Union européenne - Fonds Européen de Développement Régional

Europese Unie - Europees Fonds voor Regionale Ontwikkeling

Interreg project WISE
(Wireless Safety for Employees)

Document: Electromagnetic sources
V2.0

8th March 2013

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Content

1 INTRODUCTION

The European directive (2004/40/EC) is applicable to electromagnetic fields at frequencies between 0 and 300 GHz. In this document a list of electromagnetic sources in this frequency range will be presented. We want to note that in the framework of the Interreg IV – WISE project, the focus is on electromagnetic field (EMF) sources between 5 Hz and 40 GHz.

2 SOURCES OF OCCUPATIONAL EMF EXPOSURE

In this paragraph a list of the possible sources of occupational exposure to electromagnetic fields is presented.
The electromagnetic sources can be divided in different sectors dependent on their application [1] - [47]. In this document the following sectors are defined: industrial sector, electricity sector, broadcasting sector, telecommunications sector, air navigation systems, aviation, medical sector, trade and services, public transportation, offices, and miscellaneous. For each sector different categories are defined. For each category the available sources are listed along with the corresponding frequency and other specifications (maximum current, voltage, power, ...).

Dependent on the frequency of the source different action values are applicable. The effects on the human body are dependent on the frequency of the electromagnetic field or radiation to which it is exposed. From 0 Hz until 100 kHz nerve stimulation and above 100 kHz heating of tissues are the main health effects, therefore two different exposure limitation systems need to be considered to protect workers exposed to electromagnetic fields [1].

2.1 Industrial sector

Category	Source available	Source	Typical frequency	Other general specifications	Remarks (e.g. actual specifications)
Electrochemical processes (e.g. in elektrolysis plants, laboratories, eltrolysis, electroplating, ...)	☐	Electrochemical processes	DC	Currents of 60 kA	
	☐	Electrochemical processes	300, 600, 900 Hz harmonic components superimposed to the DC current		
Induction heaters and furnaces (e.g. used in metal processing applications)	☐	Induction heaters and furnaces	50 Hz - 8 MHz	Powers between 300 W and 5 MW	
Electric welding	☐	Arc welding	DC, pulsing DC, AC (50 Hz / 60Hz)	Currents up to 1 kA	
	☐	Induction welding	< 1 MHz	Powers up to 20 kW	
	☐	Resistive welding	AC (50 Hz / 60Hz)	Currents up to 100 kA	
Plasma devices	☐	Plasma etcher	200 KHz - 15 MHz	Powers up to 130 kW	
	☐	RF sputter	13 MHz		
RF dielectric heaters (e.g. used for drying materials, plastic sealing, ...)	☐	RF heaters	10 MHz - 100 MHz	Powers up to 1000 kW	
Microwave ovens	☐	Microwave oven	2.45 GHz	Powers of 2 kW	
Microwave dryers	☐	Microwave dryer	> 2 GHz	Powers of 1 kW to 5 kW	
Electromagnetic testing	☐	Crack detection systems	5 kHz / 50 kHz		

Table 1: RF sources in industrial environments.

2.2 Electricity sector

Category	Source available	Source	Typical frequency	Other general specifications	Remarks (e.g. actual specifications)
Electricity generation and production	☐	Power stations	AC (50 Hz / 60 Hz)		
Electricity distribution	☐	Switchyards / substations	AC (50 Hz / 60 Hz)	Voltages of 400 kV / 150 kV / 36 kV / 11 kV	
	☐	High voltage overhead power lines	AC (50 Hz / 60 Hz)	Voltages of 400 kV / 150 kV	
	☐	Transformer kiosks	AC (50 Hz / 60 Hz)	Voltages (11 kV to 230 V / 380 V)	
	☐	High voltage direct current transmission lines	DC		
	☐	Low voltage switch and distribution boxes	AC (50 Hz / 60 Hz)	Voltages of 230 V / 380 V	

Table 2: RF sources in the electricity sector.

2.3 Broadcasting sector

Category	Source available	Source	Typical frequency	Other general specifications	Remarks (e.g. actual specifications)
Radio and television	☐	AM radio tower	153 kHz - 26.1 GHz	Powers of 500 kW	
	☐	FM radio tower	87.5 MHz to 108 MHz	Powers of 100 kW	
	☐	VHF and UHF TV tower	VHF: 174 MHz - 230 MHz UHF: 470 MHz - 862 MHz	VHF: powers of 300 kW UHF: powers of 5000 kW	

Table 3: RF sources in the broadcasting sector.

