Options to Minimize Non-Ionizing Electromagnetic Radiation Exposures (EMF/RF/Static Fields) in Office Environments

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ABBREVIATIONS

1G – First generation wireless technology

2G – Second generation wireless technology

3G – Third generation wireless technology

6- OHMS – 6-hydroxy-melatonin-sulfate (main metabolite of melatonin)

AC – Alternating current

ACGIH – American Conference of Governmental Industrial Hygienists

ALARA – As low as reasonably achievable

ALATA – As low as technically achievable

AM – Amplitude modulation

A/m – Ampere per meter (unit of magnetic field strength)

AMPS – Advanced Mobile Phone System

BCCDC – British Columbia Centre for Disease Control

BMW – Bayerische Motorenwerke (German car manufacturer)

CCFL – Cold-cathode fluorescent lamp

CDMA – Code division multiple access

CERN – Conseil Européen pour la Recherche Nucléaire [European Laboratory for Particle Physics in Geneva, Switzerland]

CEU – Council of the European Union

CFF – Critical fusion frequency

CFL – Compact fluorescent lamp

CHRC – Canadian Human Rights Commission

CI – Confidence interval

COMAR – IEEE Committee on Man and Radiation

CPU – Central processing unit (computer desktop)

CRT – Cathode ray tube

DC – Direct current

DECT – Digital Enhanced Cordless Telecommunications, formerly Digital European Cordless Telecommunications

DHS – Department of Health Services (California)

DIN – Deutsche Industrie-Norm or Das Ist Norm [German national standards organization]

DOI – Digital object identifier

DSS – Digital spread spectrum

ECG – Electrocardiogram

EEG – Electroencephalogram

EHS – Electromagnetic hypersensitivity

EIRP – Equivalent isotropically radiated power (for effective isotropic radiated power)

ELF – Extremely low frequency (3-3,000 Hz)

EMC – Electromagnetic compatibility

EMF – Electromagnetic fields

EMR – Electromagnetic radiation

EPRI – Electric Power Research Institute

ESD – Electrostatic discharge

EU – European Union

FCC – Federal Communications Commission (US)

FDA – Food and Drug Administration (US)

FDMA – Frequency division multiple access

FHSS – Frequency hopping spread spectrum

FM – Frequency modulation

GHz – Gigahertz (unit of frequency)

GPO – Government Printing Office (US)

GSM – Global System for Mobile Communications

HF – High frequency

HPA – Health Protection Agency (UK)

HR – Heart rate or hazard ratio

HRV – Heart rate variability

Hz – Hertz (unit of frequency)

IARC – International Agency for Research on Cancer

IBO – Österreichisches Institut für Baubiologie und Bauökologie [Austrian Institute of Building Biology and Ecology]

ICD – International Classification of Diseases

ICEMS – International Commission for Electromagnetic Safety

ICNIRP – International Commission for Non-Ionizing Radiation Protection

iDEN – Integrated Digital Enhanced Network

IEC – International Electrotechnical Commission

IEEE – Institute of Electrical & Electronics Engineers

IR – Infrared radiation

IRPA – International Radiation Protection Association

IzgMF – Informationszentrum gegen Mobilfunk [Information Center Against Mobile Phone Communications]

LCD – Liquid crystal display

LED – Light emitting diode

L.s. – Lipoatrophia semicircularis

lux – Unit of illuminance

µT – Microtesla (unit of magnetic flux density)

µW/m^2 – Microwatts per square meter (unit of power density)

mG – Milligauss (unit of magnetic flux density)

MHz – Megahertz (unit of frequency)

MΩ – Megohm (unit of surface resistance)

MMF – Maximum magnetic field

MPR – Swedish National Board for Measurement and Testing

MRI – Magnetic resonance imaging

MTHR – Mobile Telecommunications and Health Research (UK program)

MW – Microwaves

mW – Milliwatt (unit of power output)

NBOSH – Swedish National Board of Occupational Safety and Health

NCRP – National Council on Radiation Protection and Measurement (US)

NGDC – National Geophysical Data Center (US)

NIBS – National Institute of Building Sciences (US)

NIEHS – National Institutes of Environmental Health Sciences (US)

NIOSH – National Institute of Occupational Safety and Health (US)

NISV – Verordnung über den Schutz vor nichtionisierender Strahlung [Swiss regulation concerning protection against non-ionizing radiation]

NMT – Nordic Mobile Telephone

NRPB – National Radiation Protection Board (UK)

nT – Nanotesla (unit of magnetic flux density)

NWPSC – Northwest Product Stewardship Council

OR – Odds ratio

PC – Personal computer

PCS – Personal communications service

PDA – Personal digital assistant

POPs – Persistent organic pollutants

PP – Precautionary principle

PSU – Power supply unit

RCM – Rate-of-change metric

RF – Radiofrequency (3 kHz-300 GHz)

RMS – Root mean square (effective value)

SAI – Small air ion

SanPiN – Sanitary-epidemiological norms and regulations (by Ministry of Health in Russia)

SAR – Specific absorption rate

SBM – Standard der baubiologischen Messtechnik [Standard of Building Biology Testing Methods]

SCENIHR – Scientific Committee on Emerging and Newly Identified Health Risks (EU)

SIF – Swedish Union of Clerical and Technical Employees in Industry

SMS – Short message service

SNAI – Small negative air ion

SQUID – Superconducting quantum interference device

STOA – Science and Technology Options Assessment (EU)

TCO – Tjänstemännens Centralorganisation [Swedish Confederation of Professional Employees]

TD-CDMA – Time division-code division multiple access

TDMA – Time division multiple access

TFEL – Thin film electroluminescence

TFT – Thin film transistor

TQ – Total quality

TWA – Time-weighted average

UHF – Ultra high frequency (300-3,000 MHz)

UMTS – Universal Mobile Telecommunication System

UTP – Unshielded twisted pair (cable)

UV – Ultraviolet

V – Volt (unit of electric surface potential)

VDB – Verband Deutscher Baubiologen e.V. [German Association of Building Biology Professionals]

VDE – Verband Deutscher Elektroingenieure [German Association of Electrical Engineers]

VDT – Visual display terminal

VDU – Visual display unit

VEP – Visual evoked potentials

VHF – Very high frequency (30-300 MHz)

VLF – Very low frequency (3-30 kHz)

V/m – Volt per meter (unit of electric field strength)

VOC – Volatile organic compounds

VoIP – Voice of Internet Protocol

WCDMA – Wideband-code division multiple access

WHO – World Health Organization

Wi-Fi – Brand-name for WLAN IEEE 802.11b

W/kg – Watt per kilogram
(unit of specific absorption rate)

WLAN – Wireless Local Area Network

WMAN – Wireless Metropolitan Area Network

WPAN – Wireless Personal Area Network

WWAN – Wireless Wide Area Network

EXECUTIVE SUMMARY

In contrast to the common risk assessment practice of applying safety factors to observed or estimated no observed adverse effect levels derived by establishing thermal threshold values, this paper starts out with the background levels of non-ionizing radiation in nature, documents what actual exposure levels across various frequency bands are found in office environments today, and looks at technically achievable options of how to minimize emission levels of common office equipment. Considering that at a minimum 6 out of 10 Canadians work with computers and 80% of those do so every day, the urgency of the ever increasing level of ubiquitous electromagnetic fields, RF radiation, and static fields in offices becomes clear, especially in light of the growing body of evidence concerning adverse long-term health effects from exposure to non-ionizing radiation at non-thermal effect levels. After reviewing currently permissible exposure limits and their inadequacy, as well as selected biological effects associated with EMR exposures during office work, this paper also examines why and how various countries, scientists, associations, and occupational health regulations opt for a precautionary approach. The heart of this paper can be found in the "Checklist of EMF/RF/Static Field Exposures in Office Environments," which is a list of science-based options on how to minimize exposures to electromagnetic fields, RF radiation, and static fields in office environments sorted by technology and device complete with emission data, including phone types (corded, cordless, mobile), area networks (WPAN, WLAN, WWAN), VDTs, desktops, laptops, other peripherals, types of lamps, and office furniture and furnishings. A comprehensive appendix provides many resources, annotated studies, and references on why it makes sense to take electromagnetic hypersensitivity seriously and apply the precautionary principle, and who does so for the protection of the workers' health and safety.

1 INTRODUCTION TO ENVIRONMENTAL SENSITIVITIES ASSOCIATED WITH NON-IONIZING RADIATION EXPOSURES

In modern physics, electromagnetic radiation is one of the four fundamental forces by which all phenomena in nature can be described. All matter, living or non-living, produces electromagnetic radiation. The various manifestations of electromagnetic radiation share one fundamental property: the electric charge. We distinguish between two major portions of the electromagnetic spectrum. If a given electromagnetic radiation has sufficient energy to knock electrons out of the orbits of atoms and molecules, thereby creating charged particles or ions, we speak of ionizing radiation. All other forms of electromagnetic radiation are referred to as non-ionizing because their energy is not high enough for ionization to occur, but its effects are mediated in other ways. This paper focuses on the exposure to sources of human-made non-ionizing radiation in office environments, including power-frequency alternating electric and magnetic fields, RF radiation, and static electric and magnetic fields.

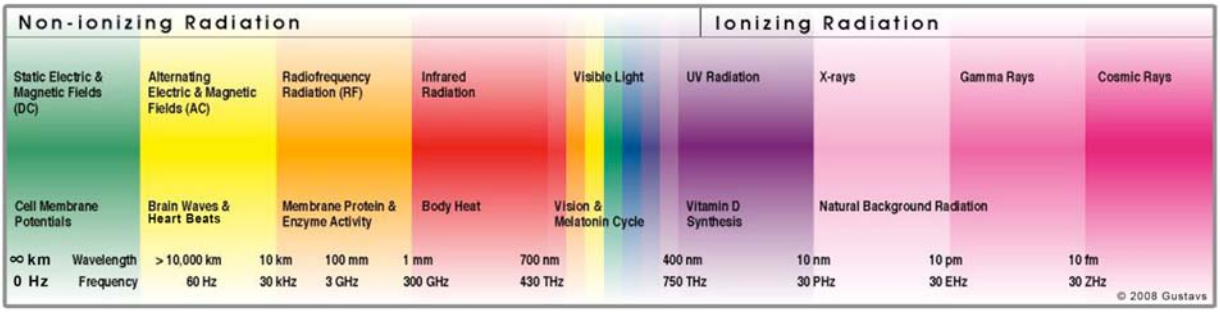

Figure 1: Electromagnetic Spectrum

Electromagnetic radiation is a universal language of life. Humans not only need electromagnetic radiation input from the outside world on an ongoing basis for their survival (e.g. visible light for melatonin cycle, UV radiation for vitamin D synthesis), but each of the trillions of cells making up the human body also use electromagnetic energy for communication purposes (e.g. heart beat, nerve signals, brain waves). Throughout human evolution, these naturally occurring

electromagnetic fields and waves have followed a unique pattern. For example, the geomagnetic field is designed to permeate everything, and its magnetosphere forms a protective shield around the earth against the deadly radiation from space. Yet there are "windows" in the atmosphere that selectively allow, for instance, visible light and infrared radiation to enter, but other types of space radiation in the ELF range, for example, are blocked out through the ionosphere. Thus, extremely low Schumann resonances can propagate on earth below the ionosphere, synchronizing biological cycles in living organisms, including humans (König et al. 1981). Ever since the first power plant delivered electricity to Lower Manhattan in 1882, this natural balance has been radically changed.

Throughout the first half of the 20th century various types of electric equipment has been introduced to offices. By the time when Time Magazine named the personal computer "Machine of the Year" in 1982, it had already changed many workplaces (Friedrich 1983). In 2000, almost 6 out of 10 Canadian workers used a computer for their job, of which 80% used the computer every day (Marshall 2001). The use of not only computers but all kinds of information and communication technology continues to rise dramatically. Depending on the province, somewhere between 50% and 80% of Canadians have access to a mobile phone, using it either for mostly personal (60%) or business (29%) calls (Decima Research 2006). A similar trend of increasing computer and wireless phone use is also seen in other industrialized countries.

As the ambient level of EMF and RF radiation continues to increase, the number of persons who attribute their health symptoms to low-level EMF or RF radiation exposures in the workplace or at home is also on the rise, from approximately ca. 1% in the mid-1990s to 5% to 13% ten years later (Hallberg and Oberfeld 2006). Despite pressure from the World Health Organization to consider healthy symptoms attributed to EMF exposures as a psychological phenomenon and not a disease (Mild et al. 2006), it is commonly referred to as electromagnetic hypersensitivity or EHS in the scientific literature.

Individual susceptibilities to environmental factors can vary greatly. Just as individuals with fairer skin are more prone to develop sunburn and erythema than those with darker skin types, individuals can be more prone to sensitivities associated with EMF and/or RF radiation and/or static fields. Such individuals can display one or several of the biomarkers: a high number of mast cells (Gangi and Johansson 2000), high critical fusion frequency (Lyskov et al. 2001), reduced heart rate variability (Sandström 2003), high skin conductance (Eltiti et al. 2007), increased levels of certain persistent organic pollutants (Hardell et al. 2008), high mercury vapor release from amalgam fillings in the vicinity of e.g. CRT monitors and mobile phones (Ganlund-Lind and Lind 2004; Ortendahl et al. 1991; Mortazavi et al. 2008).

Notwithstanding the lack of a widely recognized plausible mechanism, selected countries and especially Scandinavian countries not only acknowledge the severity of symptoms suffered by affected individuals, but some organizations also assist in lowering the exposure in the workplace as well as at home. Sweden, for example, was not only the first country in the world to introduce a successful low-emission standard for VDTs in the late 1980s (MPR and TCO), but electromagnetic hypersensitivity is now recognized as a “functional impairment” (Johansson 2006). The City of Stockholm tries to make its city accessible to all people, including those who are electromagnetically sensitive (Stockholm 2006). On the other hand, a large Swedish union, when it merged with another (Unionen 2008), cancelled its progressive Healthy Office Project and removed an informative manual on low-EMF workplaces and electromagnetic hypersensitivity from open access (SIF 1996). By ignoring the problem of the increasing electromagnetic exposure levels at office workplaces will not decrease the growing number of electrosensitive people. The current regulation on VDT use by the Swedish National Board of Occupational Safety and Health (NBOSH 1998) still calls for a “greater preparedness … for helping and supporting those who experience discomfort.” Since only a fraction of *preventable* occupational diseases are recognized as such, in 2000 the Nordic Council of Ministers assigned

an ICD-number to “electromagnetic intolerance” to monitor its prevalence and advised occupational physicians to not use a psychiatric diagnosis for individuals reporting to be affected by EMF or RF radiation exposures because symptoms usually disappear in “non-electrical environments” (Levy and Wannag 2000).

In 2007, the Canadian Human Rights Commission issued a Policy on Environmental Sensitivities that acknowledges physical causes and “encourages employers and service providers to proactively address issues of accommodation by ensuring that their workplaces and facilities are accessible for persons with a wide range of disabilities,” including electromagnetic hypersensitivity (CHRC 2007). For more detailed information on electromagnetic hypersensitivity and selected studies see Appendix 9.

It is very difficult to measure the health impact from an office environment and establish causal links between individual environmental factors and a specific health condition because it is often the synergetic effect of many different factors, such as EMF/RF levels, IAQ, illumination, thermal comfort, noise. While the the exact factor may be elusive, there is little doubt that workers’ health and productivity are intimately linked. For example, the general improvement of indoor air quality is said to increase productivity by 20% (Lorsch and Abdou 1994). In the same manner, the improvement (or reduction) of EMF and RF radiation exposures can also contribute to a healthy work environment. According to the project team “Indoor Environments” from the Queensland University of Technology (Bell 2004), “reducing total energy use by 50% will not produce the same financial return as a 1% productivity improvement.” Therefore, it should be in everybody’s interest to create the best possible office environment.

2 CURRENT EXPOSURE GUIDELINES FOR NON-IONIZING RADIATION AND THE PRECAUTIONARY PRINCIPLE

At first, the scientific community was focusing on the adverse health effects caused by the ionizing portion of the electromagnetic spectrum. Burn effects from x-rays became obvious soon after their discovery in 1897. Radiation safety commissions were formed in many countries. The US National Council on Radiation Protection and Measurement (NCRP) put the precautionary concept ALARA forward in 1954 (Mould 1993).

After the International Radiation Protection Association (IRPA 2006) had been founded in 1964, it took another ten years before the International Commission for *Non-Ionizing* Radiation Protection (ICNIRP 2007) was formed. To this day, the exposure limits issued by this nongovernmental organization of scientists and many other governments are based on thermal effects and (averaged) RMS values. The ICNIRP Guidelines (1998) state clearly that "these guidelines are based on short-term, immediate health effects such as stimulation of peripheral nerves and muscles, shocks and burns caused by touching conducting objects, and elevated tissue temperature resulting from absorption of energy during exposure to EMF." The existence of other low-level effects is mentioned, but the available scientific data is deemed too inconsistent to actually develop exposure limits for long-term health protection. Health Canada uses a similar approach.

Over the past ten years, several European countries have started to include non-thermal effects into their exposure limit considerations, resulting in much lower threshold values (see Appendix 4). But none of the legally binding exposure guidelines seem to pay attention to the rate of change and transient activity in EMFs, low-frequency or pulsing frequency components, or interference in RF radiation, all of which have been shown to impact living organisms (Philips 2004). Current exposure limits based exclusively on thermal effects are inadequate, according

to The BioInitiative Report (2007). The project leader of the REFLEX study (2004), which observed genotoxic effects in-vitro from mobile phone radiation exposures, also calls for a revision of current microwave exposure limits (Adlkofer and Lutz 2007) to include non-thermal effects. Furthermore, the many resolutions by the scientists of the International Commission for Electromagnetic Safety (ICEMS 2008) add even more studies and arguments why exposure limits should be based on the precautionary principle.

Exposure recommendations for computer workplaces differ greatly between European and North American countries. In its booklet on radiation risk and VDTs, the BC Centre for Disease Control (2002) specifically admonishes VDT users not to "purchase electromagnetic shields or any other radiation protective devices" for their VDT. The authors are correct in stating that the Swedish standard for low-emission monitors (TCO) is not an evidence-based health standard, but what is technically achievable. One year after the publication of this booklet in 2003, the chief medical officer of Russia issued a health-based sanitary regulation for low-emission VDTs whose threshold values are only slightly higher than the TCO limits (Russia 2003 Jun 30).

For some reason, however, it seems to have evaded the authors that most European countries have opted for the precautionary principle in the presence of inconclusiveness for nearly 20 years. The European Communities' Directive on the minimum requirements for VDUs (CEU 1990) states clearly that "all radiation with the exception of the visible part of the electromagnetic spectrum shall be *reduced to negligible levels* from the point of view of the protection of workers' safety and health."

The authors of the booklet from the BC Center for Disease Control (2002) try to provide comfort by pointing out that electromagnetic emissions from VDTs are "less than those produced by other appliances such as can openers." This not only ignores the cumulative effect of emissions, as electric can openers were introduced to the human environment somewhat

earlier than computers, but also ignores comparison with naturally occurring background levels in which humans have evolved. It would seem prudent to err on the side of caution as long as long-term negative consequences from ubiquitous low-level electromagnetic exposures cannot be ruled out. This is especially relevant in spaces where we spend considerable amounts of time, such as computer workstations.

Official exposure limits distinguish between the general public and occupationally exposed persons. In the case of EMF and RF radiation, occupationally exposed persons include e.g. electrical workers and RF workers who are trained to be aware of potential risks and know how to take appropriate precautions. The majority of office workers do not fall into the occupationally exposed category, therefore, the exposure limits for the general public also apply to them.

See Appendix 3 (natural background), Appendix 4 (exposure limits), and Appendix 6 (OHS regulations) for references and further details on the exposure limits discussed below.

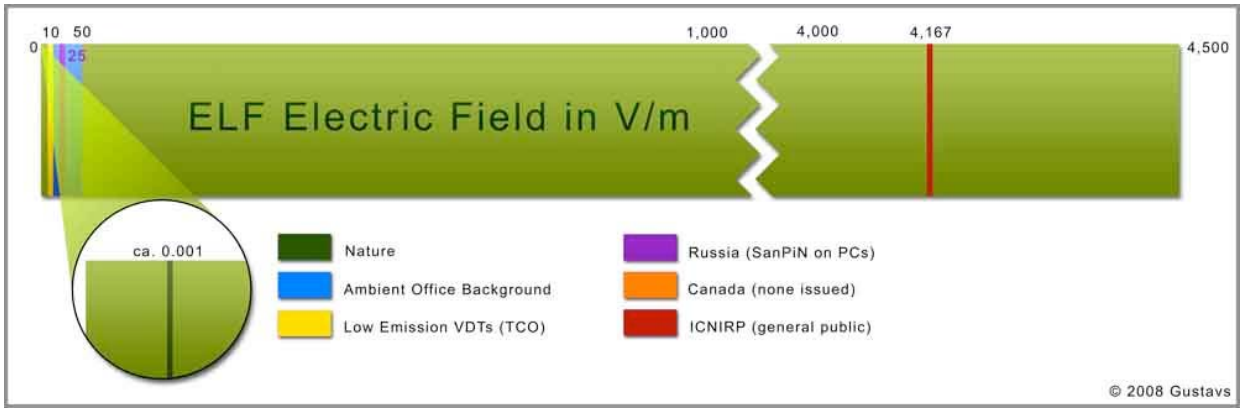

Figure 2: ELF Electric Field Levels and Exposure Limits

To date, the government of Canada has not issued environmental exposure limits for power-frequency fields. In general, the 1998 ICNIRP exposure guideline is consulted for ELF electric fields. The natural background level is roughly four million times lower than the ICNIRP reference value for 60 Hz electric fields that only protects from acute, short-term effects.

Emission limits for low-emission VDTs range from 10 V/m in the TCO certification (voluntary) to 25 V/m in the Russian sanitary regulation for PCs (mandatory).

Based on the precautionary principle, selected Austrian green building rating systems (IBO ÖKOPASS, arge TQ) require ambient exposure levels in a building to be below 10 V/m for the highest quality in the EMF category, which coincides with option 2 of the draft recommendation by the US National Council on Radiation Protection and Measurements (NCRP) from 1995.

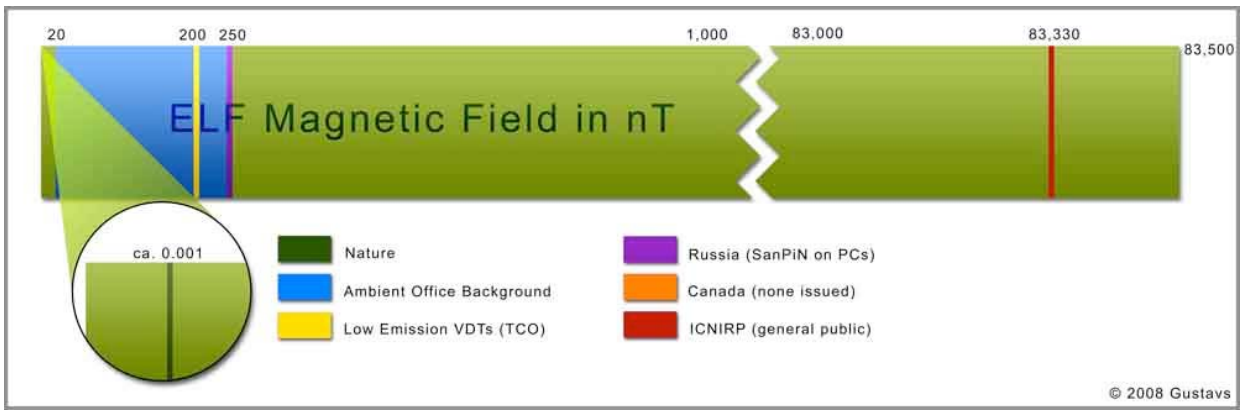

Figure 3: ELF Magnetic Field Levels and Exposure Limits

To date, the government of Canada has not issued environmental exposure limits for power-frequency fields. In general, the 1998 ICNIRP exposure guideline is consulted for ELF magnetic fields. The natural background level is roughly 80 million times lower than the ICNIRP reference value for 60 Hz magnetic fields that protects from acute, short-term effects only.

Emission limits for low-emission VDTs range from 200 nT in the TCO certification (voluntary) to 250 nT in the Russian sanitary regulation for PCs (mandatory).

Based on the precautionary principle, the US National Institute of Building Sciences (NIBS) recommends since 2006 to keep the ambient ELF magnetic field level in occupied areas of buildings below 100 nT, not exceeding 250 nT. Likewise, the BioInitiative Working Group, a group of renowned EMF scientists, recommends 100 nT for residences and sensitive areas, and 200 nT for all other existing buildings. The latter value coincides with option 2 of the draft recommendation by the US National Council on Radiation Protection and Measurements (NCRP) from 1995.

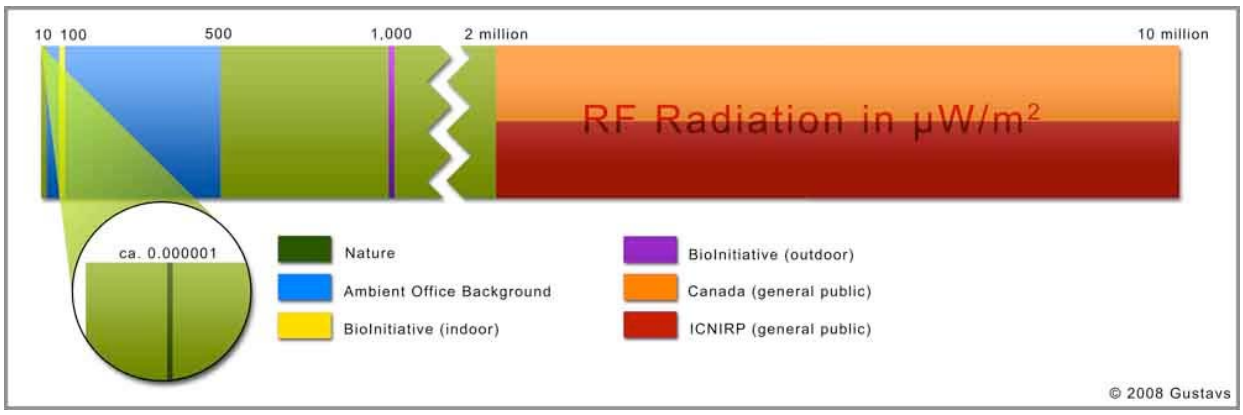

Figure 4: RF Radiation Levels and Exposure Limits

Health Canada has issued exposure limits for radiofrequency electromagnetic fields since 1991. They are similar to the reference values of the 1998 ICNIRP exposure guideline. The natural background level is roughly one to ten trillion times lower than the ICNIRP and Health Canada exposure limits that protect from acute, short-term effects only.

The Russian sanitary regulation for PCs does not specify RF radiation limits. The TCO certification for VDTs or desktops does not include RF radiation levels either. This is unfortunate because almost all computer desktops and laptops have been shipped with wireless connectivity for quite some time now. TCO certification for headsets and mobile phones, which is currently under revision, does give SAR values. The SAR value for so-called low-emission mobile phones, however, is the same value as issued by the US FCC, 0.8 or 1.6 W/kg, respectively. In 2002, the Blue Angel eco-label from Germany set its threshold value somewhat lower, at 0.6 W/kg. The independent EMF-Institut Dr. Niessen from Germany considers mobile phones only low-emission if below 0.2 W/kg. See Hinrikus (2008) for non-thermal effect levels.

Building on the precautionary Salzburg Resolution from 2000, the BioInitiative Working Group recommends to keep the sum total of RF radiation exposure below 1,000 µW/m^2 outdoors and below 100 µW/m^2 indoors. In Austria, the Salzburg Public Health Department goes even a step further by recommending in 2002 to keep the sum total of pulsed GSM signals and ultrabroadband 3G signals, below 10 µW/m^2 outdoors and below 1 µW/m^2 indoors.

Figure 5: Static Electric Field Levels and Exposure Limits

To date, the government of Canada has not issued environmental exposure limits for static electric fields. The 1994 or 1998 ICNIRP exposure guidelines did not issue any reference values on static electric fields. The natural background level of atmospheric electricity is around 130 V/m during fair weather conditions, ranging between 50 and 500 V/m most of the time, and during thunderstorms, can temporarily increase up to 20,000 V/m.

The upper limit for the electrostatic surface potential of low-emission VDTs is 500 V in the TCO certification (voluntary) as well as in the Russian sanitary regulation for PCs (mandatory). In addition, the latter regulation also specifies an upper limit for static electric fields at computer workstations, that is, 15,000 V/m.

Based on the precautionary principle, the green building rating system from the Austrian Building Biology Institute (IBO ÖKOPASS) requires ambient exposure levels from static electric fields in a building to be below 200 V/m for the highest quality in the EMF category.

