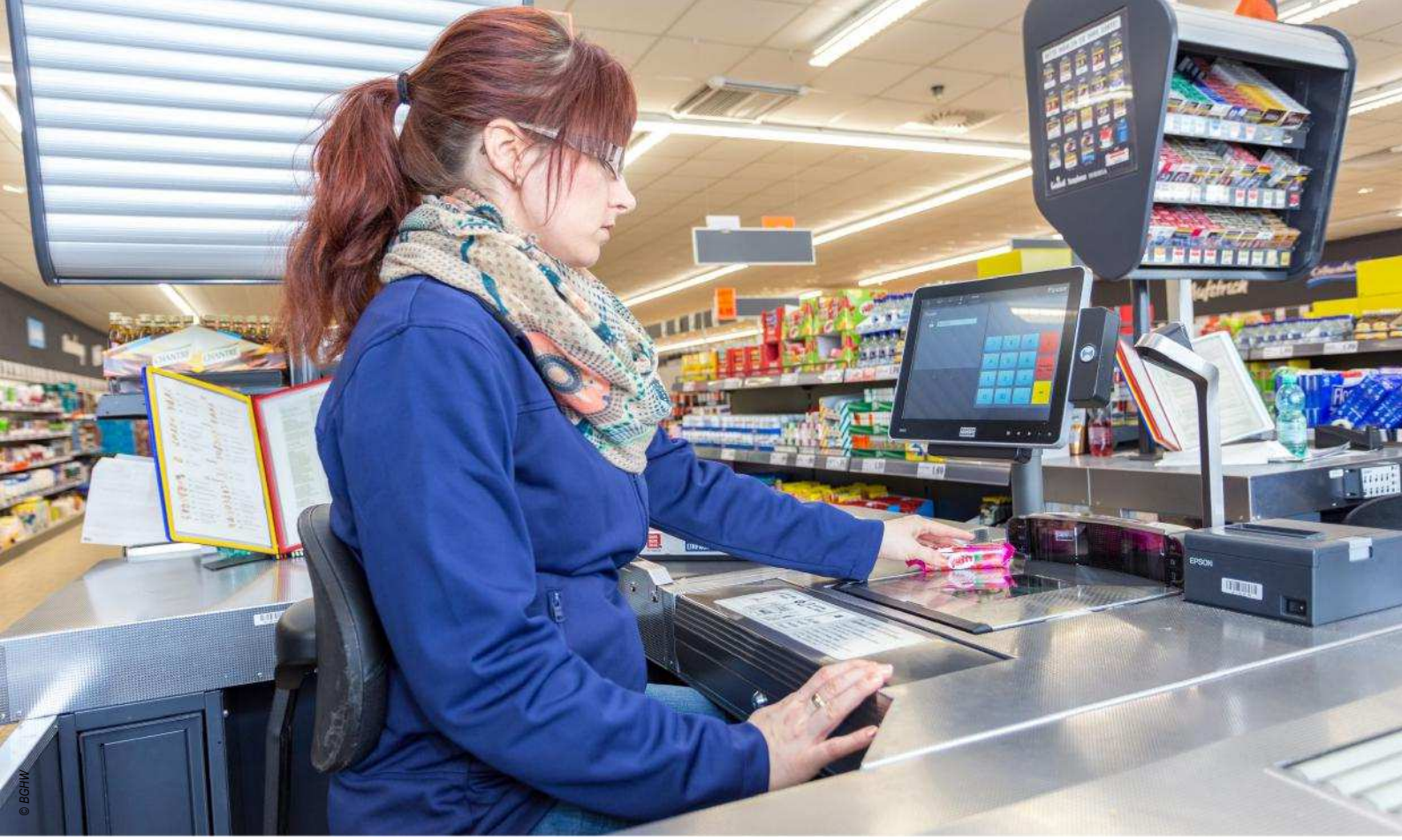

CARSTEN ALTEKÖSTER · CORINNA BECKER · INGO BÖMMELS · PETER JESCHKE· KLAUS SCHIESSL

Assessment of electronic article surveillance systems in the retail trade

Electronic article surveillance systems intended to prevent shoplifting give rise to significant exposure to electromagnetic fields. Customers, employees and employers alike are often unaware of this. Employers are therefore not fully able to meet their obligation to assess exposure and the associated risks, for example to users of implants. The purpose of this article is to summarize the information required for assessment.