2.4 Telecommunications sector

Category	Source available	Source	Typical frequency	Other general specifications	Remarks (e.g. actual specifications)
Personal handheld GSM devices	☐	Mobile phones: GSM900, GSM1800, UMTS, LTE	900 MHz / 1800 MHz / 2100 MHz / 2400 MHz	Powers of 2 W for GSM900 an 1 W for GSM1800	
Base stations	☐	GSM900 base station	880 MHz - 960 MHz		
	☐	GSM1800 base station	1770 MHz - 1880 MHz		
	☐	UMTS base station	1920 MHz - 2170 MHz		
	☐	LTE base station	2400 MHz - 2483.5 MHz / 1800 MHz band		
Cordless phone	☐	Cordless phones + cordless base stations	1880 MHz - 1900 MHz	Powers of 250 mW	
WiFi	☐	WiFi access points	2.4 GHz to 2.5 GHz	Powers of 100 mW	
	☐	WiFi access points	5.150 GHz – 5.825 GHz /	Powers of 200 mW	
Tetra	☐	Tetra handheld devices	380 MHz - 465 MHz	Powers of 3 W	
	☐	Tetra vehicle mounted transmitter	380 MHz - 465 MHz	Powers of 3 W to 30 W	
	☐	Tetra base station	380 MHz - 465 MHz	Powers of 4 W to 40 W	
Zigbee	☐	Zigbee network	2.402 GHz - 2.480 GHz	Powers of 1 mW – 100 mW	
Private mobile radios	☐	PMR / walkie-talkies	27 MHz / 446 MHz / ...		

Communication links	☐	Microwave links	> 10 GHz		

Table 4: RF sources in the telecommunications sector.

2.5 Air Navigation Systems

Category	Source available	Source	Typical frequency	Other general specifications	Remarks (e.g. actual specifications)
Air navigation systems	☐	Marine surveillance radars	500 MHz - 50 GHz		
	☐	Air traffic control radars (see section 2.6 – sector aviation)			

Table 5: RF sources in the radar sector.

2.6 Aviation

Category	Source available	Source	Typical frequency	Other general specifications	Remarks (e.g. actual specifications)
Communication	☐	VHF/UHF	118 MHz– 137 MHz / 225 MHz – 400 MHz	Powers of 43 – 47 dBm, CW and D = 29 %	
	☐	Trunking	410 MHz – 430 MHz	Powers of 33 dBm, CW (continuous wave)	
Navigation	☐	ILS (instrument landing system) Glide Path	328 MHz – 335 MHz	Powers of 47.3 dBm	
	☐	ILS Localizer	108 MHz – 112 MHz	Powers up to 61 dBm	
	☐	ILS Markers	75 MHz	Powers of 41.5 dBm	
	☐	NDB (non-directional beacon)	255 kHz -526.5 kHz	Powers of 50 dBm, CW	
	☐	DME (distance measuring equipment)	960 MHz – 1215 MHz	Powers of 27 dBm – 68 dBm, T = 3.5 µs, D = 3.4 %	
	☐	VOR (VHF omnidirectional ranging)	108 MHz – 118 MHz	Powers of 52.5 dBm, CW	
	☐	Radiolink (UHF)	440 MHz – 460 MHz	Powers of 43.6 dBm – 44.3 dBm, D = 16 – 32 %	
Surveillance	☐	PSR (Primary surveillance radar) L-band	1200 MHz – 1400 MHz	Powers of 72 dBm – 94 dBm, T = 1 – 2 µs, D = 0.09 – 7.5 %	
	☐	PSR S-band	2700 MHz – 2900 MHz		
	☐	SSR (Secondary surveillance radar)	1030 MHz / 1090 MHz	Powers of 38 dBm – 61 dBm, D = 0.02 – 60 %	
	☐	Surface radar (SMR (surface movement radar)	9170 MHz / 9437.5 MHz / 15.7 GHz – 16.2 GHz	Powers of 64 dBm – 74 dBm, T = 0.04 µs, D = 0.02 – 0.07 %	

		and ASDE (airport surface detection equipment)			
	☐	Multilateration system	1030 MHz / 1090 MHz	Powers of 52 dBm – 55 dBm, D= 100 %	
	☐	Microwave link	22.134 GHz / 23.142 GHz	Powers of 20 dBm, CW	
	☐	Beacon	1090 MHz	Powers of 50 dBm, D = 100 %	
Meteo	☐	Wheather radar	5.620 GHz	Powers of 84 dBm, T = 1 – 2.5 µs, D = 0.06 – 0.12 %	

D: duty cycle, T: pulse duration

Table 6: RF sources in the aviation sector.

