Complementary directive to the LEX 1.5.1: Control of risks related to exposure to static magnetic fields and time varying electromagnetic fields in frequency range from 1 Hz to 300 GHz

1 Definition and units

Electromagnetic field (EMF) can be considered as a dynamic entity that has two components: an electric field and a magnetic field. An electric field, **E**, exerts forces on an electric charge. Its unit is Volt per meter **(V m^{-1})**. Magnetic fields can exert physical forces on electric charges, but only when such charges are in motion. A magnetic field is quantified in terms of magnetic field strength, **H**, with unit Ampere per meter **(A m^{-1})** and magnetic flux density, **B**, with unit **Tesla (T)**. The behavior of the electromagnetic field can be divided into four different parts of a loop:

- Charged particles generate electric and magnetic fields
- The fields (electric and magnetic) interact with each other
- The fields act upon particles
- The charged particles move
- Charged particles generate more electric and magnetic fields; **cycle repeats**

Time varying electromagnetic field is characterized by its **Frequency, f** (unit **Hertz, Hz**)**,** which is number of changes in intensity or direction per second.

Given above mentioned dynamic character of EMF, the intensity or strength of the EMF of a particular frequency is either given:

- in the form of electric field strength (in **V m^{-1}**) or magnetic field strength (in **A m^{-1}**)
- in the form of power flux density (given in Watts per meter square, **W m^{-2}**).

Static magnetic or electric fields are constant fields, which do not change in intensity or direction over time, therefore have frequency 0 Hz.

2 Scope

This directive applies to all accessible places where fixed or mobile scientific equipment can produce **static magnetic fields** (frequency of 0 Hz) and time varying **EMF** with frequencies from 1 Hz to 300 GHz at EPFL. EMF in the frequency range 0 - 300 GHz cannot cause ionization in biological systems, even at high field intensity, the reason why it is called **non-ionizing EMF**. Exposure to static electric fields[1] is not examined in here.
Examples of the equipment producing non-ionizing EMF at the EPFL are the following:

- magnetic resonance imaging (MRI) scanners (20 kHz – 300 GHz, 1-7 Tesla)
- nuclear magnetic resonance (NMR) instruments (60 – 1000 MHz, up to 20 Tesla)
- superconducting quantum interference devices (SQUID) (20 kHz – 300 GHz)
- induction-based heating furnaces (50 Hz, 400 kHz)
- power transformers (50 Hz, 400 Hz)
- microwave cavities (850 – 9000 MHz)
- gyrotrons (e.g. 82.7 GHz)
- telecommunication systems (3 kHz – 3 GHz)
- etc.

Wireless communication devices (mobile and landline phones, Wi-Fi etc.), computers or other IT equipment, audio and visual equipment, microwave ovens, electrical supply at work place, electric fans and heaters and alarm systems are **excluded** from this directive.

The main objectives of this directive are the following:

- To establish the guidelines for users of non-ionizing EMF and EPFL central services.
- To ensure protection against non-ionizing EMF of every person present at EPFL: EMF users and other personnel around the experiment, maintenance or cleaning staff, student and visitor.

2.1 Compliance

This directive is in accordance with the following Swiss and EU ordinances and directives:

- Valeurs limites aux postes de travail, SUVA (2021) [1].
- Ordonnance du Département Fédéral de l'économie, de la formation et de la recherche sur les activités dangereuses ou pénibles en cas de grossesse et de maternité, DEFR (2015) [2].
- Ordonnance sur la protection contre le rayonnement non ionisant, OFEV (2022) [3]
- European parliament directive on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents, European Parliament and Council (2013/35/EU) [4].

All documents cited above are in accordance with the two publications of the **International Commission on Non-ionizing Radiation Protection (ICNIRP)**:

- Guidelines for limiting exposure to static magnetic fields, 2009 [5]

[1] Static electric fields do not penetrate the human body because of its high conductivity. The electric field induces a surface electric charge, which, if sufficiently large, may be perceived through its interaction with body hair and through other phenomena such as spark discharges (microshocks).

- Guidelines for limiting exposure to time-varying electric, magnetic and electromagnetic fields (up to 300 GHz), 1998 [6].

ICNIRP is an internationally recognized body that sets the guidelines for the protection against adverse health effects for non-ionizing radiation.

Important note: In 2010, ICNIRP has published an update of the Guidelines [6] for frequencies between 1 Hz and 100 kHz [7] and in March 2020 an update for frequencies between 100 kHz and 300 GHz [8]. In the moment of publishing the current EPFL directive, Swiss regulatory documents were not updated to reflect the ICNIRP Guidelines [7] and [8]. All dispensation from the present directive must be approved by the EPFL DSE-OHS[2] (Occupational Health and Safety).

