stations. Occupants should not place extension cords below beds. All outlets must be checked for wiring errors and corrected, including errors associated with dual 220/110V devices (stoves and dryers) that must have separate ground and isolation between their chassis and neutrals. However, when 2 wires are required for an appliance, and if the two wires are bundled parallel and very close together, the magnetic field from one will cancel the field from the other. Thus, an extension cord rarely produces much magnetic field.

Circuits must be tested for net current (See: Appendix: ***Net current remedial protocol****)*. Each neutral conductor in the panel must be disconnected and continuity-tested against remaining bussed neutrals. Shorts (common neutral connections) must be corrected, as they will not trip breakers. Each 120V hot breaker must be tested for continuity, with all breakers switched “open”, against all others for a same-phase, common hot connections, as these will not trip breakers.

If feasible, electronics (e.g.: computers) should have dedicated circuits that may be in conduits or metal-clad, with routing away from bedrooms and other long-term occupancy sites. Cablevision and digital cables may be in *EMT* / rigid conduits and routed away from long-term occupancy sites. Toroid transformers in low power sizes are fantastic in eliminating stray magnetic fields by way of coupling. If an Electric core transformer is used, it is to be shielded or to be located remotely.

Common sources of elevated powerfrequency (60Hz) magnetic fields in building wiring

"Knob and tube" (un-cancelled) wiring -in older locations, under pre-1950 electrical codes
Multi-locational switches
Corroded ground wire / water main contacts (aging or chemically-induced)
Improper panel/sub-panel neutral wire installation
Physical contact between water, gas and/or air duct conduits and grounding wires
Hybrid appliances sharing grounding wires: washers, ice-making refrigerators, gas stoves

Lighting

Dimmers & multi-locational switches, fluorescents, High Intensity Lighting (HID), Metal Halide, arc lamps are to be avoided or not used, especially in long-term use areas. They emit 100 – 1,200mG, at the transformer. They should not be installed at distances of less than 1 metre from user heads (including hung devices). Fluorescent / halogen light emission levels differ from unit to unit, in part due to aging. A significant proportion of users are sensitive to (30%) and uncomfortable with compact fluorescent bulbs – probably for their magnetic fields, “dirty electricity” (40 – 100 kHz) pulsation vectors and cathode radio emissions.

Electric heating

Electric heating devices generate strong fields electric and magnetic even at a distance of 30 to 50 cm. Even when the heating is turned “off”, the near-field electric field levels may remain elevated. When not in use, circuits for such heating devices should be able to have their breakers “shut off”, at least at the panel. If selecting an electrical floor heating system including those encased in concrete slab, inquire with the manufacturer about the magnetic fields emitted and how they could be shielded/cancelled at manufacture.

Indoor water pipes

Water pipes extended through walls may be in non-conductive materials to prevent stray, net current paths. A PVC section is sufficient in retrofits, as close to the house as practical.

Phone lines and digital cables

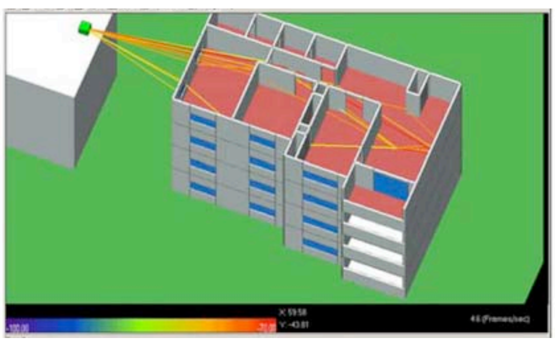
Consider inserting phone lines in either double-shielded cable (heavy braid over foil) or run in *EMT*, or rigid conduits. Standard telephone company filters ensure that lines do not carry microwaves (and “dirty” low frequency “noise”). *DSL* introduces the same issues as digital cable; their lines should be grounded to ground rods or at main panel ground bus / grounding. Do not bond their ground to indoor water pipes.

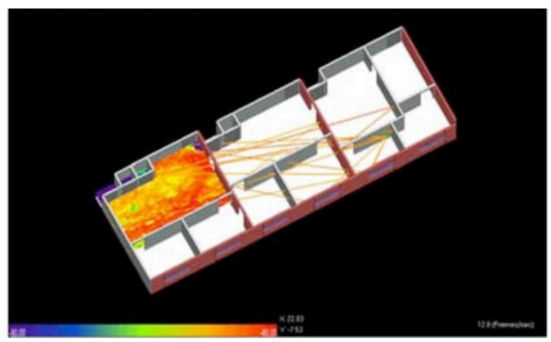
Electrostatic shielding

If no aluminum foil vapour barrier is used as an electrostatic shield, wiring may be in commercial electrical wiring *EMT* - thin walled, galvanized steel tubing. Wires may be cut 25% longer than needed, twisted with a drill before being pulled. The individual circuit pairs are twisted when larger multiple circuits conduits are used. Ground wires should be used. If a foil barrier is present, use lazy twist 12-3 *Romex*; without extra wire but ensure that the wire to clothes dryer, oven and hot water heater, etc. has a lazy twist (round, not flat).

Wireless & microwave technology systems

Generally, elevated microwave power densities occur at workstations (from computers, cellphones, wireless telephones (DECT) and wireless routers), tending to exceed safety levels due to structural, layout and ricocheting phenomena. The images show how 5 - 60cm / 900 MHz - 6GHz beams travel in built environments. Windows and doors focus/flex beams by frames; indoor/outdoor wall (ceiling & roof) construction, corridors, wall angles also modify, relative to emitters. Beam modification & absorption occurs with dense furniture and fixtures. Wireless “offices” become saturated with the 3-D ricocheting of beams, of different wavelengths /frequencies, as illustrated by the left room (right image), leading to power densities that may even surpass codes. Composite waves from multiple emitters boost power 6 to 10-fold as lower frequency units couple with highest frequency emitter.