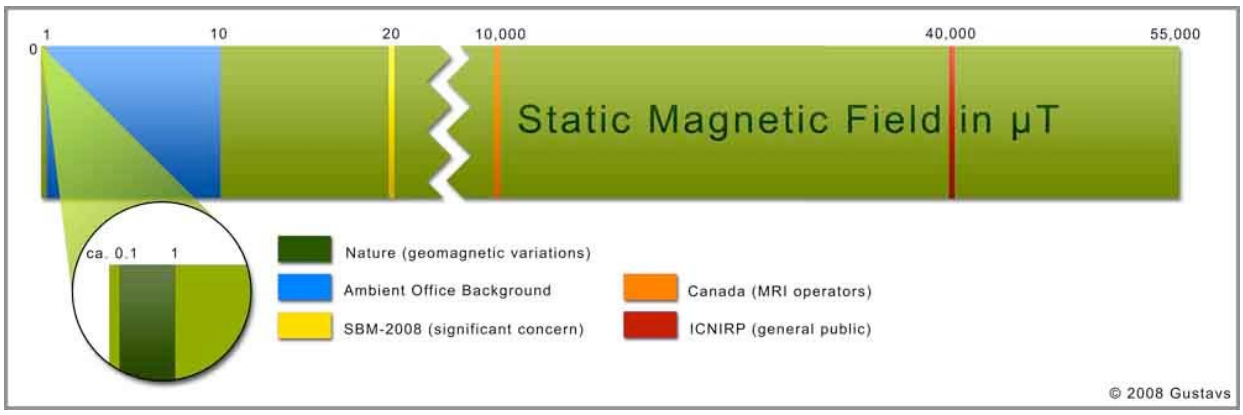

Figure 6: Static Magnetic Field Levels and Exposure Limits

To date, the government of Canada has not issued environmental exposure limits for static electric fields. In Canada, the continuous exposure of MRI operators to static magnetic fields must not exceed 10,000 µT. The 1994 ICNIRP exposure guideline on static magnetic fields sets the reference value for the general public at 40,000 µT. The naturally occurring geomagnetic field ranges from ca. 35 µT at the equator to ca. 70 µT at the poles. In Victoria on Vancouver Island it is around 55 µT. However, at any given area, for example across an office space or building, the local geomagnetic field is mostly uniform in intensity and polarity. The everyday natural variations of this field range from 0.1 to 1 µT. According to the Canadian Space Weather Forecast Centre any natural variation above 0.3 µT in the sub-auroral zone is classified as a major geomagnetic storm.

The Russian sanitary regulation for PCs as well as the TCO certification do not specify limits for static magnetic fields. Computer disks, magnetic storage media, and credit cards may be affected at 500 µT.

Though the permissible upper limit for a whole-body short-term MRI exposure, which often takes no longer than 30 minutes, can range from two to eight million microtesla, the Building Biology Evaluation Guidelines for Sleeping Areas SBM-2008 (voluntary) consider any deviation from the local geomagnetic field above 20 µT caused by steel a significant concern.

3 SELECTED BIOLOGICAL EFFECTS OF EXPOSURES TO NON-IONIZING RADIATION IN OFFICE ENVIRONMENTS

Electricity had been in use for over half a century when personal computers with VDTs were introduced to offices in the late 1970s. Health concerns about the electromagnetic emissions from these devices were raised at the onset: computer operators complained especially about headaches, fatigued eyes, and skin rashes.

In response to several reports of miscarriage and birth defect clusters in VDT operators in the late 1970s (Marcus et al. 2000), the US National Institute of Occupational Safety and Health launched a research program on the various health issues associated with VDT use (NIOSH 1999). Since very few of the cited studies found risk associations, the 1999 edition of the NIOSH report concludes that the emissions from VDTs did not present a hazard. It is argued that the ambient exposure levels from AM stations are usually higher than the VLF emissions from VDTs and that the EMF emissions of common household appliances are often similar or higher than the ELF emissions from VDTs. Following this line of thought does not constitute scientific proof and would only convey a sense of safety if, for example, power-frequency magnetic field exposures could be proven to be harmless. Yet, the opposite seems to be true (IARC 2002), some scientists (Cherry 2004) even speak of a “universal genotoxic carcinogen.”

Many of the VDT studies suffer from major methodological issues: exposure misclassification (no truly non-exposed group), selection of measurement metrics (TWA, peak values, transients), limited source identification (focus on VDT without considering the contributing emissions of other sources), and many others (Shaw 2001). Thus potential reproductive risks may be attenuated. Some newer studies on magnetic field exposure and miscarriage risk (Lee et al. 2002; Li et al. 2002) that used 24-h personal data monitoring in addition to spot measurements found a dose-response relationship for the miscarriage risk with

increasing magnetic field exposure for maximum field levels (above 1,400 nT or 1,600 nT).Even when adjustments for more than 30 variables were applied, the risk estimates for maximum magnetic field levels and miscarriage hardly changed.

Despite the sparse scientific evidence for the association between VDT use and adverse reproductive health outcomes, the Saskatchewan Public Service Commission allows pregnant women to choose a workplace without VDT during pregnancy (Saskatchewan 1986); and the Russian sanitary regulation for PCs does the same, but the latter also specifies that if a woman opts for VDT work, work hours must be limited to 3 hours per day during pregnancy (Russia 2003). Considering that modern office environments contain a myriad of different emission sources of EMFs, RF radiation, and static fields, this does not seem to make sense. Especially in view of the accumulating evidence for an increased risk of childhood leukemia and miscarriage associated with low-level ELF magnetic field exposures (IARC 2002; Neutra et al. 2002), it would be much more helpful as a preventive measure to provide actual EMF measurements and ensure an overall low-emission workplace for pregnant women (e.g. AC electric field: < 10 V/m, AC magnetic field: < 100 or 200 nT, RF: < 10 or 100 $\mu W/m^2$, static electric field: < 200 or 500 V, static magnetic field: < 10 or 20 µT). It may turn out that a current computer workstation with a low-emission LCD screen in an overall low EMF/RF ambient exposure setting will have much lower exposure levels compared to a non-computer desk with much higher ambient EMF and/or RF exposure levels due to access points, feeder cables, or transformers located adjacent to it (Milham 1996).

In this context, it is worth mentioning that magnetic field effects seem to be modified by ambient light conditions. Office lighting is notorious for being too low, well below 500 lux. Burch et al. (1999) observed progressively lower melatonin levels in office workers with increasing magnetic field exposure and decreasing ambient light levels.

Studies investigating the brain tumor risk associated with mobile phone use fall into two

large groups: those that look at risk estimates for periods of use less than 10 years and those for periods of use greater than 10 years. The majority of studies in the first category do not find an association, which is not surprising because the development of brain tumors has a certain latency period. In contrast, studies on long-term users (> 10 years) often observe a twofold risk increase or more (Hardell et al. 2008). Similar risk estimates also apply to the long-term use of cordless phones (Hardell et al. 2006). The final results of the Interphone study, an international research collaboration of 14 countries coordinated by the IARC, have been expected to be released for at least the past two years. Though many individual Interphone studies did not seem to find an increased risk at first glance (also due to study design flaws), the most recent update from October 2008 states clearly that mobile phone use of 10 years or more yields a "significantly increased risk" of glioma and acoustic neurinoma (Interphone 2008).

Even if government agencies prefer to rely on studies that do not find any association between EMF exposures and health problems in office environments, they often concede that elevated static electricity combined with low air humidity is not only a nuisance but may actually aggravate existing skin conditions (BCCDC 2002). A new study on the electromagnetic properties of office environments (Jamieson 2007) shows how increased static and alternating electric field levels within certain microenvironments of a given office cause, on the one hand, a major decline in essential small air ions, and on the other hand, a high local concentration of charged submicron particulates, thereby also increasing the risk of infection and respiratory problems from airborne contaminants. This might explain why the Ministry of Health of the Russian Federation (Russia 2003 Jun 16) issues a sanitary regulation on small air ion concentrations, which specifies a minimum of 600 negatively charged and 400 positively charged small air ions per cubic centimeter air for the indoor air at computer workplaces, but 3,000-5,000 negative air ions and 1,500-3,000 positive air ions are considered optimal.

The major outbreak of Lipoatrophia semicircularis, a lesser known skin condition with

unknown etiology, among hundreds of Belgian office workers who had just moved to their company's newest office building in 1995 was rather puzzling. The investigators (Maes et al. 2003) found that L.s. was diagnosed in persons who worked at new desks with a much higher surface electric resistance and also a much higher alternating electric field level below the desk at knee-level. When the persons with L.s. returned to their old desks with much lower electric field levels, a complete recovery could be observed, which supports the hypothesis of "galvanic coupling between the charged materials and the body." Although van Loock (2006) favors the thermal loss hypothesis as a cause, he provides electric-field exposure data that clearly exceed existing ICNIRP exposure limits by a factor of five or ten (locally up to 55 kV/m at the thigh) and recommends to "maintain a safe distance from all active electromagnetic objects, such as metals and all types of cables, wiring and antennas."

For more detailed information and additional symptoms, see the annotated list of selected studies in Appendix 5.

4 SOURCES OF NON-IONIZING RADIATION IN OFFICE ENVIRONMENTS

In modern offices, a great variety of electrical equipment and electronic devices are being used—not just VDTs. Each piece of equipment has an electromagnetic emission pattern that generally decreases with increasing distance from the source; some emit predominantly in one frequency range and others in multiple frequency ranges. Furthermore, many potential sources of electromagnetic emissions are hidden from view such as wiring in the walls and electrical rooms. For more detailed emission data of devices and ambient exposure levels in office environments see Appendix 1 and Appendix 2.

More and more electronic helpers are added each year, especially those with wireless connectivity. Consequently, the overall exposure level to RF radiation as well as EMFs still continues to increase even though the emissions of some devices (e.g. LCD monitor) have decreased. To determine the exposure levels of EMFs, RF Radiation, or static fields at a given computer workstation, testing with appropriate measurement equipment of sufficient sensitivity should be performed at relevant time periods in the actual location.

4.1 ALTERNATING ELECTRIC FIELDS (ELF/VLF)

An electric field exists in the space surrounding charged particles such as charged metal ions in a conductor. Applying an alternating potential difference or voltage across a conductor or wire produces alternating electric fields. In North America, electric power is supplied at 60 Hz (in Europe at 50 Hz), reversing its polarity 60 times per second, which is why it is referred to as alternating. The electric field strength is measured in volts per meter (V/m). Whenever an electric device is plugged into an outlet, even though it may *not* be turned on, it will emit alternating electric fields. (Hydro Québec [date unknown])

Typical ambient exposure levels of ELF or 60-Hz electric fields in work environments

range from about 10 to 50 V/m (Dingell 1993). In close proximity (< 30 cm) to an extension cord, exposure levels can easily exceeded 50 or 100 V/m, especially if ungrounded (two-pin plug). The same applies to desk lamps, electric typewriters or calculators, and unshielded CRT monitors. When a laptop is used in AC power mode, especially if ungrounded, the user's electric field exposure can reach several hundred volts per meter (Virnich and Moldan 2007), and for the hands up to 2,000 V/m (Maes 2005). Most electronic devices also emit electric fields in the VLF or kHz range; major emission sources include laptops, CRT monitors, fluorescent lighting incl. CFLs, and dimmer switches.

Major indoor sources of alternating electric fields include extension cords, power supply cords, laptops, unshielded CRT monitors, electric office equipment, desk lamps, and wiring in the walls. Overhead transmission or distribution lines can be a major external source.

4.2 ALTERNATING MAGNETIC FIELDS (ELF/VLF)

A magnetic field exists in the space surrounding moving electric charges such as freely moving electrons in a metal conductor. Alternating or power-frequency magnetic fields are generated when electrons jump from atom to atom, creating a current flow. The magnetic field strength is measured in ampere per meter (A/m), and its derived magnetic flux density is measured in nanotesla (nT) or milligauss (mG). Whenever an electric device is turned on and an electric current flows through a cable, alternating magnetic fields are emitted. (Hydro Québec [date unknown])

Typical ambient exposure levels of ELF or 60-Hz magnetic fields in office environments range from about 30 to 250 nT (Huffman 1995). Due to poor wiring practices or adjacent transformers (Milham 1996), ambient magnetic field exposures in office environments can be substantially higher than expected (up to 19,000 nT). Usually, peak exposures occur in close proximity to office equipment and can vary greatly throughout a workday (Perry 1994). Back in

1998 (Schiffman et al.), a study on ELF magnetic field exposures in office workers made clear that some types of equipment emit much higher magnetic fields than others, especially book theft detectors (up to 100,000 nT), air filters (up to 11,500 nT), pencil sharpeners (up to 5,500 nT), and fans (up to 5,000 nT). Thus, it is not necessarily the number of pieces of electrical equipment within a person's immediate work area that determines the exposure level, but rather the type of equipment (low or high emission), its distance, and the frequency of use during a workday. Since the introduction of low-emission monitors (MPR/TCO) in the late 1980s (Sawdon 1996) and LCD monitors in the early 2000s, VDTs are in many cases not the greatest source of magnetic field emissions at a computer workplace. In addition to multiple outlet power bars with cube-style adaptors next to a user's feet, electronic devices carried and used close to the body such as mobile phones and PDAs often emit much higher magnetic field levels, ranging from a few thousand nanotesla up to 75,000 nT (Tuor et al. 2005). Most electronic devices also emit magnetic fields in the VLF or kHz range; major emission sources include laptops, CRT monitors, and fluorescent lighting incl. CFLs.

Major indoor sources of alternating magnetic fields include book theft detectors, air filters, pencil sharpeners, electric typewriters/calculators, copy machines, unshielded CRT monitors, multiple outlet power bar with cube-style adaptor plugs as well as mobile phones and PDAs. Overhead or underground transmission or distribution lines as well as transformer stations can be a major external source.

4.3 RF RADIATION (RADIO WAVES AND MICROWAVES)

Radiofrequency radiation includes radio waves and microwaves, or all things wireless in the frequency range from 3 kHz to 300 GHz. In this frequency range, free electrons of an antenna oscillate very quickly—three thousand to three hundred billion times per second—and small packets of energy or photons are released to carry the radiofrequency energy across space

from office to office, to another building or city. Usually there is a transmitting antenna to emit the signal and a receiving antenna to accept it (a transceiver is an antenna that does both.) The power density of RF radiation is measured in microwatts per square meter ($\mu W/m^2$). Whenever an RF antenna (e.g. mobile handset, base station, wireless mouse, access point) actively transmits signals, RF radiation exposure occurs.

Typical ambient exposure levels of RF radiation in office environments may range from 10 to 500 $\mu W/m^2$. The mean outdoor exposure level from the sum total of RF radiation sources may range from 50 $\mu W/m^2$ (Tell and Mantiply 1982) to 500 $\mu W/m^2$ (Hamnerius and Uddmar 2000). If a mobile phone base station is mounted to the roof of the office building or another nearby building, RF exposure levels can increase to several thousands to ten thousands of microwatts per square meter (Thansandote et al. 1999, Sage 2000).

In offices that have wireless local area networks (e.g. Wi-Fi) installed, ambient RF radiation levels may be around 100 or 2,500 $\mu W/m^2$; at close range (20-35 cm) of an access point or notebook/computer, RF radiation levels can be much higher: ca. 4,000 $\mu W/m^2$ (Universität Bremen 2001) or in a worst-case scenario up to 40,000 $\mu W/m^2$ (Kramer et al. 2005). Another RF radiation source is wireless input devices such us keyboards and mice, which at 10 cm distance weigh in with ca. 6,000 $\mu W/m^2$, but for the hands and fingers RF exposures can be as high as 10,000 or up to 90,000 $\mu W/m^2$ (Kühn et al. 2005).

The majority of cordless phones based on DECT (or 2.4/5.8-GHz) technology radiate 24 hours a day. If the base station sits at the desk, continuous RF radiation exposure can range from about 20,000 $\mu W/m^2$ (1 m distance) to about 350,000 $\mu W/m^2$ (20 cm distance) (Kramer et al. 2005). When holding the handset against the head during a call, RF radiation exposure will be even higher. In the case of a mobile phone handset, the head's exposure can be well above 1,000,000 $\mu W/m^2$ (Maes 2005).

Major indoor sources of RF radiation include mobile phones incl. PDAs, cordless phones

(handset and base station), wireless area networks (computer, laptop, and access points), and wireless input devices. Depending on the proximity to the office location, external RF transmitters such as mobile phone base stations, radio/TV towers, and radar stations can also contribute to indoor RF exposure levels in office environments.

4.4 STATIC ELECTRIC FIELDS

As described above, an electric field exists in the space surrounding charged particles. In the case of static electric fields, the charge is at rest or stationary. The electric field strength is measured in volts per meter (V/m); a material's electric surface potential is measured in volt (V) and its ESD resistance in megohm (MΩ). Whenever highly chargeable materials such as vinyl, polyurethane, polyester, rubber (Kurtus 2008) rub against each other or are subject to increased air movement, the material's near-surface electrons will be transferred one way or another, producing either a negatively (attracting electrons) or positively (giving up electrons) charged surface. The lower the ambient air humidity, the higher the build-up of electrostatic charges. In the case of CRT monitors, the electrostatic field is generated by the electrostatic lens used to focus the electron beam onto the screen. Static electric fields also emanate from DC circuits and power supplies.

Typical ambient exposure levels of electrostatic fields in office environments may range from a few hundred to several thousand volts (Jamieson 2007). Exposure levels vary greatly even within a given work area. In a user's breathing zone in front of an unshielded CRT monitor, static electricity can reach up to 25,000 V/m (IEEE COMAR 1997). The build-up of electrostatic charges on a desk surface may add a few volts on a wood desk, but up to 25,000 V/m on a Plexiglas desk (Maes 2005). Or the movement of feet on a non-conductive footrest may generate up to 7,700 V (Jamieson 2007). And when walking across a non-conductive synthetic carpet, as is the case in most office environments, if no antistatic flooring was specified, static electric field levels can become charged up to 500,000 V/m (WHO 2004).

Major indoor sources of electrostatic fields include the act of walking across non-conductive carpets, working in front of an unshielded CRT monitor, and moving feet or office chair casters across a non-conductive synthetic footrest or antiskid mat, respectively. During major weather events such as thunderstorms, outdoor levels of natural atmospheric electricity—usually around 130 V/m—can increase drastically, up to 20,000 V/m (WHO 2004), for limited periods of time.

4.5 STATIC MAGNETIC FIELDS

In the space surrounding a magnet or magnetized metal, a static magnetic field occurs due to the alignment of magnetic domains. Ferromagnetic materials such as iron, cobalt, nickel, and alloys thereof, like certain types of steel, can become magnetized. Aluminum furniture is non-magnetic. Static magnetic fields also emanate from DC circuits and power supplies when a direct current flows. The magnetic flux density is measured in microtesla (µT). Around any magnet or magnetized metal, e.g. in a loudspeaker or steel tube furniture, the naturally occurring geomagnetic background field is overridden, not only in its intensity but its polarity as well. In general, the magnetic force field surrounding indoor emission sources reaches from about 30- 50 cm (phone receiver, small devices) to 100 cm or farther (furniture). From large metal structures and public transportation systems, the force field extends much farther.

Typical ambient exposure levels of static magnetic fields in office environments depend on the type of office building. Exposure levels in buildings with steel trusses and steel reinforcement may vary by more than 20% (Blackman 2007), ca. 7 to 14 µT, in addition to the naturally occurring geomagnetic field (35-70 µT), which is relatively constant within a given location. Any battery-operated electronic device, headset or phone receiver, as well as the steel mechanism in office chairs are used in close range to the human body, contributing static magnetic field exposures between 100 to 1,000 µT (Maes 2005). A car ride can add a static magnetic field exposure in the 90 µT range (WHO 2004).

Major indoor sources of static magnetic fields include headsets, loudspeakers, metal furniture incl. office chairs, and electronic devices with batteries. Major external sources include light rail, subway, and streetcar systems that may run alongside office buildings.

5 RECOMMENDATIONS FOR LOW-EMISSION OFFICE ENVIRONMENTS

In this paper, the recommendations on how to lower a computer user's EMF, RF radiation, and static field exposures in office environments are based on the ALARA principle, which means to keep non-ionizing radiation levels as low as reasonably achievable—not just from VDTs, but all other electromagnetic radiation sources as well. This precautionary approach is also favored by the European Union, Sweden, Germany, and Russia where electromagnetic field exposures at computer workplaces are either regulated with the general recommendation to reduce those to "negligible levels" (EU, Sweden, Germany) or with specific emission levels for VDTs (Russia). Even though the Workers' Compensation Board of BC does not concern itself with EMFs, RF radiation, or static field exposures at computer workplaces and Health Canada suggests that no special precautions are necessary, there is a growing number of concerned scientists who warn about adverse health effects from chronic low-level exposures to electromagnetic fields and RF radiation (BioInitiative 2007). For a detailed list of appeals and advisories by scientists and medical doctors why it is prudent to lower one's exposure see Appendix 8 as well as Appendix 7.

5.1 COMMUNICATION SYSTEMS

There are two fundamental ways of communicating electronically: wired or wireless. Wired or corded options are recommended whenever possible because they do not emit RF radiation. In contrast, wireless options do emit RF radiation in addition to magnetic fields.

Corded phones with a piezoelectric membrane in the receiver are the preferred choice because they emit no RF radiation and their magnetic field emissions are negligible.

Cordless phones emit RF radiation: analog (non-pulsed signals) and digital (pulsed

signals) phones only during a phone call, digitally enhanced phones (DECT/2.4 or 5.8 GHz) twenty-four hours a day. Conversations with a cordless phone should be kept short; models with the lowest possible output and no RF radiation emissions between phone calls should be chosen.

In 2003, the BMW Group issued an internal low-emission guideline for cordless phones (IZgMF 2004). In its Munich research center, for example, no cost was spared to equip ceiling-mounted cordless phone base stations with special shielding plates so that the new target value of 100 $\mu W/m^2$ could be met.

A mobile phone handset emits high levels of RF radiation during phone calls and lower levels in-between calls. Mobile phones should be used as little as possible and be turned off when not in use. If using a mobile phone, those with the lowest possible SAR rating (below 0.2 W/kg) are to be preferred, the active handset should be kept away from the body by using a speakerphone and an external antenna, and conversations should always be kept short. Contrary to popular belief, wired headsets tend to increase a user's *whole-body* RF radiation exposure instead of reducing it (Troulis et al. 2003). If at all, an airtube headset with earhook and ferrites could be used, but the handset should never be clipped to the waist. More options on how to lower one's exposure from mobile phone radiation can be found in Appendix 1.

In July 2008, the head of the prestigious University of Pittsburgh Cancer Institute issued an advice on the cautious use of mobile phones because he found there is sufficient data on adverse health effects and mobile phones to warrant such a precautionary advisory (Herberman 2008).

Wired area networks are the preferred choice because they do not emit RF radiation and provide secure transfer of large amounts of data with the least amount of interference.

Wireless area networks operate in three major ranges: personal networks (WPAN) up to

10 through 100 m (e.g. between a personal computer and its input devices or peripherals), local networks (WLAN/Wi-Fi) up to 50 through 200 m (e.g. between computers in an office building), or wide networks (WWAN) up to 10 through 50 km (e.g. connectivity between users in metropolitan areas). For computer input devices and peripherals, wired solutions are the option with the lowest emissions, or if wireless connectivity is required, IR connections are preferable. And if a wireless local area network is required, the lowest maximum (adjustable) power output should be chosen to meet the required need. Be aware that if the router and/or computer are capable of supporting wireless networks, they are not shut off by activating the wired network, but all wireless networks are usually activated by default and have to be disabled manually.

In January 2004, the president of the Lakehead University in Ontario, a trained biologist, issued a precautionary Wi-Fi Policy because of potential adverse health effects associated with wireless networks, recommending hard wire connectivity whenever possible (Lakehead University 2004).

More detailed recommendations and specific emission/exposure data on phones, networks, and headsets can be found in Appendix 1.

5.2 COMPUTER WORKSTATION

First of all, the computer workplace should be located away from known high-emission sources (e.g. electrical room, main feeder cable, electric baseboard heater, WLAN access point).

VDTs, CPUs, and most other office equipment are available with reduced emissions of electromagnetic fields. However, low-emission claims should only be trusted if appropriate certification is provided by, for example, TCO Development from Sweden. Flat panel displays, especially LED backlit TFT, offer the lowest emissions. A CRT monitor with high electric field emissions can be shielded with a properly grounded anti-radiation filter. If magnetic field emissions are above TCO target values, it should be replaced with a flat panel display. Since

electromagnetic field levels decrease with increasing distance, a 2-feet distance from the VDT and a 3-feet distance from all other electric office equipment are recommended. All extension cords and especially any multiple outlet power bars should be a minimum of 2 to 3 feet from the computer user. Shielded extension cords and wiring are another great way to reduce AC electric field exposures.

As mentioned above, wired input devices and computer peripherals are recommended for a low-emission office environment. And it should be noted that the default setting in computer desktops, laptops, and computer peripherals with wireless capabilities activates the wireless network(s) whether it is being used or not. To eliminate the RF emissions, wireless networks need to be disabled manually.

Though they are called laptops, these devices should not be used while resting in a lap because the EMF/RF exposure and temperature increase will be the highest in the abdomen and sperm. Laptops are best used when in battery mode (unplugged) because that is when they generate the lowest emissions. If using the laptop in AC power mode, it should have a properly grounded power cord. For long-term use, an external keyboard is recommended to reduce exposure levels to hands.

Among the green purchasing rating systems for computers, the TCO certification from Sweden is the only one to include electromagnetic emissions in its long list of ergonomic and environmental requirements. Although it is a voluntary guideline, by now 50% of all computers manufactured worldwide are certified by TCO, in northern Europe 100% and in North America only 35% (NWPSC 2008).

More detailed recommendations and specific emission/exposure data on VDTs, CPUs, laptops, and peripherals can be found in Appendix 1.

5.3 ARTIFICIAL LIGHTING

Daylighting, the utilization of natural light within buildings, is the most cost-effective and energy-efficient light source with the most beneficial spectral power distribution for best human performance (Libby 2003). Depending on the type and make, artificial lighting systems not only emit visible light and heat, but also electromagnetic fields in the ELF or VLF range and those with electronic ballasts also RF radiation.

From the lamp types listed in appendix 1, line-voltage halogen and incandescent lamps emit the lowest levels of electromagnetic fields. Consequently, they are best suited for lamps used in close proximity to the body such as in desk lamps. The power supply cord of a desk lamp should have a three-pin plug, and ideally, is electrically shielded to reduce electric-field exposure. As the light quality of the highly energy-efficient LED lamps improves, they will also become a low-emission choice, provided that the electronic drivers and wiring set-up are selected carefully.

All types of fluorescent lamps (standard, CFL, full-spectrum) come with a ballast that gives rise to flicker and elevated EMF emissions. Electronic ballasts reduce visible flicker, but at the same time increase the RF radiation exposure. All fluorescent lamps benefit from additional electric-field shielding in the form of properly grounded metal lighting fixtures and wire guards. For further reduction strategies, see Appendix 1.

Due to their high emission profile (UV, flicker, RF radiation), the widely promoted compact fluorescent lamps should not be used in close proximity to the body. Though the EU Scientific Committee on Emerging and Newly Identified Health Risks did not find sufficient scientific evidence for an association between, for example, migraines and CFLs (SCENIHR 2008), there is plenty of anecdotal evidence (Havas 2008). Recently, the UK Health Protection Agency released a warning with regard to elevated UV emissions, recommending encapsulated CFLs, and took note of a pronounced 100 Hz flicker (UK HPA 2008).

More detailed recommendations and specific emission/exposure data on different types of artificial lighting and ballasts can be found in Appendix 1.

5.4 OFFICE FURNITURE AND FURNISHINGS

Though most furniture and furnishings in an office do not plug into an outlet or answer to wireless signals at the press of a button, the static magnetic field emissions of steel furniture often exceed the naturally occurring geomagnetic field. Therefore it is best to choose desks made from non-magnetic materials such as solid wood and office chairs with the least amount of metal. If choosing composite wood or synthetic furniture materials, ensure antistatic and zero-VOC properties. It is recommended to keep a 3 feet distance to metal furniture in places where an office worker spends prolonged periods of time.

In addition, any metal structure—whether magnetic or not—will attract and reradiate ambient AC electric fields and RF radiation. Therefore, it is recommended to have large metal components properly grounded. As for the interaction with RF radiation, the reduction of wireless devices indoors will almost always result in lowered exposures. In order to determine whether metal structures shield or amplify external RF sources, an appropriate EMR survey would have to be conducted, which would also show what reduction strategies could be most successful.

Also, the electrostatic build-up of synthetic flooring and finishing materials often greatly exceeds the naturally occurring atmospheric electricity. Therefore, it is recommended to prefer (naturally) antistatic flooring materials (e.g. wood, linoleum with antistatic finishes), wall finishes (e.g. clay or casein paint), and textiles (e.g. untreated cotton, linen).

More detailed recommendations and specific emission/exposure data on office furniture and furnishings can be found in Appendix 1.

APPENDIXES

Appendix 1: Checklist of EMF/RF/Static Field Exposures in Office Environments

In each category, electronic devices and electrical equipment are listed in order of their emissions from lowest to highest. Low-emission devices and shielding strategies recommended in this paper are based on known physical laws, which can be verified with standard EMF/RF testing equipment. Chips, shields, and neutralizers that are unable to lower EMF/RF exposures in a demonstrable and replicable way are not recommended.

Please note that electromagnetic emissions from office equipment are only one—albeit a very important—aspect when choosing office equipment. Please be advised to also take all other relevant ergonomic aspects, which are beyond the scope of this paper, into consideration. For example, for a receptionist a low-emission receiver-style phone would cause muscle pain and stiffness in the neck, a low-emission wired or IR headset would be more suitable.

A1.1 COMMUNICATION SYSTEMS

Corded Phones

Magnetic field exposure occurs during phone calls while holding the handset to the ear.

❒ Wooden receiver with air-tubing	- Zero electric or magnetic field exposure
❒ Piezoelectric phone	- Magnetic field exposure < 10 nT/0.1 mG (1)
❒ Speakerphone	- Allows placing phone calls without the use of a handset - Choose farthest distance possible, min. 30 cm
❒ Standard phone with permanent magnet in receiver	Magnetic field exposure at head during phone calls: - up to 500,000 nT/5000 mG static magnetic field exposure (2) - up to 2,000 nT/20 mG alternating magnetic field exposure (2)

Options to Minimize Magnetic Field Exposure from Corded Phones

- Prefer phone receivers with piezoelectric membranes instead of permanent magnets.
  (To find out what type of receiver you have, simply hold an oil-filled compass next to the phone receiver. If the compass needle continuous to show due north, it contains a piezoelectric membrane; if the compass needle turns and deviates from due north, it contains a permanent magnet.)
- Make use of the speakerphone function as often as possible if using a standard phone.
- Consider using a low-emission wired or IR headset if using a standard phone.

