



Finnish Institute of
Occupational Health

Operating model for managing accidental overexposure to RF-fields

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FOREWORD

In Finland, general instructions on management of suspected occupational overexposure to radiofrequency fields have not been available. Also, there are no generally accepted international instructions for medical check-ups following RF overexposure.

The objective of this project was to develop an operating model for suspected cases of overexposure so as to enable the companies participating in the project to respond quickly and correctly in such cases. Another objective was to improve the entire process, including technical measures, occupational health care's instructions, medical check-ups and communication in the work community. Overexposure may occur, for example, in mast and roof work or in various testing environments.

Clear instructions help to deal systematically with unusual exposure situations throughout the whole risk management chain in workplaces, occupational health care and, if needed, specialized health care. With the instructions in place, suspected overexposure cases can be dealt with openly and documented appropriately. This ensures both the employer's and the worker's legal protection and safety and enables analysis of potential health problems. This guidance has been written for the use of Finnish occupational system, but it is also applicable in other countries by taking into account the local regulations and practices.

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CONTENTS

1. What does RF overexposure mean?	5
2. Basic information about RF radiation	5
3. Basic information about health effects from RF fields	7
4. How to act in case of overexposure	9
4.1 Immediate actions	9
4.2 Technical actions.....	10
5. Medical measures	10
6. Awareness and prevention of accidents	14
Further reading	15
Appendix 1. Initial incident report for accidental RF overexposure	16
Appendix 2. Technical report of accidental RF overexposure	18
Appendix 3. Medical check-up form for cases of accidental RF overexposure	20
Appendix 4. Limit values for occupational exposure to RF fields	22

1. WHAT DOES RF OVEREXPOSURE MEAN?

RF overexposure refers to an exceptional situation where a worker has been or is suspected of having been exposed to radiofrequency (RF) radiation exceeding the occupational exposure limits. Although the RF overexposure does not necessarily cause adverse health effects, a thorough investigation is important in order to prevent similar events in the future. This document presents an operating model for cases of accidental RF overexposure. The operating model includes basic information about RF radiation and its health effects and about the concepts of risk and hazard. In addition, the model instructs how the responsible persons in companies and in the occupational health care / the public health service should act in cases of overexposure.

2. BASIC INFORMATION ABOUT RF RADIATION

Radiofrequency radiation refers to electromagnetic fields (EMF) with frequencies between 100 kHz and 300 GHz. Specifically the frequencies between 300 MHz and 30 GHz are called microwaves. The RF electromagnetic fields and microwave radiation are used, for example, in:

- Radio and TV transmitters;
- Mobile phones and base stations;
- Radars;
- Industrial drying, heating and melting processes;
- Microwave ovens;
- Medical devices.

The EU directive on electromagnetic fields (2013/35/EU) lays down occupational exposure limits for radiofrequency fields. The directive will be transposed into EU member states legislation no later than July 1st 2016. The limit values for workers are specified in Appendix 4.

In most work environment, the transmitter antennas of radio and TV stations are the most powerful sources of RF radiation. In Finland, the highest transmit powers of LF, MF and HF antennas are about 500 kW, and those of VHF and UHF antennas are approximately 10 to 50 kW. The digital TV uses the frequencies of the VHF and UHF band, and its radiation power per multiplex is of the order 50 kW (UHF) or <5 kW (VHF). During maintenance and installation, most workers may be exposed to strong RF fields. Inside UHF antennas (TV broadcast), the exposure levels are typically over 100 W/m², and working is not allowed in the mast if the transmit power is on. Inside radio antennas, the

intensity is typically 10 to 100 W/m². The most powerful radio and TV transmitters are placed close to the top of high antenna masts, to the height of over 200 m, whereby the exposure in the ground level is negligible.

The power is reduced or shut off in masts with high-power radio and TV transmitter antennas when there are workers in the mast. In small and medium-sized masts, mostly with mobile communications antennas and low-power TV and radio transmitters, transmit powers are usually not lowered when the masts are being serviced. During installation and maintenance of telecom masts and transmitter antennas mounted on them workers may consequently work in the close vicinity of active transmitter antennas. Special attention should be paid to new digital TV transmitters, which have also been mounted on smaller mobile communications masts.