3 EFFECTS OF NON-IONIZING EMF ON HUMAN

3.1 Direct effects

The human body can not directly detect the non-ionizing EMF. However, there are three established basic coupling mechanisms through which non-ionizing time-varying electric and magnetic fields interact directly with living matter:

- coupling to low-frequency electric fields (flow of electric charges - electric current, the polarization of bound charge (formation of electric dipoles), and the reorientation of electric dipoles already present in tissue.
- coupling to low-frequency magnetic fields (induced electric fields and circulating electric currents).
- absorption of energy from electromagnetic fields (exposure to electromagnetic fields at frequencies above about 100 kHz can lead to significant absorption of energy and temperature increases in the tissues).

3.2 Indirect effects

Besides the direct effects, non-ionizing EMF can also provoke indirect effects, as described below.

3.2.1 Sensory effects (nausea, vertigo, metallic taste in the mouth, retinal phosphenes, minor transient modifications of some cerebral functions).

3.2.2 Induced contact currents, sparks

The result of a physical contact (touching or brushing) between a person and a metallic structure in the field is the flow of electric charge (contact current) that may have accumulated on the object or on the body of the person. Threshold values for these effects are frequency dependent, with the lowest threshold occurring at frequencies between 10 and 100 Hz. Spark discharges can occur when an individual comes into very close proximity with an object at a different electric potential, without actually touching it. Besides, fires and explosions can result from ignition of flammable materials by sparks caused by induced fields, contact currents, or spark discharges.

[2] go.epfl.ch/support-ohs

3.2.3 Risks of ferromagnetic objects becoming projectiles (ballistic risks)

Loose ferromagnetic object can become projectile in the vicinity of a strong magnet, with possibility to hit/ injure personnel on its way. According to [9] and [10], the threshold value for attracting ferromagnetic objects by a static magnetic field (> 100 mT) was set to **3 mT.**

3.2.4 Interference with medical devices (MD)

The term medical device (MD) covers: active implanted medical devices (AIMD), passive implanted medical devices (PIMD) or body worn medical devices (BWMD). The list of examples of MD is given in Appendix 1: Workers at particular risk, list and examples

As EMF cover all frequencies up to 300 GHz and there is a large variety of MD, it is not possible to give a general threshold value up to which a MD will not be affected. According to [5], the operation of MD is not adversely affected by static magnetic fields below 0.5 mT. Nevertheless, in case of occupation exposure, a specific analysis for each individual MD must be made according to the SN EN 50527-1,2 [11].

4 Occupational exposure limit values (ELV)

Occupational Exposure Limits Values (ELV) are the quantitative values of a physical agent, that in the current state of knowledge, does not endanger the health of the vast majority of healthy employees who are (chronically) exposed to it. The ELVs for non-ionizing EMF are defined for the unoccupied[3] work place and are given in the Appendix 2 : Occupational exposure limit values, Table 4.

4.1 General public exposure limit values

The general public comprises entire population - individuals of all ages and of varying health status, and may include particularly susceptible groups or individuals. In many cases, members of the public are unaware of their exposure to EMF. Moreover, individual members of the public cannot reasonably be expected to take precautions to minimize or avoid exposure. These considerations underlie the adoption of more stringent exposure restrictions for the public than for the occupationally exposed population. General public ELV are given in Appendix 3: Exposure limit values for general public and pregnant workers.

4.2 Exposure limit values for the pregnant workers

Strategy of ICNIRP for establishing limits for pregnant workers is based on considering fetus as general public. This approach is equally adopted by the Swiss 'Ordonnance du DEFR sur les activités dangereuses ou pénibles en cas de grossesse et de maternité' [2]. Therefore, exposure limit values for pregnant workers correspond to the limits applied to general public and are given in Appendix 3: Exposure limit values for general public and pregnant workers.

[3] Because the presence of a person strongly modifies the strength of the electric field.

4.3 Exposure limit values for multiple frequencies

Exposure limit values given in Appendix 2 and Appendix 3 correspond to a single frequency. If there is more than one frequency, emissions must be determined for each of them and summation rules [3] as given in Appendix 4. Summation rules for the presence of multiple frequencies must be applied. Limit values for the sums must not exceed value 1.