Cordless Phones

In addition to magnetic field exposures, RF radiation exposure occurs always during phone calls, but in many digital models RF radiation is also emitted 24/7 from the base station when in standby only.

❒ Analog cordless phones
CT1: 40/50 MHz or 915/960 MHz

CT1+: 885/930 MHz
Power output: 5-25 mW

Non-pulsed signals

- RF peak exposure level from handset during a call at 0.2 m distance: 4,700-25,000 µW/m^2 (3)
- Emits RF radiation during phone calls only and that with non-pulsed signals

❒ Digital cordless phones

CT2: 864-868 MHz (FDMA)

CT2+: 944-948 MHz (TDMA)

Power output: 5-25 mW

DSS output: up to 100 mW

Pulsed signals (500 Hz)

- RF peak exposure level from handset during a call at 0.3 m distance: 3,000 µW/m^2 (4)
- Emits RF radiation during phone calls only but with pulsed signals
- Some models come with powerful DSS technology, which results in much higher exposure levels

❒ Digital enhanced cordless phones (DECT)

1800-1900 MHz
2.4 GHz or 5.8 GHz (DSS/DFHSS)

Power output: up to 250 mW

Pulsed signals (100 Hz)

- RF peak exposure level from base station at 0.3 m distance: 405,000-673,000 µW/m^2 (5)
  at 1 m: still 36,000-72,000 µW/m^2 (5)
- AC magnetic field emissions from handset during calls: up to 280 nT on front (6)
  up to 500 nT on back (6)
- Base stations of most models emit RF radiation at maximum power level at all times—even when no phone call is placed

Options to Minimize RF Radiation Exposure from Cordless Phones

- Use corded phones, which emit no RF radiation, especially for longer phone conversations, preferably based on piezoelectricity.
- When using a cordless phone, keep phone conversations short.
- If cordless phone technology is necessary, prefer analog cordless phones without pulsed signals.
- If using digital cordless phones, prefer those with a lower power output and without digital spread spectrum technology (DSS).
- If using DECT or 2.4/5.8-GHz cordless phones, choose those that feature a sleep mode, which is activated as soon as the call is ended thereby reducing exposure during standby to negligible levels, and an adjustable power output, which reduces RF emission levels by 25-30% during phone calls. (7)

  Do not place the base station of a DECT or 2.4/5.8-GHz cordless phone on the desk or in an area where people spend considerable amounts of time, instead keep a minimum of 3-5 m distance.

Mobile Phones

RF radiation exposure occurs during phone conversations, it is highest when the reception quality is poor. When in standby, mobile phones emit RF signals at lower levels more or less intermittently, depending on the model and given base station network. In addition, handsets also emit magnetic fields.

SAR stands for specific absorption rate, which is a measure for the RF energy absorbed by the body. SAR values are usually averaged over 1 g (US/Australia) or 10 g (Europe) of tissue. Localized or point SAR values can be much higher, up to 5 W/kg. When the latter is averaged over 10 g, the corresponding maximum SAR value would be 1.4 W/kg. (8)

❒ Pager	- Mostly a receiver, negligible RF exposure
❒ First Generation (1G): analog mobile phones AMPS: 824-891 MHz Non-pulsed, analog signals	- Maximum SAR values in brain: 0.12-0.83 W/kg (9)
❒ Second Generation (2G): digital mobile phones GSM (TDMA): 850 MHz, 1900 MHz (pulse rates: 2, 8, 217 Hz) PCS (TDMA): 1900 MHz iDEN (TDMA): 800 MHz Pulsed signals CDMA or cdmaOne: 800 MHz, 1900 MHz Non-pulsed signals	GSM mobile phones - Maximum SAR values averaged over 10 g tissue: 0.1-2 W/kg (10) - ELF magnetic field exposure on front of phone: 8-20 µT (11) on back of phone: 35-75 µT (11) - Maximum static magnetic field emission near loudspeakers: up to 20,000 µT (11) - When touching the body, mobile phone handsets may exceed the ICNIRP SAR exposure limit of 2 W/kg: 2.16-5.84 W/kg (12)
❒ Third Generation (3G): digital mobile phones CDMA2000 UMTS (WCDMA based) Non-pulsed, broadband signals UMTS (TD-CDMA based) Pulsed signals	UMTS mobile phone SAR values averaged over 10 g tissue WCDMA – Estimated SAR values: 0.3-3 W/kg (13) TD-CDMA – Estimated SAR values: 0.05-0.2 W/kg (13) Real-life peak SAR values: 0.5-1.4 W/kg (14)

❒ Personal digital assistants (PDAs)	- Maximum RF radiation exposure at 5-cm distance: 700,000-1,000,000 µW/m^2 (15) - Magnetic field exposure near PDA peak values during cell phone use: 1,000- 3,000 nT (16) peak values during e-mail activity: 2,000-4,000 nT (16) rapid, short-duration ELF spikes range from 10 up to 60 µT (16)

Options to Minimize RF Radiation Exposure from Mobile Phones and PDAs

- Use corded phones or wired VoIP, which emit no RF radiation, especially for longer phone conversations.
- Use mobile phones as little as possible and set days aside, e.g. weekends, for not using a mobile phone at all.
- Make it a habit to turn off your mobile phone whenever possible.
- When using a mobile phone, keep phone conversations short or simply send a text message (SMS).
- Always try to keep a minimum distance, e.g. an arm's length, between your body and an active mobile phone, especially at the beginning while the connection is being established.
- Avoid putting the mobile phone next to your head (or anywhere else close to your body), instead use the integrated speakerphone and connect to an external antenna, preferably with a fiber-optic cable.
- Contrary to popular belief, wired headsets tend to increase a user's whole-body RF radiation exposure instead of reducing it. (17)
  If at all, choose airtube headsets with earhook and ferrites, and keep the handset away from the body at all times; do not clip it to your waist.
- Always keep in mind that any metal object close to the body (e.g. wire-framed spectacles, earbuds, metallic ear piercings, implants) tends to locally increase the peak SAR, up to 25%. (18) (19)
- Avoid carrying your mobile phone in close proximity to your body, e.g. in a shirt or pant pocket; prefer to put it in a purse or outer coat pocket instead—always have the keypad positioned toward your body.
- Use mobile phones only when reception quality is good, preferably outside. Do not use mobile phones in areas of poor reception when RF emissions from the handset will be highest, e.g. inside cars, buses, streetcars, trains, underground parking, etc.
- Mobile phone use in a car while driving is not recommended. Otherwise, use a hands-free mobile phone with voice-activated speakerphone and install an external antenna outside on the metal roof in the back.

- When inside a building, either step outside or close to an open window for placing your phone call.
- Always try to keep a courtesy distance to spare others the second-hand exposure, minimum 5 m.
- Prefer mobile phones with the lowest possible SAR rating, below 0.2 W/kg.
  (Keep in mind that when using a mobile phone with a low SAR, this does not mean that there was no radiation exposure. You still want to follow the advice given above. And especially in areas with poor reception, e.g. inside a building or car, or when the base station is opposite from the side of your head where the handset is held, there will still be a substantial exposure.)
- Listing of cellular telephone specific absorption rates (SAR):
  www.fcc.gov/cgb/sar/
- Listing of mobile phones with an SAR below 0.4 W/kg
  www.handywerte.de (after clicking 0.4 W/kg in the upper left-hand margin)

Area Networks

Wireless networks emit RF radiation, especially around access points as well as computers/laptops, computer peripherals, and mobile phones.

❒ Wired personal, local, or wide area network	- No RF radiation emissions (as long as all wireless personal and local area networks are disabled)
❒ Bluetooth Wireless Personal Area Network (WPAN) IEEE 802.15 2.4 GHz Pulsed signals: 1600 Hz (FHSS)	- Maximum RF radiation level at a 50 cm distance:
Class I reaches up to 100 m Peak power output: 100 mW	Class I device: 32,500 µW/m^2 (20)
Class II reaches up to 40 m Peak power output: 2.5 mW	Class II device: 200 µW/m^2 (20)
Class III reaches up to 10 m Peak power output: 1 mW	Class III device: 100 µW/m^2 (20)
❒ Wireless Local Area Network (WLAN) Pulsed Signals in Wi-Fi Networks: 10-100 Hz (standby) 10-250 Hz (transfer)	- Minimum and maximum RF radiation levels at a 50 cm distance from PC cards/access points:
IEEE 802.11g 2.4 GHz Peak power output: 100 mW Max. range: 50 m	IEEE 802.11g: 400-1,000 µW/m^2 (15)
IEEE 802.11b 2.4 GHz – Wi-Fi Network Peak power output: 100 mW Max. range: 200 m	IEEE 802.11b: 700-11,000 µW/m^2 (15)
IEEE 802.11a 5 GHz Peak power output: 200 mW Max. range: 50 m	IEEE 802.11a: 700-10,000 µW/m^2 (15)
IEEE 802.11h 5 GHz Peak power output: 200 or 1,000 mW Max. range: 50 m	

❒ WiMax – - First applications are introduced in laptops in 2008

Wireless Wide Area Network (WWAN) or
Wireless Metropolitan Area Network
(WMAN)
Pulsed signals: 350 Hz, 0.1-7 MHz

IEEE 802.16 2-11 GHz, 10-66 GHz

Peak power output:
Base stations up to 40 W
Devices between 100 mW and 4 W
Typical range 10 km (up to 50 km)

- RF exposure from WiMax modem (5.4 GHz/1,000 mW EIRP) at 2 m distance: 20,000 µW/m^2 (21)

Options to Minimize RF Radiation Exposure from Wireless Area Networks

WPAN – Wireless Personal Area Networks

- Avoid using WPANs, e.g. for computer peripherals, instead choose a wired keyboard, mouse, printer, etc., which emit no RF radiation.
- Since in computers with wireless capabilities the default setting usually activates the wireless network automatically, be sure to manually disable the Bluetooth network on the computer in the control panel (PC) or system preferences (Mac).
- If using a Bluetooth network, choose Class III (or Class II) with the lowest maximum power output and turn it off when not in use.

WLAN – Wireless Local Area Networks

- Avoid using WLANs or Wi-Fi networks, e.g. for internet connections and e-mail services, instead choose a wired local area network, which emits no RF radiation.
- Be aware that if the router and/or computer are capable of supporting wireless networks, they are not shut off by activating the wired network, but all wireless networks are usually activated by default and have to be disabled manually on a computer in the control panel (PC) or system preferences (Mac). After a power outage, routers may reset themselves and the wireless default setting may have to be disabled again.

<u>If a wireless local area network (WLAN) or Wi-Fi network is required:</u>

- Choose the network with the lowest maximum power output, which should be adjustable, to meet the required needs.
- Keep a minimum of 5-m to 10-m distance from access point(s).
- Place access points strategically, away from desk areas and away from where people spend considerable amounts of time. Furthermore, orient the antennas in such a way that nobody has to sit in a main beam axis continually, but that all devices dependent on them are provided with good reception.

- Whenever possible, disable the wireless LAN network on the computer and/or turn off the access point(s) when not in use.
- If a lot of data have to be transferred across a wireless connection, leave the desk area with the laptop or computer during this time period.

WWAN – Wireless Wide Area Network

- Avoid using WWAN or WiMax networks, e.g. for internet connections and e-mail services, instead choose a wired local area network, which emits no RF radiation.
- If a wireless network is required, choose the network with the lowest maximum power output, which should be adjustable, to meet the required needs. In general, WLANs tend to have lower maximum power outputs compared to WiMax networks.

Headsets

Headsets for mobile phones also emit RF radiation. Depending on the type and conditions of use, RF exposure can either be increased or reduced.

Wireless headset: Bluetooth 2.4 GHz Max. power output: 1 or 2.5 mW Pulsed signals: 1,600 Hz	- RF exposure from Bluetooth headsets ca. 2 to 42% of RF emission from mobile phone handset (22) - RF exposure at 5 cm ranges from ca. 5,000-65,000 $\mu W/m^2$ (22) - Depending on the mobile phone used, headsets may also emit RF radiation continually in standby
Wired headset	- Metal wire connecting headset with mobile phone handset tends to channel RF radiation directly into the ear: ca. 5-20% of RF emission from mobile phone handset (23) - Earbud (closer to body) and handset (farther away) result in similar exposure levels in the brain (23) - If mobile phone handset is clipped to the waist (or put in the shirt pocket), RF power absorbed by the body increases from 42 mW (head-operated) to 70 mW (hands-free), almost doubling the whole-body RF exposure (17)

Options to Minimize RF Radiation Exposure from Headsets

- First of all, follow the above recommendations on how to minimize your RF radiation exposure from mobile phone handsets.
- Do not use headsets with earbuds, whether they are wired or wireless.
- Contrary to popular belief, wired headsets tend to increase a user's whole-body RF radiation exposure instead of reducing it. (17)
  If at all, choose airtube headsets with earhook and ferrites and keep the handset away from the body at all times; do not clip it to your waist.
- Always keep in mind that any metal object close to the body (e.g. wire-framed spectacles, earbuds, metallic ear piercings, implants) tends to locally increase the peak SAR, up to 25%. (18) (19)
- Mobile phone use in a car while driving is not recommended. Otherwise, use a hands-free mobile phone with voice-activated speakerphone and install an external antenna outside on the metal roof in the back.
- In order to actually reduce the RF exposure while using a Bluetooth headset, the

mobile phone handset needs to be placed a minimum of 1 m away from the body, preferably in an area with good quality reception.

- In addition, the maximum power output of the Bluetooth headset should be adjustable and not exceed 1 mW (class III). Furthermore, the Bluetooth headset should be combined with a mobile phone handset, which does not continually emit RF radiation when in standby. To be sure, always turn off Bluetooth headset when not in use.
- If using a wireless headset, prefer one that operates with IR.

A1.2 COMPUTER WORKSTATION

Video Display Terminal (VDT) & Central Processing Unit (CPU)

Magnetic and electric field exposure occurs during active use; depending on the model, some exposure (mostly electric fields) also occurs during sleep or standby mode.
Desktops with wireless connectivity also emit RF radiation.

❒ Flat Panel Display TFT	EMF exposure at 30 cm from screen (24): (usually below TCO guideline values as listed below, often even lower than that) - ELF AC electric field: < 10 V/m - VLF AC electric field: < 1 V/m - ELF AC magnetic field: < 200 nT - VLF AC magnetic field: < 25 nT - Static electric field: negligible - Backlighting based on CCFL or TFEL may produce higher EMF exposures, sometimes exceeding TCO guideline values (25)
❒ CRT Monitor	EMF exposure at 30 cm from monitor (26): - ELF AC electric field: up to 65 V/m - VLF AC electric field: up to 50 V/m - ELF AC magnetic field: up to 1,200 nT - VLF AC magnetic field: up to 1,500 nT - Static electric field: up to 25,000 V/m
❒ Central Processing Unit (CPU) or Desktop	- Magnetic field exposures are similar or often lower than those from CRT monitors: 200-700 nT (27) - For RF exposure data of desktops with built-in wireless networks see tables above on area networks, especially Wi-Fi under WLAN and Bluetooth under WPAN.

Options to Minimize Electric and Magnetic Field Exposures as well as RF radiation exposure from VDTs and CPUs

- Choose low-emission, TCO certified VDTs and CPUs/desktops.
  Search the TCO Development's Product Database for certified products:
  http://www.tcodevelopment.com/pls/nvp/!tco_search

- Keep a minimum distance of 2 feet from the VDT and the CPU/desktop.
- Prefer flat panel displays, especially LED backlit TFT-LCDs.
- Avoid flat panel displays with backlighting based on cold-cathode fluorescent lamps (CCFL) or electroluminescence (TFEL). (25)
- Old-style CRT monitors with high static electric field emissions can be shielded cost-effectively with a good quality anti-glare/anti-radiation screen, which must be properly grounded to work.
- It is possible to reduce magnetic fields from CRT monitors with high emissions, but it is more cost-effective to purchase a flat panel display instead.
- If the image of a CRT monitor jitters or flickers, this indicates a higher than usual ambient magnetic field level, often above 500 nT. (28)
  By replacing the CRT monitor with a flat panel display unit, the technical interference problem would be eliminated; but for the user's sake it is recommended to either eliminate the source of the high magnetic field or relocate to a place with a low ambient background level, preferably below 100 nT.
- Use an electrically shielded power cord.
- Unplug or turn off multiple outlet power bars when not in use.
- Most new desktop computers or CPUs are shipped with wireless connectivity (e.g. Wi-Fi, Bluetooth). For more detailed information, see the above table on Area Networks including recommendations.
- Keep a minimum distance of 3 feet from the multiple outlet power bar that powers the various devices at your computer workstation, especially when there are cube-style adapter plugs plugged in, which are known for their high magnetic field emissions.
- Also keep extension cords away from your body, minimum distance 2-3 feet.
- Strategically place your computer workstation away from known high-emission sources: overhead transmission lines, main feeder cable/riser, electrical main panel, electrical room, elevator, large appliances, cell phone base stations, WLAN access points, etc.
- Consider an electrically shielded wiring system (e.g. metal conduits, raceways) for the office and/or building.

Laptops and Notebooks

Magnetic and electric field exposures always occur during active use; exposure is substantially higher when the charger is plugged in, especially with a two-wire power supply unit (PSU).

Models with wireless network capability also emit RF radiation by default.

❒ Laptop with wireless network capability	- Maximum RF radiation exposure from wireless WLAN/Wi-Fi PC card in notebook at 1-5 cm distance: ca. > 500,000 µW/m^2 (29) at 35 cm distance: ca. 4,000 µW/m^2 (30) or up to 10,000 µW/m^2 (15) - For further RF exposure data of laptops see also tables above on Area Networks, especially Wi-Fi under WLAN and Bluetooth under WPAN. - For electric and magnetic field exposures see last row of this table
❒ Laptop with two-wire PSU	- If using a laptop while plugged in, it makes a huge difference whether the PSU comes with a proper grounding cord or not. - Maximum AC electric field exposure from plugged-in laptop with two-wire PSU at 30 cm distance: up to 600 V/m (31) - For electric and magnetic field exposures see last row of this table
❒ Laptop	- Maximum electric and magnetic field exposures at 1-5 cm distance where hands are located during use (29) in battery mode: < 1 V/m (ELF) and 2-250 V/m (VLF) 10-2,000 nT (ELF/VLF) in AC power mode: 1-2,500 V/m (ELF) and 5-2,000 V/m (VLF) 20-3,000 nT (ELF) and 20-2,500 nT (VLF)

Options to Minimize Electric and Magnetic Field Exposures as well as RF Radiation Exposure from Laptops/Notebooks

- Choose low-emission, TCO certified laptops and notebooks.
  Search the TCO Development's Product Database for certified products:
  http://www.tcodevelopment.com/pls/nvp/!tco_search
- Prefer laptops with properly grounded power supply units (three pins), otherwise AC electric field exposure will be substantially higher during use when plugged into an outlet. (31) (32)
- Note that AC electric and magnetic field exposures are lowest when the laptop is in battery mode and unplugged.
- Avoid using the laptop in AC power mode and/or use an electrically shielded power cord.
- Do not place the laptop in your lap, no matter how tempting or convenient this may be. It not only makes for very high electromagnetic field and RF radiation exposure, but in males it also increases the scrotal temperature substantially, possibly negatively affecting the production of sperm in the testes. (33)
- Since all electronic circuits are located right underneath the keypad, EMF and RF radiation exposure can be quite high for the hands during typing, up to 2,500 V/m (electric field), 3,000 nT (magnetic field), and > 500,000 $\mu W/m^2$ (RF radiation). (29)
  When using the laptop for prolonged periods of time, use an external wired keyboard and input device. Keep a minimum distance of 30 cm.
- Avoid using WLANs or Wi-Fi networks, e.g. for internet connections and e-mail services, instead choose a wired local area network, which emits no RF radiation.
- Be aware that if the laptop comes with wireless network capability, it is not shut off by activating the wired network, but all wireless networks are usually activated by default and have to be disabled manually in the control panel (PC) or system preferences (Mac). Some laptops have a dedicated switch or button to turn off wireless networks.
- Whenever possible, disable the wireless LAN network on the laptop when not in use.
- If a lot of data have to be transferred across a wireless connection, leave the desk area with the laptop during this time period.
- For further information on RF radiation reduction strategies, see recommendations above under Area Networks.

Computer Peripherals

The highest magnetic field exposure occurs during active use; however, in standby mode EMF exposures from e.g. printers can still be substantial due to phantom loads.
Devices with wireless network capabilities also emit RF radiation.

❒ Keyboard	- Wired keyboard emits no RF radiation - RF exposure from wireless keyboard (34) at 10 cm distance: ≤ ca. 6,000 µW/m^2 finger exposure thumb: up to ca. 90,000 µW/m^2 little finger: up to ca. 70,000 µW/m^2
❒ Mouse	- Wired mouse emits no RF radiation - RF exposure from wireless mouse (34) at 10 cm distance: ≤ ca. 6,000 µW/m^2 finger exposure trigger finger: up to ca. 20,000 µW/m^2 mouse tip: up to ca. 10,000 µW/m^2
❒ Printer	- Printers without wireless capabilities do not emit RF radiation - Printers with wireless capabilities do either use infrared and/or RF radiation - For RF exposure data from printers with built-in wireless connections see tables above on Area Networks - Magnetic field exposure at operator's location: 600-1,400 nT (27)

Options to Minimize Electric and Magnetic Field Exposures as well as RF Radiation Exposure from Computer Peripherals

- Choose low-emission, TCO certified computer peripherals.
  Search the TCO Development's Product Database for certified products:
  http://www.tcodevelopment.com/pls/nvp/!tco_search
- Avoid using wireless input devices (e.g. Bluetooth), choose a wired keyboard and mouse instead.
- If a wireless connection is desirable, prefer infrared connections to networks employing RF radiation.
- Keep a minimum distance of 3 feet from printers, scanners, copiers, fax machines, etc.
- Use an electrically shielded power cord.
- Or unplug devices when not in use.

A1.3 ARTIFICIAL LIGHTING

Types of Lamps

All lamp types emit ELF electric and magnetic fields at varying degrees during use. (Compact) fluorescent lamps with high-frequency ballast also emit RF radiation.

(Please note that the issues of energy efficiency and light quality are very important, but their detailed discussion is beyond the scope of this paper.)

❒ Incandescent lamp	Lamp wattage 25-100 W - AC electric field exposure at 30 cm distance (35): < 5 V/m (with grounding conductor) 150-300 V/m (without grounding conductor) - AC magnetic field exposure at 5 cm distance: < 20 nT (35) - No RF radiation emission - No flicker - Keep 1-3 feet distance
❒ Line-voltage halogen lamp	- Low AC electric and magnetic field exposure similar to incandescent lamps - No RF radiation emission - No flicker - Keep 1-3 feet distance
❒ LED lamp	- Low AC electric and magnetic field emissions (with grounding conductor) - Some electronic drivers increase electromagnetic field emissions - Flicker in models without high-quality electronic driver - Keep 1-3 feet distance
❒ Low-voltage halogen lamp	Desk lamp - AC magnetic field exposure at 30 cm: 300-4,000 nT (35) (If lamp is turned off but still plugged in, transformer—often in foot of lamp—continues to emit a magnetic field.) - No RF radiation emission - No flicker - Keep 3 to 6 feet distance

❒ Fluorescent lamp with magnetic ballast	- AC electric field exposure at 50 cm: > 100 V/m (35) - AC magnetic field exposure at 30 cm: up to 3,000 nT (36) - No RF radiation emission - Dominant flicker: 100-120 pps (50/60 Hz) - Keep 3 to 6 feet distance
❒ Fluorescent lamp with electronic ballast	- AC electric field exposure at 1 m: > 50 V/m (35) - AC electric field exposure at 1 m: 25-100 nT (35) - High RF radiation emission - No obvious flicker with electronic ballast - Keep 6-9 feet distance
❒ Compact fluorescent lamp (CFL)	Lamp wattage 7-17 W (37a) - AC electric field exposure at 30 cm distance: 40-63 V/m (ELF) 7-40 V/m (VLF) - AC magnetic field exposure at 30 cm: 3-79 nT (VLF) - Exposure from poor-quality CFLs (with less built-in RF suppression) can be even higher than the above measurements - High RF radiation emission - Steep slope of 100-Hz pulse (37b) - No obvious flicker with electronic ballast - Keep 6 to 9 feet distance

Options to Minimize Electric and Magnetic Field Exposures as well as RF Radiation Exposure from Lighting Sources

- Choose natural daylight whenever possible. To avoid glare, strategically place your computer by selecting a screen-to-window angle of 90 degrees and adjusting window treatments accordingly.
- From all the lamp types listed above, incandescent and line-voltage halogen incandescent lamps—though consuming the largest amount of energy—emit the lowest levels of electromagnetic fields. Consequently, they are best suited for lamps used in close proximity to the body such as in desk lamps.

- Use desk lamps with a grounding conductor (three-pin plug) and prefer electrically shielded power supply cords to reduce the electric-field exposure even further, no matter what type of lamp is chosen.
- As the light quality (e.g. less “spikes”) and electronic driver design (e.g. no flicker) improve, LED lamps may become the lamps of the future with a low-EMF design and high-energy efficiency.
- Avoid using low-voltage lamps, especially as desk lamps, because of their high magnetic field emission.
- If using low-voltage halogen lighting, place the required transformers away from the areas where people spend prolonged periods of time and use shielded cables for such an installations.
- Do not use low-voltage halogen rope light systems, in which the current-carrying conductor and the return-current-carrying conductor are spaced apart, giving rise to high magnetic fields.
- To avoid stress-inducing flicker from fluorescent lamps, ensure a stable supply voltage and choose one of two options.
  - If replacing magnetic ballasts (50/60 Hz) with good-quality electronic ballasts (25-60 kHz) to avoid the 100 Hz (Europe) or 120 Hz (North America) flicker, choose those with additional radiofrequency suppression and install grounded electric field shielding. (38a/b)
  - Note that a significant proportion of compact fluorescent lamps with their integrated electronic ballasts can show a pronounced 100 Hz (Europe) or 120 Hz (North America) flicker. (37b)
  - If using a magnetic ballast to avoid the RF radiation exposure and interference associated with electronic ballasts, choose a high-efficiency cathode cut-out or hybrid ballast, which can be just as energy-efficient as an electronic ballast. To minimize the 100 Hz (Europe) or 120 Hz (North America) flicker, choose a combination of tandem wiring and lead-lag compensation for best results. (39)
- All types of fluorescent lamps benefit from electric field shielding—especially those with electronic ballasts—in the form of transparent, grounded wire structures. (40) To lower their emissions further, electronic ballasts may require additional RF-suppressing filters, and magnetic ballasts may require additional shielding with MuMetal.
- Full-spectrum fluorescent lamps and compact fluorescent lamps emit the same type of electromagnetic fields and RF radiation like standard fluorescent lamps, which is why the same shielding recommendations apply to them.
- Though full-spectrum fluorescent lamps tend to have the “fuller” spectral power distribution in the visible light range, the actual quality varies greatly. Always check the spectral power distribution chart, and for workplace lighting, prefer those with fewer troughs and spikes and a more continuous spectrum, no matter what type of lamp you choose. (41a/b)
- Please note that the measurements given above are for single lamp units. As soon as an entire ceiling is equipped with, for example, compact fluorescent lamps, the resulting EMF/RF exposure will be much higher, depending on the height of the ceiling. In order to successfully design a lighting system with low EMF emissions, it is recommended to test EMF emissions of specified lamps

prior to installation.

- If possible, avoid dimmer switches, especially in close proximity to work areas. Their switch-mode technology “chops up” the electricity, thereby generating strong electromagnetic fields and undesirable kHz signals in the VLF range.
- Ensure that halogen lamps and fluorescent lamps you choose are shielded for excessive UV light emissions, especially those used in close proximity to the body. Prefer halogen lamps with glass covers, standard fluorescent lamps with diffusers (and/or protective sleeves) and compact fluorescent lamps that are encapsulated (42).

A1.4 OFFICE FURNITURE AND FURNISHINGS

Furniture and Furnishings

The steel tubing in modern office furniture (as well as steel reinforcement in concrete buildings) tends to emit static magnetic fields, exceeding the level of the ambient natural magnetic field of the earth.

In addition, any metallic structure interacts with the ambient AC electric fields from the wiring, often increasing the AC electric field exposure, and the ambient RF radiation, often increasing the RF radiation exposure.

Synthetic surface treatments and covers for walls, floors, and furniture tend to cause a build-up of electrostatic charges.

Static Electric Field Exposures	
❒ Synthetic, non-conductive chair	- Electrostatic surface potential of chair with urethane foam (44): 18,000 V at 10-25% relative humidity 1,500 V at 65-90% relative humidity
❒ Synthetic, non-conductive desk	- Static electric field exposure at Plexiglas desk (45): 25,000 V/m
❒ Synthetic, non-conductive flooring	- Static electric field exposure during walk across synthetic non-conductive carpet (43): 10,000-500,000 V/m - Electrostatic surface potential during walk across vinyl tile (44): 12,000 V at 10-25% relative humidity 250 V at 65-90% relative humidity
Static Magnetic Field Exposures	
❒ Steel reinforcement	- Static magnetic field exposure from steel reinforcement at 30 cm above floor (46): 3-10 µT
❒ Steel tubing furniture	- Static magnetic field exposure while sitting in office chair with steel mechanism (46): up to 80 µT

Options to Minimize Static Electric and Static Magnetic Field Exposures from Office Furniture and Furnishings

How to Minimize Static Electric Field Exposures:

- Choose flooring materials and surface treatments that are antistatic by nature and do not support or promote the build-up of electrostatic charges:

- wood flooring or linoleum with an antistatic finish (e.g. Marmoleum) (47);
- antistatic antislip mat;
- at least one conductive caster at the office chair;
- naturally antistatic textiles for chair covers, curtains and clothing (e.g. untreated cotton, linen);
- naturally antistatic, zero-VOC paints (e.g. silicate paint, casein paint, clay paint).