In buildings, transmitter antennas of the mobile communications network are mounted either on wall structures or on a pole placed on the roof. In both cases, the objective is that the location would allow the antenna to have optimal coverage. The only part of the transmitter antenna visible on the outside is the antenna housing, the radome, from which the transmit power is directed forwards. No transmit power is directed below or above the antenna, nor to the rear or the side. However, workers performing certain tasks may have to stay in front of a base station antenna. Such situations are encountered, for example, by firefighters, window cleaners and construction workers. The transmit powers of antennas placed in buildings are usually so low that a brief stay in front of an antenna does not yet result in overexposure. If the work lasts longer, however, it is advisable to stay at least at a safety distance of one metre from the antenna in the transmit direction.

Personal electromagnetic field meters (EMF meters)

According to the Finnish occupational safety instructions for mast workers, mast worker teams should have with them a measuring instrument for detecting RF fields. Usually such instruments are personal detectors carried, for example, inside the breast pocket. The measuring instruments are excellent in giving information about the RF fields on the site, but workers must know how to use them. It is not enough to switch the meter on and put it in the pocket: this may even give a false sense of safety and lead to hazardous situations. Workers must be instructed on the use and limitations of the meters.

Usually workers attach personal RF meters to their clothing which in some cases may impair the accuracy of measurement. The meters cannot reliably measure field intensity through the human body, so the worker's body posture in relation to the antenna plays a significant role. In mast work, the workers' distance from metal structures varies and they may be exposed to near-field radiation, with the RF fields changing strongly with the distance. The personal meters are designed for these situations, but all measurement situations involve uncertainties, which must always be taken into account. When the

meter is on the worker's chest, the reading is actually indicative of the exposure to the middle section of the body. Exposure to the head is not necessarily detected by a meter in the breast pocket. The worker should therefore hold the meter at the level of his/her head for a moment so as to make sure that the transmitters at the head level have been shut off. In practice, the meter indicates whether a transmitter is on or off, since it alerts in the transmit beam of nearly all the antennas in the mast.

In addition to mast work, personal meters can also be used at other work sites, such as on rooftops. There they are not as vital as in masts, because transmit powers are usually lower and workers need not stay in the immediate vicinity of the antennas (< 1 m) for a long periods of time.

3. BASIC INFORMATION ABOUT HEALTH EFFECTS FROM RF FIELDS

All radiation consists of either electromagnetic waves or particles. Based on the type of energy, it is divided into ionizing and non-ionizing radiation. High-energy ionizing radiation is capable of ionizing, i.e. removing electrons from the matter it hits. This may break chemical bonds in the molecules (damage DNA, for example). Examples of ionizing radiation are X-radiation and radiation from radioactive materials. When the radiation energy is not strong enough to cause ionization in the medium, it is called non-ionizing radiation (NIR). The boundary between ionizing and non-ionizing radiation lies between X-radiation and ultraviolet (UV) radiation. Non-ionizing radiation includes UV radiation, visible light, infrared (IR) and radiofrequency (RF) radiation as well as low-frequency and static electric and magnetic fields.

Strong RF fields cause increase in the local temperatures of the exposed tissue, and excessive heat load may be harmful. Until now, the only scientifically proven action mechanism of RF fields is the thermal effect. When health effects are being assessed, it is important to consider how high the temperature rise must be to result in a harmful effect on different tissues or the whole body. The harmful thermal effects from RF exposure are assessed on the basis of SAR (Specific Absorption Rate) values, which indicate the rate at which RF field energy is absorbed by mass unit of biological tissue (W/kg). When the long-term (> 30 min.) whole-body SAR value exceeds 4 W/kg, the thermal stress is harmful to the human body. Since the limit values for health effects have a 10 fold safety margin, the exposure limit for the worker's whole body is 0.4 W/kg per period of six minutes. To avoid excessive temperature rises in workers' individual organs, the local SAR value has been set to be 10 W/kg. The objective is that the elevations of local temperature should not exceed 1 °C.