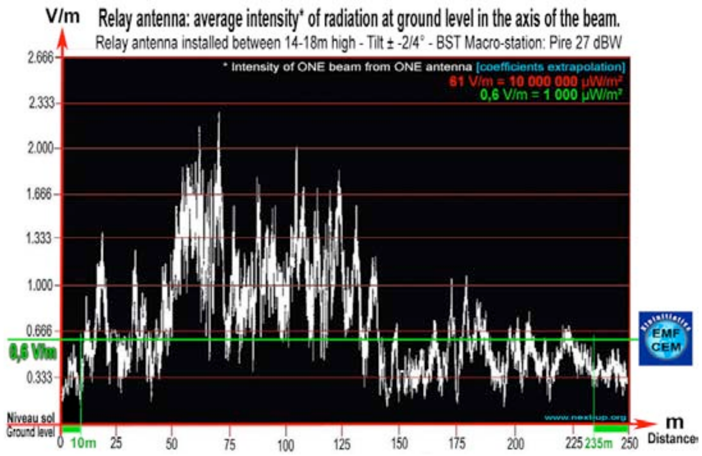




The rear of microwave ovens are not shielded for either radiofrequency/microwave emissions. Their powerfrequency magnetic fields and can affect in a similar mode space behind them for considerable distances.

SMART devices, can carry pulses about every 14 seconds with charges that are highly electronic with radiofrequency and microwave characteristics.

This new phenomenon accelerates corrosion of materials – whether pipelines, rebars in buildings and transportation infrastructure by quantum leaps. Galvanic coupling between alloys and hydrogen and *e* particles is accelerated, leading to hydrogen-induced cracking in steels. There is also greater spattering of deposits, crevice enhancements and oxidation reactions.



Radiation from wireless technology microwave beams tends is most intense at between 50 - 130 meters from source (1 emitter/single antenna). Generally, before and after this belt, power density is 10 *micro*Watt/cm^2, unless dispersed or amplified by intermediary artefacts. When soils are wet, power density can be up to 6 times higher and up to 10 times higher when several wireless systems emit together with composite waves.

Wireless appliance, device (dry weather conditions)	**μWatt/cm^2**
Cellphone @ user	9 – ***3,500***
Cellphone, second hand exposure	1 - **200**
Microwave oven @ user	**10 – *3,000***
Cordless phone base station @ 2 to 6m	7 - **17**
Analog in urban environment (1-2 blocks away)	5 – **25**
Digital in urban environment (within 100m)	0.2 - 5
Analog in rural environment 500m	0.25 - **30**
Local amplification by metal window, door frames, studs, metal pipes, grounding wire, unfiltered telephone and Cable TV wires	1 -4.5 fold power more

INTERNATIONAL Radiofrequency / Microwave EXPOSURE STANDARDS

Country	**Exposure level** (*micro*W/cm^2)
New South Wales, Australia	0.001
Salzburg, Austria (pulsed transmissions)	0.1
Italy, quality target (historic centres)	0.1
Russia / Bulgaria / Hungary/ Switzerland	2 –10
Belgium	3
China	7 –10
Italy / Toronto Board of Health	10
Auckland, New Zealand	50
Australia	200
New Zealand / Japan / Germany/ US /Canada	200 –1,000
United Kingdom	1,000 –10,000

Avoiding electromagnetic field risks

Electromagnetic field risks are difficult to study because fields can exist in many different frequencies and waveforms and can change rapidly. However, reducing exposure to EM fields can be much easier than reducing exposure to other common hazards like chemical pollution. Exposure reduction is accomplished by locating EM field sources and placing often-used furniture a specified minimum distance away from those sources. Inside a typical Canadian residence, the alternating current magnetic field averages about 2 mG (somewhat higher in the early evening and lower in the early morning). Indoor electric fields range up to about 2,000 volts per meter, but are usually less than 4 V/m. Elevated electric-field areas are found near indoor wiring, outlets, TVs, computer monitors (including laptop computers), fluorescent lights, light dimmer controls, and improperly grounded equipment. Field strength drops off rapidly if at least 1 meter away. Electric fields are high near high-voltage power lines, but these fields rarely penetrate indoors (in about 10% of residences), except by way of such conductors as metallic sidings, metallic chimneys, etc. Structures built predominantly in wood may retain electric fields in the 10 V/m range, including wooden furniture placed on wooden floors that carry electric / electronic equipment, such as office workplaces. But if such furniture is insulated from the floor with rubber/felt, electric fields at working position can be considerably reduced.

Indoor wiring polarization and grounding issues

In wiring, the "polarized" wall outlet usually has a slot for a large prong and one for a small prong. The small slot is electrically "hot"; in a typical 115 volt system it oscillates 60 times a second between about +170 volts and -170 volts, compared to ground. To get a shock, it is necessary to touch this "hot" slot (or to touch something electrically connected to it), while also touching something that connects to ground: the larger "neutral" slot, the round "grounding" slot in a 3-prong wall outlet, plumbing pipes, and any metal part of a sink or bathtub.