- For standard office environments, the flooring material's ESD resistance is recommended to be in the kilohm range and the complete floor assembly in the megohm range. (48)
  (In order to protect sensitive electronic components, which may become destroyed at levels as low as 20 V, requirements for so-called cleanrooms and microchip manufacturing facilities must meet much stricter ESD standards.)
- Walking with non-conductive shoes (e.g. rubber soles) across a non-conductive floor (e.g. synthetic carpet), or rolling with non-conductive casters of an office chair across a non-conductive antislip mat are two major sources of static buildup in office environments.
- Electrostatic discharges or static shocks can be felt from 2-4 kV and up. This is not just a nuisance, but generally indicates considerably decreased levels of biologically vital small air ions and increased levels of charged ultrafine particles. (49)
- Electrostatic buildup is most pronounced when air humidity is low, e.g. during summer or heating period. For this reason, it is preferable to keep air humidity levels above 45%. (50)

How to Minimize Static Magnetic Field Exposures:

- Prefer non-magnetic desks without large metal components that are made from, for example, solid wood with an antistatic, zero-VOC finish.
- If choosing furniture with large metal components, prefer non-magnetic metals such as aluminum or have magnetic types of steel demagnetized.
- Better yet, avoid metal components in desks and furniture in close proximity to the body, keep a minimum distance of 3 feet in areas where you spend prolonged periods of time.
- Avoid closed conductive loops in metal structures of furniture. A u-shape is preferable; in many cases it is helpful to insert a dielectric coupling or non-conductive isolation section. (48)
- Beware that large metal components—magnetic or not—attract and reradiate AC electric fields from wiring in the walls, extension cords and appliances. In order to decrease AC electric field exposure, have them grounded. Grounding should always be done by a qualified electrician.
- Shielding of AC electric fields (and extensive grounding) is always recommended, but especially if large metal enclosures and filing cabinets are unavoidable. (51)
- Large metal components—magnetic or not—also attract, reflect, and reradiate RF radiation from e.g. wireless communication systems whose transmitter(s) may be located indoors or outdoors. In a worst-case scenario, where a DECT

cordless phone base station may sit on a metal desk and a lot of steel furniture may line the nearby wall, the RF radiation exposure will most likely be increased. If the RF radiation source(s) cannot be removed, an RF survey is recommended to determine the best course of action how to lower the RF exposure level.

- In new construction, standard steel reinforcement for concrete can be replaced with electromagnetically neutral fiberglass reinforcement. Ideally, steel reinforcement is demagnetized and properly grounded.

A1.5 MAKING SENSE OF THE EXPOSURE DATA

In over 99% of the cases listed above, none of the legally binding exposure guidelines is exceeded. Since these guidelines only protect from acute, high-dosage effects, it is prudent to follow the precautionary recommendations put forward by the council directive of the European Union on the "Minimum Safety and Health Requirements for Work with Display Screen Equipment" from 1990: "***All radiation*** *with the exception of the visible part of the electromagnetic spectrum* ***shall be reduced to negligible levels*** *from the point of view of the protection of workers' safety and health." (52)*

Though standard-setting agencies and radiation protection branches are quick to point out that low-emission standards are often not "health-based", to my knowledge, there are no adverse health effects documented for the non-exposure to human-made non-ionizing radiation. In contrast, the list of evidence for biological effects and adverse health effects promoted or even caused by the random exposure to human-made non-ionizing radiation at levels below the currently valid exposure limits and well above the natural background levels continues to grow.

	Ambient*/Natural Background	**Low-Emission Guidelines**	**Canada**	**ICNIRP**
ELF Electric Field (5-2,000 Hz)	**ca. 10-50 V/m** Ambient background ca. 0.001 V/m Nature	**10 V/m** TCO 1992-2005 **25 V/m**	n/a	**4,167 V/m** (60 Hz) 5,000 V/m (50 Hz) General public exposure Guideline 1998
VLF Electric Field (2-400 kHz)		**1 V/m** TCO 1992-2005 **2,5 V/m** Russia SanPiN on PCs	n/a	**87 V/m** (3-1,000 kHz) General public exposure Guideline 1998
ELF Magnetic Field (5-2,000 Hz)	**ca. 20-250 nT** Ambient background ca. 0.001 nT Nature	**200 nT** TCO 1992-2005 **250 nT**	n/a	**83,330 nT** (60 Hz) 100,000 nT (50 Hz) General public exposure Guideline 1998
VLF Magnetic Field (2-400 kHz)		**25 nT** TCO 1992-2005 **25 nT** Russia SanPiN on PCs	n/a	**6,250 nT** (0.8-150 kHz) General public exposure Guideline 1998
RF Radiation (30 MHz-300 GHz)	**ca. 10-500 µW/m²** Ambient background ca. 0.000 001 µW/m² Nature	**100 µW/m²** BioInitiative 2007 Indoor environment **100 µW/m²** BMW Group 2003	**2,000,000 to 10,000,000 µW/m²** Safety Code 6 1999 For persons not classified as RF exposed workers incl. general public	**2,000,000 to 10,000,000 µW/m²** General public exposure Guideline 1998
Static Electric Field	**ca. 200-10,000 V/m** Ambient background 50-500 V/m Nature	**500 V** TCO 1999-2005 **500 V** VDT screen 15 kV/m VDTworkplace Russia SanPiN on PCs	n/a	No exposure limits given for static electric fields Guideline 1994 or 1998
Static Magnetic Field (All values listed are meant in addition to the local geo-magnetic field.)	**ca. 1-10 µT** Ambient background 0.1-1 µT** Nature	**> 20 µT** SBM-2008 Reference range "significant concern"	10,000 µT Safety Code 26 1999 Continuous exposure of MRI device operators	**40,000 µT** General public exposure Guideline 1994

*Average background levels in office environments
(In close proximity to electrical appliances and electronic devices, exposure levels can be much higher.)

**Variation of natural geomagnetic field (geomagnetic background field at equator 35 µT, at poles 70 µT)

For references on natural and ambient background levels see Appendix 3 and Appendix 2; and for references on guidelines (low-emission, Canada, ICNIRP) see Appendix 4 and Appendix 6.

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Appendix 2: Exposure Levels of Non ionizing Radiation in Office Environments

TABLE A2.1 AMBIENT BACKGROUND LEVELS

AC Electric Field	**in V/m**
Directly under power transmission lines (NRC 1997)	up to 10,000
Within 1 foot of small appliances Canada (Horizon Utilities 2008)	20-200
Ambient electric field at home/work (Horizon Utilities 2008)	< 100
Typical exposure levels in residences and work environments USA (Dingell 1993)	5-50
Typical exposure levels in residences USA (NRC 1997)	5-10
Ambient electric field in residences USA (Nair 1989)	1-10
AC Magnetic Field	**in nT**
Peak personal exposures in offices USA (Schiffman 1998) (max. peak values due to passage of/proximity to book theft detector)	100-109,100
Exposure range in offices Sweden/Norway (Mild 1996)	10 to over 1,000
Mean full-shift exposures in offices USA (Schiffman 1998)	80-130
Mean office area levels USA (Schiffman 1998)	20-140
Exposure range in offices USA (Huffman 1995)	30-250
Typical exposure in offices USA (EPRI 1994)	100-200
Mean work exposure USA (Zaffanella 1998)	173
Mean 24-hour exposure USA (Zaffanella 1998)	125
Mean residential exposure in bed USA (Zaffanella 1998)	111
Mean background level in offices USA (Huffman 1995)	20
RF Radiation If not otherwise indicated, values refer to outdoor exposure levels.	**in $\mu W/m^2$**
Ambient RF exposure within 100-200 feet of cell phone base stations USA (Sage 2000)	10,000-100,000

RF Radiation If not otherwise indicated, values refer to outdoor exposure levels.		**in µW/m²**
Analog mobile phone antenna on school roof Canada (Thansandote 1999)		25,600
PCS mobile phone antenna across street Canada (Thansandote 1999)		1,620
Mean exposure level from sum total of ambient RF radiation Sweden (Hamnerius 2000)		500
Prevalent RF background levels in cities Israel (Shachar 2004)		200-300
Median exposure level from sum total of GSM radiation at 250 m of cell phone base stations in urban areas Germany (Haumann 2002)		200
RF background level in a city without antenna in vicinity Canada (Thansandote 1999)		50-100
Median exposure level from sum total of ambient RF radiation in urban areas in 1978 USA (Tell 1982)		50
Residential indoor background level for pulsed RF radiation 2000-2005 Germany (Maes 2005)		ca. 0.5-5
Residential indoor background level for pulsed RF radiation 1995-2000 Germany (Maes 2005)		ca. 0.01-1
Residential indoor background level for pulsed RF radiation 1992-1995 Germany (Maes 2005)		ca. 0.001-0.1
Residential indoor background level for pulsed RF radiation 1985-1992 Germany (Maes 2005)		< 0.001
Static Electric Field		**in V/m**
Average exposure during walking on non-conductive carpets (WHO 2004)		10,000-500,000
Space with many synthetic furnishings and finishes at 20% RH (Maes 2005)		> -30,000
Plexiglas desk (Maes 2005)		+25,000
Chair with urethane foam (ESD 2001)	10-25% RH	18,000 V
	65-90% RH	1,500 V

Static Electric Field		**in V/m**
Walking across vinyl tile (ESD 2001)	10-25% RH	12,000 V
	65-90% RH	250 V
Static electricity in offices (Jamieson 2007)		
	Maximum level (moving feet on footrest)	7,700 V
	Average level	105 V
	Minimum level	2 V
Large areas of glazing (Maes 2005)		±500-2,000
Space with many synthetic furnishings and finishes at 80% RH (Maes 2005)		-250
Wood desk (Maes 2005)		+20
Static Magnetic Field		**in µT**
Exposure from headset, headphone, earphone at 1 cm (Maes 2005)		100-1,000
Exposure from loudspeakers at 30 cm (Maes 2005)		100-300
Static magnetic field ranges in conventional cars, light trucks (WHO 2004)		2.7-87.5
Exposure while sitting in office chairs with steel mechanism (Maes 2005)		up to 80
Exposure from steel reinforcement at 30 cm above floor (Maes 2005)		3-10

TABLE A2.2 EMF EMISSION LEVELS FROM VDTS

CRT Displays	Typical Range at 30 cm	Maximum Value at 30 cm
ELF AC electric field (30-300 Hz)	1-20 V/m	< 65 V/m
VLF AC electric field (3-300 kHz)	1.6 V/m	< 50 V/m
ELF AC magnetic field (30-300 Hz)	200 nT	< 1,200 nT
VLF AC magnetic field (3-300 kHz)	20-500 nT	< 1,500 nT
Static electric field (0 Hz)	2-500 V/m	< 25,000 V/m

Compiled from IEEE COMAR (1997)

Flat Panel Displays

According to Wolfgang Maes (personal communication 2008), founder of *BAUBIOLOGIE MAES* and initiator of the Building Biology Standard, flat panel displays usually meet the TCO recommendations (see Appendix 6) and in some cases their EMF emissions are considerably lower in both the ELF and VLF frequency band, static electricity is effectively zero.

In their handbook on “Bioengineering and Biophysical Aspects of Electromagnetic Fields,” Barnes and Greenebaum (2006) lament the lack of peer-reviewed data on EMF emissions from flat panel displays and caution that not all flat panel displays are created equal. According to a personal communication with Prof. Dr. Hamnerius, from the Department of Electromagnetics at Chalmers University in Goteborg, older displays using cold-cathode backlighting and those without a grounded power supply can exceed TCO recommendations.

TABLE A2.3 EMF EMISSION LEVELS FROM LAPTOP COMPUTERS

Laptop (25 models)	**Power Mode**	**Distance at 20-30 cm**
ELF AC electric field (5-2000 Hz)	AC power mode	1-500 V/m
	Battery mode	< 1 V/m
VLF AC electric field (2-400 kHz)	AC power mode	2-50 V/m
	Battery mode	2-50 V/m
ELF AC magnetic field (5-2000 Hz)	AC power mode	5-250 nT
	Battery mode	5-150 nT
VLF AC magnetic field (2-400 kHz)	AC power mode	3-60 nT
	Battery mode	2-35 nT
WLAN RF radiation (2.4 GHz)	either mode	> 50,000 $\mu W/m^2$

Compiled from Maes (2005), p. 482.

TABLE A2.4 AVERAGE MAGNETIC FIELD LEVELS FROM SELECTED OFFICE EQUIPMENT

Selected Office Equipment	Magnetic Flux Density in nT	
	at a 30 cm	at 50 cm
Air filter	11,750	3,370
Pencil sharpener	5,620	2,130
Fan	5,190	1,490
Microwave oven	3,420	1,120
Electric clock	970	300
Fluorescent lamp	370	140
Fax	190	140
Adding machine/calculator	170	90
Halogen lamp	170	110
Laptop	160	140
Printer	160	110
Scanner	130	90
Incandescent lamp	90	70

Compiled from Schiffman (1998) 100 nT = 1 mG

TABLE A2.5 EMF EMISSION LEVELS FROM COMPACT FLUORESCENT LAMPS

At 30 cm distance	**Compact Fluorescent Lamps** (7-17 W)	**Incandescent Lamp** (60 W)
ELF AC electric field (5-2000 Hz)	40-63 V/m	21 V/m
VLF AC electric field (2-400 kHz)	7-40 V/m	0
VLF AC magnetic field (2-400 kHz)	3-79 nT	0
Operating frequency	27-52 kHz	n/a
Steepness or slope of 100-Hz pulse (difference min/max dB)	2-48	n/a

Compiled from a test of 14 models by Schlegel (2007)

TABLE A2.6 RF RADIATION EMISSION LEVELS FROM WIRELESS SYSTEMS

RF Radiation Emission Levels from Wireless Systems		in μW/m²
Maximum emission level from mobile phone handset during call (Maes 2005) (1-2 W)		
	at 0.3 m distance	>1,000,000
Maximum emission levels from DECT cordless phones (13 models tested) Germany (Weitz 2006)		
	at 0.3 m distance	< 400,000
	at 0.5 m distance	26,000• 100,000
	at 1.5 m distance	2,700-11,500
	at 3 m distance	700-3,000
	at 10 m distance	50-280
Worst-case scenario emission levels (Kramer 2005)		
	DECT cordless phone at 0.2 m	ca. 350,000*
	at 1 m	ca. 20,000*
	WLAN network at 0.2 m	ca. 40,000*
	at 1 m	ca. 3,000*
	Bluetooth system at 0.2 m	ca. 30,000*
	at 1 m	ca. 2,000*
	PC Peripherals (e.g. wireless keyboard/mouse) at 0.2 m	ca. ≤ 6,000*
	at 1 m	ca. ≤ 6,000*
Office building with 16 DECT cordless phone base stations Sweden (Hamnerius 2000)		
	Peak power density at 1.6 m from a base station	3,698
	Mean power density at 1.6 m from a base station	154
WLAN network IEEE 802.11b at Bremen University Germany (Universität Bremen 2001)		
	Maximum exposure from WLAN access points in offices	1-2,500
	Out of 55 measurement spots in offices 43 were at	< 100
	Maximum exposure from WLAN PC card of notebook at 35 cm	ca. 4,000
Mean maximum exposure from WLAN access points in offices Sweden (Hamnerius 2005)		100

*In the original paper, the max. emissions are given as E-field strengths, which in the above table were converted into power density levels for ease of comparison.

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Appendix 3: Natural Background Levels

Alternating Electric Fields	**V/m**
Ambient background noise (Adey 2004)	ca. 0.01-0.1
Atmospherics 5-1,000 Hz (Bernhardt 1992)	ca. 0.0001-0.5
Human brain wave potentials at cortex (0.1-60 Hz and up)	ca. 0.01
Human brain wave potentials at scalp (0.1-60 Hz and up)	ca. 0.0001
Schumann resonances 7.5-8.4 Hz and 26-27 Hz (Bernhardt 1992)	ca. 0.000001
Alternating Magnetic Fields	**in nT**
Ambient background noise (Adey 2004)	ca. 1-10
Natural background level at 50/60 Hz (Bernhardt 1992)	ca. 0.001
Natural background level for 50-180 Hz (Fraser-Smith 1992)	ca. 0.0001-0.001
Typical range of natural background noise (Fraser-Smith 1992)	ca. 0.00002-0.0006
RF Radiation	**$\mu W/m^2$**
Sferics (dominant in kHz range) (König 1981/1986)	
at center of a local thunderstorm	up to 100
ambient atmospheric noise	ca. 0.00001
RF radiation from space between ca. 30 MHz-30 GHz (König 1981/1986; Barnes 2006)	
stormy sun	ca. 0.00001
quiet sun	ca. 0.00000001
RF radiation from space below ca. 30 MHz (wavelength 10 m)	mostly blocked out by the ionosphere
Static Electric Fields	**in V/m**
Typical electric fields in thunderclouds (Rakov 2003)	up to 200,000
Atmospheric electricity during thunderstorms (Rakov 2003)	ca. 10,000-20,000
Approaching storm (WHO 2004)	ca. 100-3,000

Static Electric Fields	**in V/m**
Atmospheric electricity during fair weather (WHO 2004)	ca. 130
Range of atmospheric electricity (IARC 2002)	50-500
Atmospheric electricity at 1,000 m altitude (WHO 2004)	ca. 45
Static Magnetic Fields	**in µT**
Geomagnetic field (NGDC)	
at equator	ca. 35
Victoria, Vancouver Island	ca. 55
at north/south pole	ca. 70
(IARC 2002) variations of natural origin	0.1 - 1
Geomagnetic activity in sub-auroral zone (Space Weather Canada 2007)	
Major storm	> 0.3
Stormy	0.1 – 0.3
Active	0.06 – 0.1
Unsettled	0.03 – 0.06
Quiet	< 0.03
Human heart magnetic field (Fishbine 2003)	0.000 1 (10-100 picotesla)
Human brain magnetic field just above skull (Fishbine 2003)	0.000 001 (0.1-1 picotesla)
SQUID detection threshold (Fishbine 2003)	0.000 000 001 (1 femtotesla)

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Appendix 4: Exposure Limits of Non-Ionizing Radiation

TABLE A4.1 EXPOSURE LIMITS OF AC ELECTRIC FIELDS

Occupational	**in V/m**
Workers' Compensation Board of BC (usually refers to ICNIRP guidelines)	n/a
American Conference of Governmental Industrial Hygienists, ACGIH (2001)	
Maximum Peak Level	25,000
Action Level	15,000
Workers with cardiac pacemakers	1,000
International Commission on Non-Ionizing Radiation Protection, ICNIRP (1998)	50 Hz: 10,000 60 Hz: 8,300
Emission Standards for Office Equipment	
Russian Sanitary Regulation for PCs (2003 June 30), Mandatory	ELF range: 25 VLF range: 2.5
Swedish Standard for Low-emission Monitors, TCO (since 1992), Voluntary	ELF range: 10 VLF range: 1
General Public, Mandatory	
International Commission of Non-ionizing Radiation Protection, ICNIRP (1998)	50 Hz: 5,000 60 Hz: 4,200
Japan for overhead power lines (1973)	3,000
Russia for outdoor environment (2001)	1,000
Russia for indoor environment (2001)	500
Veneto (Italy) for new power line installations (1999)	500
General Public, Voluntary	
US National Council on Radiation Protection and Measurements NCRP Draft Recommendation Options (1995)	option 3: 100 option 2: 10
Building Biology Guidelines for Sleeping Areas SBM-2008 Reference level "significant concern"	> 10

General Public, Voluntary	
ÖKOPASS by the Austrian Building Biology Institute IBO (2001) Certification criteria “excellent”	< 10
Austrian green building rating system argeTQ (2002) Certification criteria “very good”	< 10
Building Biology Guidelines for Sleeping Areas SBM-2008 Reference level “strong concern”	1.5-10
Building Biology Guidelines for Sleeping Areas SBM-2008 Reference level “slight concern”	0.3-1.5
Building Biology Guidelines for Sleeping Areas SBM-2008 Reference level “no concern”	< 0.3

TABLE A4.2 EXPOSURE LIMITS OF AC MAGNETIC FIELDS

Occupational	**in nT**
Workers' Compensation Board of BC (usually refers to ICNIRP guidelines)	n/a
International Commission on Non-ionizing Radiation Protection, ICNIRP (1998)	50 Hz: 500,000 60 Hz: 416,660
American Conference of Governmental Industrial Hygienists, ACGIH (2001)	
ceiling value	200,000
workers with cardiac pacemakers	100,000
Emission Standards for Office Equipment	
Russian Sanitary Regulation for PCs (2003 June 30), Mandatory	ELF range: 250 VLF range: 25
Swedish Standard for Low-emission Monitors, TCO (since 1992), Voluntary	ELF range: 200 VLF range: 25
General Public, Mandatory	
International Commission of Non-ionizing Radiation Protection, ICNIRP (1998)	50 Hz: 100,000 60 Hz: 83,330
Russia for outdoor environment (2001)	50,000
Russia for indoor environment (2001)	10,000
Switzerland for new power line installations (2000)	1,000
Veneto, Toscana, Emilia-Romagna (Italy) for new power line installations (1999/2000)	200
General Public, Voluntary	
US National Council on Radiation Protection and Measurements NCRP draft recommendation options (1995)	option 3: 1,000 option 2: 200
Building Biology Guidelines for Sleeping Areas SBM-2008 Reference range "significant concern"	> 500
Building Biology Guidelines for Sleeping Areas SBM-2008 Reference range "strong concern"	100–500

General Public, Voluntary	
Austrian green building rating system argeTQ (2002) Certification criteria “very good”	< 200
BioInitiative Working Group Recommendation (2007)	
for residences and sensitive areas	100
for all other existing buildings	200
US National Institute of Building Sciences (NIBS) (2006) Recommendation for occupied areas in buildings	max. 250 preferably < 100
ÖKOPASS by the Austrian Building Biology Institute IBO (2001) Certification criteria “excellent”	< 100
Building Biology Guidelines for Sleeping Areas SBM-2008 Reference range “slight concern”	20-100
Building Biology Guidelines for Sleeping Areas SBM-2008 Reference range “no concern”	< 20

TABLE A4.3 EXPOSURE LIMITS OF RF RADIATION

Occupational	**$\mu W/m^2$**
Workers' Compensation Board of BC	Refers to Health Canada Safety Code 6
ACGIH (1984)	
Threshold Limit Values: 1000 – 300,000 MHz	100,000,000
Health Canada Safety Code 6 (1999): For RF and microwave exposed workers	
1,500 – 150,000 MHz	50,000,000
100-300 MHz	10,000,000
US FCC Limits for Maximum Permissible Exposure (1997)	
1500 – 100,000 MHz	50,000,000
International Commission of Non-ionizing Radiation Protection, ICNIRP (1998)	
2,000 – 300,000 MHz	50,000,000
1800 MHz	45,000,000
BMW Group: internal guideline for cordless phones (2003)	100
Emission Standards for Mobile Phones	**SAR-value in W/kg** per 10 g tissue (head and trunk)
International Commission of Non-ionizing Radiation Protection, ICNIRP (1998)	2.0
European Council recommendation (1999)	
Swedish Standard for Low-emission Mobile Phones, TCO (2001)	0.8
US Federal Communications Commission, FCC (1997)	per 1 g tissue: 1.6
Blue Angel Eco-Label (2002)	0.6
EMF-Institut Dr. Niessen (former NOVA Institut) recommendation, Germany	0.2

General Public, Mandatory	**$\mu W/m^2$**
International Commission of Non-ionizing Radiation Protection, ICNIRP (1998): 2,000 – 300,000 MHz Health Canada Safety Code 6 (1999): 1800 MHz US FCC Limits for Maximum Permissible Exposure: 1,500 – 100,000 MHz	10,000,000
General Public, Mandatory	**$\mu W/m^2$**
Health Canada Safety Code 6 (1999): 900 MHz	6,000,000
Health Canada Safety Code 6 (1999): 30-300 MHz	2,000,000
Russia for sum total of RF exposure (1996) China for sum total of RF exposure (1987)	100,000
Switzerland in sensitive areas (NISV 2000): 1800 MHz	70,000
Switzerland in sensitive areas (NISV 2000): 900 MHz	40,000
General Public, Voluntary	**$\mu W/m^2$**
BioInitiative Working Group recommendation (2007) for outdoor environment Salzburg Resolution for sum total of GSM (2000)	1,000
Building Biology Guidelines for Sleeping Areas SBM-2008 Reference range “significant concern”	1,000
ÖKOPASS by the Austrian Building Biology Institute IBO (2001) Certification criteria “excellent”	< 1,000
BioInitiative Working Group recommendation (2007) for indoor environment European Parliament: STOA recommendation for GSM (2001)	100
Building Biology Guidelines for Sleeping Areas SBM-2008 Reference range “strong concern”	10-1,000
Salzburg Public Health Department recommendation for sum total of GSM/3G in outdoor environments (2002)	10
Salzburg Public Health Department recommendation for sum total of GSM/3G in indoor environments (2002)	1
Building Biology Guidelines for Sleeping Areas SBM-2008 Reference range “slight concern”	0.1-10
Building Biology Guidelines for Sleeping Areas SBM-2008 Reference range “no concern”	< 0.1

10 $\mu W/m^2$ = 0.001 $\mu W/cm^2$ = 1 nW/cm^2 = ca. 0.06 V/m

TABLE A4.4 EXPOSURE LIMITS OF STATIC ELECTRIC FIELDS

Occupational	**field strength V/m** **surface potential V**
Workers' Compensation Board of BC	n/a
International Commission of Non-ionizing Radiation Protection, ICNIRP (1994 or 1998)	no exposure limits given
Germany (DIN/VDE 0848)	40,000 V/m
Emission Standards for Office Equipment	
Russian Sanitary Regulation for PCs (2003 June 30), Mandatory	
VDT screen	500 V
VDT workplace	15 kV/m
Swedish Standard for Low-emission Monitors, TCO (since 1992), Voluntary	500 V
Electronic circuitry inside a computer (e.g. exposed microchips) may be affected	from 100 V
General Public, Mandatory	
Germany (DIN/VDE 0848)	10,000 V/m
General Public, Voluntary	
Building Biology Guidelines for Sleeping Areas SBM-2008 Reference range "significant concern"	> 2,000 V
Building Biology Guidelines for Sleeping Areas SBM-2008 Reference range "strong concern"	500-2,000 V
ÖKOPASS by the Austrian Building Biology Institute IBO (2001) Certification criteria "excellent"	< 200 V/m
Building Biology Guidelines for Sleeping Areas SBM-2008 Reference range "slight concern"	100-500 V
Building Biology Guidelines for Sleeping Areas SBM-2008 Reference range "no concern"	< 100 V

TABLE A4.5 EXPOSURE LIMITS OF STATIC MAGNETIC FIELDS

Occupational	**in µT***
Workers' Compensation Board of BC	Refers to Health Canada Safety Code 26
European Union Physical Agent (EMF) Directive (2004) - Draft	2,000,000
International Commission of Non-ionizing Radiation Protection, ICNIRP (1994)	
Ceiling value	2,000,000
Whole work day (time-weighted average)	200,000
Germany (DIN/VDE 0848)	67,900
Health Canada Safety Code 26 (1987): MRI Device Operators	
Continuous exposure should not exceed	10,000
Emission Standards for Office Equipment	
Computer disks, magnetic storage media, credit cards, and analog watches may be affected	from 500
General Public, Mandatory	
Upper Limit for Clinical Routine Whole Body *Short-term* Exposure to MRI (US FDA 2003)	8,000,000
Upper Limit for Clinical Routine Whole Body *Short-term* Exposure to MRI (IEC 2001, US FDA 1997)	4,000,000
Upper Limit for Clinical Routine Whole Body *Short-term* Exposure to MRI (Canada 1987)	2,000,000
International Commission of Non-ionizing Radiation Protection, ICNIRP (1994)	40,000
Germany (DIN/VDE 0848)	21,200
Safety Recommendation for the General Public at CERN, European Laboratory for Particle Physics (2005)	10,000
General Public, Voluntary	**in µT**
Building Biology Guidelines for Sleeping Areas SBM-2008 Reference range "significant concern"	> 20

General Public, Voluntary	in µT
Building Biology Guidelines for Sleeping Areas SBM-2008 Reference range “strong concern”	5-20
Building Biology Guidelines for Sleeping Areas SBM-2008 Reference range “slight concern”	1-5
Building Biology Guidelines for Sleeping Areas SBM-2008 Reference range “no concern”	< 1

* Exposure limits for static magnetic fields refer to exposure values in addition to the naturally occurring local geomagnetic field.