As internal SAR values are difficult to determine, measurable action levels (AL) have been derived from them. The actions levels are determined as limit values for electric and magnetic fields and for power density, which are associated with internal thermal effects of exposure. When field strengths are below the action levels, no overexposure occurs. Stronger fields, however, may have harmful health effects.

In case of continuous strong whole body RF exposure, especially if there are other factors elevating body temperature (strong physical stress; hot and humid conditions), the thermoregulation might be insufficient to maintain the heat balance of the body and tissues. This may impair the performance, cause general fatigue and trigger physical symptoms. The harmful effects of RF fields also significantly depend on the person's physical condition, dehydration and clothing.

Local exposure to very strong RF fields may cause local 'hot spots', which lead to thermal superficial burns and during very strong exposure also injuries in internal organs. A thermal injury starts to develop when the tissue temperature is continuously over 41 °C lasting 30 minutes. For shorter periods, tissues tolerate even higher elevations in temperature. The central nervous system is damaged when the temperature exceeds 42–44 °C. Skin is very sensitive to changes in temperature and even an increase of 0.08 °C can be felt as a sensation of heat. A pain is reported usually after 100 fold rise (8 °C) in temperature. In addition to the central nervous system, testicles and the eye's crystalline lenses are also very sensitive to thermal injury. If the eye temperature rises to over 41 °C, a cataract may develop. The cataract clouds the lens inside the eye and obstructs the transmission of light to the bottom of the eye. Cataract is common during ageing without any injuries. In Finland, for example, approximately every third person over 65 years has a cataract impairing vision. The normal temperature of testicles is several degrees lower than the body temperature. If their temperature repeatedly rises by 3–5 °C, sperm production will be affected. The SAR level corresponding to the temperature rise is about 50 W/kg.

In addition to the above immediate health effects from exposure, long-term effects of RF fields are frequently debated. The exposure limits protecting the workers and the general public at large against overexposure have been set with only the acute effects in mind, as there exists no reliable scientific evidence of potential long-term effects. The latest scientific information and research results are being followed closely, and the recommended limit values will be updated if needed. In 2011, the International Agency for Research on Cancer (IARC) classified radiofrequency electromagnetic fields as possibly carcinogenic to humans (Group 2B). The IARC classification indicates that it has not been possible to rule out risks related to long-term RF exposure and that it is important to continue investigating the issue.

4. HOW TO ACT IN CASE OF OVEREXPOSURE

4.1 Immediate actions

RF overexposure is comparable to a common case of accident at work, except that the special characteristics of RF fields need to be taken into account.

When RF overexposure is suspected, the primary action is to get the worker away from the vicinity of the RF exposure source. In case of emergency requiring patient transfer, the general occupational safety instructions for most workers are followed.

The next step is to assess the need for first aid and immediate care. Immediate care is needed if the worker has suffered burns, has pains or his/her body temperature has risen. In practice, this kind of instant injury requiring immediate care may be generated only in the immediate vicinity of the most powerful TV and radio transmitters whose transmit power has not been lowered for the most work.

Suspected overexposure must be reported to the supervisor immediately, and the exposed worker must consult an occupational physician or – out of hours – some other physician. The employer's representative reports the suspected overexposure to the occupational health care, the occupational safety and health personnel, the ordering party and the mast holder. If there is a cause to suspect that the injury is severe, the labour protection authority must also be informed.

The supervisor tells the worker what to do (medical check-up at the occupational health care) and asks for an initial report of the accidental overexposure (Appendix 1). The exposed worker can fill in the initial report himself/herself, or the employer's representative can request the information by phone. The main thing is that the initial report is submitted as soon after the event as possible. If the exposed worker needs an occupational or other medical assessment, (s)he should give the initial report to the physician performing the check-up. All hazardous situations should be reported to the manager and to the workplace's occupational safety and health organization in order that safety could be improved.