In old, “non-polarized” extension cords (with same size prongs), when the cord is plugged in the opposite way that it should be, several types of appliances may become a shock hazard and will have high electric field. If an appliance has a polarized plug, use only a polarized extension cord (1 small + 1 large prong). Outer cases of plugged-in appliances are supposed to be connected to ground; sometimes they are accidentally connected to the electrical "hot" wire - if the “polarized” plug is inserted upside down. Due to the risk of such improper grounding, one should never touch a plugged-in appliance while taking a bath, or while touching the metal of a sink or the water stream in a sink. Plug-in appliances should not be allowed to get wet, because water makes it more likely that the outer case will become at least weakly connected to electrical "hot".

Aside the shock hazard issue, an improperly grounded appliance produces alternating current electric fields, which induce currents in living tissue by proximity, even without actual contact with live appliances. Improper grounding can sometimes detected by lightly sliding a fingertip across the surface, using very little pressure. A weak vibration may be felt if the surface is "hot". AC voltmeter (connected between a known ground and the case of a live device) or an alternating current electric field meter can be used to check if the case is “hot”.

Electric field shielding

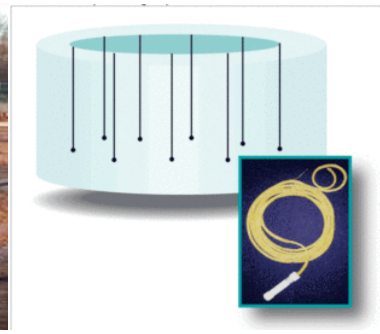
Elevated electrical fields from appliances may be shielded with conductive sheets, such as aluminum window screen that is connected to electrical ground for maximum efficiency, in front of a live device. When ground is suspect (for example, connected to municipal waterworks) it may be best not to ground, as the sheet may then become a transmitter of radio-frequency, microwave and "dirty electricity" (40 – 100 kHz) emissions in its own turn being distributed in indoor wiring because of security and other "smart" technology using such wiring, as well as distribution of broadband wireless signals in the electric utility wires (primary and secondary).

location / device	**Typical electric field readings** in Volts per Meter (V/m)
broiler	130
toaster	40
stereo	90
hallway	13 - 100
bedrooms	2 – 20
electric blankets	100 - 2,000

In special problem cases, higher frequency (up to about 100KHz) "dirty electricity" micro-pulsations, radiofrequency and microwave electric field emissions from such sources as indoor wiring, smart devices, simmers, TV digital tuner and switching power supply can be reduced by a combination of aluminum foil (1 mil thick heavy-duty household aluminum foil) and mild steel (or galvanized steel). As large an area (1.2m X 1.2m minimum) on the adjacent wall to the TV is recommended (but it will do little to reduce magnetic fields). Both materials should have seams lapped by about 10cm and foil taped. *Ace* brand foil tape is recommended. It may help to provide a ground connection to the surface - but this is a matter of "tuning"- some frequencies will be lessened more than others. Theoretically "properly grounded" metal conduits and cases do not emit electric fields.

Grounding is not required but is often helpful, with shield material being grounded via a very short, very large (000) welding cable to an "earth rod farm"- a group of rods tied together or to a grid to pick up currents away from a facility – a helpful solution in farm buildings, reservoirs, storage tanks and like large structures, but not in typical residences and other indoor locations. Some electrically sensitive individuals have found low frequency electric field relief by hooking the shield material to the nearest electrical outlet "ground". Even a foil layer on an adjacent wall first may provide significant relief for some individuals, or next to an offending television set.

When cathode protection from premature corrosion associated with large steel or metal-clad structures subjected to electric fields (even those induced by transformation from magnetic fields from powerlines, elevated emissions from radiofrequency/wireless technology) is required, one may consider applying novel measures. Metals, at the micro-level, are not homogeneous; minor differences in electrical potential may occur naturally from one area to another along the surface, leading to local electrolysis between minute "anodes" and "cathode". As metals are electrical conductors, the adjacent cathode and anode steel regions have a metallic path and all that is needed is a suitable electrolyte – water, soil, even a thin film of condensation for corrosion to occur. But if this current returns (cancels out) to the metallic structure, there may be no corrosion reaction; instead hydrogen molecules form at the surface blanketing the surface from ambient electrolysis effects. Below are images of techniques applied for such electrolysis avoidance engineered by MATCOR Inc., Doylestown, Pennsylvania.

Typical residential electromagnetic field exposure situations

A recent survey of 10 Montreal-area residences, done for the consumer magazine, **Protégez-Vous**, with a baseline of 67 rooms led to the following observations:

Room magnetic field levels are less affected by appliances and indoor wiring than by outdoor conditions + ground currents & net currents which may be circulating indoors through conductors. The average magnetic field spot location conditions with all power "off" compared to the "as is" (0.48 versus 1.06 mG or, 2.2 X). The ratio between the average room "as is" and the "all power on" (1.06 mG versus 1.50 mG is 1.4 X), probably reflecting the influence of appliances and wiring. The magnetic field levels in rooms during the "all power on" are 3.12 times higher than in the "all off" state.

Kitchen/dining room measurements may more realistically representative of the lifestyle exposure of occupants during the hours of highest electrical consumption, at noon and in the evening. Montreal area master bedroom occupants can expect to sleep during the coldest and hottest days, with average "as is" conditions of 2.73 mG; the magnetic fields drop to 1.20 mG most of the year, and 1.63mG during extreme climatic conditions (all levels of considerable health risk). There are cases where magnetic field levels reach the 20 - 30 mG level.