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Canada

Health and Welfare Canada. 1987. Safety Code 26: Guidelines on exposure to electromagnetic fields from magnetic resonance clinical systems [Internet]. 87-EHD-127. Ottawa (ON): Minister of National Health and Welfare; 20 p. [cited 2008 May 12]; 73 p. Available from: http://www.hc-sc.gc.ca/ewh-semt/pubs/radiation/87ehd-dhm127/index_e.html

Health Canada. 1999. Safety Code 6: limits of human exposure to radiofrequency electromagnetic fields in the frequency range from 3 kHz to 300 GHz [Internet]. 99-EHD-237. Ottawa (ON): Minister of Public Works and Government Services; [cited 2008 May 12]; 73 p. Available from: http://www.hc-sc.gc.ca/ewh-semt/pubs/radiation/99ehd-dhm237/index_e.html

Workers' Compensation Board of British Columbia. 2008. Occupational Health and Safety Regulation: part 7 noise, vibration, radiation and temperature: division 3: radiation exposure [Internet]. Richmond (BC): Crown Publications; [cited 2008 May 12]. Available from: http://www2.worksafebc.com/publications/OHSRegulation/Part7.asp

China

Ministry of Health China. 1987. [EMF Regulations] [Internet]. [cited 2008 May 12]. Chinese. Reference available from: http://www.salzburg.gv.at/Proceedings_(20)_Chiang.pdf and http://www.who.int/docstore/peh-emf/EMFStandards/who-0102/Asia/China_files/table_ch.htm

European Union

Council of the European Union. 1999 Jul 12. Council recommendation on the limitation of exposure of the general public to electromagnetic fields (0 Hz to 300 GHz) [Internet]. Official Journal of the European Union. [cited 2008 May 12]; 1999/519/EC:L 199/59-L 199/70. Available from: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:1999:199:0059:0070:EN:PDF

Council of the European Union. 2004 Apr 30. Council directive on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (electromagnetic fields) [Internet]. Official Journal of the European Union. [cited 2008 May 12]; 2004/40/EC:L 184/1-L 184/9. Available from: http://www.senseaboutscience.org.uk/pdf/PhysicalAgentsDirective.pdf

Safety Commission Group. 2005. Safety rules for the use of static magnetic fields at CERN [Internet]. IS36 rev. 2. [cited 2008 May 12]; 4 p. Available from: http://edms.cern.ch/file/335801/LAST_RELEASED/IS36_E.pdf

Germany

DIN-VDE 0848. Sicherheit in elektrischen, magnetischen und elektromagnetischen Feldern (0 Hz bis 300 GHz) [Safety in electric, magnetic and electromagnetic fields (0 Hz to 300 GHz]. Beuth, Germany: Verband der Elektrotechnik Elektronik Informationstechnik e.V. German. Order information available from: www.beuth.de

Italy

Three Italian regions have set their own regional exposure limits for new power line installations near sensitive areas. Since 2003 a National Decree prevents any other region in Italy from doing the same.

Regione Toscana. 1999 Aug 11. Regolamento in materia di linee elettriche ed impianti elettrici: Regolamento relativo alla legge N. 51.

Regione Emilia-Romagna. 2000 Oct 31. Legge sull-elettrosmog: Legge Regionale 31.

Regione Veneto. 1999 Oct. Bollettino Ufficiale della Regione del Veneto, N. 93. Legge Regionale N. 48.

Eurelectric, Environment & Society Working Group. 2006 Mar. EMF exposure standards applicable in Europe and elsewhere [Internet]. Brussels, Belgium: Union of the Electricity Industry; [2008 May 12]; p. 26. Reference available from: http://www.eurelectric.org/Download/Download.aspx?DocumentID=19100

Japan

Ministry of International Trade and Industry. 1973. [Ministerial Ordinance of Technological Standards for Thermal Facilities] (Article 112). Japanese. Reference in: Eurelectric, Environment & Society Working Group. 2006 Mar. EMF exposure standards applicable in Europe and elsewhere [Internet]. Brussels, Belgium; Union of the Electricity Industry; [2008 May 12]; p. 27. Reference available from: http://www.eurelectric.org/Download/Download.aspx?DocumentID=19100

Russia

English translations of selected Russian Sanitary Norms available from: http://www.russian-national-standards.com/russian-sanitary-norms.html

Ministry of Health of the Russian Federation. 1996. [Sanitary rules and norms on radiofrequency radiation] [Internet]. Norm No.: SanPiN 2.2.4/2.1.8.055-96. [cited 2008 May 12]. Russian. Reference available from: http://www.who.int/peh-emf/meetings/en/day2Varna_Foster.pdf and http://www.who.int/docstore/peh-emf/EMFStandards/who-0102/Europe/Russia_files/table_rs.htm

Ministry of Health of the Russian Federation. 2001. [Sanitary-epidemiological norms and regulations for residential buildings] [Internet]. Norm No.: SanPiN 2.1.2.1002-00. [cited 2008 May 12]. Russian. Original available from: www.who.int/docstore/peh-emf/EMFStandards/who-0102/Europe/Russia_files/table_rs_files/sanpin2.1.2.1002_00.pdf

English explanation of the standard by the Russian Center for Electromagnetic Safety available from: www.tesla.ru/english/protection/standards.html

Ministry of Health of the Russian Federation. 2003 Jun 16. [Sanitary and epidemiological norms on hygienic requirements to ionic air formula for industrial and public quarters] [Internet]. Norm No.: SanPiN 2.2.4.1294-03. [cited 2008 Aug 9]. Russian. English translation of excerpts available from: http://www.ionization.info/issue/iss6.htm

Ministry of Health of the Russian Federation. 2003 Jun 30. [Sanitary and epidemiological norms on hygienic requirements for personal computers and work organization]. Norm No.: SanPiN 2.2.2./2.4.1340-03. [cited 2008 Oct 30]. Russian.

Switzerland

Der Schweizerische Bundesrat. 1999 Dec 23. Verordnung vom 23. Dezember 1999 über den Schutz vor nichtionisierender Strahlung (NISV) [The ordinance from 1999 December 23 on the protection from non-ionizing radiation][Internet]. [cited 2008 May 12]. German. Available from: www.admin.ch/ch/d/sr/814_710/index.html and http://www.bafu.admin.ch/elektrosmog/01100/01101/index.html?lang=de

USA

[ACGIH] American Conference of Governmental Industrial Hygienists. 2001. Documentation of the threshold limit values for physical agents. 7th ed. Cincinnati (OH): American Conference of Governmental Industrial Hygienists. Order information available from: www.acgih.org/Store/ProductDetail.cfm?id=654

[FCC] Federal Communications Commission. 1997. Guidelines for the environmental effects of radiofrequency radiation [Internet]. ET Docket 93-62. [cited 2008 May 12]. Available from: http://www.fcc.gov/oet/dockets/et93-62/

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BMW Group issued an internal guideline for cordless phones in 2003 to reduce RF radiation exposure for its employees.
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EMF-Institut Dr. Niessen (www.emf-institut.de) maintains the Handywerte web site with up-to-date SAR values, which was initiated by the NOVA Institut, to help consumers make low-emission choices with regard to mobile phones.
EMF-Institut. [date unknown]. Handywerte: aktuelle Informationen über die Strahlenbelastung verschiedener Handymodelle [SAR values: up-to-date information on radiation exposure from different mobile phone models][Internet]. [cited 2008 May 12]. German. Available from: www.handywerte.de

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Emission Standards for Equipment

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Joint English press release by the Federal Environment Agency of Germany (UBA) and Blue Angel available from http://www.umweltbundesamt.de/uba-info-presse• e/2007/pdf/pe07-054.pdf

TCO Development (The Swedish Confederation of Professional Employees) launched its first labeling program for low-emission office equipment in 1992. [cited 2008 May 12]. Current standards available in English from: http://www.tcodevelopment.com after clicking on English in the drop-down menu in the upper right corner.

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Appendix 5: Selected Biological Effects Associated with Exposures to Non-Ionizing Radiation

A5.1 Symptoms Associated with Office Environments and VDT Use

For all studies listed below that document associations between EMF/RF exposure(s) and biological or health effects, there are many studies that did and do not find such associations. Listings of no-effects studies can be found in the reviews by the UK NRPB and the US NIOSH documentations on VDT use listed further below. Measurement metrics are rather complicated; in most cases a statistically significant trend can only be observed when actual, real-life measurements of e.g. peak values and long exposure periods are taken and considered.

A5.1.1 ADVERSE REPRODUCTIVE OUTCOMES ASSOCIATED WITH VDT USE AND MAGNETIC FIELD EXPOSURE

Lindbohm ML, Hietanen M, Kyyrönen P, Sallmén M, von Nadelstadh P, Taskinen H, Pekkarinen M, Ylikoski M, Hemminki K. 1992. Magnetic fields of video display terminals and spontaneous abortion. Am J Epidemiol. 136(9):1041-1051.

In this case-control study, the VDT use of female bank clerks and office workers aged 20-35 from three companies in Finland was analyzed in relation to spontaneous abortion. The study period was from 1975 to 1985; the final study population had 191 cases and 394 matched controls. In addition to interviews and company information, measurements of the magnetic field strengths of the VDTs but not the actual workstations were taken.

*"The present study showed a **significantly increased odds ratio [OR 3.8] for spontaneous abortion** for workers using a **video display terminal with high magnetic field levels (> 0.9 µT in the extremely low frequency range)** [27% of cases, 12% of controls] when they were compared with workers using video display terminals with low magnetic field strength [< 0.4 µT]."* (p. 1048)

Marcus M, McChesney R, Golden A, Landrigan P. 2000. Video display terminals and miscarriage. JAMWA. 55(2):84-85.

In this review paper, ten epidemiological studies of miscarriages and VDT use are discussed, including a listing of 12 reports of clusters of adverse pregnancy outcomes among women who use VDTs.

"There is some evidence that two exposures common among VDT operators—electromagnetic fields and occupational stress—could plausibly increase the risk of miscarriage." (p. 85)

*"Work with VDTs during pregnancy is unlikely to increase the risk of miscarriage for most women in modern offices. The **miscarriage risk** for women who work at high-stress jobs or with older, **high-emission VDTs (ELF > 3 mG [300 nT])**, however, is **still uncertain**."* (p. 88)

Shaw GM. 2001. Adverse human reproductive outcomes and electromagnetic fields: a brief summary of the epidemiologic literature. Bioelectromagnetics Suppl. 5:S5-S18.

In this brief summary, the epidemiologic evidence for potential associations between a number of adverse reproductive outcomes and parental exposures to electromagnetic fields is discussed, including lists of relevant literature reviews and studies.

"The lack of epidemiologic data in this area, coupled with some speculations about potential biological effects associated with EMFs, ***raises the importance of researching this area further****."* (p. S5)

Lee GM, Neutra RR, Hristova L, Yost M, Hiatt R. 2002. A nested case-control study of residential and personal magnetic field measures and miscarriages. Epidemiology. 13(1):21-31.

In this nested case-control study, 177 cases and 550 controls were assessed for the relationship between actual magnetic field measurements (retrospective) and miscarriage. A prospective sub-study with 219 participants was also conducted. The study subjects were drawn from the northern California Kaiser Permanente medical care system in the San Francisco area. All magnetic field measurements were collected at waist level, including 24-hour personal data monitoring and spot measurements. It is the first study to evaluate personal magnetic field exposures for three different metrics: time-weighted average (TWA), rate-of-change metric (RCM), maximum value (MAX). The interviews were standardized computer-assisted telephone interviews.

"…, the ***personal TWA magnetic field exposures above 2.0 mG [200 nT]*** *for the total home and for the other environments were* ***positively associated with miscarriage risk****."* (p. 28)

"The maximum personal magnetic field exposures [from 1,431 nT] and the exposures with large average differences between consecutive levels (the RCM) [from 43 nT] are associated with the risk of clinical miscarriages. These metrics show a dose response with an increase in exposure and with the number of environments that have exposure above the 50th percentile level." (p. 28)

"About three-fourths of our participants experienced a ***personal maximum field exposure above 14 mG [1,400 nT]*** *or an average change in fields* ***(RCM) above 0.42 mG [42 nT]*** *during the 24-hour measurement period. An* ***odds ratio of about 2.0 or higher*** *was found for these metric values. Hence, if these exposures were actually causal, they could account for a nontrivial proportion of the background rate of miscarriages."* (p. 30)

Li DK et al. 2002. A population-based prospective cohort study of personal exposure to magnetic fields during pregnancy and the risk of miscarriage. Epidemiology. 13(1):9-20.

In this population-based prospective cohort study, a total of 969 subjects made the final analysis. The study subjects were drawn from the northern California Kaiser Permanente medical care system in the San Francisco area. In addition to a time-weighted average (TWA), magnetic field measurements also included 24-hour personal data monitoring and spot measurements, both with maximum magnetic field value (MMF). The interviews were conducted in person.

"Spot measurements did not show a consistent pattern of an association between increased exposure level (in quartiles) and the rate of miscarriage. In our study, the residential wire-code category was not associated with either MMF [maximum magnetic field] or risk of miscarriage …" (p. 13)

"This population-based cohort study with prospectively measured MF exposure level revealed an ***increased risk of miscarriage associated with an MMF exposure level >/= 16 mG [1,600***

nT]. *… Prenatal MMF exposure was more strongly associated with early miscarriage (< 10 weeks of gestation) … The association was much stronger when women whose 24-hour MF measurements may not reflect their true prenatal MF exposure were excluded."* (p. 18)

"The robustness of the association between MMF and miscarriage risk against potential confounders was supported by evidence that despite adjustment for more than 30 variables of known or suspected risk factors for miscarriage, the estimates were barely altered." (p. 18/19)

Commentary by Savitz on the above studies by Lee et al. (2002) and Li et al. (2002)

Savitz DA. 2001 Jan. Magnetic fields and miscarriage. Epidemiology. 13(1):1-3.

"All other things being equal, a woman experiencing nausea will be less likely to move around her home or workplace or community, and therefore less likely to experience the diverse magnetic field sources in those places. As a result, she is less likely to encounter high magnetic field peaks and less likely to have substantial magnetic field variability over time." (p. 2)

Response by the authors to Savitz' commentary

Li DK, Neutra RR. 2002 Mar. Magnetic fields and miscarriages. Epidemiology. 13(2):237-238.

"After adding the nausea and vomiting variables … to the Cox model, the HR for the association of maximum MF with risk of miscarriage remained essentially the same, if not strengthened …" (p. 237)

Response by Savitz to the authors

Savitz DA. 2002 Mar. Magnetic fields and miscarriages. Epidemiology. 13(2):238.

"The virtual lack of correlation reported by Lee et al. between exposures in early and late pregnancy for the maximum magnetic field (r=0.09) and rate-of-change metric (r=0.19), far lower than for the time-weighted average (r=0.64), would be consistent with a nearly random phenomenon. However, a random event would not be expected to be associated with risk of miscarriage …"

Response by the authors to Savitz' response

Li DK, Neutra RR. 2002 May. Magnetic fields and miscarriages. Epidemiology. 13(3):372.

"There is a great deal of repetitiveness in our daily activities. With regard to the poor correlation between two MMF measures that were obtained some 20 weeks apart in the study by Lee et al., it may have had less to do with the randomness of MMF measurements, as Savitz was implying, and more to do with the possibility that a significant portion of women were measured on non-typical days. … The latter study also showed that no association was found if the study was restricted to women who were measured on a non-typical day. This suggests that peak exposures need to occur on a daily basis … in early pregnancy to have an effect. Of course, the ultimate resolution of the question of reliability of MMF measurement will come from studies that measure MMF on multiple days, both typical and atypical."

A5.1.2 BRAIN TUMORS ASSOCIATED WITH CELL PHONE USE

(Most studies on cell phone radiation and brain tumors that do not find an increased tumor risk in cell phone users consider only short-term exposure periods of several years, certainly below the possible minimum tumor latency period of 10-15 years.)

Hardell L, Carlberg M, Söderquist F, Mild HM. 2008. Meta-analysis of long-term mobile phone use and the association with brain tumours. Int J Onc [Internet]. [cited 2008 Oct 4]. 32:1097• 1103. Available from: http://environmentaloncology.org/files/file/Publications/Scientific%20Pubs/Hardell2008.pdf

In this meta-analysis, studies on the long-term use of mobile phones and the risk for brain tumors was evaluated: 10 studies on glioma, 9 studies on acoustic neuroma, 7 studies on meningioma.

*"We conclude that this meta-analysis gave a **consistent** pattern of an **association between mobile phone use and ipsilateral glioma and acoustic neuroma using ≥10-years latency period**."* (p. 1097)

Hardell L, Carlberg M, Mild KH. 2006. Case–control study of the association between the use of cellular and cordless telephones and malignant brain tumors diagnosed during 2000–2003. Environ Res. 100:232–241.

In this case-control study, a total of 820 cases aged 20 to 80 and diagnosed during 2000 to 2003, of which 395 had a malignant brain tumor, were selected from the Swedish cancer registry. Only living patients were included in the study. Each case was matched with one population-based control from the same region and age range.

*"Our main finding was a **significantly increased risk for high-grade astrocytoma for all three studied phone types** [analog, digital, cordless]. The OR increased both with the increasing number of hours of use and tumor latency period. The **highest risk was found for a >10-year latency period**."* (p. 239)

"Regarding different types of malignant brain tumors, the highest risk was found for high-grade astrocytoma. With a >10-year latency period,
analog phones yielded OR=4.7, 95% CI=2.4–9.2,
digital cellular phones OR=4.5, 95% CI=2.0–10, and
cordless phones OR=3.7, 95% CI=1.8–7.2." (p. 234)

Schüz J et al., Interphone Study Group Germany. 2006. Cellular phones, cordless phones, and the risks of glioma and meningioma. Am J Epidemiol. 163:512-520.

In this case-control study of the German part of the Interphone Study, 366 glioma cases and 381 meningioma cases aged 30 to 69 and diagnosed during 2000 to 2003 were selected from four large clinics in the Ruhr region. The 1,494 cases were drawn from population registries and matched for age, gender and region.

*"There was no increased risk of glioma or meningioma for most of the exposure measurements. Among **long-term cellular phone users** (>/= 10 years), however, a **twofold risk of glioma was observed**."* (p. 515)

A5.1.3 CANCER ASSOCIATED WITH AC MAGNETIC FIELD EXPOSURE

(VDTs are not the only source of electromagnetic fields in an office environment. With regard to a computer user, the field strength of all ambient sources combined can be much higher as demonstrated in the case listed below.)

Milham S. 1996. Increased incidence of cancer in a cohort of office workers exposed to strong magnetic fields. Am J Ind Med. 30:702-704.

In this cohort study, 410 office workers exposed to strong magnetic fields (before 1992 retrofit: 9,000-19,000 nT; after 1992 retrofit: 1,200-3,200 nT) from three 12-kV transformers located beneath the first-floor office developed eight incident cancers over a 15 year exposure period between 1980 through 1994, compared to 4.2 expected.

"In this cohort, risk of developing cancer increases with increasing duration of employment and, presumably, with increasing duration of exposure to strong magnetic fields. This suggests that ***cumulative magnetic field exposure may be of etiologic importance****."* (p. 703)

"Since many buildings are designed with internal electrical substations, the exposure situation described here may be fairly common. In case-control occupational studies of cancer using job titles, the workers studied here would be classified as 'nonexposed' to magnetic fields compared to 'exposed' electrical workers. This exposure misclassification leads to underestimation of risk."

A5.1.4 HEADACHES ASSOCIATED WITH CONVENTIONAL BALLASTS IN FLUORESCENT LIGHTING

(See under Artificial Lighting in appendix 1 for more detailed ballast recommendations.)

Wilkins AJ, Nimmo-Smitz I, Salter AI, Bedocs L. 1989. Fluorescent lighting, headaches and eyestrain. Lighting Res Technol [Internet]. [cited 2008 Sep 9]; 21(1):11-18. Available from: http://www.essex.ac.uk/psychology/overlays/1988-76.pdf

Staff members (ca. 129) of a government legal department, who performed close visual work almost entirely without the use of computer displays, completed a weekly headache questionnaire for one year beginning April 1986. In this study, one group of office workers was exposed to conventional fluorescent lighting with magnetic ballasts and the other group was exposed to fluorescent lighting with electronic ballasts. In the middle of winter, the lighting conditions were reversed (double-blind cross-over design).

"Despite certain difficulties of interpretation, the data as a whole show a consistent pattern indicating that new high-frequency lighting [fluorescent lighting with electronic ballast] may be preferable to conventional lighting [fluorescent lighting with magnetic ballast]: (a) ***headaches and eyestrain were reduced by a factor of two or more when the controlling circuitry was changed to the new high-frequency ballast*** *and the light no longer fluctuated in intensity; (b) the nature of the phosphor, and the speed with which the lamps ignited did not appear to affect the incidence of headaches; (c) among participants exposed to conventional lighting there was a tendency for headaches to decrease as the amount of available natural light increased; (d) the conventional lighting was switched on for less time than the new; (e) subjects appeared to be unaware of the change of lighting and its effects on headaches and eyestrain. Perhaps conventional fluorescent lighting contributes to 'building sickness'."* (p. 17-18)

Küller R, Laike T. 1998. The impact of flicker from fluorescent lighting on well-being, performance and physiological arousal. Ergonomics. 41(4):433-447.

In this exposure study, a total of 37 healthy males and females aged 21 to 50 were subjected to fluorescent lighting either powered by conventional or high-frequency ballasts in a laboratory office environment. Each participant was exposed to both experimental conditions for 3 h in the laboratory office with 1 week in-between. One sham exposure was scheduled 1 week prior to the experiments. The impact on subjective well-being, performance and physiological arousal (EEG, ECG) was measured. No daylight was present during exposure periods.

"However, when the light was powered by the ***conventional ballasts****,* ***individuals with high critical flicker fusion frequency*** *(CFF) responded with a* ***pronounced attenuation of EEG α waves****, and an increase in speed and decrease in accuracy of performance. These results may be understood in terms of heightened arousal in the central nervous system in response to the pronounced light modulation caused by the conventional ballasts. In order to alleviate this potential stress source, it is recommended that fluorescent lighting be powered by electronic high-frequency ballasts of good quality."* (p. 433)

"However, the lack of effects on headache and eye-strain are contrary to the findings in the field study by Wilkins et al. (1989). It may be that the exposure time of 3 h was insufficient in this respect." (p. 443)

A5.1.5 MELATONIN LEVELS ASSOCIATED WITH EMF/RF RADIATION EXPOSURE

Burch JB, Reif JS, Yost MG, Keefe TJ, Pitrat CA. 1999. Reduced excretion of a melatonin metabolite in workers exposed to 60 Hz magnetic fields. Am J Epidemiol. 150:27-36.

In this epidemiological study, 142 male employees aged 30 and 50 from three municipal electric utilities in Colorado (39% distribution, 20% generation, 40% administrative/maintenance) were studied over a one-year period during daytime work hours. Data were collected for the first 3 days of the work week: melatonin metabolite 6-OHMS urine sample after shift, work shift personal data magnetic field and ambient light exposure logging at waist.

"Adjusted mean 6-OHMS/cr concentrations among subjects within the highest quartile [>1,791 lux] of ambient light exposure were 14 percent lower than those in the lowest quartile [≤262 lux], whereas those in the highest quartile [>135 nT] of temporally stable magnetic field exposures had adjusted mean 6-OHMS/cr levels that were 31 to 35 percent lower compared with those in the lowest quartile [≤78 nT]. Among individuals in the lowest quartile of ambient light exposure [≤262 lux], there was a 36 percent difference in adjusted mean 6-OHMS/cr levels between those in the upper and lower quartiles of temporally stable magnetic field exposures. ***A dose-response trend of progressively lower 6-OHMS/cr levels with increasing exposure to temporally stable magnetic fields was noted for those with low workplace light exposure.****"* (p. 34)

"Low levels of light exposure were most strongly associated with a magnetic field effect and ***subjects with low TWA light exposures were primarily engaged in office work****."* (p. 34)

"Thus, modest (~30 percent) decreases in evening melatonin levels may reduce melatonin receptor activation, thereby altering functional melatonin responses. … The combined reduction of both daytime and nocturnal melatonin secretion would lead to reduced 24-hour melatonin secretion, which could alter immunologic, oncostatic, or antioxidant processes influenced by melatonin." (p.34)

"Results presented here provide further evidence that occupational exposure to magnetic fields is associated with reduced post-work shift 6-OHMS/cr excretion. Low ambient light exposures appear to have an important modifying effect." (p. 34)

Burch JB, Reif JS, Noonan CW, Ichinose T, Bachand A, Koleber TI, Yost MG. 2002. Melatonin metabolite excretion among cellular telephone users. Int J Rad Biol. 78 (11):1029-36.

This is the first epidemiological study to evaluate the potential effects of analog cell phone use on human melatonin levels among male employees aged 18 to 60 from nine electric utilities. Over three consecutive days, the following data were collected: melatonin metabolite 6-OHMS in urine (total overnight, post-work), personal data magnetic field and ambient light exposure logging at waist. In the 1997 Study 1, no statistically significant difference or trend in nocturnal melatonin levels was observed because the inadequate number of cell phone users in the highest exposure category (> 25 min) limited its statistical power. In the 1998 Study 2, the highest cell phone exposure category (> 25 min) included sufficient numbers of participants. Non-work cell phone use was not determined.

"There were no statistically significant differences in mean nocturnal 6 OHMS excretion on the first and second participation days and no differences in post-work 6-OHMS levels on any given day (data not shown). ***On the third day of participation****, Study 2* ***participants with > 25 min of cellular telephone use had lower adjusted mean nocturnal 6-OHMS/cr concentrations*** *(12.7 ng/mg cr …) compared with those with … no cellular telephone use (21.3 ng/mg cr …)."* (p. 1032)

"The results suggest that a minimum daily and/or a multi-day threshold of cellular telephone use may be necessary to reduce 6-OHMS excretion." (p. 1033)

"The greatest reductions in mean nocturnal 6-OHMS excretion occurred among Study 2 participants whose daily cellular telephone use [>10 min] and workplace MF exposures [ca. 5,000 nT] were both elevated." (p. 1034)

A5.1.6 RESPIRATORY AND EYE CONDITIONS ASSOCIATED WITH INCREASED PARTICLE DEPOSITION DUE TO ELEVATED ELECTROSTATIC AND ELECTRIC FIELD LEVELS

Nielsen NF, Schneider T. 1998. Particle deposition onto a human head: influence of electrostatic and wind fields. Bioelectromagnetics. 19:246-258.

Two separate models, electrostatic field model and particle deposition model, are investigated and discussed for two different facial shapes, Caucasian and East-Asian, to calculate aerosol particle deposition.

"This work demonstrates that within any group of persons there is great variability in the particle deposition rate caused by external factors other than concentration of particles in the air. These differences are not reflected by measurements of airborne particle concentrations because measurement instruments are designed to reflect particle deposition in various compartments of the airways and not deposition onto the eyes. These causes of variability have not previously been considered in epidemiological studies, and they could explain in part, why dose-effect relationships regarding air-borne dust and ocular symptoms have remained elusive in the indoor environment." (p. 255/256)

Kjaergaard SK, Hempel-Jørgensen A, Mølhave L, Andersson K, Juto JE, Stridh G. 2004. Eye trigeminal sensitivity, tear film stability and conjunctival epithelium damage in 182 non allergic, non-smoking Danes. Indoor Air. 14:200-207.

From a random sample of 3,581 persons in a Danish county area, 182 aged 18-60 were selected to be interviewed about home and workplace environment irritations. In addition, the study subject also underwent medical examinations for the eyes, allergens, tear film stability (BUT), erosion of the conjunctival epithelium (ED) and CO_2 sensitivity of the eyes (COI).

"The finding that ***exposure to electrostatic fields (EF) is related to decreased BUT*** *[tear film stability or break-up time] is new, while dust association is supported by experimental and epidemiological studies … However, one may speculate that such an association with EF is linked to an increased deposition of particles as shown by Schneider et al. (1994)."* p. 206

Schneider T, Bohgard M, Gudmundsson A. 1994. A semiempirical model for particle deposition onto facial skin and eyes. Role of air currents and electric fields. J Aerosol Sci. 25(3):583-593.

"The model predicts that deposition of particles from typical indoor environments will be enhanced for persons exposed to electric fields, irrespective of the direction of the field." (p. 583)

Jamieson KS, ApSimon HM, Jamieson SS, Bell JNB, Yost MG. 2007. The effects of electric fields on charged molecules and particles in individual microenvironments. Atmos Environ. 41:5224-5235.

In this case study, small air ion (SAI) concentrations, electrostatic potentials and AC electric field levels were measured in office spaces of a steel-reinforced concrete building with natural ventilation and air-conditioning in Bergen, Norway.

"Many individuals may spend large periods of their time in 'Faraday cage'-like conditions exposed to **inappropriate levels and types of electric fields** that can reduce localised concentrations of biologically essential and microbiocidal small air ions. Such conditions **may**

escalate their risk of infection from airborne contaminants, including microbes, whilst **increasing localised surface contamination**." (p. 5224)

"… very low SAI concentrations were found in the microenvironments where the operator was sitting and where high electric fields occurred. In the personal breathing zone of the computer operator concentrations of 10-280 SNAI cm^{-3} [small negative air ions] were detected, whilst the ***influence of inappropriate types and levels of fields on SAI concentrations was also clearly seen*** *for the anglepoise desk-light … where concentrations of 0-40 SNAI cm^{-3} were registered." …*

"The lowest measurements taken clearly indicate that concentrations of negative small air ions measured in the room used for the case study were well below the minimum acceptable level of 600 SNAI cm^{-3} [small negative air ions] given in the Russian SanPIN (2003) guidelines." (p. 5229)

"Though the AC electric fields emitted from the monitors complied with both Russian and Swedish guidelines, the fields emitted by the junction box on the workstation and the anglepoise desk-light exceeded those suggested guidance levels for computers, thereby preventing the creation of low-field conditions in those microenvironments and creating high local concentrations of charged sub-micron particulates." (p. 5230)

"Moreover, the influence of triboelectric charging in creating high electrostatic potentials is clearly demonstrated … with the greatest potential measured in the room being created by frictional charging of the footrest of the computer operator's chair by the user." (p. 5231)

*"****Creating conditions where such particles*** *[singlet ultrafine particles of ca. 20 nm]* ***gain charge may greatly increase risk of infection and respiratory problems.****"* (p. 5233)

A5.1.7 SKIN CONDITIONS ASSOCIATED WITH VDT USE

Sandström M, Mild KH, Stenberg B, Wall S. 1995. Skin symptoms among VDT workers and electromagnetic fields: a case referent study. Indoor Air. 5:29-37.

