

Health issues relating to HVDC cable technology

Expert Opinion by Eric van Rongen, PhD

**Provided at the request of the Department of Communications, Energy &
Natural Resources of the Republic of Ireland**

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1 Background

EirGrid, the statutory transmission system operator of the Republic of Ireland, is developing a connection between the electricity grid in Ireland and that in Britain. This East-West Interconnector will consist of undersea and underground cables. This infrastructure is deemed vital to the development of the economy of Ireland.^a

The proposed route of the underground cables in Ireland runs from the location of landfall at the village of Rush to the converter station of Woodland. Concerns on possible health effect of exposure to the electric and magnetic fields generated by the underground cables for people living nearby have been expressed by the Rush Community Council (RCC). These concerns have been addressed by EirGrid in direct communications to the RCC and the general public.^b

An Bord Pleanála organized an oral hearing on the East-West Interconnector on 10-12 March 2009.^c At the request of EirGrid, Dr William H. Bailey of the Center for Exposure and Dose Reconstruction, Exponent Health Services, New York, USA, prepared a Statement of Evidence “Static (DC) Magnetic Field Assessment for the East West Interconnector Project”. In this Statement of Evidence Dr Bailey presented worst-case calculations of the magnetic fields expected over the underground cables, a brief overview of the result of scientific research into possible health effects of exposure to such fields, the results of the analyses of these results performed by the International Agency on Research on Cancer (IARC)¹ and the World Health Organization (WHO)², and the exposure guidelines for static magnetic fields proposed by the International Commission of Non-ionizing Radiation Protection (ICNIRP).^{3,4}

Since the RCC has remained unconvinced by the information provided by EirGrid, by Dr Bailey and by the Government, and the project is of strategic national importance, the Minister of Communications, Energy & Natural Resources has offered to recommend one or more international experts to give an expert, independent opinion on health risks from the proposed project. Upon request by the Department of Communications, Energy & Natural Resources, I agreed to provide such opinion.

^a www.eirgridprojects.com/projects/east-westinterconnector/overview/

^b www.eirgridprojects.com/media/EirGrid%20reponses%20to%20RCC%20presentation%20to%20DC%20ENR%20August%202010.pdf;

www.eirgridprojects.com/media/Facts%20about%20the%20Interconnector%20Issue%201.pdf;

www.eirgridprojects.com/media/Letter%20to%20Rush%20residents%206%20Sept%202010.pdf;

www.eirgridprojects.com/media/Everyday%20sources%20of%20magnetic%20fields.pdf;

www.eirgridprojects.com/projects/east-westinterconnector/healthsafety/EMF%20Factsheet.pdf

^c www.pleanala.ie/documents/reports/VA0/RVA0002A.pdf

2 Qualifications of Eric van Rongen, PhD

I am Eric van Rongen, PhD, a radiobiologist and an internationally recognized expert in health effects of electromagnetic fields. I hold a position of Senior Scientific Staff Member with the Health Council of the Netherlands, an independent statutory scientific advisory body of the Dutch Government and Parliament.^d Since the commencement of my employment with the Health Council in 1992 I continuously monitor, analyze and review the scientific literature on electromagnetic fields and health. As Scientific Secretary of several Expert Committees I have written many advisory reports and several scientific papers on the health effects of static, low and high frequency electromagnetic fields, UV radiation and ionizing radiation.

I am member of the International Advisory Committee of the WHO International EMF Project^e from the start of the Project in 1996, and I was member of the WHO Task Groups that drafted the Environmental Health Criteria on Static Fields (2006)² and on Extremely Low Frequency Fields (2007).⁵ From 2002-2007 I was part-time seconded to WHO to work on the International EMF Project.

