OHUTUS ELEKTERKUUMUTUSPAIGALDISTES JA ELEKTROMAGNETILINE TÖÖTLUS. OSA 1: ÜLDNÕUDED

Safety in installations for electroheating and electromagnetic processing - Part 1: General requirements

EESTI STANDARDIKESKUS
ESTONIAN CENTRE FOR STANDARDISATION

EESTI STANDARDI EESSÕNA

NATIONAL FOREWORD

See Eesti standard EVS-EN 60519-1:2015 sisaldab Euroopa standardi EN 60519-1:2015 ingliskeelset teksti.	This Estonian standard EVS-EN 60519-1:2015 consists of the English text of the European standard EN 60519-1:2015.
Standard on jõustunud sellekohase teate avaldamisega EVS Teatajas	This standard has been endorsed with a notification published in the official bulletin of the Estonian Centre for Standardisation.
Euroopa standardimisorganisatsioonid on teinud Euroopa standardi rahvuslikele liikmetele kättesaadavaks 22.05.2015.	Date of Availability of the European standard is 22.05.2015.
Standard on kättesaadav Eesti Standardikeskusest.	The standard is available from the Estonian Centre for Standardisation.

Tagasisidet standardi sisu kohta on võimalik edastada, kasutades EVS-i veebilehel asuvat tagasiside vormi või saates e-kirja meiliaadressile standardiosakond@evs.ee.

ICS 25.180.10

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 60519-1

May 2015

ICS 25.180.10

Supersedes EN 60519-1:2011

English Version

Safety in installations for electroheating and electromagnetic processing - Part 1: General requirements (IEC 60519-1:2015)

Sécurité dans les installations destinées au traitement électrothermique et électromagnétique - Partie 1: Exigences générales
(IEC 60519-1:2015)

Sicherheit in Elektrowärmeanlagen und Anlagen für elektromagnetische Bearbeitungsprozesse - Teil 1: Allgemeine Anforderungen
(IEC 60519-1:2015)

This European Standard was approved by CENELEC on 2015-04-14. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN-CENELEC Management Centre or to any CENELEC member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

CENELEC members are the national electrotechnical committees of Austria, Belgium, Bulgaria, Croatia, Cyprus, the Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

CEN-CENELEC Management Centre: Avenue Marnix 17, B-1000 Brussels

Foreword

The text of document 27/947/FDIS, future edition 5 of IEC 60519-1, prepared by IEC/TC 27 "Industrial electroheating and electromagnetic processing" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN 60519-1:2015.

The following dates are fixed:

• latest date by which the document has to be implemented at national level by publication of an identical national standard or by endorsement	(dop)	2016-01-14
• latest date by which the national standards conflicting with the document have to be withdrawn	(dow)	2018-04-14

This document supersedes EN 60519-1:2011

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CENELEC [and/or CEN] shall not be held responsible for identifying any or all such patent rights.

This document has been prepared under a mandate given to CENELEC by the European Commission and the European Free Trade Association, and supports essential requirements of EU Directive(s).

For the relationship with EU Directive(s) see informative Annex ZZ, which is an integral part of this document.

This standard covers the Principle Elements of the Safety Objectives for Electrical Equipment Designed for Use within Certain Voltage Limits (LVD - 2006/95/EC).

Endorsement notice

The text of the International Standard IEC 60519-1:2015 was approved by CENELEC as a European Standard without any modification.

In the official version, for Bibliography, the following notes have to be added for the standards indicated:

IEC 60079 (series)	NOTE	Harmonized as EN 60079 (series).
IEC 60204 (series)	NOTE	Harmonized as EN 60204 (series).
IEC 60335 (series)	NOTE	Harmonized as EN 60335 (series).
IEC 60601 (series)	NOTE	Harmonized as EN 60601 (series).
IEC 60974 (series)	NOTE	Harmonized as EN 60974 (series).
IEC 61140:2001	NOTE	Harmonized as EN 61140:2001.
IEC 61140:2001/A1:2004	NOTE	Harmonized as EN 61140:2001/A1:2006.
IEC 61439 (series)	NOTE	Harmonized as EN 61439 (series).
IEC 62226 (series)	NOTE	Harmonized as EN 62226 (series).
IEC 62271 (series)	NOTE	Harmonized as EN 62271 (series).

IEC 62311	NOTE	Harmonized as EN 62311.
ISO 5349-1:2001	NOTE	Harmonized as EN ISO 5349-1:2001.
ISO 7010	NOTE	Harmonized as EN ISO 7010.
ISO 15265:2004	NOTE	Harmonized as EN ISO 15265:2004.

Annex ZA
(normative)

Normative references to international publications with their corresponding European publications

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

NOTE 1 When an International Publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

NOTE 2 Up-to-date information on the latest versions of the European Standards listed in this annex is available here: www.cenelec.eu.