1. Introduction

Electronic article surveillance (EAS) is widely used in the retail trade to prevent shoplifting. The systems concerned are also used for inventory control, and increasingly at self-checkouts. This article provides information on the safety of persons in the proximity of electronic article surveillance systems in consideration of exposure to the electromagnetic fields (EMFs) generated by them.

To this end, we will first discuss the responsibility that use of such a system places on the employer operating it (referred to below as the "employer"). The operating principle of EAS systems and the various technologies they employ will be described. Legal principles against which EAS systems are assessed will be set out. Finally, the article will provide recommendations for the selection and operation of EAS systems.

This information has been drawn up jointly by representatives of the accident insurance institutions in Austria (AUVA) and Germany (BGHW and IFA) and the German Federal Institute for Occupational Safety and Health (BAuA). It is intended for employers, but is also of interest to anyone coming into contact with EAS systems.

Figure 1: Security gate at an entrance/exit

2. Employer's responsibility and need for action

Employers have a legal obligation to determine whether EMF exposure occurs or can occur at the workplace. Where this is the case, they must assess all resulting hazards to the safety and health of their employees, and determine measures to be taken where required. The technology therefore necessitates performance of risk assessments for all EAS systems.

At the same time, the employer is responsible for the safety and health of customers in his store. The provisions governing public health are relevant in this context.

> The declaration of conformity is not a substitute for the risk assessment required for occupational safety and health purposes.

To make their products available on the European Single Market, a manufacturer or distributor declares that the EAS system concerned satisfies the essential requirements for safe products for the European Single Market. This is generally assured by means of a declaration of conformity. In the case of EAS systems, conformity is demonstrated with reference to the standards complied with, such as EN 50364:2018 [7] and the associated EN 62369-1:2009 [8]. For protection against potential hazards presented by EMF, these product standards reference Council Recommendation 1999/519/EC on the limitation of exposure of the general public to electromagnetic fields (EU Council Recommendation on EMF) [9].

However, the declaration of conformity is not a substitute for a risk assessment required for occupational safety and health purposes, as the latter requires reference to other codes. The need for additional information over and above the declaration of conformity arises, for example, from shortcomings in EN 50364 and from the fact that application of the standards does not necessarily reflect the actual situation in practice. Knowledge is required for example of whether, and if so in what situation:

- action thresholds/values or exposure limit values for EMF (in accordance with Section 5 of the German OSH Ordinance on electromagnetic fields (EMFV) [1] and Sections 3, 4 of the Austrian Ordinance on electromagnetic fields (VEMF) [18]) are exceeded;
- risks may exist for users of active medical implants;
- pregnant women are allowed to work on these systems.

Only then can any labelling requirements in force or further measures be determined.

The documentation supplied with the products by the manufacturer is often seen to be of inadequate quality, owing in part to the shortcomings of the standards applied. Instructions for operation or use in which the conditions of use should be clearly described are also often unavailable.

It is therefore essential that the employer assess the possible hazards to groups of persons (employees, customers, users of implants, pregnant women) presented by exposure to EMF generated by EAS systems. The assessment must cover all components of the EAS system.

3. Operating principle and technology of EAS systems

3.1 Operating principle

EAS technology exploits the radio frequency identification (RFID) concept, a method for non-contact identification of objects by means of EMF. In this method, a security device (tag, label) that can be identified electronically is attached to the goods and can be detected by an antenna system. When an active security device enters the detection range of the antennae, an alarm is triggered unless the security device was properly deactivated or removed when the article was paid for.