Averages of magnetic flux density, 67 rooms *in miiliGauss / sample size Montreal Region, 2008*

location	*"All power off"*	*"As is"*	*"All power on"*	*High Consumption*
Master bedrooms	***0.90****/6*	***2.00****/10*	***2.60****/10*	***2.73***
All bedrooms	***0.60****/12*	***1.20****/23*	***1.50****/23*	***1.63***
Baby bedrooms (crib)	***0.50****/4*	***1.06****/5*	***1.76****/5*	***1.44***
Kitchen (at sink)	***0.30****/6*	***0.60****/10*	***1.10****/10*	
Living room (at couch)	***0.40****/6*	***0.80****/10*	***0.90****/10*	
Dining Table	***0.30****/6*	***0.50****/10*	***1.40****/10*	
Workstations	***0.40****/9*	***1.30****/14*	***1.30****/14*	***1.76***
average*, all readings*	***1.02****/213*			

The most elevated electric fields tend to be found where occupants sleep and work. This is mainly due to the presence of inadequately insulated wiring for light fixtures and the proximity of electrically-active wiring.

In residences where outdoor electric fields are elevated, the presence of indoor electric fields can cancel some of the outdoor electric fields emissions; in our sample, this cancellation phenomenon was brought out in the dining room measurements, which were more elevated when all power was turned “off” in a building affected by Hydro Quebec distribution lines in the city street in front.

Averages of electric flux density, 67 rooms *in Volt/metre / sample size*
Montreal Region, 2008

location	*"All power off"*	*"As is"*	*"All power on"*
Master bedrooms	***1.8****/6*	***8.4****/10*	***11.9****/10*
All bedrooms	***0.7****/12*	***4.8****/23*	***6.6****/23*
Baby bedrooms (crib)	***0.7****/4*	***4.6****/5*	***6.7****/5*
Kitchen (at sink)	***1.3****/6*	***2.8****/10*	***3.8****/10*
Living room (at couch)	***0.9****/6*	***0.9****/10*	***3.3****/10*
Dining Table	***2.9****/6*	***2.2****/10*	***2.3****/10*
Workstations	***1.5****/9*	***11.7****/14*	***9.1****/14*
average*, all readings*	***4.2****/213*		

Averages of radiofrequency and microwave power, 67 rooms *in microwatt/cm^2 / sample size*
Montreal Region, 2008

location	*environmental / background effect*	*"As is"*	*wireless equipment “on”*
Master bedrooms	***0.004****/6*	***0.087****10*	***0.095****/10*
All bedrooms	***0.005****/12*	***0.041****/23*	***0.088****/23*
Baby bedrooms (crib)	***0.003****/4*	***0.025****/5*	***0.074****/5*
Kitchen (at sink)	***0.055****/6*	***0.093****/10*	***0.097****/10*
Living room (at couch)	***0.017****/6*	***0.023****/10*	***0.066****/10*
Dining Table	***0.051****/6*	***0.080****/10*	***0.238****/10*
Workstations	***0.017****/9*	***0.226****/14*	***0.255****/14*
average*, background*	***0.043****/43*	***average****, indoors*	***0.106****/164*

Indoor background power density is about 10% of outdoor levels. At the kitchen sink/dining table - often near a window - emissions levels are at least double of those in other rooms. Many residences are equipped with microwave technologies: ovens, cellphones, cordless phones, routers, DECTs, wireless computer devices, baby monitors, security systems, which double- to-triple wireless power emissions sourced from outdoors. Both indoor and outdoor wireless technology emissions are doubling each year; a proportional rise of microwave power levels in housing approaches critical health risk levels. Wireless emitters contribute significantly to “dirty electricity” in wiring, along with resistors, fluorescent lamps and transformers.

Background power emissions (0.5 MHz – 3GHz band) selected Canadian cities, 2007 *micro*Watt/cm^2

City	**μWatt/cm^2**	**City**	**μWatt/cm^2**
Windsor	0.2 - **15**	**Cornwall**	0.3 - 5
London	0.2 – 5	**Ottawa**	0.1 - **25**
Brantford	0.8 – **50**	**Montreal**	0.1 – **10**
Hamilton	2 – **10**	**St-Hyacinthe**	0.1 – 4
Burlington	1 – **10**	**Mississauga**	4.0 – **25**
Oakville	1 – **15**	**Drummondville**	0.1 – 4
Toronto	2.5 – **120**	**Laval**	0.1 – 5
Ajax	1 – **10**	**St-Sauveur / Ste-Adèle**	0.1 - 3
Oshawa	1 – **10**	**Mirabel Airport**	0.3 – **8**
Trenton	0.2 - **20**	**Gatineau**	0.1 – 5
Belleville	0.2 – 5	**Renfrew**	0.1 – 3
Kingston	0.3 - 5	**Peterborough**	0.3 - 3

Note that the above figures have increased between 5 to 10-fold by end of 2009.

Appendices

Magnetic field conversion units

1 gauss (G) = 1 x 10^3 milligauss (mG)	1 milligauss (mG) = 1 x 10^{-7} tesla (T) or 0.1 µT
1 gauss (G) = 1 x 10^{-4} tesla (T)	1 milligauss (mG) = (4π) A/m
1 A/m = 4 π x 10^{-3} oersteds (Oe)	1 tesla (T) = 1 weber (Wb)/m^2

European Parliament Environmental, Public Health and Food Safety Committee Resolution

In a 43-1 vote, the European Parliament Committee on the Environment, Public Health and Food Safety adopted OVERWHELMINGLY a Resolution urging the European Commission to recognize growing public and scientific concern over health risks from electromagnetic fields. The Resolution will be voted on in plenary by the full Parliament on 26 March 2009. This vote by the Parliament's Environmental Committee on February 23, 2009 mirrors the 522-16 vote by the full Parliament last September on the EU Environment and Health Action Plan which called on the European Council to *'amend its Recommendation 1999/519/EC in order to take into account the Member States' best practices and thus to set stricter exposure limits for all equipment which emits electromagnetic fields in the frequencies between 0.1 MHz and 300 GHz'*. The Resolution identified existing conditions that have lead to the need for the Commission to take urgent notice and take action to address the exponential growth of new technologies that may place societies at increased health risks, and to review the scientific basis and adequacy of the EMF limits.