Publication	Year	Title	EN/HD	Year
IEC 60071-1	-	Insulation co-ordination - Part 1: Definitions, principles and rules	EN 60071-1	-
IEC 60204-1 (mod)	2005	Safety of machinery - Electrical equipment of machines - Part 1: General requirements	EN 60204-1	2006
+A1	2008		+A1	2009
-	-		+corrigendum Feb.	2010
IEC 60204-11	2000	Safety of machinery - Electrical equipment of machines - Part 11: Requirements for HV equipment for voltages above 1 000 V a.c. or 1 500 V d.c. and not exceeding 36 kV	EN 60204-11	2000
-	-		+corrigendum Feb.	2010
IEC 60228	-	Conductors of insulated cables	EN 60228	-
-	-		+corrigendum May	-
IEC 60335-1:2010/A1:2013	2013		-	-
IEC 60335-1 (mod)	2010	Household and similar electrical appliances - Safety - Part 1: General requirements	EN 60335-1	2012
-	-		+A11	2014
-	-		+AC	2014
IEC 60335-2-24	-	Household and similar electrical appliances - Safety - Part 2-24: Particular requirements for refrigerating appliances, ice-cream appliances and ice makers	EN 60335-2-24	-
IEC 60335-2-89	-	Household and similar electrical appliances - Safety - Part 2-89: Particular requirements for commercial refrigerating appliances with an incorporated or remote refrigerant condensing unit or compressor	EN 60335-2-89	-
-	-		+AC	-
IEC 60364-1 (mod)	2005	Low-voltage electrical installations - Part 1: Fundamental principles, assessment of general characteristics, definitions	HD 60364-1	2008
IEC 60364-4-41	-	Low-voltage electrical installations - Part 4-41: Protection for safety - Protection against electric shock	HD 60364-4-41	-
-	-		+corrigendum Jul.	-
IEC 60364-4-42	-	Low-voltage electrical installations - Part 4-42: Protection for safety - Protection against thermal effects	HD 60364-4-42	-

IEC 60364-4-44	-	Low-voltage electrical installations - Part 4-44: Protection for safety - Protection against voltage disturbances and electromagnetic disturbances	HD 60364-4-442	-
IEC 60364-5-53	-	Electrical installations of buildings - Part 5-53: Selection and erection of electrical equipment - Isolation, switching and control	-	-
IEC 60364-5-54	-	Low-voltage electrical installations - Part 5-54: Selection and erection of electrical equipment - Earthing arrangements and protective conductors	HD 60364-5-54	-
IEC 60398	-	Installations for electroheating and electromagnetic processing - General performance test methods	-	-
IEC 60417	-	Graphical symbols for use on equipment	-	-
IEC 60445	-	Basic and safety principles for man-machine interface, marking and identification - Identification of equipment terminals, conductor terminations and conductors	EN 60445	-
IEC 60529	-	Degrees of protection provided by enclosures (IP Code)	-	-
IEC 60664-1	-	Insulation coordination for equipment within low-voltage systems - Part 1: Principles, requirements and tests	EN 60664-1	-
IEC 60825-1	-	Safety of laser products - Part 1: Equipment classification and requirements	EN 60825-1	-
IEC 60865-1	-	Short-circuit currents - Calculation of effects - Part 1: Definitions and calculation methods	EN 60865-1	-
IEC 60909-0	-	Short-circuit currents in three-phase a.c. systems - Part 0: Calculation of currents	EN 60909-0	-
IEC 60990	1999	Methods of measurement of touch current and protective conductor current	EN 60990	1999
IEC 61000-3-3	-	Electromagnetic compatibility (EMC) - Part 3-3: Limits - Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems, for equipment with rated current 16 A per phase and not subject to conditional connection	EN 61000-3-3	-
IEC 61000-3-11	-	Electromagnetic compatibility (EMC) - Part 3-11: Limits - Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems - Equipment with rated current <= 75 A and subject to conditional connection	EN 61000-3-11	-
IEC 61000-6-2	-	Electromagnetic compatibility (EMC) - Part 6-2: Generic standards - Immunity for industrial environments	EN 61000-6-2	-
-	-		+corrigendum Sep.	-
IEC 61000-6-4	-	Electromagnetic compatibility (EMC) - Part 6-4: Generic standards - Emission standard for industrial environments	EN 61000-6-4	-
IEC 61010-1	2010	Safety requirements for electrical equipment for measurement, control and laboratory use - Part 1: General requirements	EN 61010-1	2010
IEC 61082-1	-	Preparation of documents used in electrotechnology - Part 1: General requirements	EN 61082-1	-