3.2 EAS systems

Three different technical systems have been widely adopted in the retail sector. They differ in the frequency range employed and the physical principle of interaction between the security device and the EMF used for wireless detection. Specifically, the three systems are radio frequency (RF), acousto-magnetic (AM) and electromagnetic (EM) systems.

The following features are common to all three systems:

- The **security device**, which can be attached to the goods mechanically in the form of a hard label or applied as an adhesive label
- A **security gate** (antenna system) at the store entrance/exit; gates are often also located at the entrances to changing rooms or toilets
- A **deactivator** for deactivating the security device and/or a **magnetic hard label remover** at the checkout The antennae emit a continuous or pulsed EMF to detect the security device. The following frequencies are generally used in practice, according to the system:

RF systems:	8.2 MHz (detection/ deactivation)
AM systems:	58 kHz (detection)/ 500 Hz - 2 kHz (deactivation)
EM systems:	230 Hz (detection/deactivation)

Figure 2: *Magnetic hard label remover*

The risk assessment can be simplified considerably by means of appropriate manufacturer's information on EMF exposure.

As a rule, the security devices are detected and deactivated automatically by the deactivator during the payment process. This requires the goods to be within the detection range of the deactivator. For this reason, the device is often either integrated into the checkout counter together with the product scanner or mounted below the checkout counter, and is not visible. Whereas the frequencies used for detection of the security devices are the same as those employed at the security gates, the frequencies used for deactivation may differ. The EMFs used in the deactivation process are significantly stronger than those in the detection process.

Magnetic security tag removers are used solely for removing hard labels at the checkout. A strong permanent magnet in the remover unlocks a mechanism inside the hard label, enabling it to be removed from the goods (such as clothing, spirits).

4. Assessment of exposure caused by EAS systems

The obligation to assess EMF exposure and the procedure for this purpose are taken from Directive 2013/35/EU (EMF Directive) [17]. This directive has been transposed into national law in the individual EU Member States with detail differences, but identically with respect to the minimum requirements (objective of protection). Germany and Austria are following a very similar path with the EMFV and VEMF respectively.

THE AUTHORS

Dr Carsten Alteköster
Research fellow in the Subcommittee Electromagnetic Fields, Unit Machine Safety, Industrial Security and Implants, Expert Committee Accident Prevention at the Institute for Occupational Safety and Health of the German Social Accident Insurance (IFA);
carsten.altekoester@dguv.de

Corinna Becker
Head of Unit, Physical hazards in Prevention, German Social Accident Insurance Institution for the trade and distribution industry (BGHW);
c.becker@bghw.de

Ingo Bömmels
Head of the Subcommittee Electromagnetic fields, Unit Machinery Safety, Industrial Security and Implants, Expert Committee Accident Prevention at the Institute for Occupational Safety and Health of the German Social Accident Insurance (IFA);
ingo.boemmels@dguv.de

The legal framework for performance of a risk assessment is laid down in Section 3 (1) of the EMFV and Sections 6, 7 of the VEMF.

4.1 Employees

The employer must assess whether employees could be exposed to EMF hazards during activities at the workplace. Satisfaction of the requirements of the EMFV/VEMF must be checked. This means that the exposure limits and action values specified in these regulations must be complied with.

Important: Since the action values are greatly exceeded on many EAS systems, particularly the AM systems, the systems can be assessed only by application of the exposure limits.

According to the result of the risk assessment, suitable measures must be determined to ensure the employees' safety and health. The technical rules pursuant to the EMFV, which have yet to be published, provide practical support for satisfying the requirements formulated in it. In Austria, support takes the form of acknowledged good practice, for example by way of ~~of~~ standards.