2.7 Medical sector

Category	Source available	Source	Typical frequency	Other general specifications	Remarks (e.g. actual specifications)
MRI	☐	MRI scanner	- static fields (DC) - pulsed gradient magnetic fields around 1 kHz - pulsed RF fields between 10 MHz and 400 MHz		
Electrosurgery	☐	Electrosurgical treatment equipment	300 kHz - 600 kHz	Powers of 500 W	
Hyperthermia	☐	Hyperthermia equipment (used in cancer treatment)	1 MHz - 1000 MHz	Powers between 25 W and 2000 W	
Diathermy	☐	Shortwave diathermy	10 MHz - 100 MHz	Powers to 400 W	
	☐	Microwave diathermy	300 MHz - 100 GHz	Powers to 400 W	
Electrical nerve stimulator	☐	Electrical nerve stimulator			
Transcranial magnetic stimulation (TMS)	☐	Magnetic nerve stimulator			

Table 7: RF sources in the medical sector.

2.8 Trade and services

Category	Source available	Source	Typical frequency	Other general specifications	Remarks (e.g. actual specifications)
Electronic article surveillance (EAS)	☐	Acousto magnetic activator / deactivator	58 kHz		
	☐	Radio frequent activator / deactivator	5.5 MHz - 9.1 MHz		
	☐	Electromagnetic activator / deactivator	50 Hz / 230 Hz / 485 Hz		
Metal detectors	☐	Metal detectors	Detectors using pulsating waves between 89 Hz and 909 Hz		
	☐	Metal detectors	Detectors using sinusoidal signals between 630 Hz and 7.375 kHz		
	☐	Metal detectors	Hand detectors using sinusoidal signals between 13 kHz and 1.9 MHz		
RFID	☐	RFID	1 Hz - 500 Hz		
	☐	RFID	2 MHz - 30 MHz		
	☐	RFID	850 MHz - 950 MHz / 2.45 GHz / 5.8 GHz		

Table 8: RF sources in the trade and services sector.

2.9 Public transportation

Category	Source available	Source	Typical frequency	Other general specifications	Remarks (e.g. actual specifications)
Railway	☐	DC railway	DC		
	☐	AC railway	AC (50 Hz / 60 Hz)		
Train	☐	Magnetic levitation train	DC		
	☐	Electro-magnetic and electro-dynamic brakes			
	☐	Transformers in trains and influence as function of time due to e.g. acceleration			
Train control security system	☐	KVB: Kontrole Voie Balise	27 MHz		
	☐	TBL1+	27 MHz		
	☐	ETCS (European Train Control System)			

Table 9: RF sources in the public transportation sector.

2.10 Offices

Category	Source available	Source	Typical frequency	Other general specifications	Remarks (e.g. actual specifications)
Screens	☐	CRT screen	30 Hz - 300 Hz / 20 kHz – 100 kHz		
	☐	LCD screen			
Power wiring	☐	AC cables	AC (50 Hz / 60 Hz)	Voltages of 230 V	
Office equipment	☐	Copying machine	AC (50 Hz / 60 Hz)	Voltages of 230 V	
	☐	Tape eraser	AC (50 Hz / 60 Hz)	Voltages of 230 V	
	☐	Computer equipment (including the computer itself)	AC (50 Hz / 60 Hz)	Voltages of 230 V	
	☐	Fax machine	AC (50 Hz / 60 Hz)	Voltages of 230 V	

Table 10: RF sources in the offices sector.

2.11 Miscellaneous

Category	Source available	Source	Typical frequency	Other general specifications	Remarks (e.g. actual specifications)
Lighting	☐	Electronic ballasts of fluorescent lamps	Up to 100 kHz		
Industrial electrical equipment	☐	Electric pumps			
	☐	Electric motors			
	☐	Air coils in inductive banks / capacitors banks (e.g. for power factor correction)			
	☐	Air conditioning system			
	☐	Heating system			
Small electrical equipment (similar to household equipment)	☐	Battery charger	AC (50 Hz / 60 Hz)		
	☐	Induction stoves	Up to 100 kHz		
	☐	Small electrical handheld equipment (e.g. handheld drill, vacuum cleaner for dirt and water, ...)	AC (50 Hz / 60 Hz)		
Battery charger stations	☐	Charger stations in a company to charge for example electrical forklifts			

Table 11: Miscellaneous RF sources.

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