I have been Corresponding Member of ICNIRP from 2001, member of the Standing Committee on Biology of ICNIRP from 2006, and member of the Main Commission of ICNIRP since May 2010.^f I was also member of the Task Group of ICNIRP that provided a first draft of the revised guidelines for exposure to static electric and magnetic fields, that were published in its final form in 2009.⁴

I am member of the Independent Expert Group on Electromagnetic fields of the Swedish Radiation Safety Authority, member of ICES (International Commission on Electromagnetic Safety) of IEEE (Institute of Electrical and Electronics Engineers) and member of the pool of scientific experts for the European Commission and as such has been member of the working groups that drafted the two latest EMF opinions of SCENIHR (Scientific Committee on Emerging and Newly Identified Health Risks).^{6,7}

I am representative of the Netherlands with the European COST (Cooperation on Science and Technology) action BM0704 - Emerging EMF-Technologies and Health Risk Management.^g

I am member of the External Advisory Board of the EU-funded project Sound Exposure & Risk Assessment of Wireless Network Devices (SEAWIND).^h

^d www.gezondheidsraad.nl/en

^e www.who.int/peh-emf/en/

^f www.icnirp.de/cv.htm#VanRongen

^g www.cost-bm0704.org/

^h seawind-fp7.eu/

3 Terms of Reference

The Terms of Reference for this opinion as formulated by the Department of Communications, Energy & Natural Resources are as follows:

The Department of Communications, Energy and Natural Resources seeks the provision of an Expert Opinion on the relationship between HVDC cable technology and electromagnetic fields, and any related human health issues. The opinion will include

- Observations on HVDC cable technology and its relationship to static magnetic fields and electromagnetic fields;
- Clarification on the role of the International Commission on Non-Ionising Radiation Protection (ICNIRP) in relation to the establishment of guideline limits for electromagnetic field exposure for different technologies and an explanation of the relevant limits.

The Opinion should have regard to information provided to the Minister for Communications, Energy and Natural Resources by Rush Community Council (a local representative group in Ireland who have concerns in relation to the East West Interconnector HVDC project currently being developed by EirGrid, Ireland's statutory transmission system operator) and by EirGrid.

Further information relating to the East West Interconnector project (EWIC) being developed by EirGrid, is publically available from Ireland's statutory planning authority, An Bord Pleanála, who granted consent to this project in September 2009.

Noting that the EWIC has been granted full planning consent and that construction is already underway, there is an urgency to this task which will necessitate an immediate response and the provision of the Expert Opinion to the Department within five days of commencement.

As part of the assignment, the consultant will be required to come to Ireland to present their findings and relevant travel costs should be included in the price for this work.

The consultant will work directly to the Department of Communications, Energy and Natural Resources and present the final Expert Opinion to the Department.

September 2010

Disclaimer

This work has not been undertaken as part of my duties with the Health Council of the Netherlands, but in my qualifications as an independent scientific expert. The views and conclusions expressed in this report therefore are not to be considered as those of the Health Council of the Netherlands, but as my own.

4 HVDC and static fields

This chapter contains some observations on HVDC cable technology and its relationship to static magnetic fields and electromagnetic fields. It also provides an explanation of the process of health risk assessment that is followed by the major international and national scientific advisory bodies. Finally a brief overview is given of the biological effects of exposure to static magnetic fields observed in scientific studies and the conclusions with regards to health risks that can be derived from this information.

4.1 HVDC technology

High Voltage Direct Current (HVDC) technology is used to transport electrical energy over long distances. In comparison with High Voltage Alternating Current (HVAC) technology, the energy losses in HVDC are considerably less, and it has other technical advantages. For undersea power cables, HVDC is the only viable option.¹

4.1.1 Electric and magnetic fields

Electrical current generates electric and magnetic fields. With the alternating currents used in household and industry, the polarity of the fields continuously changes from positive to negative. The number of such full cycles of changes per second is called the frequency of the fields and is expressed in hertz (Hz). In Ireland, as in the rest of Europe, the frequency of the electricity supply is 50 Hz. With direct currents, the polarity of the fields does not change (effectively these fields have a frequency of 0 Hz). These differences in characteristics of the electric and magnetic fields are reflected in differences in effects these fields induce in living organisms.

The strength of the magnetic field is usually expressed in the magnetic flux density, with the unit of tesla. In daily practice, the strengths of static magnetic fields are much less than a tesla. Therefore more commonly the units of millitesla (= 1/1000 tesla) and microtesla (1/1 000 000 tesla) are used.