4.2 Users of active or passive medical implants

In accordance with Section 3 (Risk assessment), Paragraph 4 (11) of the EMFV and Section 7 of the VEMF, account must be taken of all impacts upon the safety and health of employees requiring particular protection. This group primarily includes users of active medical implants, such as pacemakers (PMs) or implantable cardioverter defibrillators (ICDs). Depending on the situation however, consideration must also be given to users of passive medical implants, such as stents. For this reason, the German Federal Ministry of Labour and Social Affairs (BMAS) has supplemented the EMFV with publication of Research Report 451 concerning electromagnetic fields at the workplace: safety of employees with active and passive body aids exposed to electromagnetic fields [10]. This document is used in the field in both Germany and Austria as acknowledged good practice. It contains action values for EMF. If these are observed, an impermissible influence on PMs or ICDs is not anticipated. Since these action values were specified for a worst-case scenario, they can be applied to the general public, i.e. customers, as well as employees. Where more detailed information is available on an employee's implant, a risk assessment can also be carried out specifically for the individual. Evaluations of passive medical implants are also available in an AUVA research report [3].

4.3 Pregnant women

Where a pregnant woman is exposed to EMF up to the limit values for employees, i.e. above the limit values for the general population, a possible risk to the unborn child cannot be excluded [11] [14].

The EMFV does not contain any provisions that can be used to assess the permissible EMF exposure of pregnant employees; instead, the protection of the health of the woman and her child at the place of work, training and study during pregnancy is governed by the German Maternity Protection Act (MuSchG) [15]. Under Section 11 (Impermissible activities and working conditions for pregnant women), Paragraph 3 of this act, the employer may not allow a pregnant woman to carry out any activities or subject her to any working conditions in which she is or may be exposed to physical hazards to a degree presenting an irresponsible risk to her or her child. Unfortunately, secondary codes supporting the MuSchG by which a corresponding assessment could be performed do not exist at this stage.

Owing to the lack of corresponding codes in Germany and the required preventive concept for protection, employers resort in practice to the requirements for the protection of the general public set out in the 26th Ordinance pursuant to the German Federal Control of Pollution Act (26th BImSchV) [19].

In Austria, the reference levels and basic restrictions set out in the EU Council Recommendation on EMF, which are based on the 1998 ICNIRP Guidelines (ICNIRP 1998) [13], have been laid down as a protective measure for pregnant employees in accordance with Section 5 of the VEMF. Where applied, these values correspond to the provisions of the 26th BImSchV in Germany.

Conclusion: Pregnant women

The application of basic restrictions and thus performance of a sound assessment in the proximity of EMF sources is possible in principle. The objective of protection is focussed upon the unborn child/foetus. It is however apparent that the concepts of the now somewhat older EU Council Recommendation on EMF and of ICNIRP 1998 are not without their problems, particularly with regard to assessment of exposure of the pregnant woman's abdomen, and thus of the foetus. When these documents were issued, only an assessment of exposure of the pregnant woman's central nervous system (CNS) was required for the low-frequency range, and application of the concept in full to protection of

the foetus was discouraged. Although some assessments used simple models to consider the foetal CNS, only an assessment of all tissue types (pregnant woman and foetus) in accordance with the 2010 ICNIRP Guidelines (ICNIRP 2010) [12] appears to be both the state of the art and consistent with the objective of protection. In the specific case of assessment of local exposure of the foetus to low-frequency magnetic fields (as may be caused by an EAS system), preference should therefore be given to assessment by means of the basic restrictions for the general population in accordance with ICNIRP 2010.

4.4 Customers

The declaration of conformity demonstrates that a product complies with the applicable safety requirements, including with regard to the emission of EMFs. The declaration must be present when the product is placed on the European Single Market.

Through application of product legislation, the reference values and basic restrictions of the EU Council Recommendation on EMF therefore acquire stronger legal significance for protection of the public, and therefore also customers; more recent product standards implement the limit value concept of ICNIRP 2010, however.

With respect to controlling exposure, no nationally binding values apply in Germany to EAS systems comparable to those set out for installations within the scope of the 26th BImSchV. Application of the values from Annex 1 of the 26th BImSchV to EAS systems is however generally recommended for protection of the general public. In practice however, the absence of basic restrictions in the 26th BImSchV may present problems, since many EAS systems can be assessed only against such values. It is therefore expedient for the basic restrictions of the EU Council Recommendation on EMF to be used.