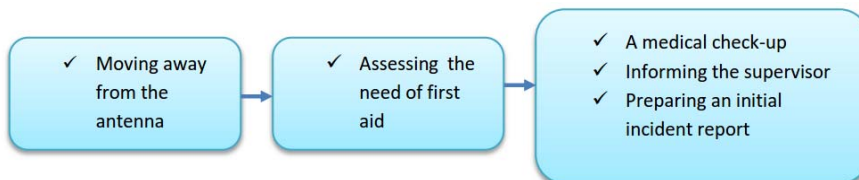


Figure 1. Immediate actions in case of overexposure

4.2 Technical actions

When accidental RF overexposure is suspected, the company's occupational safety and health organization together with the occupational health care should launch technical actions to determine the causes of the accident, the magnitude of exposure and the steps to be taken to prevent such accidents in the future, and to document the whole process. The extent of the technical actions is determined based on the severity and consequences of the suspected accident. The form enclosed as Appendix 2 may be of help when a more detailed technical assessment of the magnitude of exposure is being made.

The most important thing is to analyse the factors relevant to the exposure, such as the characteristics of the transmitter (power, frequency, etc.). Many relevant pieces of information, such as the causes of the accident and the worker's location during the exposure, may already be known based on the initial report drafted immediately after the exposure. If the magnitude of exposure cannot be assessed from the technical data, the next step can be to determine the exposure by measuring. The person measuring the exposure should have adequate knowledge of RF radiation measurements and understand the factors affecting the measurement results. All details detected should be documented and, where necessary, forwarded to those responsible for the worker's health care. The magnitude of exposure should be compared with the relevant occupational exposure limits (Appendix 4).

When the causes of the accident have been analysed, plans should be made for preventing such accidents in the future. Attention should also be paid to 'false alarms', as their prevention is also important. False alarms are often due to lack of information rather than hazardous work environments. Provision of training, communication about special circumstances and specification of the information available on the site usually leads to an improvement in the working practices.

5. MEDICAL MEASURES

RF fields increase the accumulation of thermal energy in tissue. If the body's temperature regulation mechanisms fail to balance the heat load, the tissue temperature rises and harmful health effects may appear. In case of overexposure, injury occurs on the body location that has been exposed. Therefore, it is fundamental to analyse the circumstances of the accident carefully. If needed, the situation can be modelled afterwards by photographing a worker of the same body size in similar work positions on the site of the accident. The information related to the fields can be presented based on the background information. It is often advisable to consult work environment specialists familiar with assessment of electromagnetic fields.

Overexposure to RF fields is very rare. No cumulative effects due to repeated exposure to field strengths lower than the safety limits have been detected. However, overexposure may have severe and long-term health effects, so it is important for the occupational health care to have instructions on what to do in such cases.

Symptoms, findings and examinations

A rise in tissue temperature may cause a mild superficial sensation of heat. The exposed areas of skin, however, should be checked for burns, which appear instantly upon exposure. Superficial thermal injuries are treated according to the general guidelines.

If eyes are exposed to a strong RF field, the exposure may cause an inflammation of the sclera, iris or conjunctiva. The symptoms include redness around the eyes, hard pain in the eyes, redness, sensitivity to light, and constriction of the pupil (prevents irritating light from reaching the fundus of the eye). A cataract is a rare but possible late complication. The cataract takes some weeks or months to develop. There are no reports of late effects occurring years afterwards. The examination of the eyes is in the first check-up to detect acute effects and to verify the state of the eyes for the follow up. Even without any pathological findings initially, the eyes should be examined again no later than three months after the first check-up. Consulting an ophthalmologist is often advisable.

Strong local overexposure may cause a medial compartment syndrome in the limb muscle tissue. The muscle cells are damaged, the tissue distends and becomes inflamed. Minor blood vessels may be occluded causing local hypoxia. In the worst case, permanent damage may occur. Deep changes may develop without any signs of superficial damage. The symptoms include pain, swelling, paleness in the limb and sensory loss. An ultrasound scan is useful to detect tissue damage. Magnetic resonance imaging can be performed in severe cases. Blood testing for muscle enzyme CK (creatine kinase) gives further information about the tissue damage. Common laboratory tests of inflammation should also be controlled. The medial tibial compartment syndrome requires immediate treatment. It develops instantaneously or at the latest within a few days after the exposure.