As part of the Office Illness Project, a questionnaire was sent to 5,986 office workers from three different cities in Northern Sweden. A case was defined as an office worker who suffers from sensory symptoms, including itching, stinging, tight or burning sensation on facial skin, and who works at least one hour per day at the VDT. A referent was defined as an office worker without facial skin symptoms, but who also worked at least one hour per day at the VDT. Out of 2,295 persons, 75 cases and the same number of matched referents were selected. In total, 150 workplaces in 53 offices were investigated. In addition to the questionnaire, the following measurements were taken: electrostatic field, electric field (ELF and VLF), magnetic field (ELF and VLF), body voltage, room temperature, relative humidity.

"An exposure-response relationship between VDT work and skin symptoms was established among men (P=0.003), as well as women (P=0.02), who generally reported more symptoms." (p. 32)

Background Fields

"High values for the 50 Hz magnetic flux density in the rooms were not associated with an increased occurrence of skin symptoms among VDT workers. However for a ***50 Hz electric field in the room, the prevalence for VDT workers with skin symptoms increased with increasing field strength****." [OR 3 with 95% CI (1.2-7.2) for AC-ELF electric field >/= 31 V/m]* (p. 33)

VDT Emissions

"It seems persons working with ***terminals with the highest emitted magnetic field and for the greatest number of hours per day have the highest odds ratio****." [VDT use > 4h/day: OR 7.7 with 95% CI (1.85-32) for AC-ELF magnetic field >/=300 nT]* (p. 35)

Fluorescent Lighting

"The visual inspection … of the rooms showed that rooms where the fluorescent tubes were screened with glass or plastic, compared with those with a metallic screen, had an increased risk for skin symptoms." (p. 36)

Johansson O, Gangi S, Liang Y, Yoshimura K, Jing C, Liu PY. 2001. Cutaneous mast cells are altered in normal healthy volunteers sitting in front of ordinary TVs/PCs: results from open-field provocation experiments. J Cutan Pathol. 28:513-519.

Thirteen non-smoking, healthy volunteers without any history of dermatoses, allergic diseases or other somatic disease participated in this provocation study. The volunteers were seated 40 cm from 5 PCs and 3 TVs, having their backs exposed to electric field levels of 250-500 V/m (on position) as well as magnetic field levels >10,000 µT/s (on position). The provocation lasted 2 to 4 h, after which biopsies were taken from the challenged areas.

"Results: Our present in vivo study indicates that ***normal cutaneous mast cells could be altered by exposure from ordinary TV/PC screens****. To our great surprise, we found the number of mast cells in the papillary and reticular dermis to increase, to varying degrees, in 5 out the 13 subjects after such an exposure. A migration of mast cells towards the uppermost dermis appeared as the most important event. … These findings could only be seen in the exposed skin. Two of the 13 cases instead showed a decrease in mast cell number, but the shift in mast cells towards the upper dermis was still visible. Twenty-four h after the provocation, the*

cellular number and location were normalized in all subjects." (p. 513)

Maes A, Curvers B, Verschaeve L. 2003. Lipoatrophia semicircularis: An electromagnetic Hypothesis. Electromagnetic Biology and Medicine. 22(2):183-193. DOI: 10.1081/JBC-120024627.

In 1995, a major bank and insurance company moved its employees to a new office building in Brussels, Belgium. Within the first six months, 135 mostly female office workers had developed lipoathrophia semicircularis. Hundreds more were diagnosed over the next years, 5% of the company's entire staff. Though the etiology of this disease is unknown, this paper discusses electrostatic discharge from new, synthetic desks as one of the cause.

"According to our observations, L.s. finds its origin in the electromagnetic environment of work places. It apparently occurs as a result of galvanic coupling between charged materials and the body." (p. 184)

"Magnetic fields appeared to be normal (between 0.2 and 2 mG). However, the ***electric fields under the desks, at knee-level, were higher than the normal background. [50-299 V/m]****"* (p. 185)

*"****It appeared that L.s. was diagnosed in people who worked on tables with higher superficial electric resistance*** *(above 10^{11} and up to 10^{13} Ohm in the laboratory). Desks with a high superficial resistance can be electrostatically charged. The resulting hypothesis therefore is that L.s. results from electrostatic charging of the desktop due to electric leakage from computers, the screen, and/or the cables (e.g. UTP cable for data transmission). Coupling (galvanic or capacitive) with a conductor, in this case a human being, results in a discharge of the table on that local region where the human body is coupled with the edge of the table (thighs at 72 cm measured standing up from the floor). The phenomenon … may even be more serious in those 'new' offices where the ambient air is (too) dry due to air conditioning systems."* (p. 186)

*"****When L.s. subjects return to work at the old desk that was used before L.s. was diagnosed, a complete recovery was observed*** *in all persons involved."* (p. 186)

A5.2 Reviews on Biological Effects from Exposure to Electromagnetic Fields and Radiofrequency Radiation

1991 NIOSH Publications on Video Display Terminals

This is a compendium of NIOSH publications and reports on video display terminals. It lists the various occupational health issues relating to VDT use, and contains a comprehensive bibliography of NIOSH-authored as well as NIOSH-funded documents from the beginning of the 1980s through the 1990s. In the majority of publications cited, the authors were unable to confirm an association between suspected health problems and the low-level radiation exposure from VDT use. Several publications, however, did find such an association.

US Department of Health and Human Services: National Institute for Occupational Safety and Health: Public Health Service. 1999 Sep. NIOSH publications on video display terminals [Internet]. DHHS (NIOSH) Publication No. 99-135. 3rd ed. Cincinnati (OH): NIOSH; [1st edition 1991; cited 2008 Oct 3]. Available from: http://www.cdc.gov/niosh/docs/99-135/

1994 UK NRPB Report on Health Effects from VDU Use

The Advisory Group on Non-Ionising Radiation (AGNIR) of the former National Radiation Protection Board (NRPB) in the UK, which today is called the Health Protection Agency (HPA), prepared this report.

"Of the nine epidemiological studies of spontaneous abortion and VDU use reviewed here, six found no increase in risk, even in heavy users of VDUs, and three reported some increase in certain subgroups. … Overall the results indicate that VDU use does not increase the risk of spontaneous abortion." (conclusion #12)

"Skin diseases do not appear to be caused by the electromagnetic fields from VDUs, although there is anecdotal evidence unsupported by epidemiology that in conditions of low humidity the associated electrostatic fields may aggravate existing skin problems and the strain of the actual work may give rise to skin problems among those with a predisposition to them. Where such problems are considered to be aggravated by electrostatic fields, either from VDUs or from the other characteristics of the workplace furnishings, they can possibly be alleviated by grounding the operator and by electrostatic shielding of the screen of the VDU." (conclusion #15)

"It is concluded that the totality of the epidemiological and experimental evidence provides no good reason to suppose that low frequency electromagnetic fields encountered through the use of VDUs cause any harm to the fetus in utero. Skin diseases do not appear to be caused by electromagnetic fields from VDUs, although existing conditions may be aggravated. Work with VDUs does not appear to cause a predisposition to the formation of cataracts." (conclusion #17)

Doll R, chairman. 1994. Health effects related to the use of visual display units: report of an Advisory Group on Non-Ionising Radiation [Internet]. NRPB documents vol. 5, no. 2. [cited 2008 Oct 3]. Conclusions available from: http://www.hpa.org.uk/web/HPAweb&HPAwebStandard/HPAweb_C/1210231706971

1999 NIEHS Report on Health Effects from Power-Line Frequency Electric and Magnetic Fields

The report by the National Institute of Environmental Health Sciences was prepared in response to the 1992 Energy Policy Act. Many scientists contributed their expertise to this report, especially the participants of the four NIEHS Working Group meetings in 1998. The majority of the contributing scientists voted for a "possible 2B" classification with regard to childhood leukemia.

"In summary, the NIEHS believes that there is weak evidence for possible health effects from ELF-EMF exposures, and until stronger evidence changes this opinion, inexpensive and safe reductions in exposure should be encouraged." (p. 38)

NIEHS EMF-RAPID Program Staff. 1999 May. NIEHS report on health effects from exposure to power-line frequency electric and magnetic fields [Internet]. NIH Publication No. 99-4493. Research Triangle Park (NC): NIH, NIEHS; [cited 2008 Oct 3]; 67 p. Available from: http://www.niehs.nih.gov/health/docs/niehs-report.pdf

2001 IARC Monograph on Static and ELF Electric & Magnetic Fields

The IARC monograph on static and ELF electric and magnetic fields represents the views and expert opinions of an IARC Working Group on the Evaluation of Carcinogenic Risks to Humans, which met in Lyon from 19–26 June 2001.

Overall Evaluation

"**Extremely low-frequency magnetic fields are *possibly carcinogenic to humans (Group 2B)***. Static electric and magnetic fields and extremely low-frequency electric fields are *not classifiable as to their carcinogenicity to humans (Group 3)*." (p. 338)

IARC Working Group on the Evaluation of Carcinogenic Risks to Humans. 2002. IARC monographs on the evaluation of carcinogenic risks to humans: non-ionizing radiation, part 1: static and extremely low-frequency (ELF) electric and magnetic fields [Internet]. vol. 80. Lyon, France: IARCPress; [cited 2008 Oct 3]; 429 p. Available from: http://monographs.iarc.fr/ENG/Monographs/vol80/index.php

2002 California EMF Program

On behalf of the California Public Utilities Commission (CPUC), three scientists (V. DelPizzo, PhD, R. R. Neutra, MD, DrPH, G. Lee, PhD) who work for the California Department of Health Services (DHS) were asked to review the studies about possible health problems from electric and magnetic fields (EMFs). This review did not include radiofrequency radiation from cell phones and radio towers.

Executive Summary

*"To one degree or another, all three of the DHS scientists are inclined to believe that EMFs can cause some degree of **increased risk of childhood leukemia, adult brain cancer, Lou Gehrig's Disease, and miscarriage**."* (p. 3)

Neutra RR, DelPizzo V, Lee GM, editors. 2002. An evaluation of the possible risks from electric and magnetic fields (EMFs) from power lines, internal wiring, electrical occupations, and appliances [Internet]. California Health Department, Oakland: California EMF Program; [cited 2008 Oct 3]; 401 p. Available from: http://www.ehib.org/emf/RiskEvaluation/riskeval.html

2007 WHO Environmental Health Criteria on ELF Fields

This review was written by an international group of experts under the joint sponsorship of the International Labour Organization (ILO), the International Commission on Non-Ionizing Radiation Protection (ICNIRP), and the World Health Organization (WHO). Studies on health effects associated with EMF exposures were found to be inadequate as to their carcinogenicity.

"New human, animal and in vitro studies, published since the 2002 IARC monograph, do not change the overall classification of ELF magnetic fields as a possible human carcinogen." (p.11)

Extremely low frequency fields. 2007. Environmental Health Criteria No. 238 [Internet]. Geneva, Switzerland: World Health Organization; [cited 2008 Oct 3]; 519 p. Available from: http://www.who.int/peh-emf/publications/elf_ehc/en/index.html

2007 BioInitiative Report

The BioInitiative Working Group consists of 14 international scientists and public health policy professionals who included many peer-reviewed studies on low-level chronic exposures from ELF electric and magnetic fields as well as RF radiation in their report, which are not considered by many of the other major reviews.

Section 1: Summary for the Public

by Cindy Sage, MA

"For brain tumors, people who have used a cell phone for 10 years or longer have a 20% increase in risk (when the cell phone is used on both sides of the head). For people who have used a cell phone for 10 years or longer predominantly on one side of the head, there is a 200% increased risk of a brain tumor." (p. 9)

"The risk of brain tumor … from cordless phone use is 220% higher (both sides of the head). The risk from use of a cordless phone is 470% higher when used mostly on only one side of the head." (p. 11)

"The evidence from studies on women in the workplace rather strongly suggests that ELF is a risk factor for breast cancer for women with long-term exposures of 10 mG and higher." (p. 11)

"There is strong evidence that long-term exposure to ELF is a risk factor for Alzheimer's disease." (p. 13)

"Both ELF and RF exposures can be considered genotoxic … under certain conditions of exposure, including exposure levels that are lower than existing safety limits." (p. 17)

"ELF exposure levels of only 5 to 10 mG have been shown to activate the stress response genes." (p. 17)

"Chronic provocation by exposure to ELF and RF can lead to immune dysfunction, chronic allergic responses, inflammatory diseases and ill health if they occur on a continuing basis over time." (p. 18)

Section 5: Evidence for Effects on Gene and Protein Expression
by Zhengping Xu, PhD and Guangdi Chen, PhD

"Based on current available literature, it is justified to conclude that EMF exposure can change gene and/or protein expression in certain types of cells, even at intensities lower than ICNIRP recommended values. However, the biological consequences of most of the changed genes/proteins are still unclear, and need to be further explored." (p. 17)

Section 6: Evidence for Genotoxic Effects
by Henry Lai, PhD

"From this literature survey, since only 50% of the studies reported effects, it is apparent that there is no consistent pattern that radiofrequency radiation exposure could induce genetic damages/changes in cells and organisms. However, one can conclude that under certain conditions of exposure, radiofrequency radiation is genotoxic. Data available are mainly applicable only to cell phone radiation exposure." (p. 11)

Section 7: Evidence for Stress Response
by Martin Blank, PhD

"The most important finding to keep in mind is that both ELF and RF fields activate the synthesis of stress proteins. All cells do not respond to EMF,

but activation of the same cellular mechanism by both thermal and non-thermal stimuli in a variety of cells shows that both ELF and RF are biologically active …" (p. 4)

Section 8: Evidence for the Effects on the Immune System
by Olle Johannson, PhD

"• Measurable physiological changes (mast cells increases, for example) that are bedrock indicators of allergic response and inflammatory conditions are stimulated by EMF exposures. …

• It is possible that chronic provocation by exposure to EMF can lead to immune dysfunction, chronic allergic responses, inflammatory responses and ill health if they occur on a continuing basis over time." (p. 30)

Section 10: Evidence for Brain Tumors and Acoustic Neuromas
by Lennart Hardell, PhD; Kjell Hansson Mild, PhD; Michael Kundi, PhD

"In summary we conclude that our review yielded a consistent pattern of an increased risk for acoustic neuroma and glioma after >10 years mobile phone use." (p. 18)

Carpenter D, Sage C, editors. 2007 Aug 31. BioInitiative report: a rationale for a biologically-based public exposure standard for electromagnetic fields (ELF and RF) [Internet]. [cited 2008 May 21]; 610 p. Available from: http://www.bioinitiative.org

Appendix 6: Occupational Health and Safety Recommendations on EMF/RF Radiation

A6.1 CANADA

BC Centre for Disease Control. 2002. Radiation risk ergonomics & video display terminals (VDTs) [Internet]. Vancouver (BC): BC Centre for Disease Control; [cited 2008 May 22]; 12 p. Available from: http://www.bccdc.org/downloads/pdf/rps/reports/vdtbooklet.pdf

> *"As can be seen from Table A, there are no harmful radiation emissions coming from VDTs. Therefore, a VDT does not present a radiation health hazard."* (p. 2)
>
> *"**DON'T Purchase electromagnetic shields** or any other radiation protective devices **for your VDT**."*
>
> *"DO Investigate indoor humidity and static electricity, and **implement antistatic control measures** where VDT operators experience skin rashes."* (p. 12)

Health Canada. 2002. Safety of exposure to electric and magnetic fields from computer monitors and other video display terminals [Internet]. Ottawa (ON): Ministry of Health; [updated 2004; cited 2008 May 22]; 2 p. Available from: http://www.hc-sc.gc.ca/iyh-vsv/prod/monit_e.html

> *"**There is also no convincing evidence that problems such as skin disorders, headaches, dizziness, tiredness, eye fatigue and pain are caused by EMFs from VDTs.** However, it is possible that these symptoms could be caused by other factors in an office, such as lighting, poor air quality, room temperature or improper posture while working in front of VDTs."*
>
> *"Do not be alarmed if the image on your computer monitor jitters. Magnetic fields that cause jitter on VDTs are well below the levels that would cause human health effects."* (p. 1)

Occupational Health Clinics for Ontario Workers Inc. [date unknown]. Office ergonomics handbook [Internet]. 4th ed. Don Mills (ON): Occupational Health Clinics for Ontario Workers Inc.; [cited 2008 May 22]; 51 p. Available from: http://www.opseu.org/hands/Ergonomichandbook.pdf

> *"Another problem associated with computer workstations is electrostatic emissions, or static fields. Static fields attract dust to the computer screen. **Some skin problems that have occurred in computer users may be due to the attraction of electrically charged dust particles to the skin**.*
>
> *To help control static, use a grounded glare screen or keyboard pad. Anti-static acrylic or plastic chair mats are also available.*
>
> *What Precautions Should I Take to Reduce EMF Exposure?*
>
> - *Sit at least arm's length 71cm (28 inches) away from the computer monitor, and approximately 4 feet from the backs and sides of co-workers' monitors.*
> - *Electromagnetic emissions are reduced with distance; magnetic fields are not blocked by baffles or walls.*

- *Avoid sitting next to electrical equipment (fax machines, laser printers, photocopiers).*
- *Take regular breaks away from computer work. This will reduce the exposure time to the electromagnetic fields.*
- *Radiation-reducing glare screens (or shields) may reduce the electric component of the electromagnetic fields. Do not use a shield that distorts the clarity of print on the monitor.*
- *Turn off the computer when not in use.*
- *Use equipment manufactured after 1983. Regulations were issued requiring that the radio frequency radiation from all computers be shielded to minimize interference with radio transmissions. Equipment manufactured prior to 1970 should never be used because it may emit X-ray radiation."* (p. 39)

Saskatchewan Public Service Commission. 1986. Human resource manual: video display terminals [Internet]. Section: PS 708. [rev. 2001; cited 2008 May 22]. 3 p. Available from: http://www.psc.gov.sk.ca/Default.aspx?DN=57291cc2-f72b-44da-9e22-6b4e59a3d464

> *"**Reassignment Due to Pregnancy***
> *(permanent and probationary employees only)*
> *An employee who regularly operates a VDT can request either protective equipment or a temporary assignment to other duties upon the provision of a medical certificate to the permanent head of her department indicating that she is pregnant."* (p. 2)

A6.2 EUROPEAN UNION

Council of the European Union. 1990 May 29. Council directive 90/270/EEC on the minimum safety and health requirements for work with display screen equipment: fifth individual directive within the meaning of Article 16(1) of directive 89/391/EEC [Internet]. [cited 2008 May 22]; [10 p.] Available from: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31990L0270:EN:HTML

> *"Annex MINIMUM REQUIREMENTS (Articles 4 and 5) Preliminary remark*
> *The obligations laid down in this Annex shall apply in order to achieve the objectives of this Directive and to the extent that, firstly, the components concerned are present at the workstation, and secondly, the inherent requirements or characteristics of the task do not preclude it.*
>
> *1. EQUIPMENT*
>
> *(a) General comment*
>
> *The use as such of the equipment must not be a source of risk for workers.*
>
> *…*
>
> *(f) Radiation*
>
> ***All radiation** with the exception of the visible part of the electromagnetic spectrum **shall be reduced to negligible levels** from the point of view of the protection of workers' safety and health."*

A6.3 GERMANY

Bundesministerium der Justiz. 1996. Verordnung über Sicherheit und Gesundheitsschutz bei der Arbeit an Bildschirmgeräten (Bildschirmarbeitsverordnung - BildscharbV) [Health and Safety Regulation for VDT Workstations in Offices] [Internet]. Berlin: Bundesministerium der Justiz; [updated 2006; cited 2008 May 22]; [7 p.] German. Available from: www.gesetze-im•internet.de/bildscharbv/BJNR184300996.html

> *"19. Die Strahlung muß - mit Ausnahme des sichtbaren Teils des elektromagnetischen Spektrums - so niedrig gehalten werden, daß sie für Sicherheit und Gesundheit der Benutzer des Bildschirmgerätes unerheblich ist. [**All radiation** with the exception of the visible part of the electromagnetic spectrum **shall be reduced to negligible levels** from the point of view of the protection of workers' safety and health]."*

A6.4 RUSSIA

Ministry of Health of the Russian Federation. 2003 Jun 30. [Sanitary and epidemiological norms on hygienic requirements for personal computers and work organization]. Norm No.: SanPiN 2.2.2./2.4.1340-03. [cited 2008 Oct 30]. Russian.

This mandatory regulation on working with computers is health-based and was issued by the Chief Medical Sanitary Officer of the Russian Federation to avoid factors that may impair the health of computer users. It not only applies to computer workplaces in an occupational setting, but also to children, youth, and adults using computers at educational institutions (incl. preschool), public places, and video game machines. In addition to the commonly addressed ergonomic factors (e.g. VDT, office chair, indoor air quality, noise level, lighting), the electromagnetic emissions from VDTs (AC electric fields, AC magnetic fields, static electric fields) are also considered.

If an employee uses a personal computer more frequently than 50% of his or her working hours, a medical examination is required at the start of the position and thereafter at regular intervals. (SanPiN 2.2.2./2.4.1340-03: XIII. 13.1)

During pregnancy, a female employee is eligible to switch to a workplace without a personal computer or have the hours working with a personal computer limited to three hours per day. (SanPiN 2.2.2./2.4.1340-03: XIII. 13.2)

SanPiN 2.2.2./2.4.1340-03 Appendix 1
Table 3: Temporary Permissible Level of EMFs Emitted by VDTs

	Frequency Range	Temporary Permissible EMF Level
AC electric field strength	5-2,000 Hz	25 V/m
	2,000-400,000 Hz	2,5 V/m
AC magnetic flux density	5-2,000 Hz	250 nT
	2,000-400,000 Hz	25 nT
Electrostatic potential of VDT screen		500 V

SanPiN 2.2.2./2.4.1340-03 Appendix 2
Table 1: Temporary Permissible Level of EMFs Emitted by VDTs at the Workplace

	Frequency Range	Temporary Permissible EMF Level
AC electric field strength	5-2,000 Hz	25 V/m
	2,000-400,000 Hz	2,5 V/m
AC magnetic flux density	5-2,000 Hz	250 nT
	2,000-400,000 Hz	25 nT
Electrostatic field strength		15 kV/m

Whenever a new computer workplace is installed or an old one renovated, it is a requirement to measure the electromagnetic field levels. (Appendix 3: 1.1)

EMF measurements are to be taken at a distance of 50 cm from the VDT screen at three different heights: 0.5 m, 1.0 m, and 1,5 m. (Appendix 3: 4.1)

If EMF measurement results exceed the permissible level, the VDT should be turned off to determine the ambient level of electromagnetic fields. The ambient AC electric field strength at 50 Hz must not exceed 500 V/m. The ambient AC magnetic flux density must stay below which it may give rise to interference problems on the monitor. (Appendix 3: 5.2)
[The regulation does not specify an actual field strength, but magnetic fields are known to cause interference problems in CRT monitors from ca. 500 nT upward.]

(Please note that none of the excerpts from the Russian SanPiN 2.2.2./2.4.1340-03 provided above are literal translations but summarizing statements only.)

A6.5 SWEDEN

Swedish National Board of Occupational Safety and Health [NBOSH]. 1998. Work with display screen equipment: provisions of the Swedish National Board of Occupational Safety and Health on work with display screen equipment together with general recommendations on the implementation of the provisions [Internet]. AFS 1998:5. Solna, Sweden: Swedish Work Environment Authority; [cited 2008 May 22]; 28 p. Available from: www.av.se/dokument/inenglish/legislations/eng9805.pdf

> *"Emissions: Section 9:*
> ***Emissions from the display screen** and appurtenant equipment, **such as** noise, heat, chemical substances and **electrical and magnetic fields, may not be disturbing or cause the operator discomfort or unpleasantness constituting a risk to his/her safety and health**."* (p. 8)
>
> The following general recommendations are not mandatory, but help elucidate the meaning of the Provisions (p. 19).
>
> *"Guidance on Section 9 Emissions: …*
>
> *Research, however, has failed to establish any connections between display screen work and pregnancy disturbances. Where skin disorders are concerned, certain studies*

do suggest a connection with display screen work, but no connection has been detectable with the electric or magnetic fields emitted from display screens. If anything, the focus of attention is more on dry and/or warm air and stress in connection with display screen work as possible causes. It is believed likely that the problem of electrical hypersensitivity is due to a combination of several factors, both occupationally and individually related. It is unclear whether electric or magnetic fields are among these factors; repeated experiments have failed to establish any such influence. Other factors suggested as possible contributory factors where "electrical hypersensitivity" is concerned include, for example, allergies, light sensitivity, modulated (varied) light, chemical substances, factors relating to the individual, and the way in which work is organised. Research continues, ***but pending research findings, greater preparedness is needed for helping and supporting those who experience discomfort. If problems of this kind occur at the workplace, it is important that the employer, assisted for example by the occupational health service, should carry out an investigation and take steps to help the person affected.*** *It is essential for these measures to be taken as early as possible, and for the investigation to employ a broad perspective, without narrowing down the inquiry at an early stage to individual factors."* (p. 22)

TCO Certification of Office Equipment

The TCO certification was developed as a joint effort by the TCO Development (Tjänstemännens Centralorganisation or The Swedish Confederation of Professional Employees), Naturskyddsföreningen (The Swedish Society for Nature Conservation), NUTEK (The National Board for Industrial and Technical Development in Sweden) and Semko AB (a Swedish Testing Institute).

"TCO is a quality and environmental labeling system, the purpose of which is to influence the development of products to ensure optimum user-friendliness and minimum impact on the environment."

Its first **labeling program for low-emission computer monitors** was launched in 1992, including considerations for

ergonomics, preventing harmful effects on human health;

emissions, reducing noise emissions and **electromagnetic radiation emissions**;

ecology, protecting the natural environment from human interventions/harmful substances and promoting sustainable manufacturing practices

energy efficiency, minimizing energy consumption.

"The mandatory requirements are based on the ***ambition to reduce the electrical or magnetic alternating fields to such a low level as not to burden the work environment with unnecessary factors****. The mandatory requirements shall not be regarded as hygienic limit values."*

Currently the following standards are available: TCO'99 Displays, TCO'99 Desktops, TCO'99 Keyboards, TCO'99 Printers, TCO'01 Mobile Phones, TCO'03 Displays, TCO'04 Office Furniture, TCO'05 Notebooks, TCO'05 Desktops, TCO'06 Media Displays, TCO'07 Headsets.

Available in English from: http://www.tcodevelopment.com

For a more detailed listing of these standards see the last page of Appendix 2.

	Displays TCO'99/TCO'03	Notebooks TCO'99/TCO'05	Printers TCO'99	Desktops TCO'99/TCO'05
Static Electric Field	+/- 500 V	n/a	n/a	n/a
ELF Electric Field 5 – 2,000 Hz	≤ 10 V/m (30 cm in front)	≤ 10 V/m (30 cm in front)	≤ 10 V/m (50 cm in front)	≤ 10 V/m (30 cm in front)
ELF Magnetic Field 5 – 2,000 Hz	≤ 200 nT ≤ 2 mG (30 cm in front)	≤ 200 nT ≤ 2 mG (30 cm in front)	≤ 200 nT ≤ 2 mG (50 cm all around)	≤ 200 nT ≤ 2 mG (30 cm in front)
VLF Electric Field 2 – 400 kHz	≤ 1 V/m (30 cm in front)	≤ 1 V/m (50 cm all around)	≤ 1 V/m (50 cm all around)	≤ 1 V/m (30 cm in front)
VLF Magnetic Field 2 – 400 kHz	≤ 25 nT ≤ 0.25 mG (50 cm all around)	≤ 25 nT ≤ 0.25 mG (50 cm all around)	≤ 25 nT ≤ 0.25 mG (50 cm all around)	≤ 25 nT ≤ 0.25 mG (50 cm all around)

(Distances in brackets denote measurement distance from given office equipment.)

A6.6 USA

National Institute for Occupational Safety and Health. 1999. NIOSH publications on video display terminals [Internet]. 3rd ed. Cincinnati (OH): US Department of Health and Human Services; [cited 2008 May 22]; 141 p. Available from: http://www.cdc.gov/niosh/docs/99-135/

> *"Based on the survey data,* ***NIOSH concludes that VDTs do not emit radiation levels that present a hazard*** *to employees working at or near the terminals."*

Occupational Safety and Health Administration. rev. 1997. Working safely with video display terminals [Internet]. Washington (DC): US Department of Labor; [cited 2008 May 22]; 28 p. Available from: www.osha.gov/Publications/osha3092.pdf

> *"The radio frequency and extreme low-frequency electromagnetic fields are still at issue despite the low emission levels. To date, however,* ***there is no conclusive evidence*** *that the low levels of radiation emitted from VDTs pose a health risk to VDT operators.* ***Some workplace designs****, however, have incorporated changes—such as increasing the distance between the operator and the terminal and between work stations—****to reduce potential exposures to electromagnetic fields.****"* (p. 5)

Appendix 7: General Resources on the Precautionary Principle

There is no one definition of the precautionary principle, but they all share in the same vision to promote health and safety in the face of uncertainty. According to Rogers and Wieners (2002), there are three main definitions of the precautionary principle (PP):

Version 1: *Uncertainty does not justify inaction*. In its most basic form, the PP is a principle that permits regulation in the absence of complete evidence about the particular risk scenario.

Version 2: *Uncertainty justifies action.* This version of the PP is more aggressive.