4.4 Exposure limits set at EPFL

The exposure limits for EMF at EPFL are set as illustrated in the Figure 1 and described below:

- Occupational ELV are applied to those individuals who are exposed to EMF as a result of performing their regular or assigned job activities at the EPFL.
- As respecting occupational ELV will not sufficiently protect workers at particular risk (wearers of MD), they are subject to a medical surveillance.
- General public ELV are applied to pregnant workers.
- ELV of 0.5 mT is applied to general public for the static magnetic fields and f ≤ 10 Hz.
- General public ELV for the alternative fields with f > 10 Hz are applied to general public (students, visitors, technical, cleaning staff…). Additional warning is set for general public at particular risk (e.g. the wearers of MD).

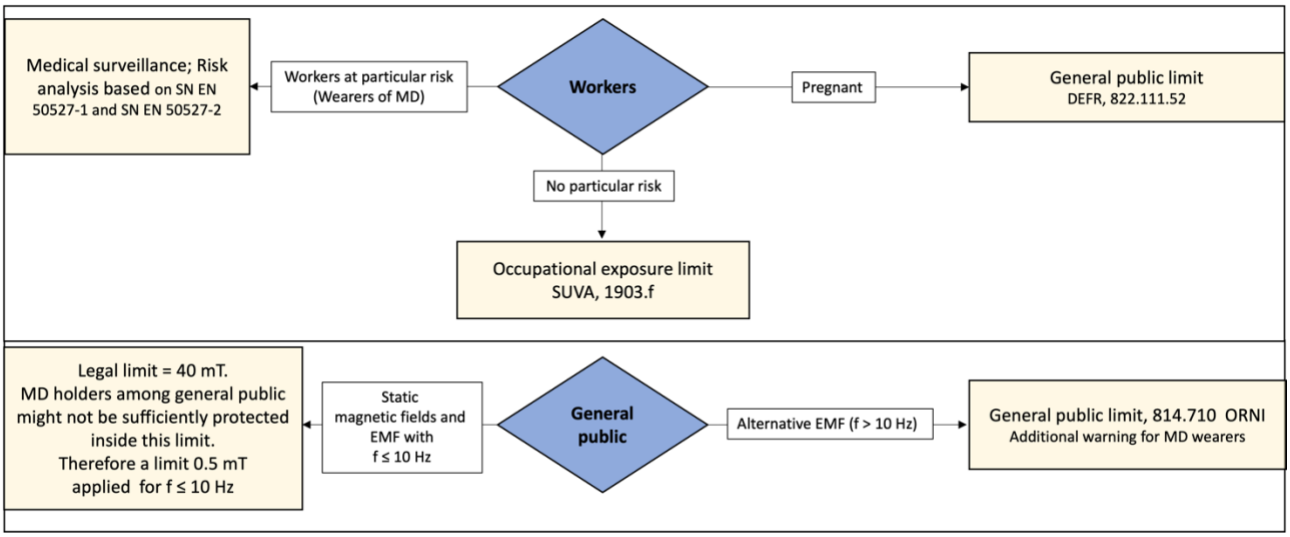

FIGURE 1. ILLUSTRATION OF THE EXPOSURE LIMITS APPLIED AT THE EPFL. THE STRATEGY IN ENSURING RESPECT OF THE LIMITS IS DESCRIBED BELOW IN THE PARAGRAPH 5.

5 Risk evaluation and safety measures

5.1 Safety measures provided by the DSE-OHS

5.1.1 Measurement, inventory and marking of the static magnetic field's lines

a. At the EPFL, the EMF of all instruments as defined in the **Scope** above will be measured by DSE-OHS or evaluated using numerical simulation, technical data or user manual provided by the

manufacturer. The instruments must be set to (or assumed producing) maximum field emission during the evaluation.

b. Based on the measurement and evaluation, the DSE-OHS makes the instrument field cartography.
c. DSE-OHS keeps the inventory of all instruments and their cartography.

5.1.2 Technical and organizational protective measures

Following EMF inventory and cartography, DSE-OHS will undertake technical and organizational measures as below:

a. If occupational ELV values (Appendix 2) can be exceeded, one or more of the following will be put in place to reduce the exposure (below the ELV):
   - instrument shielding
   - modification of instrument in agreement with the constructor (integrated shielding)
   - reduction of emission
   - isolation of work zone (use of interlocks, access restriction and control)
b. The choice of risk reduction measures will depend on the instrument/ situation.
c. The cartography made by DSE-OHS is transmitted to DSE-EXPL for the placement of the field marking stripes on the laboratory floor. The values of magnetic flux density of the static fields that are indicated on the floor, and corresponding safety measures and access restrictions are given in the Table 1.
d. Non-static fields are also measured and evaluated in reference to occupational and general public ELVs. As each instrument has its own emission frequency, the ELVs depend on this frequency. The stripes will be placed as indicated in the Table 2.
e. ELV are designed to protect workers from the direct thermal effect of high frequency fields and the discomfort caused by static and low frequency. Due to contact with large metallic structures, unpleasant sensations may be perceived. In such cases, OHS will advise, by selective earthing or by insulation of these structures, a reduction in the contact current (I_{cont}) sufficient to make these unpleasant effects disappear. This is decided based on case by case analysis. Limit values for the contact current in function of field frequency are given in the Table 3. They concern occupational exposure. Values for general public are halved (safety factor of 2) [3].

TABLE 1. *THE ZONES WITH MAGNETIC FLUX DENSITY VALUES FOR STATIC FIELDS AND F<10 HZ, DESRIPTION OF LIMITS AND SELECTED SAFETY MEASURES.*

ELV value and description	Description/ Safety measure	Access forbidden to
0.5 mT value used for static magnetic fields and EMF with f ≳ 10Hz Maximum value authorized for holders of medical devices (MD) 	- The field indicated on the laboratory door panel or with a chain if it is not a closed space. - Indicated by a yellow stripe on the laboratory floor - Staff training mandatory if yellow line is outside the instrument itself, or can be accessed during the experiment in normal use. - Controlled access and special management of laboratory cleaning if yellow line ≲ 50 cm from the instrument itself.	- No access to general public behind yellow stripe on the floor or zone delimited by the chain - No access for the holders of MD 
3 mT	- Possible attraction of small ferromagnetic objects by the field, they can become projectiles.	- Any ferromagnetic objects
2 T Occupational ELV	- Access restriction - Indicated on the laboratory door panel - Indicated by the red stripe on the floor - Training, information - Health surveillance	- Only trained and authorised personel can access, forbidden to all remaining staff.
Above occupational ELV	- Interlock, access restriction - Warning, information of employees	- All personnel

TABLE 2. *THE ZONES WITH EMF AS INDICATED ON THE LABORATORY FLOOR, DESCRIPTION OF LIMITS AND SELECTED SAFETY MEASURES.*

ELV value and description	Description/ Safety measure	Access forbidden to
General public ELV used for EMF > 10 Hz The values will depend on the instrument emission frequency. 	- Indicated by a yellow stripe on the laboratory floor - Indicated on the laboratory door panel or with a chain if it is not a closed space. - Staff training mandatory if yellow line is outside the instrument itself, or can be accessed during the experiment in normal use. - Controlled access and special management of laboratory cleaning if yellow line ≥ 50 cm from the instrument itself.	- No access to general public behind yellow stripe on the floor or zone delimited by the chain - No access to the holders of MD 
Occupational ELV Value will depend on the instrument emission frequency.	- Access restriction - Indicated on the laboratory door panel - Indicated by the red stripe on the floor - Staff training, information - Health surveillance	- Only trained and authorised personel can access, forbidden to all remaining staff.
Above occupational ELV	- Interlock, access restriction - Warning, information of employees	- All personnel.

TABLE 3. LIMIT VALUE FOR THE INTENSITY OF CONTACT CURRENT FOR OCCUPATIONAL EXPOSURE AND GENERAL PUBLIC. FREQUENCY F FOR THE **2.5 – 100 KHZ** RANGE IN THE TABLE IS TO BE EXPRESSED IN MHZ.

Frequency	Limit value for effective value of current intensity (mA) (occupational setting)	Limit value for effective value of current intensity (mA) for general public
< 2.5 kHz	1	0.5
2.5 – 100 kHz	0.4 f	0.2 f
0.1-110 MHz	40	20

5.1.3 Information and Training

DSE-OHS provides the training on EMF hazards, as following:

Online training. This is a *mandatory training* for all employees fulfilling the criteria given in the Table 1 and Table 2 and must be completed in the first 2-4 weeks of work. The training will include:

- details of possible health, sensory and indirect effects and what to do if these are experienced.
- an explanation on ELV
- details of safe working practices to adopt to eliminate or reduce the risks.
- explanation on safety signage used.
- information for employees at particular risk such as pregnant women and wearers of MD.

The link to the online training is available at this address: https://go.epfl.ch/magnets-hazards, user training tab.