It is controversial whether RF overexposure can have direct effects on peripheral nerves. Very strong exposure, such as caused by powerful radar or military weapons, may cause disruption in nerve tissue. The symptoms of peripheral nervous system damage include tactile sensation problems, numbness and sensory loss. An electroneuromyography (ENMG) reveals the injury. There is no clear evidence of damages in central nervous system. The brain is well-protected even against local thermal effects. An accident may trigger a mental stress reaction mimicking brain damage. The symptoms of stress

reaction may include memory problems, lack of concentration, mood changes and sleep problems. The magnetic resonance imaging of the brain reveals potential tissue damage, and neuropsychological tests are often useful to assess the different aspects of symptoms after the RF overexposure. The stress reaction may also cause functional disorders of the autonomic nervous system with a wide range of symptoms: headache, sweating, vertigo, intestinal disorders. Also, the pulse rate may accelerate easily or be abnormally high all the time. Further, changes in blood pressure are common. Early, comprehensive rehabilitation prevents chronic stress symptoms and maintains functional and work ability.

Special groups

Workers with metal implants form a special group. Cardiac pacemakers, other subcutaneous devices or orthopedic implants serve as antennas boosting the RF impact on tissue and thereby increasing the risk of local damage. Also, overexposure may damage the medical device so that it no longer works properly. All this should be taken into account in the medical check-up and further analyses. For example, an EKG should be performed on a patient with a pacemaker, and if a patient has a medication pump, its operation should be checked. If necessary, medical specialists should be consulted.

Workplaces with a risk of overexposure should prepare action plans to be followed in case of accident. The occupational health care personnel must have appropriate knowledge of the actions needed (Fig. 2). When overexposure is suspected, a medical check-up should always be performed. The form enclosed as Appendix 3 may be of help in the check-up. In connection with the medical check-up, it should be ensured that investigatory actions related to the exposure have been launched. In visual examination, special attention is paid to those areas of the body that have suffered abnormal exposure. In addition to detect acute injuries, a careful primary check-up helps to assess rare but possible late effects during follow up. If signs of symptoms of local injuries are detected or deeper damages are suspected, the patient should be sent to specialized health care for immediate further examination.

Careful primary actions and documentation, discussion with the patient, systematic medical check-up also help to alleviate the stress effects of accident.

As accidental RF overexposures are rare, the occupational health care may consult local radiation experts in the early stages (The Finnish Institute of Occupational Health and/or The Radiation and Nuclear Safety Authority in Finland). All cases of overexposure – even the suspected ones – should be reported.