In the absence of dedicated legislation concerning protection against exposure, Austria falls back on technical rules such as OVE R 23-1:2017 [16], which implements the limit values for the general population according to ICNIRP 2010. As in Germany, product standards are applicable for placing on the market.

5. Recommendations for the operation of EAS systems

Measures are explained and recommendations given below which, in the view of the authors, can be implemented efficiently and have proved effective in practice. They are based on the results of exposure assessments conducted by experts at workplaces involving EAS systems.

5.1 Selection of the system

To minimize exposure of all groups of people to EMF, EAS systems with the lowest possible emissions should be installed. As measurements have shown, RF systems are clearly superior to EM and AM systems in this respect and should therefore be given preference [4] [5]; see Table 1. The measures to be taken are usually reduced and simplified appreciably by the use of RF systems. This applies in particular to the group of implant users.

More and more manufacturers are now equipping their EAS systems with additional functions. Integral metal detectors in the security gates are intended to detect fraudulent attempts to shield protected goods against security devices. Other functions aim to deactivate third-party security devices automatically when the customer enters the store, in order to optimize the error detection rate. These and similar auxiliary systems may increase exposure to EMFs and must be covered by the risk assessment, for example for employees of security services companies. Whether these additional functions are actually needed should therefore be considered carefully.

Newly procured or legacy EAS systems may also permit operation at a reduced power setting. In this context, critical consideration must be given to the maximum area that can be covered by the security gates and what coverage is actually advantageous for the required detection rate to be attained. The same applies to the height above the deactivator at which a security device can still be reliably deactivated. In the case of the deactivator, substitution may even be possible, for example by use of a permanent magnet mat.

The power settings should be documented in a comprehensible form (see Chapter 5.2), since experience has shown that the strength of the EMF may vary greatly even on systems of identical design, owing to differences in power settings. Careful consideration should therefore be given to whether an existing assessment of an EAS system can be used or an identical system needs to be reassessed separately.

THE AUTHORS

Dr Peter Jeschke
Research fellow, Physical Agents Unit, Federal Institute for Occupational Safety and Health (BAuA), Friedrich-Henkel-Weg 1-25, 44149 Dortmund, Germany;
physical.agents@baua.bund.de

Dr Klaus Schiessl *Expert body in the field of exposure to electromagnetic fields within the prevention department at the head office of the Austrian General Accident Insurance Board (AUVA);*
klaus.schiessl@auva.at.

EAS system technology / evaluation basis		Is the presence at the workplace permitted for… ? employees	users of active or passive medical implants: assessment	users of active or passive medical implants: safety distance	pregnant women or customers in general
		EMFV	Research Report FB 451		Council Recommendation 1999/519/EC (EMF)
Radio-frequency (8,2 MHz)					
antenna system		😐	🙂	-	😐
deactivator at the checkout	detection	🙂	🙂	-	🙂
	deactivation	🙂	🙂	-	🙂
Acousto-magnetic (58 kHz)					
antenna system		😐	😐	40 cm	😐
deactivator at the checkout	detection	🙂	😐	40 cm	😐
	deactivation	😐	☹	110 cm	😐
Electromagnetic (230 Hz)					
antenna system		🙂	☹	no pass	☹
static magnetic field (0 Hz)					
magnetic hard label remover		🙂	😐	20 cm	😐

legend:

🙂 = presence permitted without restrictions; a safety distance is not necessary

😐 = presence permitted under conditions, e.g. maintaining a safety distance (usually a few decimeters). Proof of compliance with exposure limits usually required.

☹ = presence not permitted resp. evaluated safety distance not practiable. Proof of compliance with the basic restrictions according to Annex 2 of the EU Council Recommendation on EMF may be required.

Table 1: EMF assessment of EAS systems based on workplace measurements Source: BGHW [5]

5.2 Manufacturer's, distributor's, service technician's information

The EMF emitted by an EAS system can be determined in several different ways for the purposes of risk assessment. In addition to instrumented measurement, the manufacturer's information can also be used. Where information provided by manufacturers or distributors is used, its scope and quality must be critically reviewed for its applicability to the situation in hand. The information provided in connection with the declaration of conformity is not usually sufficient for this purpose.