4.1.2 Calculated fields above HVDC cables

According to the specifications the HVDC cable will be buried at 1 metre under the ground surface. It has been calculated that under worst case conditions the strength of the magnetic field at the surface will be 43 microtesla, and at 1 metre above the ground it will be 13 microtesla.^j This is less than the strength of the earth's geomagnetic field, which is approximately 49 microtesla in Ireland.

4.2 Types of studies and their use in health risk assessment

A large number of studies have been performed into effects of exposure to electric, magnetic and electromagnetic fields.^k These studies include studies in cultured cells, animals, humans and human populations. Each of these types of studies has its distinctive advantages and disadvantages.

ⁱ en.wikipedia.org/wiki/High-voltage_direct_current; en.wikipedia.org/wiki/Submarine_power_cable
^j www.eirgridprojects.com/media/EirGrid%20reponses%20to%20RCC%20presentation%20to%20DC%20ENR%20August%202010.pdf

^k With frequencies much higher than 50 Hz the electric and magnetic fields are coupled; in that case they are referred to as electromagnetic fields. This is thus not the case with the fields generated by power systems, be it DC or AC, and is mentioned here solely to indicate the fact.

Studies in cultured cells (in vitro studies) are very suitable for studying cellular and molecular mechanisms of exposure to environmental factors such as electric and magnetic fields. They have, however, limited predictive values for possible adverse health effects in intact organisms, because the cells are cultured in an artificial environment and lack the interaction with other types of cells, organs and organ systems they experience in their natural environment.

Studies in animals have the advantage that the response to exposure can be studied in an intact organism, and that exposure can be widely manipulated and controlled. In many ways however the most frequently used animals for such studies, mice and rats, differ considerably from human beings. Therefore extrapolation from results of animal studies to humans is not straightforward.

Experimental studies with humans are possible only to a very limited extent. In humans, therefore, effects of exposure to environmental factors are mostly investigated in epidemiological studies. These are studies in population groups, where associations with exposure are investigated. If such an association is strong, this might be a strong indication of a causal relationship. In order to conclude about causal relationships with weaker associations, they require support from other types of studies, such as animal studies.

In the health risk assessments such as performed by WHO, ICNIRP and other scientific expert groups, evidence from all types of studies described here is considered and used in a weight-of-evidence approach (taking also into account the scientific quality of the individual studies) to arrive at conclusions.

4.3 Qualification of scientific evidence

IARC uses a system for qualification of the scientific evidence with regard to the carcinogenicity of agents (or mixture of agents, or specific exposure circumstances). This system has been used, sometimes slightly modified, by other organizations for the qualification of other health hazards of agents. In the IARC system, the evidence is classified into one of the following categories¹:

Sufficient evidence of carcinogenicity:

- a) *In humans*: a causal relationship is considered to be established between exposure to the agent, mixture or exposure circumstance and human cancer. That is, a positive relationship has been observed between the exposure and cancer in studies in which chance, bias and confounding could be ruled out with reasonable confidence.
- b) *In animals*: a causal relationship is considered to be established between the agent or mixture and an increased incidence of malignant neoplasms or of an appropriate combination of benign and malignant neoplasms in (a) two or more species of animals or (b) in two or more independent studies in one species carried out at different times or in different laboratories or under different protocols. Exceptionally, a single study in one species might be considered to provide sufficient evidence of carcinogenicity when malignant neoplasms occur to an unusual degree with regard to incidence, site, type of tumour or age at onset.

Limited evidence of carcinogenicity:

- a) *In humans*: a positive association has been observed between exposure to the agent, mixture or exposure circumstance and cancer for which a causal interpretation is considered to be credible, but chance, bias or confounding could not be ruled out with reasonable confidence.

- b) *In animals*: the data suggest a carcinogenic effect but are limited for making a definitive evaluation because, e.g. (a) the evidence of carcinogenicity is restricted to a single experiment; or (b) there are unresolved questions regarding the adequacy of the design, conduct or interpretation of the study; or (c) the agent or mixture increases the incidence only of benign neoplasms or lesions of uncertain neoplastic potential, or of certain neoplasms which may occur spontaneously in high incidences in certain strains.

Inadequate evidence of carcinogenicity:

- a) *In humans*: the available studies are of insufficient quality, consistency or statistical power to permit a conclusion regarding the presence or absence of a causal association between exposure and cancer, or no data on cancer in humans are available.
- b) *In animals*: the studies cannot be interpreted as showing either the presence or absence of a carcinogenic effect because of major qualitative or quantitative limitations, or no data on cancer in experimental animals are available.