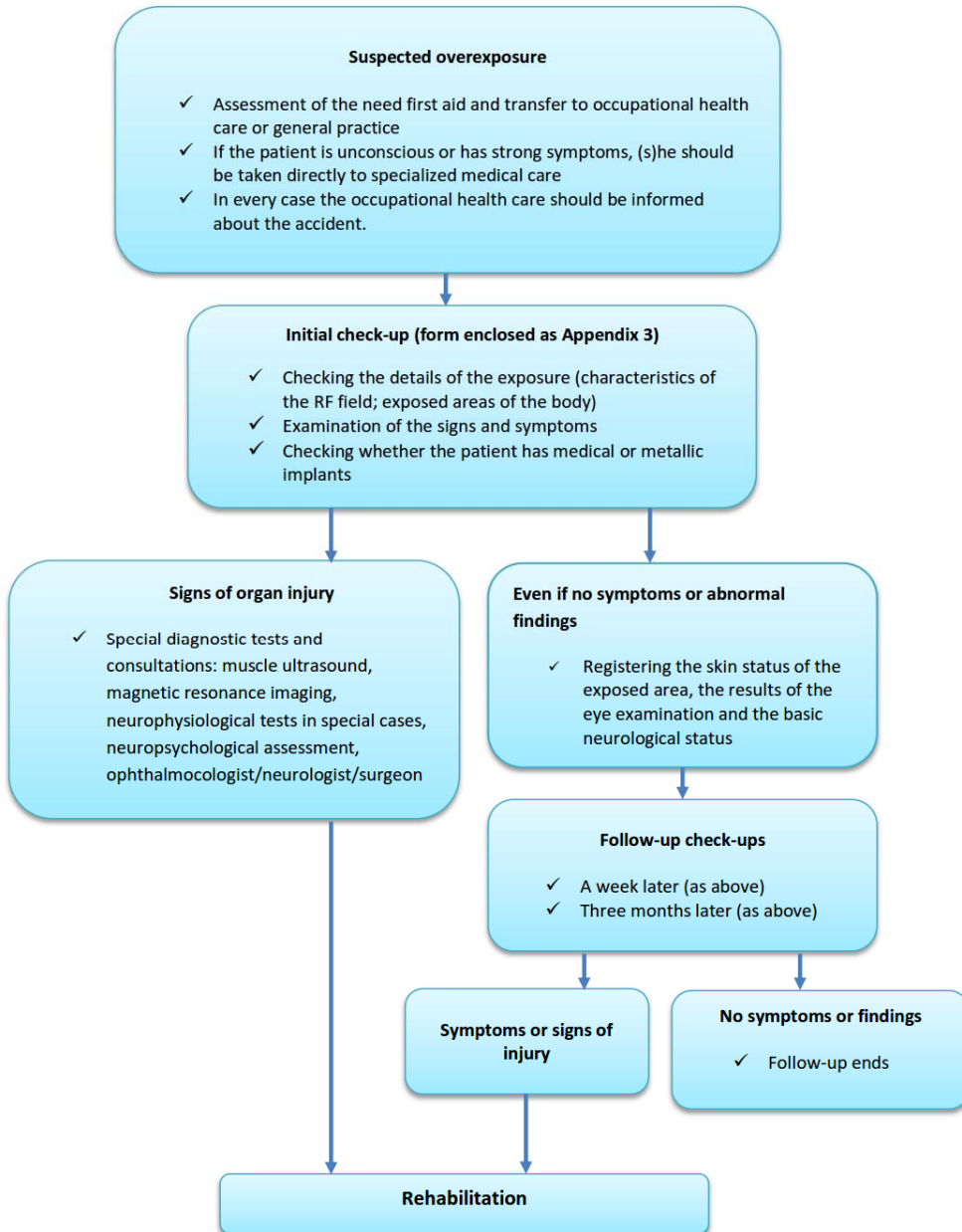


Figure 2. Health service's actions in case of RF overexposure

6. AWARENESS AND PREVENTION OF ACCIDENTS

The concepts of risk and hazard are not always clear when discussing the threats encountered in the work environment. 'Hazard' refers to a factor or circumstance that may jeopardize the worker's health. 'Risk', on the other hand, refers to the likelihood that the hazard will materialize and the worker be consequently injured. 'Risk assessment' is a process of assessing the risk posed by the hazard to the workers' health and safety. The extent of the risk is assessed in relation to the severity and likelihood, and risk management is used to intervene in situations where the risk level is unacceptable for a safe work environment. A precondition for successful management of the EMF related risks at the workplace is a good general risk management culture, in which the EMF risks form only one sub-area. Several guidebooks are available for general risk assessment and management.

Electronic and magnetic fields are not detectable by the human senses, so determining a personal risk is always based on information obtained in some other way. People value different things differently, and the sense of risk also varies with people even when the circumstances are the same. One of the foremost factors affecting the perception of risk and thereby also of hazard is how well the person knows and understands what causes the risk. An unknown threat may cause more insecurity, so increasing transparency and available information are the best ways to effect on the risk perception.

The perception of risk can also be addressed in the work environment. One of the most important things is to understand what electromagnetic fields are all about. The training on the characteristics and health effects of the RF fields enables the workers to establish a personal risk perception on the subject. On the other hand, the opportunity to control the risk personally reduces the perception of risk. Where most workers are concerned, for example, personal radiation detectors help the workers to control their personal exposure. Another example is up-to-date information available about the work sites: the information allows the workers to plan their work tasks safely.

In suspected cases of overexposure, the most important thing at all times is transparency towards the worker. The exposed worker should receive all the details of his/her accident. External specialists may also be consulted, if more support is needed. On the other hand,

it should be remembered that mild overexposure does not necessarily have harmful health effects, as the RF exposure limits have high safety factors.