To reduce substantially the effort entailed by risk assessment, the employer should request further information from the manufacturer, the distributor, and if relevant the service technician on site. This information includes:

- **Technical information** such as the type name, frequency of the detection and deactivation signal, maximum power, power setting on site, form of the EMF emission (continuous, pulsed) or pulse shape used, operating modes
- **Safety-related information on labelling and safety distances, including for persons requiring special protection:** particularly in the retail trade, the assignment of employees with medical implants and pregnant employees to work involving EAS systems is also a situation that should be taken into account (or, if necessary, excluded) by the manufacturer. Operators of such systems are therefore strongly advised to request an assessment for this purpose from the manufacturer, if possible stating realistic distances in use.
- **Results of EMF measurements:** including clear information on performance and results of the measurements, which must enable measurement to be reproduced if necessary (see DGUV-R 103-013 [6], Annex 1, 1.5 (measurement protocol)). Where exposure is inhomogeneous, as is always the case in practice, only an assessment by means of the maximum field strength guarantees adequate protection of employees and customers. Averaging of the measured values over the body volume may circumvent the objective of protection and should therefore not be applied.
- **Numerical calculations**, preferably with the use of digital anatomical body models, that are suitable for demonstrating compliance with maximum permissible values within the human body as required by the various bodies of regulations (such as exposure limits in accordance with the EMFV). Such calculations may be necessary should it not be possible to demonstrate that the values to be complied with (such as action values) that can be checked directly by measurements at the workplace can be met for all areas in which persons may be present. This is typically the case with AM systems. The calculations must take account of the actual position of the employee at each individual component of the EAS system. The simplified body models proposed in the standards are not able to reflect realistic working positions and postures and should therefore not be used.

Ideally, the information against which risk assessment is subsequently to be performed (relevant manufacturer's information on EMF emission, exposure measurement performed as a service) can be requested from the manufacturer or distributor when an EAS system is procured. This enables the outlay for the employer to be kept within reasonable limits.

The settings performed on site by the service technician, which should represent an acceptable compromise between the detection/deactivation range and reduction of the EMF emissions, should be documented unambiguously and comprehensibly.

5.3 Installation and labelling

One of the simplest means of reducing EMF exposure is to increase the distance between the source and the exposed person. It is therefore advantageous to label the components of EAS systems as sources of EMF and, if possible, to install them where they are clearly visible and in such a way that they cannot be accessed directly, even unintentionally.

With regard to the possibility of reducing EMF exposure, the following in particular should be assessed:

- **"Rummage tables"** located in the immediate proximity of the security gates
- **Security gates at the checkout**, for example on the goods trays
- **Concealed installation** of security gates in floors or door frames (visibility)
- Covering **of security gates with advertising** (visibility)
- Generally **poorly visible security gates** which customers may lean against or easily touch

Labelling is mandatory when permissible values are exceeded and/or a hazard for particular groups of persons such as implant users cannot be ruled out. Suitable warning signs are listed in the ASR A 1.3 technical rules for workplaces [2]. Irrespective of this requirement, voluntary labelling is also recommended in order to make components of the article security systems more visible.

5.4 External support

Should you as an employer receive insufficient or no support from the manufacturer, distributor or service technician of your EAS system, or be unsure whether a risk assessment that has been carried out is sufficient, you can contact your responsible accident insurance institution. ■

BIBLIOGRAPHY

[1] Arbeitsschutzverordnung zu elektromagnetischen Feldern (EMFV) of 15 November 2016 (BGBl. I p. 2531), amended by Article 2 of the Ordinance of 30 April 2019 (BGBl. I p. 554)

[2] ASR A 1.3, Sicherheits- und Gesundheitsschutzkennzeichnung, Technische Regeln für Arbeitsstätten (ASR), GMBl 2013, p. 334, last amended by GMBl 2017, p. 398, February 2013