Complementary classroom training on EMF hazards: this training can be organized upon request, **go.epfl.ch/support-ohs.**

5.2 Safety measures organized by the group/ personnel working with the EMF

5.2.1 Instrument registration

The DSE-OHS owns a database of existing instruments (as defined in the Scope above) at EPFL. When a new such instrument is acquired by the research group, a registration form must be completed and sent to DSE-OHS. Besides, any modification of the apparatus implying a change of the emitted EMF or change of place etc. has to be reported to the DSE-OHS. To register an instrument or notify on the change, the user opens a safety ticket: go.epfl.ch/support-ohs.
After receiving the safety ticket, DSE-OHS sends to the user the registration form to fill in. The form is illustrated in the Appendix 5: THE REGISTRATION FORM FOR A NEW MAGNET OR EMF EMITTER.
The purpose of the registration is twofold:

- DSE-OHS team will help for planning the most adequate place for the instrument installation (e.g. ensure the field lines do not extend into office or common spaces).
- DSE-OHS is responsible for enforcing present directive and controlling that the ELV are respected and safety measures put in place for each new installation.

5.2.2 Other safety measures organized by the research group

a. For each instrument, indicate the presence of EMF on the door safety panel, as specified in the Table 1 and Table 2.
b. Follow the online training and/or complementary classroom training.
c. Respect the markings/ indicated limits.
d. Do not bring ferromagnetic tools and other objects that could be attracted to the sources of EMF.
e. Announce any problem or ask a question by sending a request for support: go.epfl.ch/support-OHS
f. Require medical visit/ risk evaluation if criteria in: **Health surveillance** below are satisfied.
g. Report any undesired or unexpected health effect while working with the EMF to: sante@epfl.ch.

5.3 Health surveillance

a. Health surveillance is mandatory for the following cases:
   - all employees working inside the zone delimited by a red stripe as defined in Table 1 and Table 2.
   - all employees bearing a MD (see Appendix 1: Workers at particular risk, list and examples) that will be **working** with or in vicinity of an instrument as defined in the Scope.
b. If one of the above criteria is met, send an email to: sante@epfl.ch to register for medical surveillance.
c. The OHS service will get in touch with the employee and organize a medical checkup and a workplace visit whose goal is to make a risk analysis and implement risk control. Pending risk analysis, the exposure must be avoided.
d. The possibility of interaction of MD with EMF will depend on: frequency content of the emitter, modulation format, power of the signal, proximity to the device, coupling factors and duration of exposure.

e. Risk analysis will therefore require to get the information on the device implanted/ worn from the manufacturer and health professional who completed the medical procedure. The analysis is done according to the SN EN 50527-1 and 2 [11].
f. If MD is susceptible to electromagnetic interference, the activity of the employee will be re-organized to avoid any exposure to hazardous fields values.

5.4 Respecting the Occupational Exposure Limit Values for the pregnant workers

The ELV for pregnant workers are given in Appendix 3. In order to make sure ELV are respected for expecting mothers working with EMF, it is strictly necessary to announce the pregnancy immediately. This is done using the following link[4]: https://www.epfl.ch/campus/security-safety/en/health/health-at-work/maternity/

Following the pregnancy announcement, the OHS will visit work place, measure the EMF at the workplace and take actions to control/ limit the risk by ensuring that the ELV is not exceeded for the person concerned.

5.5 Laboratory cleaning

All laboratories containing EMF and with controlled/ restricted access (See Table 1 and Table 2) have to be cleaned by the trained personnel only. The training/ information is provided by the DSE-OHS.

5.6 Instructions regarding maintenance and intervention

Maintenance team: Respect the signs postings and restrictions (especially medical devices wearers!), do not bring any ferromagnetic tools in the vicinity of EMF instruments.

Intervention team: respect signposting and restrictions. Do not bring *any* firefighting equipment, such as metallic fire extinguishers, hoses, halligan bars, axes, and portable radios, into the room containing magnetic field.

Extinguishing small fires must be done using nonmagnetic fire extinguishers. if the fire is larger and requires more extinguishers or a fire hose, quenching the MRI magnet will be necessary. The intervention team therefore must be familiar with the locations of MRI instruments, their magnetic fields lines and quench button.

[4] Pregnancy announcement is confidential.