The work community may be informed of the exposure according to the standard information practices. It is advisable, for example, to go through the causes of the accident and to discuss new practices intended to prevent such accidents in the future and to engage the workers in the new operating model.

FURTHER READING

Directive 2013/35/EU of the European Parliament and of the Council on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (electromagnetic fields). Official Journal of the European Union, 2013, L 179/1. Available at:

<http://eurlex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2013:179:0001:0021:FI:PDF>

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Reeves G. Review of extensive workups of 34 USAF patients overexposed to RF. *Aviat Aero Emt Med* 2000; 71: 206-215.

Working in electromagnetic fields with a cardiac pacemaker. Finnish Institute of Occupational Health. 2012. Available at:

http://www.ttl.fi/en/publications/Electronic_publications/Pages/Working_in_electromagnetic_fields.aspx

APPENDIX 1. INITIAL INCIDENT REPORT FOR ACCIDENTAL RF OVEREXPOSURE

Name of exposed worker:
Location of incident (for example, mast number and address of property):
Time (date and time of day):
Other people present:
What parts of the body were exposed; what symptoms occurred instantly; what symptoms were detected later on the site:
Were any injuries caused by overexposure detected (Yes/No): <input type="checkbox"/> Yes <input type="checkbox"/> No If yes: What kind of injuries occurred:
In what areas of the body did the injuries occur:
How have the injuries been treated: <input type="checkbox"/> No treatment <input type="checkbox"/> First aid <input type="checkbox"/> Medical check-up

The exact location where the exposure occurred:

The source of the exposing RF field:

Estimate of the RF transmitter's frequency and power:

What is the estimate based on?

Estimate of the duration of exposure:

How did the exposure occur:

Suggestion how to prevent similar accidents in future:

Initial report drafted on (date):

Report received by:

APPENDIX 2. TECHNICAL REPORT OF ACCIDENTAL RF OVEREXPOSURE

Name of exposed worker:
Location of incident (for example, mast number and address of property):
Time (date and time of day):
Description of the situation (causes, location of the person and time of exposure):
Information on the transmitter (for example, transmit frequency/band, transmit power (average and maximum), modulation features, duty factor, transmitter type and details (size, gain, bandwidth, directivity)):
Estimated extent of exposure (based on technical data) and need to carry out field measurements: <input type="checkbox"/> No overexposure <input type="checkbox"/> Not possible to conclude based on initial data <input type="checkbox"/> Probable overexposure Basis for this conclusion and further measures:

Reconstruction of the exposure and the measurement results (if necessary):

Conclusions from the consequences of the exposure:

Suggestion how to prevent recurrence:

Technical report drafted on (date):

Report drafted by:

APPENDIX 3. MEDICAL CHECK-UP FORM FOR CASES OF ACCIDENTAL RF OVEREXPOSURE

Name of physician:		Place of business:		Date of check-up:
Name of exposed worker:				
Personal identity number of exposed worker:				
Work assignment of exposed worker:				
Time and description of accident:				
Does the patient have any of the following symptoms	Yes	No	If any of the above symptoms are detected -> a more detailed description (for example, where, how strong, has the sensation changed from the time of exposure):	
Burning sensation on the skin				
Weakness, dizziness				
Headache				
Balance disorders				
Trembling				
Sweating				
Anxiety				
Visual disturbances				
Auditory disturbances				
Tactile disturbances				
Pain				
Tinnitus				
Muscle cramps				

Medical check-up

Blood pressure: mmHg

Pulse rate:

Neurological examination: normal abnormal

Balance test (Romberg):

Sensation in the limbs:

Cranial nerve reflexes:

Examination of the skin:

Erythema:

Burn:

Signs of a disorder of local blood circulation (pale skin, lack of sensation, swelling):

Examination of the eyes (pain, redness, sensitivity to light, visual disorder, redness in skin around the eyes; red reflex observed with an ophthalmoscope, using a +10 dpt lens in a dimly-lighted room at a distance of about 10 cm)

Laboratory tests (findings/results)

Stix analysis of the urine (not repeated, if normal):