Highlights of Adopted Motion (Summary of 29 Points Adopted in Resolution)

- Calls for review of adequacy of the existing EMF limits.
- Calls for specific consideration of biological effects.
- Calls for Member States and industry to address new technologies to reduce EMF exposure
- Encourages negotiation for new cell siting and transmission lines to avoid siting too close to schools, retirement homes, and health care institutions.
- Calls for studies on electromagnetic compatibility of artificial EMF with the living human body.
- Calls on the Commission to issue an annual report on EU levels of EMF and actions taken to protect human health and the environment.
- Calls for worker protection from EMF (steps to speed implementation of Directive 2004/40/EC)
- Deplores the delay in publication of the final Interphone Report, and asks the Commission to ask those in charge of the Interphone Project why no definitive findings have been published and, should it receive an answer, to inform Parliament and the Member States without delay.
- Requests the Commission to earmark funds for awareness campaigns for young Europeans who are cell phone users, including information on health risks and safer methods of use.
- Calls for ICNIRP and WHO to be more transparent and open to dialogue in standard-setting
- Proposes the EU's Indoor Air Quality policy should encompass study of wireless (indoor WIFI, DECT at home) and in public venues.
- Calls for improved consumer information and labelling on wireless devices.
- Calls for a single standard for ELF exposure along electric high-voltage grids.
- Calls on Member States to recognize persons that suffer from electro-hypersensitivity as being disabled so as to grant them adequate protection as well as equal opportunities (as Sweden has done).
- Instructs its President to forward the Resolution to the Council, the Commissions, the governments and parliaments of the Member States, the Committee of the Regions and the WHO.

The full Report and result of final vote in Committee can be viewed at:
http://www.europarl.europa.eu/oeil/file.jsp?id=5680652

Observation	**Effects of microwave emissions**	**Exposure level**
Effects on DNA	Single and double-strand breaks, electron flows within staked base pairs of double helix of DNA, direct gene transcription, 40-90% increase in *Fos mRNA* from cellphone signals,	2h, 0.6W/kg, 0.001W/kg
Blood brain	Toxins may reach brain tissues: serotonin, glucose, selective permeability, allows glucose to pass	After 2 min: 0.0004W/kg
Psychoactive Drugs	Neurotransmitter functions modified: Pentobarbital (alters narcosis), entylenetetrazol (more convulsions), Curare (less anaesthesia), Valium, Librium (potentiated). Endogenous *opiods* activated: increase in alcohol use, less of withdrawal symptoms in morphine-dependents	
Behaviour	Major errors in judgment, vision altered; disruptive attitude(hyperactivity);memory problems, *synthase* inhibition caused by increase in body nitric oxide production by digital (pulsed) signals	
Cognitive functions	Faster reaction time, auditory memory retrieval [mind control], difficulty in concentration, "fuzzy thinking", dizziness (indication of *serotonin* activity increase)	0.16 μWatt/cm^2
Sleep	May promote sleep, sleepiness, reduction of REM sleep (important to memory, learning)	
Fundamental life processi	ELF-encodes in wireless transmissions may imitate heartbeat, cell communications, brainwaves, cell growth, metabolism; sperm count lowered, irreversible infertility in mice after 5 generations from "an antenna park", chicken embryo mortality increases by half	As low as 0.005 W/kg
Dosedependency	Observed in Korean War, US embassy personnel in Moscow, cumulative effects	
Microwave syndrome	Fatigue, irritability, nausea, anorexia, depression Cardiovascular disorders, hypo /hypertension Change in skin, skin allergies, eczema, psoriasis Increase in *lymphocytes*, effects in EEGs, reduced insulin production, multiple allergies, *Tinnitus*, itches in the ear, ears feel heated	As low as 0.02 to 8.0 μWatt/cm^2