Evidence suggesting lack of carcinogenicity:

- a) *In humans*: there are several adequate studies covering the full range of levels of exposure that human beings are known to encounter, which are mutually consistent in not showing a positive association between exposure to the agent, mixture or exposure circumstance and any studied cancer at any observed level of exposure. A conclusion of ‘evidence suggesting lack of carcinogenicity’ is inevitably limited to the cancer sites, conditions and levels of exposure and length of observation covered by the available studies. In addition, the possibility of a very small risk at the levels of exposure studied can never be excluded.
- b) *In animals*: adequate studies involving at least two species are available which show that, within the limits of the tests used, the agent or mixture is not carcinogenic. A conclusion of evidence suggesting lack of carcinogenicity is inevitably limited to the species, tumour sites and levels of exposure studied.

Scientific evidence is often difficult to interpret with regard to its evidence for human health hazards. This categorization is merely a coarse one, with not always a clear delineation between categories. If the scientific evidence does not clearly indicate the presence or the absence of an effect (which is most of the time the case), then the interpretation of the material by scientific experts will be a crucial factor for the categorization and the subsequent health risk analysis.

4.4 Biological effects of field exposure

As indicated earlier, the effects of exposure to alternating and static fields on the human body differ. It thus should be realized that effects that have been observed or suspected to occur with exposure to alternating fields are not predictive for effects of exposure to static fields, and vice versa.

It is important to stress that the discussion on a possible association between an increased risk for childhood leukaemia and living near overhead power lines and the associated exposure to 50 Hz magnetic fields DOES NOT pertain to HVDC cables; since HVDC operates with direct currents, only static fields will be generated.

Because the HVDC cables are shielded and buried, the static electric field will be effectively zeroed in the living environment. Therefore, only the knowledge on effects of static magnetic fields will be briefly summarized, since these are the only effects of relevance in this case.

The basis for this summary is the WHO report of 2006, which gives the most recent and complete overview of effects of exposure to static fields.²

4.4.1 Static magnetic fields – acute effects

4.4.1.1 Physical interactions

Three types of physical interactions of static magnetic fields with biological systems are well established on the basis of experimental data:

a) *Electrodynamic effects:*

Electrically charged particles that move through a static magnetic field lead to the induction of electrical potentials and currents. The principal effect in the body occurs as the result of the flow of blood, that contains charged particles (proteins and other molecules). If the body is exposed to a static magnetic field small currents will be induced in blood vessels, the largest in the aorta, which is vessel with the largest diameter and the fastest blood flow. These currents have not been shown to have any adverse effects, except that at very high strengths of the magnetic field they may lead to a reduction of blood flow. For the aorta it has been estimated that a field of 15 tesla leads to a reduction in blood flow of about 10%. A similar effects occurs when the body moves through a static magnetic field. The faster the movement and the stronger the field, the stronger the induced current. Induction of currents in the organ of balance through this effect may explain reports of vertigo and nausea in people moving through very strong (more than 2 tesla) fields such as used in magnetic resonance imaging (MRI). These effects disappear when the movement is stopped. They are not observed with lower field strengths.

b) *Magnetomechanical effects:*

This is the effect that operates a compass: objects that are not magnetically uniform, but contain opposite polarities (such as ‘north’ and ‘south’ in a bar magnet) will be forced to orient in a magnetic field. Freely moving objects will indeed orient, but on fixed structures (that may include biological molecules) this effect will lead to the generation of forces. A compass may work in the very low earth magnetic field because the friction of the needle is minimal. For the movement of structures in the body much higher fields strengths than that of the geomagnetic field are necessary. MRI operates due to the forced orientation of water molecules in the body. In order to achieve this, very high field strengths, more than a million times stronger than the earth’s geomagnetic field, are necessary. Forces on metallic objects both inside and outside the body are the interaction mechanism of most concern.

c) *Effects on chemical reactions:*

Several types of organic chemical reactions may be influenced by static magnetic fields in the range of 10 to 100 millitesla under very specific conditions. It has not been demonstrated, and is also considered to be very unlikely, that this may have any physiological effects.