6 Appendix

APPENDIX 1: Workers at particular risk, list and examples

Workers at particular risk	Examples
Workers wearing Active Implanted Medical Devices (AIMD)	Cardiac pacemakers, implantable cardiac defibrillators, cochlea implants, brain stem implants, inner ear prostheses, neuro-stimulators, retinal encoders, implanted drug infusion pumps.
Workers wearing Passive Implanted Medical devices containing metal (PIMD)	Artificial joints, pins, plates or screws, surgical staples and clips, stents, heart valve prostheses, annuloplasty rings, metallic contraceptive implants.
Workers wearing Active Body-worn Medical Devices (BWMD)	Insulin pumps, hormone infusion pumps, hearing aids, Continuous Glucose Monitoring Systems.

APPENDIX 2 : Occupational exposure limit values

TABLE 4. OCCUPATIONAL EXPOSURE LIMIT VALUES FOR STATIC MAGNETIC FIELDS AND SOME CHOSEN (SINGLE) FREQUENCIES OF EMF **[6]**. FREQUENCY IN CALCULATION MUST BE EXPRESSED IN THE UNIT IN THE FIRST COLUMN. FOR FREQUENCIES BETWEEN 100 KHZ AND 10 GHZ, P^2, E^2 , H^2 , AND B^2 ARE TO BE AVERAGED OVER ANY 6-MIN PERIOD. FOR FREQUENCIES EXCEEDING 10 MHZ, IT IS SUGGESTED THAT THE PEAK EQUIVALENT PLANE WAVE POWER DENSITY, AS AVERAGED OVER THE PULSE WIDTH, DOES NOT EXCEED 1,000 TIMES THE P RESTRICTIONS, OR THAT THE FIELD STRENGTH DOES NOT EXCEED 32 TIMES THE FIELD STRENGTH EXPOSURE LEVELS GIVEN IN THE TABLE. FOR FREQUENCIES EXCEEDING 10 GHZ, P^2, E^2, H^2 , AND B^2 ARE TO BE AVERAGED OVER ANY $68/F^{1.05}$ MIN PERIOD (F IN GHZ).

Occupational exposure limits				
Static magnetic fields, f = 0 Hz and up to 1 Hz				
Exposure limit characteristics			**Magnetic flux density**	
Head and trunk			2 T	
Limbs			8 T	
EMF for frequency > 1 Hz (effective values)				
f (Hz)	**$E_{G,f}$ (V/m)**	**$H_{G,f}$ (A/m)**	**$B_{G,f}$ (μT)**	**$P_{G,f}$ (W/m²) Equivalent plane wave power density**
1-8 Hz	20 000	$1.63\times10^5/f^2$	$2\times10^5/f^2$	Not applicable for this frequency
8-25 Hz	20 000	$2\times10^4/f$	$2.5\times10^4/f$	Not applicable
F (kHz)	**$E_{G,f}$ (V/m)**	**$H_{G,f}$ (A/m)**	**$B_{G,f}$ (μT)**	**$P_{G,f}$ (W/m²)**
0.025-0.82	500/f	20/f	25/f	Not applicable
0.82-65	610	24.4	30.7	Not applicable
f (MHz)	**$E_{G,f}$ (V/m)**	**$H_{G,f}$ (A/m)**	**$B_{G,f}$ (μT)**	**$P_{G,f}$ (W/m²)**
0.065-1	610	1.6/f	2.0/f	Not applicable
1-10	610/f	1.6/f	2.0/f	Not applicable
10-400	61	0.61	0.2	10
400-2000	$3f^{1/2}$	$0.008f^{1/2}$	$0.01f^{1/2}$	f/40
f (GHz)	**$E_{G,f}$ (V/m)**	**$H_{G,f}$ (A/m)**	**$B_{G,f}$ (μT)**	**$P_{G,f}$ (W/m²)**
2-300	137	0.36	0.45	50

APPENDIX 3: Exposure limit values for general public and pregnant workers

TABLE 5. ELV FOR GENERAL PUBLIC. THE SAME VALUES ARE APPLIED TO PREGNANT WORKERS. (*): THE HIGHEST EFFECTIVE (RMS) VALUE IS DECISIVE. IT MUST NOT UNDER ANY CIRCUMSTANCES BE EXCEEDED. FREQUENCY F IN FORMULAS EXPRESSED IN THE UNIT OF THE FIRST COLUMN.