BIOLOGICAL EFFECTS OF MICROWAVES BELOW U.S. & CANADA'S REGULATORY LIMIT

(*micro*W/cm^2)	Reported Biological Effects	References
0.0000000000001	Altered genetic structure in *E. Coli*	Belyaev 1996
0.0000000001	Threshold of human sensitivity	Kositsky 2001
0.000000001	Altered EEG in human subjects	Bise 1978
0.0000000027	Growth stimulation in *Vicius fabus*	Brauer 1950
0.00000001	Effects on immune system in mice	Bundyuk 1994
0.00000002	Stimulation of ovulation in chickens	Kondra 1970
0.000005	Effect on cell growth in yeast	Grundler 1992
0.00001	Conditioned "avoidance" reflex in rats	Kositsky 2001
0.000027	Premature aging of pine needles	Selga 1996
0.001	**100 metres from Cell Phone**	
0.002	Sleep disorders, abnormal blood pressure, nervousness, weakness, fatigue, limb and joint pain, digestive problems, fewer schoolchildren promoted	Altpeter 1995, 1997
0.0027	Growth inhibition in *Vicius fabus*	Brauer 1950
0.0027 to 0.065	Smaller tree growth rings	Balodis 1996
0.007	**15 m from a Cordless Phone**	
0.01	Human sensation	Kolbun 1987
0.016	**1.6 Km from a Cellular Tower**	
0.06	Altered EEG, disturbed carbohydrate metabolism, enlarged adrenals, altered adrenal hormone levels, changes in rat, rabbit liver, spleen, testes, and brain	Dumanskij 1974
0.06	Slowing of the heart, change in EEG in rabbits	Serkyuk, in McRee 1980
0.05	**3 meters from a Wireless Computer**	
0.1	Increase in melatonin in cows	Stark 1997
0.1 to 1.8	Decreased life span, impaired reproduction, structural and developmental abnormalities in duckweed plants	Magone 1996
0.13	Decreased cell growth (human epithelial amnion cells)	Kwee 1997
0.168	Irreversible sterility in mice	Magras 1997
0.2 to 8.0	Childhood leukemia near transmitters	Hocking 1996
0.3	Impaired motor function, reaction time, memory and attention of school children, and altered sex ratio of children (fewer boys)	Kolodynski 1996
0.6	Change in calcium ion efflux from brain tissue	Dutta 1986
0.6	Cardiac arrhythmias and sometimes cardiac arrest (frogs)	Frey 1968
0–4	Altered white blood cell activity in schoolchildren	Chiang 1989
1.0	Headache, dizziness, irritability, fatigue, weakness, insomnia, chest pain, difficulty breathing, indigestion (humans—occupational exposure)	Simonenko 1998
1.0	Stimulation of white cells in guinea pigs	Shandala 1978
2.5	Breakdown of blood-brain barrier (used a digital cell phone to radiate)	Salford 1997
5.0	Leukemia, skin melanoma and bladder cancer near TV and FM transmitter	Dolk 1997
2.0	(lower "Microwave hearing" - clicking, buzzing, chirping, hissing, or high-pitched threshold note tones known)	Frey 1963,69,71,73,88, Justeson 79,Olsen 80, Wieske 1963, Lin 1978
5.0	Biochemical and histological changes in liver, heart, kidney, and brain tissue	Belokrinitskiy l982

From: Meg Sears, *Medical Perspective on Environmental Sensitivities*, **Canadian Human Rights Commission,** 2007.

Indoor Net current remedial protocol

The current that results in a circuit where some of the neutral return current[i] takes another circuit or conducting path is known as "*net current'*. Such pathways include metallic water pipes or another circuit's neutral return current wire. Net current is of concern because it tends to produce elevated magnetic fields. Its removal is conducive to the policy of reducing fields to levels as low as possible in occupied zones.

Net and single wire current field dispersion rate

R = distance rate from line source

has a field dispersion rate of only 1/R,
instead of the $1/R^2$ for regular wiring and point sources such as appliances, or
$1/R^3$ for transformers, coils, and most electric panels.

1 Amp current at 1 metre distance = 2 mG / 200 nanoTesla / 0.02 *micro*Tesla

The requirements of the ***Electrical Code*** are based only on the risk of fire and electrical shock. They do not concern with either EMI (Electromagnetic interference), or health issues.

Even relatively low voltages differentials on grounds due to connection of neutral to ground on the load side of the electrical service can cause computer problems. For example, a copy machine on a circuit with a net current wiring error will generate massive magnetic field spikes when it switches "on". Most *net current* wiring errors can be identified for each circuit at the breaker panel using a clamp-on Ammeter. Each correctly wired cable or group of conductors will give a reading of "0.00" on a clamp-on Ammeter. Any other reading indicates a net current along a faulty circuit. Some *net currents* will remain unidentified at the breaker panel as they begin and end in the circuit (such as incorrect 3-way switch wiring). Such type of *net current* will be spotted with a magnetic field meter when the fields increase significantly as lights are turned "on" in a room.

Net current is generated when neutral current is shunted at:

Subpanel (neutral bus bonded to panel)
Equipment grounding conductors connected to neutral bus
Junction box (2 branch circuits sharing each other's neutral)
3-way switch circuits (load circuit feeds into neutral of other)
Water pipes
Gas pipes
Heating pipes
Ventilation and Air conditioning ducts
Structural steel elements
Metal Lathes
Ceiling panel grids
Window frames
Other conduits

Sometimes the neutral current is diverted to the grounding system by the pinching of neutrals, nicking the insulation - as in improperly-mounted fluorescent light fixtures, or in the bonding of the neutral terminal of a receptacle to the grounding screw, with sheet rock nails.

In large installations, a net current frequently results from a **junction box** error. The neutrals from 2 branch circuits are inappropriately bonded together, so a return current from the loads of one circuit will, at the breaker panel, pass on through both the dedicated neutral as well as the neutral in a second branch circuit. So, both circuits will have the same net current: in one of these, it will be an excess of neutral return current the other, it represents an equal deficit of return current. The intensity of the associated magnetic field associated will be the same.

The miswiring associated with **3-way switch** circuit is easily traced when the magnetic field increases significantly when the lights are turned "on". In this miswiring error, the hot conductor is used from one switch feed, with the neutral capped off. The neutral, then, is used from the other switch feed, with the hot wire capped off or leading to another circuit, often a receptacle circuit. The hot is being run in one circuit segment, and the neutral in another. To correct this, the 2-conductor cable must be replaced with the proper 3-conductor one.

Indoor net current circuit identification panel protocol

Only authorized persons may open electrical panels & junction boxes under live conditions. Professional cautionary measures should be taken to avoid shock.

During the exercise, most circuits should be loaded, as would be during a typical situation.