Basic blood count and C- reactive protein (CRP, repeated a week later):

Serum creatine kinase (S-CK, not repeated, if normal):

EKG (not repeated, if normal):

APPENDIX 4. LIMIT VALUES FOR OCCUPATIONAL EXPOSURE TO RF FIELDS

The workers' exposure to electromagnetic fields is restricted by an EU directive setting minimum health and safety requirements¹. The directive is to be transposed into legislation in all EU countries by July 1, 2016 at the latest. This appendix presents measurable action levels (electric and magnetic fields; power density) related to most work (frequency range 10 MHz to 300 GHz), as laid down in the new directive. The action levels are functional levels, and complying with them indicates that the workers' exposure is below the corresponding exposure limit values. The action levels of the electric and magnetic fields have been derived from the limit values for internal health effects based on the threshold values associated with internal temperature effects caused by exposure.

Table L1. Action levels for exposure to RF fields in the frequency range 10 MHz to 300 GHz.

Frequency range	Electric field (E) [Vm ⁻¹] (RMS)	Magnetic flux density (B) [μT] (RMS)	Power density (S) (Wm ⁻²)
10 ≤ f < 400 MHz	61	0,2	-
400 MHz ≤ f < 2 GHz	3×10 ⁻³ f ^{1/2}	1.0×10 ⁻⁵ f ^{1/2}	-
2 GHz ≤ f < 6 GHz	1.4×10 ²	4.5×10 ⁻¹	-
6 GHz ≤ f < 300 GHz	1.4×10 ²	4.5×10 ⁻¹	50

Note: In the table, f is the frequency in hertz (Hz).

Action levels E² and B² are calculated as average values over a six-minute period. Where RF pulses are concerned, the average peak power density over the pulse width shall not exceed 1,000 times the value of the respected action level (S).

¹ Directive 2013/35/EC of the European Parliament and of the Council (<http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2013:179:0001:0021:EN:PDF>)

The action levels relate to calculated or measured maximum EMF values at the worker's body. Intensity is calculated as an average value per exposed area of 20 cm². The maximum values of spatial intensity, calculated as averages per 1 cm², must not exceed 20 fold the value 50 Wm⁻². Intensities in frequency range 6–10 GHz are calculated as averages per period of six minutes. In the frequency band over 10 GHz, intensities are calculated as averages $68/f^{1.05}$ per period of one minute (f is the frequency in Gigahertz).

The action level is 40 mA (RMS) for continuous contact current and 100 mA (RMS) for limb-induced current in frequency range $10 \text{ MHz} \leq f \leq 110 \text{ MHz}$. The action level for induced current (I^2) is calculated as an average per period of six minutes.

Table L2. Examples of transmitter frequencies and corresponding action levels

Transmitter		Frequency	Electric field (E) [Vm ⁻¹] (RMS)	Magnetic flux density (B) [μT] (RMS)	Power density (S) (Wm ⁻²)
FM	radio transmitters (VHF)	30–300 MHz	61	0.2	-
TETRA	(VIRVE network)	400 MHz	61	0.2	-
F-OFDM		460 MHz	64	0.2	-
GSM		900 MHz	90	0.3	-
GSM		1,800 MHz	127	0.4	-
UMTS		900 MHz	90	0.3	-
UMTS		2,200 MHz	140	0.45	-
LTE		1,800 MHz	127	0.4	-
LTE		2,600 MHz	140	0.45	-
Radio links		2 GHz ≤ f < 6 GHz	140	0.45	-
Radio links		6 GHz ≤ f ≤ 300 GHz	140	0.45	50

In this project an operating model was developed to situations where occupational radio frequency (RF) field overexposure is suspected. The model gives guidance how to react quickly and correctly to possible overexposure situations. Clear instructions will help to deal with unexpected exposures systematically in the workplace, occupational health care and, if necessary, specialized care. In the project the whole process was taken into account from the technical measures to the occupational health service guidelines, medical examinations and communication at work. These guidelines allow the suspected overexposure situations to be dealt with in a transparent and documented way, so that the workers safety can be ensured and possible adverse effects detected.

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