4.4.1.2 Effects in humans

Endpoints investigated in human experimental studies have included peripheral nerve function, brain activity, behaviour, cognitive function, sensory perception, cardiac function, blood pressure, heart rate, serum proteins and hormone levels, body and skin temperature, and therapeutic effects, with field strengths up to 8 tesla.

The only effects that have been observed are the already mentioned vertigo and nausea associated with movement in very strong fields. However, because most of the studies were very small, is not possible to draw any conclusions regarding the wide variety of end-points.

4.4.1.3 Effects in animals

Also in animal studies a number of different endpoints have been studied. The most consistent responses are seen in studies on behaviour, that suggest that the movement of laboratory rodents in very strong static magnetic fields, equal to or greater than 4 tesla, may be unpleasant. This is thought to be due to the same effect as the induction of vertigo and nausea in humans with movement in these field strengths.

There is some evidence that several animal species are able to use static magnetic fields, at levels as low as the strength of the earth's geomagnetic field, for orientation. However, these responses are not thought to have any significance for health and in any case do not occur in humans.

Cardiovascular studies have indicated that several hours of exposure to very high field strengths of up to 8 tesla in the heart region did not result in any effects in pigs.

Studies into other endpoints have not shown clear effects.

4.4.1.4 Effects in cultured cells

In some studies effects have been observed in cultured cells exposed to magnetic fields generally above 1 tesla. WHO concludes that "Taken together, the in vitro experiments do not present a clear picture of specific effects of static magnetic fields, and they consequently also do not indicate possible adverse health effects."²

4.4.2 Static magnetic fields – long term effects

4.4.2.1 Effects in humans

Studies on effects of long term exposures to static magnetic fields have been carried out almost exclusively on populations of workers exposed to such fields generated by equipment using large DC currents. Exposure was generally to static magnetic fields of up to several tens of millitesla and included welders, aluminium smelters, or workers in various industrial plants using large electrolytic cells in chemical separation processes. However, with such work it is also likely that workers were exposed to a variety of potentially hazardous substances. Moreover, the DC currents in such industrial environments are often produced by rectified power supplies, which results in the presence also of low frequency fields. This makes the interpretation of the data difficult.

Although in some of these studies increased risks of various cancers, e.g. lung cancer, pancreatic cancer, and haematological malignancies, were reported, the results were not consistent across studies. Assessment of the actual exposure has been poor, exposure to other agents may have confounded the results and the number of participants in some of the studies has been very small.

The available scientific evidence does not allow to draw any firm conclusions with regard to chronic and delayed effects of exposure to static magnetic fields. IARC concluded therefore that there was "inadequate evidence in humans" for the carcinogenicity of these fields, and that no relevant data were available from experimental animals.¹ Therefore at present their carcinogenicity to humans is not classifiable.

4.4.3 Conclusions on biological and adverse health effects

It seems from the available data on acute and long term effects that if any effects occur at all, this is at field strengths in the millitesla range or higher. It is highly unlikely that field strengths in the microtesla range may lead to effects.

5 Health risk assessment of HVDC cables

It is important to make a distinction between biological and adverse health effects. A biological effect is any response of a biological system to a physical, chemical or biological factor. Organisms such as humans are continuously challenged by many of such factors, and have a large capacity of compensating their influences. Only when these compensatory mechanisms are insufficient and the induced effect is potentially damaging, an adverse health effect may develop.

As indicated in the previous chapter, there are only indications of biological effects, either acute or long term, for exposures in at least the millitesla range. No adverse health effects have been scientifically established, not even with exposures up to several tesla.

The static magnetic fields that the HVDC cable will generate under worst case conditions is 43 microtesla at surface level and 13 microtesla at 1 meter above the surface of the ground. This is crudely a factor 1000 less than the (millitesla) level at which in some studies biological effects have been observed. Again, adverse health effects resulting from exposure to these levels have not been scientifically established.

Life on earth has developed in the presence of the geomagnetic field and historical data show long term variations in strength and polarity over time. Currently the geomagnetic field varies in strength with latitude: the lowest fields of approximately 30 microtesla are found at the equator and the highest ones of some 70 microtesla are located at the Poles.¹ The earth's geomagnetic field is 49 microtesla in Ireland.