f (Hz)	$E_{G,f}$ (V/m)	$H_{G,f}$ (A/m)	$B_{G,f}$ (μT)	Measurement time (minutes)
Static fields, 0 Hz and up to 1 Hz				
< 1Hz	-	32 000	40 000	(*)
Frequencies 1-100 kHz				
1-8 Hz	10 000	$32\,000/f^2$	$40\,000/f^2$	(*)
8-25 Hz	10 000	4000/f	5000/f	(*)
0.025-0.8 kHz	250/f	4/f	5/f	(*)
0.8-3 kHz	250/f	5	6.25	(*)
3-100 kHz	87	5	6.25	(*)
Frequencies > 100 kHz				
100-150 kHz	87	5	6.25	6
0.15-1 MHz	87	0.73/f	0.92/f	6
1-10 MHz	$87/\sqrt{f}$	0.73/f	0.92/f	6
10-400 MHz	28	0.073	0.092	6
400-2000 MHz	$1.375\ \sqrt{f}$	$0.0037\ \sqrt{f}$	$0.0046\ \sqrt{f}$	6
2-10 GHz	61	0.16	0.20	6
10-300 GHz	61	0.16	0.20	$68/f^{1.05}$

TABLE 6. ELV for pulsed EMF for general public. The same values are applied to pregnant workers. besides the values in the Table 5, the emission limit values below apply to pulsed immissions relating to the effective value of the electric field intensity, the magnetic field intensity and the magnetic flux density. f in MHz.

ELV for the effective value				
f (Hz)	**$E_{P,f}$ (V/m)**	**$H_{P,f}$ (A/m)**	**$B_{P,f}$ (µT)**	**Measurement time (minutes)**
10-400 MHz	900	2.3	2.9	Pulse duration
400 – 2000 MHz	$44\sqrt{f}$	$0.12\sqrt{f}$	$0.15\sqrt{f}$	Pulse duration
2-300 GHz	1950	5.1	6.4	Pulse duration

APPENDIX 4. Summation rules for the presence of multiple frequencies

TABLE 7. Summation rules for the presence of multiple frequencies. If there are several frequencies, the emissions are determined separately for each frequency. The emissions thus determined are weighted by a frequency-dependent factor and summed according to the table below. The emission limit value is less or equal to 1 for each sum calculated according to the table.

Frequency range	Physical quantity	Summation instruction	Duration of the appreciation
1Hz-10 MHz	Intensity of electrical field	$\sum_{1Hz}^{1MHz} \frac{E_f}{E_{G,f}} + \sum_{>1MHz}^{10MHz} \frac{E_f}{87}$	The highest effective value is decisive
	Intensity of magnetic field	$\sum_{1Hz}^{65kHz} \frac{H_f}{H_{G,f}} + \sum_{>65kHz}^{10MHz} \frac{H_f}{5}$	The highest effective value is decisive
	Magnetic flux density	$\sum_{1Hz}^{65kHz} \frac{B_f}{B_{G,f}} + \sum_{>65kHz}^{10MHz} \frac{B_f}{6.25}$	The highest effective value is decisive
100 KHZ-300 GHZ	Intensity of electrical field	$\sqrt{\sum_{100kHz}^{1MHz} \left(\frac{E_f}{87}\right)^2 \cdot f + \sum_{>1MHz}^{300GHz} \left(\frac{E_f}{E_{G,f}}\right)^2}$	6 minutes
	Intensity of magnetic field	$\sqrt{\sum_{100kHz}^{1MHz} \left(\frac{H_f}{0.73}\right)^2 \cdot f^2 + \sum_{>1MHz}^{300GHz} \left(\frac{H_f}{H_{G,f}}\right)^2}$	6 minutes
	Magnetic flux density	$\sqrt{\sum_{100kHz}^{1MHz} \left(\frac{B_f}{0.92}\right)^2 \cdot f^2 + \sum_{>1MHz}^{300GHz} \left(\frac{B_f}{B_{G,f}}\right)^2}$	6 minutes
Pulsed fields 100 kHz-300 GHz	Intensity of electrical field	$\sqrt{\sum_{10\,MHz}^{300\,GHz} \left(\frac{E_f}{E_{P,f}}\right)^2}$	pulse duration
	Intensity of magnetic field	$\sqrt{\sum_{10\,MHz}^{300\,GHz} \left(\frac{H_f}{H_{P,f}}\right)^2}$	pulse duration
	Magnetic flux density	$\sqrt{\sum_{10\,MHz}^{300\,GHz} \left(\frac{B_f}{B_{P,f}}\right)^2}$	pulse duration

Summation is always carried out in the frequency domain indicated on the summation symbol for all frequencies f which are present simultaneously in emissions.

Explanation of symbols:

f - frequency in MHz

$\mathbf{E_f}$ – effective (RMS) value of the electric field intensity in V / m at the frequency f

$\mathbf{E_{G,f}}$ - emission limit value for the effective value of the electric field intensity in V/m at frequency f according to Table 4 and Table 5.