The panel should be visually inspected. If it is not the service entrance panel, examine whether any green or bare conductors are bonded to the neutral bus to the panel box. The neutral bus bonding screw should be backed out or removed. Subpanel neutral/ground bonds should be removed. Equipment grounding conductors should be provided with their own bus. The neutral bus must be electrically isolated from the panel box.

To identify circuits with any net current, clamp an Ammeter around each circuit or group of circuits leaving the panel box. In a crowded box right sized jaws are required. Draw a rough diagram of the panel box, identifying each conduit leaving the panel and its measurements. Each group of conductors should zero out, and such results should be written down. If there is in a circuit a reading of 1.OA, note it down for the group. Now check if the 1.OA net current is the result of a missing or excess neutral current. Clamp the hot wire(s); likewise for the neutral(s) and record the information. The 2 figures should be the same. If not, check whether there is a missing or excess neutral current. Measure equipment grounding conductors associated with the circuit, and record. If there is more than, say 0.1A there may be a neutral/ground connection somewhere in the circuit. A general finding of a 1/10th of an amp or so on equipment-grounding conductors suggests that somewhere neutral current is flowing along grounding wires. To identify the circuit with the error - when there is more than 1 circuit in a group - measure each conductor separately: each hot and record, noting its color, followed by each neutral and record. How do they compare? Does a hot wire match with a neutral and one that does not? Follow such a hot wire to its breaker to identify the circuit. Often it will be a lighting circuit with a junction box.

If 1 neutral appears to go with 2 or 3 hot wires, clamping around the group of hot wires should yield the same resultant in amps as the accompanying neutral. A mix-up in neutrals may appear like this: a hot wire has a 5A and its neutral also carrying 5A. Clamping both wires together should give 0.00 A. If one reads 10A, that neutral was from the other "phase" or hot part in a single-phase service. It is an improper neutral. If it reads 7A, it is from another phase of a 2 or 3-phase panel (and the wrong neutral). So the neutrals are scrambled and must be properly re-sorted in the associated junction box.

When there is either excess or deficit of neutral in a circuit, clamp groups of conductors to find a second circuit carrying the missing neutral deficit or excess current. It will be the same net current, unless more than 2 circuits have been mixed up, usually in pairs. Trace such circuits to find where they share a junction box (with a wire nut binding all the neutrals together). Use then 2 wire nuts and separate the neutrals so that each is wired to the appropriate load circuits - and with no connections between the circuits.

If a circuit that pairs with the first net current one is not found, then there be the case of another circuit that shares a neutral current from another subpanel. Such net current is located by clamping around the feeder for the panel. The missing or excess neutral will give the same net current as in the circuit. Clamping around the feeder hot wires and comparing with the neutral will give more information. Often the neutral deficit measured around the feeder stems from a neutral/ground connection, shunting some return neutral to pipes, other conduits (see list above).

Tracing the location of the net current causing error

Once the net current circuit or circuits is/are identified, trace for the error (often in a junction box). If it is a neutral/neutral error, almost certainly it is in a junction box. If it is a neutral/ground error it may well be accidental and may lead to the error area for further visual or instrumented inspection.

Examine the conduits accessible by removing ceiling panels. Clamp on the Ammeter around conduits until one is found with a net current. Visually note the location of the first junction box and open it. Clamp on the circuits. Follow the net current. Go on till the miswired box is located. Use the second wire nut to separate the 2 neutrals. The Ammeter will read zero; the net current and its field will be gone.

With *Romex* wiring, trace circuits wherever accessible. If the wiring is behind sheet rock and plaster, measure in switch boxes used as junction boxes.

If there is current on grounding conductors in an apartment, a possible source is an electric range or a dryer where the neutral/ground bond that the appliance was delivered with has not been disconnected. The installation instructions explain how to disconnect the bonding conductor, which runs to a green screw on the appliance case and to re-connect it to the neutral screw. This means that the neutral bonding conductor is being connected back to where it came from so that it is not left loose. This neutral/ground bond is supplied with the appliance for installation in older buildings, which do not have a grounding conductor running to the appliance receptacle.

Tracing neutral/ground connections can be more difficult if it is due to accident. The net current on the circuit may suddenly cease of decrease somewhere. Search now for pinched neutrals in a fixture or receptacle or a possible nail shorting neutral to equipment grounding conductor. Sometimes an electrician has connected a wire between neutral screw and grounding screw in a receptacle. Sometimes a green wire was eventually replaced with a white one, leading to miscoding errors.

Walk-Through Protocol for detecting magnetic fields from wiring errors

A walk-through with a gaussmeter can identify areas affected by miswired circuits or appliances. This can be done under the following conditions:

1. The building is energized and the lights in the building turned on.
2. A triaxial gaussmeter is available to monitor the magnetic field level (in milliGauss – mG).
3. Access is available to the individual units.

Gaussmeter

A triaxial gaussmeter is recommended because it will give the correct reading when held in any position. A single-axis meter may also be used but it takes some skill to use correctly, and takes more time to use.

Background field levels

In a building that is not within the field from a power line, the normal background when walking through hallways with lights on in the building will vary from 0 mG to one or two tenths (0.1- 0.2) of a milliGauss. Usually the tenths are from the ballasts of fluorescent lights. The field may go up to a few milliGauss when you pass near a wall shared by a refrigerator in a unit.

To know if the building is within a power line field watch the display of the meter when you are approaching the building and going inside. If the source of the field is external it will be obvious.