Version 3: *Uncertainty requires shifting the burden and standard of proof.* This version of the precautionary principle is the most aggressive. It holds that uncertain risk requires forbidding the potentially risky activity until the proponent of the activity demonstrates that it poses no (or acceptable) risk.

Wiener J, Rogers M. 2002. Comparing precaution in the United States and Europe. J Risk Research [Internet]. [cited 2008 July 25]; 5(4):317-349. Available from: http://eprints.law.duke.edu/1191/1/5_J._Risk_Research_317_(2002).pdf

1970 Germany: Crash Program for Environmental Protection

On 28 October 1969, the new chancellor of Germany, Willy Brandt, makes his first policy statement to the Bundestag, giving air, water, and noise protection a high priority. In 1970, the federal government of Germany launches the “Sofortprogramm zum Umweltschutz,” a crash program for environmental protection, thereby for the first time introducing the “Vorsorgeprinzip” or precautionary principle, which demands that uncertainty does not justify inaction. This crash program also introduces the polluter pays principle as well as the cooperation principle into legislative measures. The resulting Environment Program from 1971 (BT-Drs. VI/2710) initiated over 100 environmental laws with varying degrees of successful changes.

Vorsorgeprinzip [Precautionary Principle

According to the precautionary principle, measures to prevent risks are to be taken before definite hazards manifest themselves. Precautionary policies are designed to reduce hazardous emissions (substances, radiation, noise) based on the current state of technology. And environmental precaution grows in significance when environmental protection is integrated into all levels of how we live and do business.]

Verursacherprinzip [Polluter Pays Principle

According to the polluter pays principle, those who cause damage to the environment must also bear the costs of its remediation or removal. The public is only called on in those cases where the polluting party cannot be found.]

Kooperationsprinzip [Cooperation Principle

The cooperation principle is directed at making environmental protection the collective responsibility of government, citizens and corporations. Environmental education and environmental information, voluntary environmental initiatives by corporations and other players as well as the inclusion of a broad spectrum of groups in the process of developing environmental policies are all part of the cooperation principle.]

Federal Ministry for the Environment, Nature Conservation and Nuclear Safety. 2007 March. Nachhaltigkeit als Integrationsaufgabe [Sustainability as a call for integration] [Internet]. [cited 2008 July 25]. German. Available from: http://www.bmu.de/nachhaltige_entwicklung/stategie_und_umsetzung/praktizierte_nachhaltigkeit/doc/2397.php

1972 UN: Stockholm Declaration

This was the first UN conference on the environment, laying the foundation for environmental action at an international level and launching the UN Environmental Program.

"Man has the fundamental right to freedom, equality and adequate conditions of life, in an environment of a quality that permits a life of dignity and well-being, and he bears a solemn responsibility to protect and improve the environment for present and future generations." (Principle 1)

United Nations. 1972. Declaration of the United Nations Conference on the Human Environment [Internet]. Stockholm (Sweden): United Nations Conference on the Human Environment; 1972 Jun 5 to 16; [cited 2008 Jul 25]. Available from: http://www.unep.org/Documents.Multilingual/Default.asp?DocumentID=97&ArticleID=1503

1987 UN: Brundtland Report

After three years of public hearings and over five hundred written submissions, the World Commission on Environment and Development submitted a report to the UN General Assembly about "Our Common Future," also known as the Brundtland Report. It called for a sustainable development, which was defined as follows:

"Sustainable development meets the needs of the present without compromising the ability of future generations to meet their own needs." (p. 43)

United Nations. 1987. A report by the World Commission on Environment and Development: our common future [Internet]. [cited 2008 Jul 25]. Available from: http://www.un-documents.net/wced-ocf.htm

1992 UN: Rio Declaration on Environment and Development

Known as the Earth Summit, the United Nations Conference on Environment and Development launched a global action plan for sustainable development, called Agenda 21, and the signees of its declaration acknowledged that scientific uncertainty should not prevent countries from taking precautionary action. It is the most commonly used definition of the precautionary principle.

"In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation." (Principle 15)

United Nations. 1992. Rio Declaration on Environment and Development [Internet]. Rio de Janeiro (Brazil): United Nations Conference on Environment and Development; 1992

Jun 3 to 14; [cited 2008 Jul 25]. Available from: http://www.unep.org/Documents.Multilingual/Default.asp?DocumentID=78&ArticleID=1163

1998 SEHN: Wingspread Consensus Statement

Under the leadership of the Science and Environmental Health Network (SEHN), 32 eminent scientists, philosophers, lawyers and environmental activists from the United States, Canada, and Europe came together in Wingspread, Wisconsin, to discuss how far existing environmental policies actually protect public health, identifying four components of the precautionary principle and demanding more anticipatory action in the face of scientific uncertainty.

"Precautionary measures are to be taken even if some cause and effect relationships are not fully understood or scientifically established."

"The proponent of a potentially harmful activity, rather than the public, should bear the burden of proof."

"The process of applying the Precautionary Principle must be open, informed and democratic and must include potentially affected parties."

"[The precautionary principle] must also involve an examination of the full range of alternatives, including no action."

The Wingspread Consensus Statement on the Precautionary Principle [Internet]. 1998. Wingspread (WI): Wingspread Conference on the Precautionary Principle; 1998 Jan 26; [cited 2008 Jul 25]. Available from: http://www.sehn.org/wing.html

1999 EU/WHO: London Declaration

Building on the previous Environment and Health conferences (Frankfurt 1989, Helsinki 1994), the ministers and representatives of the European Member States of the WHO came together in London to renew their commitment "to action in partnership for improving the environment and health in the twenty-first century."

*"33. **We invite WHO** to establish a working group, involving representatives of the media, environmental health professionals, NGOs and other key partners in assessment or communication of risks, to elaborate guidelines on risk communication, having regard to relevant international work in this field and taking into account **the need to rigorously apply the precautionary principle in assessing risks and to adopt a more preventive, pro-active approach to hazards**, and to report to the next Environment and Health conference."* (p. 10)

Commission of the European Communities, Action in Partnership, WHO Regional Office Europe. 1999. London Declaration on Action in Partnership [Internet]. London (GB); Third Ministerial Conference on Environment and Health; 1999 Jun 16-18; [cited 2008 Jul 25]; 17 p. Available from: http://www.euro.who.int/Document/E69046.pdf

As a result, the WHO presented a draft on the "Precautionary Framework for Public Health Protection" in May 2003, which continues to be in draft form.

"Ideally, thinking within a precautionary framework involves shifting attention to

addressing questions about risks as a priority before introducing an agent. For example, before asking, "What level of risk is acceptable?" or "How much contamination can a human or an ecosystem assimilate?" ***a proactive, precautionary strategy would first ask, "How much contamination can we avoid while still achieving our goals?",*** *"What are the alternatives or opportunities for prevention?". These questions should be routinely asked before any evidence of harm is apparent."* (p. 3)

[WHO] World Health Organization. 2003. Draft for review (2 May 2003): precautionary framework for public health protection [Internet]. [cited 2008 Jul 25]; 17 p. Available from: http://www.who.int/peh-emf/meetings/archive/en/Precaution_Draft_2May.pdf

1999 Sweden: Environmental Quality Objectives

It is the intention of the Swedish Government "to hand on to the next generation a society in which the major environmental problems facing Sweden have been solved." (p. 8) In order to meet this "generation goal" by 2020, 16 environmental quality objectives (the 16th on biodiversity was added in 2004) were adopted, including a safe radiation environment.

A Safe Radiation Environment

"Risks associated with electromagnetic fields will be studied on an ongoing basis and necessary action will be taken as any such risks are identified." (p. 27)

Ministry of Sustainable Development Sweden. 2004. Environmental quality objectives: a shared responsibility [Internet]. Summary of Government Bill 2004. Stockholm (Sweden): Ministry of Sustainable Development; [cited 2008 Jul 25]; 97 p. Available from: http://www.sweden.gov.se/content/1/c6/06/69/79/80a58d03.pdf

1999 Canada: Environmental Protection Act (CEPA)

Though the *Canadian Environmental Protection Act* has adopted the precautionary principle in its preamble, this principle is not yet written into the operative articles, but the ministerial discretion still holds the greater power.

"Whereas the Government of Canada is committed to implementing the precautionary principle that, where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation;"

Canadian Environmental Protection Act [Internet]. 1999, S.C. 1999, c. 33. [cited 2008 Jul 25]. Available from: http://www.canlii.org/ca/sta/c-15.31/.

2000 EU: European Commission

In 1999 the Council of the European Union asked the Commission to develop clear and effective guidelines for the application of the precautionary principle because it is not defined in the Treaty or other Community instruments. The proposed guidelines are not meant to justify arbitrary decisions, but provide decision-makers with recommendations on how to apply the precautionary principle and introduce more transparency in the risk assessment process.

Introduction

"The dimension of the precautionary principle goes beyond the problems associated with a short or medium-term approach to risks. It also concerns the longer run and the well-being of future generations." …

"Whether or not to invoke the Precautionary Principle is a decision exercised where scientific information is insufficient, inconclusive, or uncertain and where there are indications that the possible effects on the environment, or human, animal or plant health may be potentially dangerous and inconsistent with the chosen level of protection."

European Commission. 2000. Communication from the Commission on the precautionary principle [Internet]. Luxembourg: Office for Official Publications of the European Communities; [cited 2008 Jul 25]. Available from: http://eur-lex.europa.eu/smartapi/cgi/sga_doc?smartapi!celexplus!prod!DocNumber&lg=en&type_doc=COMfinal&an_doc=2000&nu_doc=1 or http://europa.eu.int/scadplus/leg/en/lvb/l32042.htm

2001 EEA: Late Lessons from Early Warnings

A team from the European Environment Agency interviewed scientists about their area of expertise to find out what the first credible scientific early warning was, when and what regulatory action or inaction was taken to reduce risks, what the resulting costs and benefits were and what lessons can be learnt from those experiences. The 14 environmental issues discussed range from radiation, benzene and asbestos to antimicrobials, hormones, and mad cow disease. The twelve late lessons intend to provide a basis for the practical implementation of the precautionary principle:

1. *"Acknowledge and respond to ignorance, as well as uncertainty and risk, in technology appraisal and public policy-making."*
2. *"Provide adequate long-term environmental and health research into early warnings."*
3. *"Identify and work to reduce 'blind spots' and gaps in scientific knowledge."*
4. *"Identify and reduce interdisciplinary obstacles to learning."*
5. *"Ensure that real world conditions are adequately accounted for in regulatory appraisals."*
6. *"Systematically scrutinise the claimed justifications and benefits alongside the potential risks."*
7. *"Evaluate a range of alternative options for meeting needs alongside the option under appraisal, and promote more robust, diverse and adaptable technologies so as to minimise the costs of surprises and maximise the benefits of innovation."*
8. *"Ensure use of 'lay' and local knowledge, as well as relevant specialist expertise in the appraisal."*
9. *"Take full account of the assumptions and values of different social groups."*
10. *"Maintain the regulatory independence of interested parties while*

retaining an inclusive approach to information and opinion gathering."

11. *"Identify and reduce institutional obstacles to learning and action.2*
12. *"Avoid 'paralysis by analysis' by acting to reduce potential harm when there are reasonable ground for concern."* (p. 168-169)

European Environment Agency. 2001. Late lessons from early warnings: the precautionary principle 1896–2000 [Internet]. Environmental issue report No. 22. Luxembourg: Office for Official Publications of the European Communities; [cited 2008 Jul 29]; 210 p. Available from: http://reports.eea.europa.eu/environmental_issue_report_2001_22/en/Issue_Report_No_22.pdf

Appendix 8: The Precautionary Principle Applied to EMF/RF Radiation

1998 Oct **Vienna EMF Resolution**

By participants of the Symposium on Possible Biological and Health Effects of RF Electromagnetic Fields

*"**The participants agreed that biological effects from low-intensity exposures are scientifically established.** However, the current state of scientific consensus is inadequate to derive reliable exposure standards. The existing evidence demands an increase in the research efforts on the possible health impact and on an adequate exposure and dose assessment."*

Vienna EMF-Resolution 1998. Workshop on possible biological and health effects of RF electromagnetic fields [Internet]; 1998 Oct 25-28; Vienna, Austria: University of Vienna; [cited 2008 May 20]. Available from: http://www.irf.univie.ac.at/emf/index.htm

1999 Oct **Germany: Bürgerforum Resolution**

By scientists, medical professional associations, organizations of building biology professionals, citizen groups against electromagnetic pollution as well as associations of electrosensitive people in preparation of the Bürgerforum Elektrosmog [Citizen's Forum on Electromagnetic Pollution] convened by the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety in Bonn on 1999 Oct 19-20

"Die Bildung von Grenzwerten muss neben Wärmewirkungen auch die gesundheitlich wichtigeren nichtthermischen Wirkungen berücksichtigen, außerdem das bereits heute existierende "Multifrequenzspektrum" und die Umweltgesamtbelastung, der die Bevölkerung ausgesetzt ist (das sind in diesem Zusammenhang vor allem die Schwermetall- und chemischen Belastungen). Der Gedanke, sich an der Natur zu orientieren, darf wieder Eingang finden. [Beside thermal effects, the setting of exposure limits also needs to consider non-thermal effects that are more relevant to health as well as the "multiple frequency spectrum" and the environmental exposures the population is already exposed to (in this context especially heavy-metal and chemical exposures). The idea of using nature as a guide is again justified.] "

"Die Erfahrung mit den neuen schnurlosen Haustelefonen nach dem DECT-Standard ist derart negativ und die Zahl der gesundheitsbedingten Reklamationen so groß, dass ein Verbot gefordert werden muss. [The experience with the new cordless phones based on the DECT standard is so negative and the number of health complaints so huge that a ban must be called for.]"

Precautionary Recommendations for Chronic Exposures of the General Population

	Daytime Exposure Reference Values	Nighttime Exposure Reference Values
AC electric field (ELF)	10 V/m	1 V/m
AC magnetic field (ELF)	100 nT (1 mG)	20 nT (0.2 mG)
RF Radiation, non-pulsed	100 μW/m^2	1 μW/m^2
RF Radiation, pulsed	1 μW/m^2	0.01 μW/m^2

Resolution: Minimierung der allgemeinen Elektrobelastung [Minimization of ambient electromagnetic exposures] [Internet]. 1999. [cited 2008 Aug 18]; 3 p. German. Available from: http://www.buergerwelle.de/d/doc/aktuell/Resolution.htm

2000 May **The Stewart Report**

By the Independent Expert Group on Mobile Phones in the UK

Summary and Recommendations

"In the light of the above considerations ***we recommend that a precautionary approach to the use of mobile phone technologies be adopted until much more detailed and scientifically robust information on any health effects becomes available."*** (p.3)

"We note that a precautionary approach, in itself, is not without cost … but we consider it to be an essential approach at this early stage in our understanding of mobile phone technology and its potential to impact on biological systems and on human health." (p.3)

Stewart W, chairman. 2000. Mobile phones and health [Internet]. Report of the Independent Expert Group on Mobile Phones. [cited 2008 May 20]. Available from: http://www.iegmp.org.uk/report/text.htm

2000 Jun **Salzburg Resolution**

By participants of the International Conference on Cell Tower Siting

"It is recommended for existing and new base stations to exploit all technical possibilities to ***ensure exposure is as low as achievable*** *(ALATA-principle) and that new base stations are planned to guarantee that the exposure at places where people spend longer periods of time is as low as possible, but within the strict public health guidelines."*

"Recommendations of specific exposure limits are prone to considerable uncertainties and should be considered preliminary. For the ***total of all highfrequency irradiation*** *a limit value of* ***100 mW/m²*** *(10 μW/cm²) is recommended.*

*"For preventive public health protection a preliminary guideline level for the **sum total of exposures from all ELF pulse modulated high-frequency** facilities such as GSM base stations of **1 mW/m²** (0.1 µW/cm²) is recommended."*

Salzburg Resolution on mobile telecommunication base stations. 2000. Resolution of the International Conference on Cell Tower Siting: linking science & public health [Internet]; 2000 Jun 7-8; Salzburg, Austria: University of Vienna; [cited 2008 May 20]. Available from: www.salzburg.gv.at/salzburg_resolution_e.htm

2002 Sep **Catania Resolution**

By the participants of the International Conference on

The State of the Research on Electromagnetic Fields

- *"Epidemiological and in vivo and in vitro experimental evidence demonstrates the existence of electromagnetic field (EMF) induced effects, some of which can be adverse to health.*
- *We take exception to arguments suggesting that weak (low intensity) EMF cannot interact with tissue.*
- *There are **plausible mechanistic explanations for EMF-induced effects which occur below present ICNIRP and IEEE guidelines** and exposure recommendations by the EU.*
- *The **weight of evidence calls for preventive strategies** based on the precautionary principle. At times the precautionary principle may involve prudent avoidance and prudent use."*

Catania Resolution. 2002. International Conference on the State of the Research on Electromagnetic Fields, Scientific and Legal Issues [Internet]; 2002 Sep 13-14; Catania, Italy: National Institute for Prevention and Work Safety of Italy (ISPESL), University of Vienna, City of Catania; [cited 2008 May 20]. Available from: http://www.icems.eu/benevento_resolution.htm

2002 Oct **Freiburg Appeal**

By the Interdisciplinary Society of Environmental Medicine (IGUMED)

"Out of great concern for the health of our fellow human beings do we - as established physicians of all fields, especially that of environmental medicine - turn to the medical establishment and those in public health and political domains, as well as to the public. We have observed, in recent years, a dramatic rise in severe and chronic diseases among our patients, especially:

- Learning, concentration, and behavioural disorders (e.g. attention deficit disorder, ADD)

- Extreme fluctuations in blood pressure, ever harder to influence with medications

- Heart rhythm disorders

- Heart attacks and strokes among an increasingly younger population

- Brain-degenerative diseases (e.g. Alzheimer's) and epilepsy

- Cancerous afflictions: leukemia, brain tumors"

*"On the basis of our daily experiences**, we hold the current mobile communications technology** … **and cordless digital telephones (DECT standard) to be among the fundamental triggers for this fatal development**."*

[IGUMED] Interdisziplinäre Gesellschaft für Umweltmedizin e.V. 2002. Freiburger Appell [Internet]. Bad Säckingen, Germany: Interdisziplinäre Gesellschaft für Umweltmedizin e.V.; [cited 2008 May 20]. English translation available from: http://www.feb.se/NEWS/Appell-021019-englisch.pdf

German original available from: http://www.igumed.de/ after clicking on "Betr. Mobilfunk Freiburger Appell" at the lower end of the left-hand menu.

2003 Feb **WHO: Application of the Precautionary Principle to Electromagnetic Fields**

A conference held by the WHO, EC and US NIEHS in Luxembourg

From the Rapporteur Report on statements by Dr. Repacholi, head of the WHO EMF project at that time (p. 3):

"WHO would now like to develop a frame work and guidelines that would allow the application of the PP not only for EMF but also for WHO policy generally. It is not a question of whether we apply it. It is a question of how we apply it." (p. 3)

Rapporteur Report. 2003. Conference on the Application of the Precautionary Principle to Electromagnetic Fields (EMF) [Internet]; 2003 Feb 24-26; Luxembourg, Luxembourg: World Health Organization, European Commission, US National Institutes of Environmental Health Sciences; [cited 2008 May 20]; 8 p. Available from: http://www.who.int/peh-emf/meetings/en/Lux_final_rapp_report.pdf or http://www.who.int/peh-emf/meetings/Lux_PP_Feb2003/en/

As a result, the WHO presented a draft on the "Precautionary Framework for Public Health Protection" in May 2003, which continues to be in draft form.

2004 Jan **General: Wi-Fi Policy**

Issued by Lakehead University (Ontario)

*"The purpose of this policy is to **limit wireless connectivity based on the 'precautionary principle'** as there are numerous scientific studies that suggest there is a basis for concern that continuous or frequent long-term exposure to WiFi electromagnetic fields (EMFs) could have adverse health effects."*

"There will be no use of WiFi in those areas of the University already served by hard wire connectivity until such time as the potential health effects have been scientifically rebutted or there are adequate protective measures that can be taken."

General: WiFi policy [Internet]. 2004. Lakehead (ON): Lakehead University. [cited 2008 May 20]. Available from: http://policies.lakeheadu.ca/policy.php?pid=178

2005 Feb **IDEA Position on Electro-Magnetic Radiation**

By the Irish Doctors Environmental Association (IDEA)

*"The Irish Doctors' Environmental Association believes that a **sub-group of the population are particularly sensitive to exposure to different types of electro-magnetic radiation.** The safe levels currently advised for exposure to this non-ionising radiation are based solely on its thermal effects. However, **it is clear that this radiation also has non-thermal effects**, which need to be taken into consideration when setting these safe levels."*

"The strictest possible safety regulations should be established for the installation of masts and transmitters, and for the acceptable levels of potential exposure of individuals to electro-magnetic radiation."

[IDEA] Irish Doctors Environmental Association. 2005. Position on electro-magnetic radiation [Internet]. [cited 2008 May 20]. Available from: http://www.ideaireland.org/emr.htm

2005 Mar **IAFF Position on the Health Effects from RF/MW Radiation**

by International Association of Firefighters (IAFF)

*"IAFF **oppose the use of fire stations as base stations** for towers and/or antennas."*

International Association of Firefighters, Division of Occupational Health, Safety and Medicine. 2005. Position on the health effects from radio frequency/microwave (RF/MW) radiation in fire department facilities from base stations for antennas and towers for the conduction of cell phone transmissions [Internet]. Washington (DC): International Association of Firefighters; [cited 2008 May 20]. Available from: http://www.iaff.org/hs/Facts/CellTowerFinal.asp

2005 Aug **10 Medical Rules for Cell Phone Use**

Issued by the Vienna Medical Association (Austria)

[The microwave radiation given off by cell or mobile phones is possibly not as safe as cell phone service providers claim it to be.

*Therefore the Vienna Medical Association has decided to show responsibility and **inform the people of Austria from a medical perspective about how to minimize the potential negative effects of cell phone radiation**.*

10 Medical Rules for Cell Phone Use

- *Keep cell phone conversations as infrequent and as short as possible. - Use a landline or VoIP. Children and teenagers under the age of 16 should have a cell phone for emergencies only.*
- *Keep the cell phone away from your head and body while establishing a connection (arm's length distance).*
- *Do not use cell phones in vehicles (car, bus, railway) because the microwave radiation is higher.*
- *While sending SMS messages, keep the cell phone as far away from your*

body as possible.

- *When purchasing a cell phone, look for the lowest possible SAR-value as well as an external antenna connection.*
- *Do not put cell phones in your pocket. The microwave radiation can interfere with male fertility.*
- *At home, use a landline and turn the cell phone off.*
- *Do not play games on a cell phone.*
- *When using headsets or integrated speakerphones, always keep the cell phone as far away from your body as possible (e.g. coat pocket, purse).*
- *Wireless LAN or UMTS also result in a high continuous microwave radiation exposure.]*

Ärztekammer für Wien [Vienna Medical Association]. 2005. Strahlende Informationen [Radiation Information] [Internet]. 4th ed. Vienna, Austria: Vienna Medical Association; [updated 2008 Apr; cited 2008 May 20]; [1 poster].

German original available from:
http://www.aekwien.or.at/media/Plakat_Handy.pdf

English summary of first edition available from:
http://www.powerwatch.org.uk/news/20050815_reflex.asp

2006 Feb **Benevento Resolution**

By participants of the International Conference on The Precautionary EMF Approach: Rationale, Legislation and Implementation

*"Based on our review of the science, **biological effects can occur from exposures to both extremely low frequency fields (ELF EMF) and radiation frequency fields (RF EMF).** Epidemiological and in vivo as well as in vitro experimental evidence demonstrates that exposure to some ELF EMF can increase cancer risk in children and induce other health problems in both children and adults. Further, there is accumulating epidemiological evidence indicating an increased brain tumor risk from long term use of mobile phones, the first RF EMF that has started to be comprehensively studied."*

*"We encourage governments to **adopt** a framework of guidelines for public and occupational EMF exposure that reflect **the Precautionary Principle** -- as some nations have already done."*

*"**Designate wireless-free zones** in cities, in public buildings (schools, hospitals, residential areas) and, on public transit, to permit access by persons who are hypersensitive to EMF."*

Benevento Resolution. 2006. Resolution of the International Conference on The Precautionary EMF Approach: Rationale, Legislation and Implementation, dedicated to W. Ross Adey, M.D. (1922-2004) [Internet]; 2006 Feb 22-24; Benevento, Italy: International Commission for Electromagnetic Safety (ICEMS); [cited 2008 May 20]. Available from:
http://www.icems.eu/benevento_resolution.htm

Oct 2006 **Consensus Statement on Electromagnetic Radiation** (Draft)

By the EMF Working Group of the Collaborative on Health and the Environment
http://www.healthandenvironment.org/wg_emf_news/772

"We believe there are legitimate health concerns regarding exposure to radiofrequency electromagnetic radiation (EMR), which has rapidly become one of the most pervasive environmental exposures in modern life."

"While research continues, we believe ***there is sufficient evidence to recommend precautionary measures that people can take to protect their health,*** *and the health of their families, co-workers and communities."*

The Collaborative on Health and the Environment, EMF Working Group. 2006. EMF consensus statement on electromagnetic radiation: draft.

2007 Jul **Radiation Impacts from Wireless Local Area Networks**

Reply by the Federal Government of Germany to the Inquiry on Radiation Impacts from Wireless Local Area Networks (WLAN) spearheaded by the Green Party of Germany

"Direkte Vorsorgemaßnahmen werden von der Bundesregierung nicht getroffen. Die Bundesregierung empfiehlt allgemein, die persönliche Strahlenexposition durch hochfrequente elektromagnetische Felder so gering wie möglich zu halten, d. h. herkömmliche Kabelverbindungen zu bevorzugen, wenn auf den Einsatz von funkgestützten Lösungen verzichtet werden kann.
[The German Government does not take direct precautionary measures. The ***German Government suggests*** *as a general recommendation that* ***people keep their personal radiation exposure to radiofrequency electromagnetic fields as low as possible****, for example, by preferring conventional wired connections when it is possible to forego wireless solutions.]"*

Deutsche Bundesregierung. 2007 Jun 23. Strahlenbelastung durch drahtlose Internet-Netzwerke (WLAN) [Radiation impacts from wireless local area networks WLAN] [Internet]. Printed matter 16/6022. Bonn, Germany: Federal Government of Germany. [cited 2008 May 20]; 5 p. German. Available from: http://dip21.bundestag.de/dip21/btd/16/061/1606117.pdf

2007 Aug **BioInitiative Report**

By the BioInitiative Working Group, an international working group of scientists, researchers and public health policy professionals

Summary for the Public by Cindy Sage:

"The clear consensus of the BioInitiative Working Group members is that the ***existing public safety limits are inadequate*** *for both ELF and RF."* (p. 5)

"There may be no lower limit at which exposures do not affect us. Until we know if there is a lower limit below which bioeffects and adverse health impacts do not occur, it is unwise from a public health perspective to continue "business-as-usual" deploying new technologies that increase ELF and RF exposures, particularly involuntary exposures." (p. 7)

*"While new **ELF limits** are being developed and implemented, a reasonable approach would be a **1 mG planning limit for habitable space** adjacent to all new or upgraded power lines and a 2 mG limit for all other new construction. It is also recommended for that a **1 mG limit be established for existing habitable space for children and/or women who are pregnant**."* (p. 26)

*"A **precautionary limit of 0.1 µW/cm2** … should be adopted **for outdoor, cumulative RF exposure**. … This recommendation should be seen as an interim precautionary limit that is intended to guide preventative actions; and more conservative limits may be needed in the future."* (p. 24)

Carpenter D, Sage C, editors. 2007 Aug 31. BioInitiative report: a rationale for a biologically-based public exposure standard for electromagnetic fields (ELF and RF) [Internet]. [cited 2008 May 21]; 610 p. Available from: http://www.bioinitiative.org

Jun 2008 **The Venice Resolution**

Initiated by the International Commission for Electromagnetic Safety (ICEMS), a group of renowned research scientists, this resolution builds on the Benevento Resolution by the same organization from 2006.