$\mathbf{E_{P,f}}$ - emission limit value for the effective value of the electric field intensity in V / m at frequency f according to Table 6.

$\mathbf{H_f}$ - effective value of the magnetic field strength in A / m at the frequency f

$\mathbf{H_{G,f}}$ - emission limit value for the effective value of the magnetic field strength in A / m at frequency f according to Table 4 and Table 5.

$\mathbf{H_{P,f}}$ - emission limit value for the effective value of the magnetic field strength in A / m at frequency f according to Table 6.

$\mathbf{B_f}$ - effective value of magnetic flux density in µT at frequency f

$\mathbf{B_{G,f}}$ - emission limit value for the effective value of the magnetic flux density in µT at frequency f according to Table 4 and Table 5.

$\mathbf{B_{P,f}}$ - emission limit value for the effective value of the magnetic flux density in µT at frequency f according to Table 6

APPENDIX 5: THE REGISTRATION FORM FOR A NEW MAGNET OR EMF EMITTER

This registration form is mandatory for permanent magnet, pulsed magnet and any electromagnetic waver emitter with frequency up to 300 GHz (defined in Scope above).

Principal investigator

Name : _____ *eg. Thomas Meier*

Unit : _____ *eg. ISIC-GSST*

Phone number : _____ *eg. 31234*

Device identification

Manufacturer : _____ *eg. PowerMagnet*

Model : _____ *eg. LDM405*

Purchase date : _____ *eg. 2020.06.06*

Room number : _____ *eg. CH J2 632*

EPFL inventory number (see example): _____ *eg. B123456*

Example of EPFL inventory number

Device characteristics

Field type : ☐ Magnetic ☐ Electric ☐ Electromagnetic (below 300 GHz)

Field max strength : _____ *eg. 4 T, 4 kV/m*

Frequency(ies) : _____ *If alternative field, eg. 25 MHz*

Cryogenics : ☐ Liquid nitrogen ☐ Liquid helium

☐ Open loop cooling ☐ Closed loop cooling

Field outside device: ☐ >0.5 mT ☐ >3 mT ☐ >2 T

Field inside device: ☐ Users can access the field during normal operating condition

Remark(s) : _____

_____

Date : _____ Visa : _____

7 Bibliography

[1] Protection de la santé, Division médecine du travail, 1903.f, Valeurs limites d'exposition aux postes de travail, Luzern: SUVA, 2021.

[2] DEFR, "822.111.52, Ordonnance du DEFR sur les activités dangereuses ou pénibles en cas de grossesse et de maternité," 2015.

[3] Conseil Fédéral Suisse, "Ordonnance sur la protection contre le rayonnement non ionisant, 814.710," 2022.

[4] The European parliament and the council, "Directive 2013/35/EU of the European parliament and of the council of 26 June 2013 on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (electromagnetic fields)," 2013.

[5] International Commmission on non-ionizing radiation protection, "ICNIRP guidelines on limits of exposure to static magnetic fields," *Health Physics,* vol. 96, no. 4, pp. 504-514, 2009.

[6] ICNIRP, "ICNIRP Guidelines for limiting exposure to time-varying electric, magnetic and electromagnetic fields (up to 300 GHz)," *Health physics,* vol. 74(4), pp. 494-522, 1998.

[7] International Commission on non-ionizing radiation protection, "ICNIRP Guidelines for limiting exposure to time-varying electric and magnetic fields (1 Hz – 100 kHz)," *Health Physics,* vol. 99(6), pp. 818-836, 2010.

[8] International Comission on non-ionizing radiation protection, "ICNIRP guidelines for limiting exposure to electromagnetic fields (100 KHZ TO 300 GHZ)," *Health Physics,* vol. 118 (5), pp. 483-524, 2020.

[9] International Electrotechnical Commission, "IEC 60601-2-33, Medical electrical equipment: particular requirements for the basic safety and essential performance of magnetic resonance equipment for medical diagnosis," 2010.

[10] K. G. Jolanta Karpowicz, "Experimental evaluation of ballistic hazards in imaging diagnostic center," *Polish Journal of radiology,* vol. 2013, no. 78(2), pp. 31-37.

[11] Electro Suisse, "Procedure for the assessment of the exposure to electromagnetic fields of workers bearing active implantable medical devices," Electro Suisse, CH-8320 Fehraltorf, 2016.

[12] International Commission on Non-Ionizing Radiation Protection (ICNIRP), "ICNIRP home page," [Online]. Available: https://www.icnirp.org/en/home/index.html.