Walk-through

Walk down all halls and into sample units. It may not be necessary to check all units. Turn on all lights in the unit. Take your measurements two feet or more from walls, since there are always local fields around switches or fluorescent lights. Expect a local field around the refrigerator (due mainly to the freezer fan motor) and near the electric clock or timer on an electric range. If you see an area where the field is more than a few tenths of a mG, use the meter to get an idea of where the pathway is in the wall, ceiling or floor. Net currents follow linear pathways, whether in circuits or pipes, etc. Make notes. You might try turning off some lights to see how the magnetic field is affected, as this may help to localize the source, but you may want to leave this kind of tracing for the electrician. It helps to have a legal sized clipboard with *Velcro* strips applied to the lower part of the board and on the back of your gauss meter.

Three-way switches

Sometimes 3-way switch circuits are miswired, in which case there will be a substantial magnetic field when the lights are turned on. This is easy to check by turning the lights on and off.

Electric dryer locations

When the building has a laundry room it is necessary to check the dryers to see if they were installed correctly. If the bonding conductor connecting neutral and ground as delivered has not been disconnected or correctly re-connected, there will be neutral current on grounding paths. There are 2 ways to check this. One way is to turn on a couple of dryers and see if you detect any magnetic field on your meter in the laundry room and adjacent hall. A simpler way is to use a multimeter set to ohms (or "continuity"). Pull out one dryer plug. Measure the continuity between the grounding contact and the neutral contact. There should be no connection, so the meter should not show anything ("infinity"). If it buzzes or shows a value on the display, the bond has not been removed and the installer must make the correction, according to the instructions that came with the dryer and which are also found on the label on the back.

Evaluating your results

If you have found any net current magnetic fields and noted where they occur, this information can be given to the electrician as an indication of where to start his search. Also, if you have found dryers with grounded neutrals, the electrician should know what to do about that. If not, he can refer to the protocol developed for him, or the instructions on the back of the dryer and in the instruction booklet. It is important to understand that net currents and their magnetic fields do not occur in buildings that have been correctly wired according to *Code*.

There is one exception: if the water service for the building enters at a point distant from the electrical service entrance, and the pipes are metallic, there may be a net current along the path of the grounding electrode conductor leading to the water pipe, and along the pipe itself. In this case there will also be a similar net current on the service entrance cable. This seldom occurs in multiple-family buildings, since water and electricity usually enter in the same area.

(Prepared for the Michigan State Housing Development Authority by Karl Riley)

Rigid Magnetic Shielding

Rigid *magnetic shielding* is divided into two fundamental types based upon the magnetic properties of the materials: *flux-entrapment shields* and *lossy shields*. A *flux-entrapment shield* is constructed with highly permeable (μ), specially annealed ferromagnetic *MuMetal* alloy composed of 80% nickel and 20% iron (Hipernom Alloy, CO-NETIC AA, AMuMetal, AD-MU-80) which either surrounds (cylinder or rectangular box) or separates ("U" shaped or flat-plate) the *victims* from the magnetic source. Ideally, magnetic flux lines incident upon the *flux entrapment shield* prefer to enter the highly permeable (μ) material traveling inside the material via the path of least magnetic reluctance-□, rather than passing into the *protected* (shielded) space. The relative permeability (μ_r) of *MuMetal* ranges between 350,000-500,000 depending on the composition and annealing process. Unfortunately, *MuMetal* sheets are extremely expensive: a single fully annealed 30 x 120 inch sheet (0.04-inches thick) costs around $1,250 (prices are very volatile due to fluctuation in nickel costs).

Lossy shielding depends on the *eddy-current* losses that occur within highly conductive materials (copper and aluminum), and low permeable (μ) materials that are also conductive such as iron, steel, and silicon-iron. When a conductive material is subjected to a time-varying (60-Hz) magnetic field, currents are induced within the material that flow in closed circular paths -- perpendicular to the inducing field. According to *Lenz's Law,* these *eddy-currents* oppose changes in the inducing field, so the magnetic fields produced by the circulating *eddy-currents* attempt to cancel the larger external fields near the conductive surface, thereby generating a shielding effect. It is often very effective and extremely expensive to shield with multiple layers composed of low permeable/conductive materials (silicon-iron sheets or 1010 annealed steel plates), highly conductive aluminum/copper plates, and highly permeable *MuMetal* sheets.

Shielding factor (SF) is the ratio between the unperturbed magnetic field $\mathbf{B_o}$ and the shielded magnetic field $\mathbf{B_i}$ as expressed in: $\mathbf{SF = B_i / B_o}$ or decibels $\mathbf{SF_{dB} = 20 \log_{10} (B_i / B_o)}$. The final shielding design depends on the following critical factors: maximum predicted *worst-case* 60-Hz magnetic field intensity (magnitude and polarization) and the earth's geomagnetic (DC static) field at that location; shield geometry and volumetric area; type of materials and properties -- conductivity (σ), permeability (μ), induction and saturation which are a function of material thickness; number of shield layers; and, the spacing between sheet materials and layers.

Small, fully-enclosed shields for video display terminals, electronic equipment, and electrical feeders follow simple formulas that guide the design engineer through the process to a functional, but not necessarily optimal, design. After assembling a prototype, the design engineer measures the *shielding factor (SF)* and modifies the design (adds materials, additional layers, anneals bends, etc.) to achieve the maximum shielding requirements. This is a very iterative design process, from concept to final product. Unfortunately, magnetic shielding is more of an art than a science, especially when shielding very large areas and rooms from multiple, high-level, magnetic field sources.

At this time there are no reliable design formulas or EMF simulation programs that offer design engineers practical guidelines for shielding large exposed areas from multiple, high-level, magnetic field sources.