Everybody in Ireland and the rest of the world has been continually exposed to the geomagnetic field throughout his or her lifetime. There are no indications at all that such exposure may lead to adverse health effects. Indeed it has to be assumed that all living organisms on earth, including humans, are perfectly well adapted to functioning in this static magnetic field.

Under worst case conditions the HVDC cable will add a level of less than that of the geomagnetic field in Ireland to the exposure. In practice this may be considerably less, while specific orientations of the cable may also result in counteracting the geomagnetic field and therefore to a reduction in overall exposure. (A static magnetic field not only has a field strength but also a direction; fields that run in opposite directions will cancel each other out.)

An absolute guarantee that the HVDC-induced exposure to static fields is safe cannot be given. This is impossible, since it is fundamentally not possible to demonstrate the absence of any effect under all conceivable circumstances. However, from current scientific knowledge there are no indications that exposure to the static magnetic fields generated by the HVDC cable will in any way adversely affect human health, neither through acute nor through long term effects. The risk associated with this exposure can be considered to be as close to zero as possible.

¹ en.wikipedia.org/wiki/Earth's_magnetic_field

6 ICNIRP

In this chapter a clarification is provided on the role of the International Commission on Non-Ionizing Radiation Protection (ICNIRP) in relation to the establishment of guideline limits for electromagnetic field exposure for different technologies and an explanation of the ICNIRP static fields limits is given.

6.1 *What is ICNIRP?*

The International Commission on Non-Ionizing Radiation Protection (ICNIRP) is a body of independent scientific experts in the disciplines necessary for non-ionizing radiation protection.^m The Commission members are elected on the basis of their own expertise. They do not represent either their countries of origin or their institutes nor can they be employed by industry. The scientific expertise of ICNIRP includes medicine, dermatology, ophthalmology, epidemiology, biology, photobiology, physiology, physics, electrical engineering and dosimetry. ICNIRP's Main Commission members are elected by the Commission under the rules of its Charter.ⁿ

ICNIRP is officially recognised by the WHO and the International Labour Organization (ILO) as the international independent advisory body for non-ionizing radiation protection. ICNIRP also collaborates with the European Commission, principally DG SANCO (Health), with the European Society for Skin Cancer Prevention, EUROSkin, the International Commission on Illumination (CIE), the International Commission for Occupational Hygiene (ICOH), the European BioElectromagnetics Association (EBEA), COST action BM0704 and others.

6.2 *Process of setting exposure guidelines*

ICNIRP bases its exposure guidelines on an evaluation of the scientific literature. In the past decade, the setting of guidelines for exposure to electromagnetic fields by ICNIRP has been the last part in a chain of events. This starts with an evaluation of the carcinogenicity of a specific frequency range of electromagnetic fields by IARC. The next step is a full health risk assessment by WHO, that also includes all other health effects that have been investigated. This state-of-the-art review is then used by ICNIRP, if necessary with even more recent scientific data, for setting exposure guidelines.

The first draft of the guidelines may be prepared by one of the Standing Committees of ICNIRP, or by an ad hoc Working Group, as has been the case with the most recent static fields guidelines. The draft is then discussed by the Main Commission and a first complete version is opened for comments by interested parties. These comments are again discussed by the Main Commission, and a final version of the guidelines is elaborated. This is then published in a scientific journal and on the ICNIRP's website.

The ICNIRP electromagnetic fields exposure guidelines formed the basis for the recommendation of exposure limits for the general public by the Council of the European Union issued in 1999⁸, and for the European directive with exposure limits for workers issued in 2004.⁹ The ICNIRP guidelines have been adopted by many countries around the world.