*"The **non-ionizing radiation protection standards** recommended by international standards organizations, and supported by the World Health Organization, are **inadequate**."*

*"We recognize the growing public health problem known as **electrohypersensitivity**; that this adverse health condition can be quite disabling; and, that this condition requires further urgent investigation and recognition."*

Venice Resolution. 2008. Venice Workshop on the Foundations of Bioelectromagnetics: Towards a New Rationale for Risk Assessment and Management [Internet]; 2008 Jun 6; Venice, Italy: International Commission for Electromagnetic Safety (ICEMS); [cited 2008 Aug 2]; 3 p. Available from: http://www.icems.eu/docs/Venice_Resolution_0608.pdf

2008 Jun **Statement on Wi-Fi in Libraries and the Precautionary Principle**

By the Progressive Librarians Guild

*"Based on this information, Progressive Librarians Guild recommends that via their professional organizations, information workers address the risks of wireless technology in public spaces, take steps in learning about the risks of wireless in terms of exposure and impact on library services, monitor wireless technology in their facilities, **critically evaluate and adopt alternatives to wireless technology** especially in children's sections of libraries, create warning signage on risks of wifi throughout their libraries, and act as a community resource in the public education on wireless technologies."*

Progressive Librarians Guild. 2008 June 16. Progressive Librarians Guild statement on Wi-Fi in libraries and the precautionary principle [Internet]. [cited 2008 Aug 2]. Available from: http://libr.org/plg/wifiresolution.php

Jul 2008 **UPCI: Important Precautionary Advice Regarding Cell Phone Use**

By the head of the University of Pittsburgh Cancer Institute, Ronald B. Herberman, MD

*"An **international expert panel** of pathologists, oncologists and public health specialists recently declared that **electromagnetic fields emitted by cell phones** should be **considered a potential human health risk**."*

"Practical Advice to Limit Exposure to Electromagnetic Radiation Emitted from Cell Phones

1. *Do not allow children to use a cell phone, except for emergencies. …*
2. *While communicating using your cell phone, try to keep the cell phone away from the body as much as possible. …*
3. *Avoid using your cell phone in places, like a bus, where you can passively expose others to your phone's electromagnetic fields.*
4. *Avoid carrying your cell phone on your body at all times. …*
5. *If you must carry your cell phone on you, make sure that the keypad is positioned toward your body and the back is positioned toward the outside so that the transmitted electromagnetic fields move away from you rather than through you.*
6. *Only use your cell phone to establish contact or for conversations lasting a few minutes, as the biological effects are directly related to the duration of exposure. For longer conversations, use a land line with a corded phone, not a cordless phone, which uses electromagnetic emitting technology similar to that of cell phones.*
7. *Switch sides regularly while communicating on your cell phone to spread out your exposure. …*
8. *Avoid using your cell phone when the signal is weak or when moving at high speed, such as in a car or train, as this automatically increases power to a maximum as the phone repeatedly attempts to connect to a new relay antenna.*
9. *When possible, communicate via text messaging rather than making a call, limiting the duration of exposure and the proximity to the body.*
10. *Choose a device with the lowest SAR possible (SAR = Specific Absorption Rate, which is a measure of the strength of the magnetic field absorbed by the body). …"*

Herberman RB, head of UPCI. 2008 Jul 23. Important precautionary advice regarding cell phone use [Internet]. Pittsburgh (PA): University of Pittsburgh Cancer Institute (UPCI); [cited 2008 Aug 2]. Available from: http://www.upci.upmc.edu/news/upci_news/2008/072308_celladvisory.html or http://environmentaloncology.org/node/202

2008 Sep **European Parliament Resolution**

By the European Parliament on the mid-term review of the European Environment and Health Action Plan 2004-2010

Votes of Members of Parliament: 522 yes votes, 16 no votes

"12. Calls, therefore, on the Commission to revise the criteria laid down in its aforementioned Communication as regards recourse to the precautionary principle pursuant to European Court of Justice case-law, in order to ensure that an action and security principle based on the adoption of provisional and proportionate measures lies at the heart of Community health and environment policies;"

*"15. **Recommends that**, in order to reduce damaging effects of the environment on health, the Commission should call upon Member States, by means of tax concessions and/or other economic incentives, **to interest market operators in** improving the quality of indoor air and **reducing exposure to electromagnetic radiation in their buildings, branch establishments and offices;"***

*"21. Is greatly concerned at the Bio-Initiative international report concerning electromagnetic fields, which summarises over 1500 studies on that topic and which points in its conclusions to the **health risks posed by emissions from mobile-telephony devices** such as mobile telephones, UMTS, Wifi, Wimax and Bluetooth, and also DECT landline telephones;"*

*"22. Notes that the **limits on exposure to electromagnetic fields** which have been set for the general public **are obsolete**, since they have not been adjusted in the wake of Council Recommendation 1999/519/EC of 12 July 1999 on the limitation of exposure of the general public to electromagnetic fields (0Hz to 30 GHz), obviously take no account of developments in information and communication technologies, of the recommendations issued by the European Environment Agency or of the stricter emission standards adopted, for example, by Belgium, Italy and Austria, and do not address the issue of vulnerable groups, such as pregnant women, newborn babies and children."*

European Parliament. 2008 Sep 4. European resolution of 4 September 2008 on the mid-term review of the European Environment and Health Action Plan 2004-2010 [Internet]. Document No.: A6-0260/2008. prov. ed. Brussels, Belgium. [cited 2008, 7 Sep]. Available from: http://www.europarl.europa.eu/sides/getDoc.do?type=TA&reference=P6-TA-2008-0410&language=EN

Appendix 9: Resources on Electromagnetic Hypersensitivity

A9.1 DEFINITION

The WHO has proposed to replace EHS by the term Idiopathic Environmental Intolerance (IEI), EMF attributed, because the term EHS implies that a causal link between reported symptoms and EMF exposure would have been established. The common term in the scientific literature continues to be electromagnetic hypersensitivity or EHS.

World Health Organization. 2005 Dec. Electromagnetic fields and public health: electromagnetic hypersensitivity [Internet]. Fact sheet no. 296. [cited 2008 Aug 4]. Available from: http://www.who.int/mediacentre/factsheets/fs296/en/index.html

A9.2 DISEASE CLASSIFICATION

World Health Organization

The WHO has not recognized EHS as a disease, consequently it does not have an international classification disease code or ICD-number.

Nordic Council of Ministers

Since only a fraction of preventable occupational diseases are recognized as such, the Nordic Council of Ministers has tried to change this by adapting the classification of occupationally related disorders to the ICD-10. The group of not well specified conditions with an etiology attributed to environmental factors, "which in Nordic countries are claimed, but not yet proven, to be caused by occupational exposures" received special attention.

ICD-10 Code	
R00-R99	Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified
R50-R69	General symptoms and signs
R68.8	Other specified general symptoms and signs Suggestions by the Nordic Council of Ministers: "idiopathic/environmental intolerance (IEI)," including "multiple chemical sensitivity (MCS)"; "electromagnetic intolerance"

"We have concluded that our advice in regard to ICD-10 (where none of the above mentioned 'conditions' have codes) is:

1. Disease/symptom code: Take the most prominent symptom and use the R-code for that condition. Alternatively use R68.8 'Other specified general symptoms and signs' if there is no single prominent symptom.

2. To underscore that the condition has no accepted aetiology: We suggest to 'tag' the disease/symptom code with R69 'Unknown and unspecified causes of morbidity' (like we 'tag' the other disease/symptom codes with Y96 or Y97 to express the occupational/environmental aetiology of the disorder).

The use of psychiatric diagnosis** (F45,-, F45.0 or F45.9) **for these conditions has been discussed. However, we advice that they should not be used by occupational physicians at the present state of knowledge.

F45.-, F45.0 or F45.9 should only be used when a full somatization syndrome

('Environmental somatization syndrome' (ESS)) *is diagnosed by a psychiatrist.* (p. 49)

'Electromagnetic intolerance'
'El-allergy'
Usually general symptoms (tiredness, nausea, memory- and concentration difficulties etc.) related to use of TV/PC/data-screens, electrical transformers or fluorescent lamps. Symptoms disappear in 'non-electrical environments'." (p. 50)

Levy F, Wannag A, editors. 2000. The Nordic adaptation of classification of occupationally related disorders (diseases and symptoms) to ICD-10 [Internet]. Oslo, Norway: Nordic Council of Ministers; [cited 2008 Jul 26]; 51 p. Available from: http://www.nordclass.uu.se/verksam/NordICD10.pdf

Sweden

Swedish municipalities follow the 22 "Standard Rules on the Equalization of Opportunities for Persons with Disabilities," recommended by the UN since 1993. In Sweden, electromagnetic hypersensitivity is considered a functional impairment or disability. The world's first Association for ElectroSensitive People (FEB) is one of the 43 organizations that comprise the Swedish Disability Federation.

"People with electrohypersensitivity also have a general (legal) right to be supported by their employer so that they can work despite of this impairment. For instance, they can get special equipment such as computers that are of low-emission type, high-frequency fluorescent lamps can be changed to ordinary light bulbs, wireless DECT telephones removed from their rooms, and so on."

Johansson O. 2006. Electrohypersensitivity: state-of-the-art of a functional impairment. Electromagnetic Biology and Medicine [Internet]. [2008 Jul 26]; 25(4):245-258. Available from: http://www.informaworld.com/smpp/content~content=a768405312~db=all~order=page#main_mainbody

Canada: Workers Compensation Board of British Columbia

With regard to electricity, there are only injury code numbers for the various degrees of electrical burns as well as electrical shock and electrocution. Though multiple chemical sensitivity (48100) is given its own code number in the category "Multiple symptoms, signs, and ill-defined conditions," there is no individual number for electromagnetic hypersensitivity as of 2008.

Workers' Compensation Board of BC. 2006 Mar 10. Nature of injury codes [Internet]. Vancouver (BC): Workers' Compensation Board of BC; [cited 2008 Jul 26]; 18 p. Available from: http://www.worksafebc.com/health_care_providers/Assets/PDF/nature_injury_complete.pdf

A9.3 SELF-REPORTED SYMPTOMS

The information listed below is taken from a survey commissioned by the Swiss Federal Office of Public Health. 394 individuals reporting to suffer from electromagnetic hypersensitivity participated in this survey.

53% of the survey participants stated their physical impairment with “very severe” or “severe,” 41% rated their mental impairment with severe, and 17% stated to be “partly incapacitated for work” due to their EMF related symptoms.

A comparison between the symptom patterns reported by people suffering from MCS and EHS revealed that sleep disorders are far more prevalent in EHS sufferers and allergic symptoms of the skin and respiratory tract are far more common in MCS sufferers.

Röösli M et al. 2004. Symptoms of ill health ascribed to electromagnetic field exposure: a questionnaire survey. Int J Hyg Environ Health [Internet]. [cited 2008 Jul 27]; 207:141-150. Abstract available from: http://www.ncbi.nlm.nih.gov/pubmed/15031956?dopt=Abstract

Top 12 Self-reported Symptoms

Sleep disorder (58%)

Headache (41%)

Nervousness/Distress (19%)

Fatigue (18%)

Concentration Difficulties (16%)

Tinnitus (14%)

Dizziness (11%)

Limb pain (11%)

Heart disease (11%)

Arthropathy (7%)

Skin rash (6%)

Oculopathy (6%)

EMF Sources Reported to Be Related to the Symptoms

Mobile phone base stations (87%)

Power lines (61%)

Transformers (53%)

Mobile phone (48%)

Broadcast transmitters (44%)

Cordless phone (36%)

Train and tram lines (36%)

Use of train/tram (36%)

Computer (29%)

Low voltage lighting (18%)

TV set (18%)

A9.4 ESTIMATED PREVALENCE OF ELECTROSENSITIVE PEOPLE

The number of self-reported cases of electromagnetic hypersensitivity has been increasing steadily since it was first documented.

Adopted from:
Hallberg Ö, Oberfeld G. 2006. Letter to the editor: will we all become electrosensitive? Electromagnetic Biology and Medicine [Internet]. [cited 2008 July 25] 25:189-191. Available from: http://www.informaworld.com/smpp/content~content=a756630784~db=all~order=page

Measured Year	Percent EHS	Country Reported Year	Reference No. See original paper.
1985	0.06	Sweden 1991 (0.025-0.125%)	1
1994	0.63	Sweden 1995	2
1995	1.50	Austria 1995	3
1996	1.50	Sweden 1998	4
1997	2.00	Austria 1998	5
1997	1.50	Sweden 1999	6
1998	3.20	California 2002	7
1999	3.10	Sweden 2001	8
2000	3.20	Sweden 2003	9
2001	6.00	Germany 2002	10
2002	13.30	Austria 2003 (7.6-19%)	11
2003	8.00	Germany 2003	12
2003	9.00	Sweden 2004	13
2003	5.00	Switzerland 2005	14
2003	5.00	Ireland 2004	15
2004	11.00	England 2004	16
2004	9.00	Germany 2005	17
2017	50.00	Extrapolated to 50%	

A9.5 SELECTED SCIENTIFIC STUDIES, ANALYSES, AND CASE HISTORIES

1991 Rea WJ et al. 1991. Electromagnetic field sensitivity. J Bioelectricity [Internet]. [cited 2008 July 27]; *10*(1&2):241-256. Available from: http://www.aehf.com/articles/em_sensitive.html

In this multiphase study at the Environmental Health Center in Dallas, TX, the authors tried to find an effective method to evaluate electromagnetic hypersensitivity in patients. From 100 patients with self-reported symptoms, 25 reacted only to active challenges, but not to sham exposures. None of the individuals in the control group reacted to any active challenges. The authors of the study conclude that "EMF sensitivity is a real phenomenon in some environmentally sensitive patients."

2001 Lyskov E, Sandström M, Mild KH. 2001. Neurophysiological study of patients with perceived 'electrical hypersensitivity.' Int J Psychophysiology. 42(3):233-241.

In this case-control study, 20 patients with self-reported symptoms of electromagnetic hypersensitivity (e.g. general fatigue, headache, skin symptoms) were matched with the same number of symptom-free controls. The following neurophysiological parameters were tested: visual functions, blood pressure, HR, HRV, electrodermal activity, respiration, EEG, VEP. In electrosensitive patients a higher mean value of heart rate in rest condition, "a higher critical fusion frequency (43 vs. 40 Hz), and a trend to increased amplitude of steady-state VEPs at stimulation frequencies of 30-70 Hz" was observed, which indicates a "hyperresponsiveness to sensor stimulation and heightened arousal."

2002 Levallois P. 2002. Hypersensitivity of human subjects to environmental electric and magnetic field exposure: a review of the literature. Environ Health Perspect [Internet]. [cited 2008 July 27]; 110(suppl 4):613-618. Available from: http://www.ehponline.org/members/2002/suppl-4/613-618levallois/levallois-full.html

In this review the author prefers the term "hypersensitivity to electric and magnetic fields," as proposed by the California Department of Health Services, thereby limiting his selection of studies to those considering ELF sources of electric and magnetic fields only. The very few studies published in peer-reviewed journals frequently lack the required numbers of subjects and detailed description of exposures. According to the studies evaluated, which mostly come from Nordic countries, no evidence was found for "a link between VDU skin disorders and exposure to EMFs" though some observations were made that associate health status with VDU use. In view of the lack of scientific data, the author is intrigued by the phenomenon that self-aid groups attract large numbers of people who claim to be electrosensitive and calls for more research "to clarify the nature of the health problem labeled HSEMF."

2003 Sandström M. Lyskov E, Hörnsten R, Mild KH, Wiklund U, Rask P, Klucharev V, Stenberg B, Bjerle P. 2003. Holter ECG monitoring in patients with perceived electrical hypersensitivity. Int J Psychophysiology. 49(3):227-235.

In this case-control study, 14 electrosensitive patients and their matched controls were monitored for ECG, hear rate (HR), and heart rate variability (HRV) as well as magnetic field exposure. Both groups had a similar 24-h magnetic field exposure as well as mean HR values. However, the electrosensitive showed a disturbed pattern of circadian rhythms of HRV, e.g. lacking the increase of high-frequency components during sleep.

2004 Ganlund-Lind R, Lind J, editors. 2004. Black on White: voices and witnesses about electro-hypersensitivity: the Swedish experience [Internet]. 2nd ed. [cited 2008 Jul 27]; 143 p. English translation available from: http://www.feb.se/feb/blackonwhite-complete-book.pdf

In 1997 the Council for Work Life Research (RALF) was commissioned by the Swedish government to launch an investigation about electromagnetic hypersensitivity. A total of 400 electrosensitive people as well as their relatives, medical doctors and EMF remediation engineers submitted reports of their experiences and knowledge. Since RALF never published these case histories, Rigmor Ganlund-Lind and John Lind did just that in Swedish in 2002.

2005 Rubin GJ, Munshi J, Wessely S. 2005 Mar-Apr. Electromagnetic hypersensitivity: a systematic review of provocation studies. Psychosom Med [Internet]. [cited 2008 Aug 9]; 67(2):224-232. Available from: http://www.psychosomaticmedicine.org/cgi/reprint/67/2/224

Seitz H, Stinner D, Eikmann T, Herr C, Röösli M. 2005. Electromagnetic hypersensitivity (EHS) and subjective health complaints associated with electromagnetic fields of mobile phone communication: a literature review published between 2000 and 2004. Science of the Total Environment. 349(1-3): 45-55.

Both reviews acknowledge the severity of the reported symptoms. Though some studies listed found a positive association between EMF exposure and self-reported electromagnetic hypersensitivity symptoms, the authors find the majority of the available studies inconclusive and sometimes contradictory. They call for more research. The review by Rubin et al. contains a list of 13 studies that looked at VDU use and skin health. The review by Seitz et al. considers 13 mobile phone radiation exposure studies with regard to 10 different health systems.

2006 Huss A, Röösli M. 2006. Consultations in primary care for symptoms attributed to electromagnetic fields: a survey among general practitioners. BioMed Central [Internet]. [cited 2008 Aug 9]; 6:267. [9 p.] Available from: http://www.biomedcentral.com/1471-2458/6/267

In this telephone survey, 342 randomly chosen Swiss general practitioners (GPs) were interviewed about patients who attribute symptoms to EMF exposure. 69% of the GPs reported at least one consultation due to EMF exposure. Though a clear-cut symptom-EMF source pattern could not be found, in 54% of the cases the GPs judged the relationship between EMF exposure and symptom to be “plausible”.

2006 Johansson O. 2006. Electrohypersensitivity: state-of-the-art of a functional impairment. Electromagnetic Biology and Medicine [Internet]. [2008 Jul 26]; 25(4):245-258. Available from: http://www.informaworld.com/smpp/content~content=a768405312~db=all~order=page#main_mainbody

In this review, Olle Johansson from the Karolinska Institute in Sweden discusses

electromagnetic hypersensitivity as a functional impairment and how people with this disability are helped in Sweden. According to his research, a "profound increase of mast cells" could be demonstrated in facial skin samples of electrosensitive people, which may explain a higher incidence of skin rashes caused by the release of e.g. histamine.

2006 Leitgeb N, Schröttner J, Böhm M. 2005. Does "electromagnetic pollution" cause illness? An inquiry among Austrian general practitioners. Wien Med Wochenschr [Internet]. [cited 2008 Jul 27]; 155(9-10):237-241. Abstract available from: http://www.springerlink.com/content/n80768306r707217/?p=36b6380830f140c5902ee90b8f814645&pi=6

A comprehensive two-page questionnaire was mailed to 400 general practitioners (GPs) in Austria. From the 49% of the GPs who responded, 95% agreed that "electromagnetic pollution" can cause illness. The authors of this paper are mystified about the "widespread contradiction between physicians' opinions and established national and international health risk assessment."

2007 Sears ME. 2007 May. The medical perspective on environmental sensitivities [Internet]. Ottawa (ON): Canadian Human Rights Commission; [cited 2008 July 27]; 79 p. Available from: http://www.chrc-ccdp.ca/pdf/envsensitivity_en.pdf and http://www.chrc•ccdp.ca/research_program_recherche/esensitivities_hypersensibilitee/toc_tdm-en.asp

This is a comprehensive overview on the broad spectrum of environmental sensitivities, including electromagnetic phenomena.

"Accommodation of people with environmental sensitivities is an opportunity to improve environmental quality and workers' performance, and to prevent the development of sensitivities in others. Sensitivities vary greatly from one individual to another, so the affected worker should be involved in determining accommodations to minimize potentially harmful exposures in the workplace." (executive summary)

2007 Eltiti S et al. 2007. Does short-term exposure to mobile phone base station signals increase symptoms in individuals who report sensitivity to electromagnetic fields? a double-blind randomized provocation study. Environ Health Perspectives [Internet]. [cited 2008 Jul 27]; 115(11):1603-1608. Available from: http://www.ehponline.org/members/2007/10286/10286.pdf

Though the authors realize that the resolving power of their study is not significant enough (due to a lack of participating electrosensitive subjects) to be able to detect a statistically significant effect, they are quick to conclude that "short-term rf-emf exposure from mobile phone technology is not related to levels of well-being or physical symptoms in IEI-EMF individuals." They even go so far to claim that electrosensitive individuals are "unable to detect the presence of rf-emf." Unfortunately, their conclusion does not highlight their finding that electrosensitive study participants had a statistically significant higher skin conductance. For a detailed discussion on how the findings of this study can be interpreted differently, see the correspondence by other researchers at: http://www.ehponline.org/docs/2008/116-2/EHP116pa62PDF.PDF.

2008 Hardell L et al. 2008. Increased concentrations of certain persistent organic pollutants in

subjects with self-reported electromagnetic hypersensitivity: a pilot study. Electromagnetic Biology and Medicine [Internet]. [cited 2008 July 27]; 27:197-203. Available from: http://www.informaworld.com/smpp/content~content=a793877932~db=all~order=page

In this hypothesis-generating pilot study, it was found that concentrations of most POPs, especially brominated flame retardant PBDE #47, were higher in EHS subjects than in the comparison group.

A9.6 RECOMMENDATIONS, STANDARDS, AND POLICIES

1996 **City of Stockholm's Policy for Electrosensitive People**
Based on the 22 "Standard Rules on the Equalization of Opportunities for Persons with Disabilities," recommended by the UN since 1993, Stockholm has created its own policy to support electrosensitive people. Any electrosensitive person, living in Stockholm, can apply for help and financial support to the city's planning and housing department. A technician will come and assess exposure levels and will make suggestions for remediation.

2003 Seminar on Electrical Sensitivity and the Situation of the ElectroSensitive [DVD]. 2003 Apr 8; Stockholm, Sweden: Socialtjänstförvaltningen Stockholms Stad. Swedish with English subtitles.

2006 Seminar on Electrohypersensitive People's Right to an Accessible Society [DVD]. 2006 May 8; Stockholm, Sweden: Socialtjänstförvaltningen Stockholms Stad; Stockholms läns landsting. Swedish with English subtitles.

The DVDs with English subtitles published by the Social Services Department of Stockholm are available from Johan Bonander, researcher for disability guidelines and policies from the City of Stockholm.
E-mail: johan.bonander@sot.stockholm.se
Phone: +46-8-50825003

English translations of quotes taken from speeches held at the above-listed seminar "Electro-Hypersensitive People's Right to an Accessible Society" are available from: http://www.mastsanity.org/index.php?option=com_content&task=view&id=162&Itemid=131

In its decision-making process, the City of Stockholm reasoned as follows:

"Today there are many people who are electro-hypersensitive in Stockholm - people who are impaired due to their electro-hypersensitivity. Scientifically, there is no undisputable knowledge of the medical reasons for electro-hypersensitivity. We know that all living cells in animals and humans are affected by electricity and this new and very complicated area is already very extensive and growing rapidly. On the other hand, experience shows that electro-hypersensitivity is a reality. Some computer screens and other electric devices are the triggering factors. The city will work to minimise negative health effects and as far as possible use the precautionary principle by taking protective measures before evidence is available."

A referral department of the City of Stockholm that supports electrosensitive people made the following observation:

"Many people feel they have substantial problems with electro-hypersensitivity. Different scientific reports discuss whether these problems are due to electro-hypersensitivity or not. Regardless of who is right, people who consider themselves as Electro-Hypersensitive in many cases claim they become much better if their homes are electro-sanitized. This result is important for the individual, regardless of whether electro-hypersensitivity exists or not. Financial support for home modifications is to be considered in respect of each individual in the same way. This is done for people with other needs, regardless of medical diagnosis."

2005 UK Health Protection Agency

Generally speaking, the author of the review below recommends a precautionary approach. With regard to management recommendations, it is interesting to note that the summary only mentions psychological therapies, but further down in the review itself, a Swiss investigation is discussed, in which the top three actions listed by subjects who attribute their symptoms to EMF exposure are all avoidance strategies (disconnecting electricity, removing indoor source, avoiding exposure).

"There is only limited evidence to guide the management of affected individuals. The majority of conventional medical effort to date has been directed at psychological therapy, such as cognitive behavioural therapy." (p. V)

"The significant difference between ES and these others [idiopathic environmental intolerances] is the attribution by the sufferer of symptoms to an EMF source. Other than noting the ongoing debate about this attribution, however, this review is unable to comment further." (p.28)

Irvine N. 2005. Definition, epidemiology and management of electrical sensitivity report for the Radiation Protection Division of the Health Protection Agency [Internet]. Report No.: HPA-RPD-010. Chilton (GB): Health Protection Agency, Centre for Radiation, Chemicals and Environmental Hazards, Radiation Protection Division; [cited 2008 Jul 27]; 34 p. Available from: http://www.hpa.org.uk/webw/HPAweb&HPAwebStandard/HPAweb_C/1195733810369?p=1197637096018

2006 WHO: International Seminar on EMF Hypersensitivity

In the conclusions from the proceedings of the workshop (p. 2-4), it was acknowledged that "the symptoms are certainly real," but according to the studies reviewed by the majority of the participants these symptoms "do not seem to be correlated with EMF exposure." Though no other cause(s) were substantiated, it was speculated "whether stress reactions as a result of worrying about believed EMF health effects, rather than the EMF exposure itself" could be the culprit. It is unclear what motivates the WHO to recommend against "commercial products to shield against EMF" so adamantly even though this strategy to lower one's EMF exposure has shown positive results.

"National authorities should not ignore the plight of IEI individuals as it affects some 2-3% of populations in a number of countries. Governments need to provide general physicians with appropriate advice based on information provided by qualified experts. To that end, it was recommended that WHO issue a fact sheet that contains information on the symptoms of IEI individuals, indicating that, at present, these symptoms cannot be attributed to EMF, warn against commercial products to shield against EMF and provide advice on how best to manage IEI." (p. 4)

Mild KH, Repacholi M, van Deventer E, Ravazzani P, editors. c2006. Electromagnetic Hypersensitivity. Proceedings of the International Workshop on EMF Hypersensitivity [Internet]; 2004 Oct 25-27; Prague, Czech Republic. Geneva, Switzerland: World Health Organization; [cited 2008 Jul 28]; 182 p. Available from: http://www.who.int/peh-emf/publications/reports/EHS_Proceedings_June2006.pdf and http://www.who.int/peh-emf/meetings/hypersensitivity_prague2004/en/index.html

2007 Canadian Human Rights Commission: Policy on Environmental Sensitivities

In June 2007, the Human Rights Commission of Canada adopted a progressive policy on environmental sensitivities, acknowledging physical causes and recommending to support affected people in lowering their exposures and creating healthier work environments, including electromagnetic fields.

"This medical condition [environmental sensitivities] is a disability and those living with environmental sensitivities are entitled to the protection of the Canadian Human Rights Act, which prohibits discrimination on the basis of disability."

"The CHRC encourages employers and service providers to proactively address issues of accommodation by ensuring that their workplaces and facilities are accessible for persons with a wide range of disabilities."

Canadian Human Rights Commission. 2007. Policy on environmental sensitivities [Internet]. Ottawa (ON): Canadian Human Rights Commission; [approved 2007 Jun 15; cited 2008 Jul 27]; screen 1. Available from: http://www.chrc• ccdp.ca/legislation_policies/policy_environ_politique-en.asp?lang_update=1

A9.7 SELECTED ASSOCIATIONS FOR ELECTROSENSITIVE PEOPLE

1987 Sweden: Elöverkänsligas Riksförbund
World's first Association for ElectroSensitive People

http://www.feb.se/index_int.htm

2003 UK: Electrosensitivity UK

http://www.es-uk.info/index.asp

2004 Germany: Erforschung und Therapie der Elektrosensibilität e.V.
[Association for Research and Therapy of Electrosensitivity e.V.]

http://www.umweltphysik.info/

A9.8 TIMELINE OF TECHNOLOGY DEVELOPMENT

1880s Telephone

1844 First news dispatched by electric telegraph invented by Morse

1876 First complete sentence transmitted via telephone invented by Bell

1879 First telephone exchange outside the US in London, England

1883 First telephone exchange linking two cities: New York and Boston

1900s Electricity

1878 First successful demonstration of incandescent light bulb by Swan

1879 Edison presents first commercially viable incandescent light bulb
First street lighting in Cleveland, Ohio

1882 First electric power plant station in New York City by Edison

1901 First power line between Canada and the US was opened

1908 Electric vacuum cleaner and washing machine

1920s Broadcasting

1896 First wireless transmission over 30 km by Tesla

1900 First audio radio transmission by Fesseden

1902 First transatlantic radio wave transmission by Marconi

1906 Amplitude modulation radio (AM) invented by Fesseden

1922 “Broadcasting boom” in the US

1933 Frequency modulation radio (FM) invented by Armstrong

1940s Radar

1904 First demonstration on the use of radio echoes for detecting ships with a Remote Object Viewing Device by Hülsmeyer

1937 World’s first operative radar network in the UK, called Chain Home

1945 Microwave oven invented by Percy Spencer

1950s Television

1927 First televised speech transmitted from Washington DC to New York

1940 Commercial TV services become available in the US

1970s Computer

1953 IBM ships first mass-produced electronic computer (701 EDPM)

1981 IBM introduces its PC

1984 Apple Computer launches first successful mouse-driven computer

1991 World Wide Web introduced to public

1980s Mobile Phones

1956 First fully automatic mobile phone system in Sweden by Ericsson

1971 Zero Generation: First truly successful public mobile phone network in Finland

1980 1st Generation: Analog mobile phone networks (NMT, AMPS)

1983 First handheld mobile phones become commercially available in the US

1990 2nd Generation: Digital mobile phone networks (GSM, TDMA, CDMA)

2000 3rd Generation: Digital mobile phone networks (CDMA2000, UMTS)

2000s Wireless Local Area Networks

1970 First wireless computer communication network at University of Hawaii

1999 First wireless LAN becomes available to home users (AirPort)

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I am especially grateful to the many dedicated people in the field of electromagnetic health who were so kind to provide me with hard-to-access information or copies of papers, or to answer my technical questions, namely Dr.-Ing. Martin Virnich; Wolfgang Maes, Initiator of the Building Biology Standard; Dr. Leberecht von Klitzing; Prof. Yuri Grigoriev; Don Maisch, AAS; Cindy Sage, MA; Dr. Thomas Haumann; Peter Sierck, REA. And without the expert language help of Dr. phil. Owe Gustavs, I would not have been able to read and understand the EMF relevant sections of the Russian sanitary regulation for computer workplaces. Naturally, I remain responsible for any mistakes still present.

Also, a big thank you to Pelle Gustavs who helped me with creating the graphs to show how huge the difference between natural background levels and official exposure limits is.

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