[3] AUVA Report R78, Bestimmung der im Gewebe induzierten elektrischen Feldstärken und Gewebeerwärmung in der Nähe von metallischen Implantaten bei Magnetfeldexposition am Arbeitsplatz, AUVA, 2018

[4] Bundesamt für Strahlenschutz (BfS), Themenseite zu Warensicherungsanlagen, at http://www.bfs.de/DE/themen/emf/nff/anwendung/warensicherungsanlagen/warensicherungsanlagen_node.html (accessed on 30 March 2020)

[5] DGUV Fachbereich Handel und Logistik, FBHL-011, Einsatz elektronischer Artikelsicherungssysteme im Handel, at https://publikationen.dguv.de/regelwerk/fachbereich-aktuell/handel-und-logistik/3634/fbhl-011-einsatz-elektronischer-artikelsicherungssysteme-im-handel (accessed on 3 April 2020)

[6] DGUV Regel 103-013 (formerly BGR B11), Elektromagnetische Felder, October 2001, available at https://publikationen.dguv.de/regelwerk/regeln/1000/elektro-magnetische-felder (accessed on 3 April 2020)

[7] EN 50364:2018, Product standard for human exposure to electromagnetic fields from devices operating in the frequency range 0 Hz to 300 GHz, used in Electronic Article Surveillance (EAS), Radio Frequency Identification (RFID) and similar applications

[8] EN 62369-1:2009, Evaluation of human exposure to electromagnetic fields from short range devices (SRDs) in various applications over the frequency range 0 GHz to 300 GHz – Part 1: Fields produced by devices used for electronic article surveillance, radio frequency identification and similar systems

[9] Council Recommendation 1999/519/EC of 12 July 1999 on the limitation of exposure of the general public to electromagnetic fields (0 Hz to 300 GHz) (OJ L 199 p. 59)

[10] Forschungsbericht 451 (FB 451), Elektromagnetische Felder am Arbeitsplatz Sicherheit von Beschäftigten mit aktiven und passiven Körperhilfsmitteln bei Exposition gegenüber elektromagnetischen Feldern, Bundesministerium für Arbeit und Soziales, January 2015

[11] ICNIRP Guidelines for limiting exposure to electromagnetic fields (100 kHz to 300 GHz), Health Physics 118(5):483-524; 2020.

[12] ICNIRP Guidelines for limiting exposure to time-varying electric and magnetic fields (1 Hz − 100 kHz), Health Physics 99(6):818-836; 2010

[13] ICNIRP Guidelines for limiting exposure to time-varying electric, magnetic and electromagnetic fields (up to 300 GHz), Health Physics 74 (4):494-522; 1998

[14] Liorni et al., Computational assessment of pregnant woman models exposed to uniform elf-magnetic fields: compliance with the European current exposure regulations for the general public and occupational exposures at 50 Hz, Radiat Prot Dosimetry, Vol. 172, No. 4, pp. 382–392, 2016

[15] Mutterschutzgesetz (MuSchG) of 23 May 2017 (BGBl. I p. 1228), amended by Article 57 Paragraph 8 of the law of 12 December 2019 (BGBl. I p. 2652)

[16] OVE-Richtlinie R 23-1:2017-04-01, Elektrische, magnetische und elektromagnetische Felder im Frequenzbereich von 0 Hz to 300 GHz – Part 1: Begrenzung der Exposition von Personen der Allgemeinbevölkerung

[17] 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) (OJ L 179 p. 1)

[18] Verordnung des Bundesministers für Arbeit, Soziales und Konsumentenschutz über den Schutz der Arbeitnehmer/innen vor der Einwirkung durch elektromagnetische Felder (Verordnung elektromagnetische Felder − VEMF) (BGBl. II No 179/2016)

[19] 26. Verordnung des Bundes-Immissionsschutzgesetzes; Verordnung über elektromagnetische Felder (26. BImSchV), as notified on 14 August 2013 (BGBl. I p. 3266)