^m www.icnirp.de/what.htm

ⁿ www.icnirp.de/documents/charter.pdf

6.3 ICNIRP's static magnetic fields guidelines

The first guidelines on exposure to static magnetic fields were published by ICNIRP in 1994.³ Only limited data on biological effects of these fields was available at that time. ICNIRP considered that this data showed that transient exposure up to 2 tesla and continuous exposure up to 200 millitesla did not result in any adverse effects. These values were therefore proposed as occupational exposure limits. For the general public a maximum value of 40 millitesla for continuous exposure was proposed, without the ceiling value for short term exposures that was suggested for occupational situations. ICNIRP also recommended that, to prevent interference of the static magnetic fields with electronic devices, locations with field strengths higher than 0.5 millitesla should be posted with appropriate warning signs. In addition ICNIRP recommended that persons with cardiac pacemakers should be discouraged from entering in an environment where the pacemaker could be exposed to field strengths higher than 0.5 millitesla.

Following the publication of the IARC review on the carcinogenicity of static and low frequency fields in 2000¹, and publication of the WHO health risk assessment on static fields in 2006², ICNIRP has re-evaluated the scientific basis of its static fields guidelines and issued new recommendations in 2009.⁴ Because considerably more scientific information was available, the biological basis of the exposure limits is firmer than that of the 1994 guidelines. However, since there is still a lack of scientifically established adverse health effects, even for transient exposures up to 8 tesla, the current guidelines are based, as were the previous ones, upon knowledge on the absence of effects.

ICNIRP thus considered that there are no indications for any serious health effects resulting from the acute exposure of stationary humans to static magnetic fields up to 8 tesla. ICNIRP notes, however, that such exposures can lead to potentially unpleasant sensory effects such as vertigo and transient decrements in the performance of some behavioural tasks during head or body movement. These are transient effects that do not result in any acute or long term adverse health effects.

With respect to the studies on long term effects, such as carcinogenesis, ICNIRP concludes that these do not indicate strong effects of static magnetic field exposure of the level of tens of milliteslas on the various health outcomes studied, but they would not be able to detect small to moderate effects.

ICNIRP bases its recommendations for exposure limits on acute effects only. For occupational exposure a limit of 2 tesla is proposed (this is an instantaneous value that should not be exceeded at any time; no time averaging is allowed). This will generally prevent unpleasant sensory effects when moving through the field. In special circumstances and under controlled conditions a limit of 8 tesla is acceptable; the controlled conditions primarily refer to appropriate working practices such as a low speed of movement through the field.

ICNIRP considers temporary sensory effects in principle to be acceptable, since there are no indications that they lead to any acute or long term adverse health effects. ICNIRP does note, however, that avoidance of such sensory effects will provide adequate protection against other effects of induced currents in the head and trunk such as peripheral nerve stimulation (which in itself is also not an adverse health effect, but merely an unpleasant sensation).

As was the case in the 1994 static field exposure limits, ICNIRP applies a reduction factor of 5 to the occupational exposure limit to arrive at the exposure limit for the general public. Consequently the exposure limit for the general public is 400 millitesla. Again, this is an instantaneous value that should not be exceeded at any time; no time averaging is allowed.

ICNIRP notes that there is also a need for the prevention of indirect adverse health effect resulting from the influence of static fields on implanted electronic medical devices and implants containing ferromagnetic materials, and injuries due to flying ferromagnetic objects. Therefore ICNIRP calls for practical policies to be implemented to prevent these effects. This could mean that in general a much lower exposure level, such as 0.5 millitesla, could be observed.

ICNIRP has also issued guidelines for exposure of patients in MRI. Higher exposure limits for static magnetic fields are suggested here, but these refer to medical exposures for which the balance between risk and benefits is different than for exposures in everyday life. These MRI limits have therefore no relevance to the situation with the HVDC cable.

6.4 Comparison of the HVDC fields and the ICNIRP guidelines

In worst case situation at ground level directly above the HVDC cable, the static magnetic field will be 43 microtesla. The exposure limit proposed by ICNIRP for the general public is 400 millitesla. That means that the exposure induced by the HVDC cable will be minimally a factor 9300 less than the exposure limit.

Even when compared to the lower value of 0.5 millitesla that ICNIRP suggest to prevent indirect health effects as a result of an influence on implanted electronic medical devices and implants containing ferromagnetic materials, and injuries due to flying ferromagnetic objects, the exposure induced by the HVDC cable will still be minimally a factor 11 less.

Again, absolute safety can, by definition, not be assured, but in practice this means the absence of any known risk from exposure to the static magnetic field generated by the HVDC cable.

7 References

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