IEC 61310	series	Safety of machinery - Indication, marking and actuation	EN 61310	series
IEC 61326-3-1	-	Electrical equipment for measurement, control and laboratory use - EMC requirements - Part 3-1: Immunity requirements for safety-related systems and for equipment intended to perform safety-related functions (functional safety) - General industrial applications	EN 61326-3-1	-
IEC 61508	series	Functional safety of electrical/electronic/programmable electronic safety-related systems	EN 61508	series
IEC 61672-1	-	Electroacoustics - Sound level meters - Part 1: Specifications	EN 61672-1	-
IEC 61672-2	-	Electroacoustics - Sound level meters - Part 2: Pattern evaluation tests	EN 61672-2	-
IEC 61786-1	-	Measurement of DC magnetic, AC magnetic and AC electric fields from 1 Hz to 100 kHz with regard to exposure of human beings - Part 1: Requirements for measuring instruments	EN 61786-1	-
IEC 61786-2	-	Measurement of low-frequency magnetic and electric fields with regard to exposure of human beings - Part 2: Guidance for measurements	-	-
IEC 61936-1	-	Power installations exceeding 1 kV a.c. - Part 1: Common rules	EN 61936-1	-
-	-		+AC	-
-	-		+AC	-
-	-		+AC	-
IEC 62061	-	Safety of machinery - Functional safety of safety-related electrical, electronic and programmable electronic control systems	EN 62061	-
-	-		+corrigendum Feb.	-
IEC 62471 (mod)	2006	Photobiological safety of lamps and lamp systems	EN 62471	2008
IEC 82079-1	-	Preparation of instructions for use - Structuring, content and presentation - Part 1: General principles and detailed requirements	EN 82079-1	-
IEC Guide 104	-	The preparation of safety publications and the use of basic safety publications and group safety publications	-	-
ISO 3746	-	Acoustics - Determination of sound power levels and sound energy levels of noise sources using sound pressure - Survey method using an enveloping measurement surface over a reflecting plane	EN ISO 3746	-
ISO 3864-1	-	Graphical symbols - Safety colours and safety signs - Part-1: Design principles for safety signs and safety markings	-	-
ISO 6385	-	Ergonomic principles in the design of work systems	EN ISO 6385	-
ISO 7000	-	Graphical symbols for use on equipment - Registered symbols	-	-
ISO 12100	2010	Safety of machinery - General principles for design - Risk assessment and risk reduction	EN ISO 12100	2010

ISO 13577-1	-	Industrial furnaces and associated processing equipment - Safety - Part 1: General requirements	-	-
ISO 13577-2	-	Industrial furnaces and associated processing equipment - Safety - Part 2: Combustion and fuel handling systems	-	-
ISO 13732-1	-	Ergonomics of the thermal environment - Methods for the assessment of human responses to contact with surfaces - Part 1: Hot surfaces	EN ISO 13732-1	-
ISO 13849	series	Safety of machinery - Safety-related parts of control systems	EN ISO 13849	series
ISO 13850	-	Safety of machinery - Emergency stop - Principles for design	EN ISO 13850	-
ISO 13855	-	Safety of machinery - Positioning of safeguards with respect to the approach speeds of parts of the human body	EN ISO 13855	-
ISO 13857	-	Safety of machinery - Safety distances to prevent hazard zones being reached by upper and lower limbs	EN ISO 13857	-
ISO 14119	-	Safety of machinery - Interlocking devices associated with guards - Principles for design and selection	-	-
ISO 14120	-	Safety of machinery – Guards - General requirements for the design and construction of fixed and movable guards	-	-
ISO 14159	-	Safety of machinery - Hygiene requirements for the design of machinery	EN ISO 14159	-
ISO 19353	-	Safety of machinery - Fire prevention and protection	-	-
IEC/TR 61000-3-6	-	Electromagnetic compatibility (EMC) - Part 3-6: Limits - Assessment of emission limits for the connection of distorting installations to MV, HV and EHV power systems	-	-
IEC/TS 61000-3-5	-	Electromagnetic compatibility (EMC) - Part 3-5: Limits - Limitation of voltage fluctuations and flicker in low-voltage power supply systems for equipment with rated current greater than 75 A	-	-
ISO/IEC Guide 51	-	Safety aspects - Guidelines for their inclusion in standards	-	-
CISPR 11	-	Industrial, scientific and medical equipment - Radio-frequency disturbance characteristics - Limits and methods of measurement	EN 55011	-

Annex ZZ
(informative)
Coverage of Essential Requirements of EU Directive 2006/42/EC

This European Standard has been prepared under a mandate given to CENELEC by the European Commission and the European Free Trade Association and within its scope the standard covers all relevant essential requirements as given in the EU Directive 2006/42/EC (Machinery Directive).

Compliance with this standard provides one means of conformity with the specified essential requirements of the Directive concerned.

WARNING: Other requirements and other EU Directives may be applicable to the products falling within the scope of this standard.

CONTENTS

INTRODUCTION

This fifth edition of IEC 60519-1 is a product safety publication and is intended to:

– include all types of installations or equipment that are in the scope of IEC TC 27 dealing with industrial **electroheating** (**EH**) and **electromagnetic processing of materials** (**EPM**);

– cover in these General Requirements all hazards that are relevant for more than one type of equipment or installation individually dealt with in Particular Requirements;

– give requirements on electrical safety, touch currents, electric fields, magnetic fields and radiation, thus mirroring the broad scope of installations covered and their processing frequency;

– give means for verification of the requirements;

– make extensive use of the standards developed by IEC committees with horizontal or group safety functions and of relevant ISO standards by reference, including publications developed by ISO/TC 244 (more information is given in Annex H), in compliance with IEC Guide 104;

– be useable like a type-C standard in the sense of ISO 12100;

– include all material, references and requirements suitable for risk assessment and list significant hazards.

This standard adresses mainly **manufacturers** making made-to-order equipment on a single project base. The **manufacturer** is well aware that it is his responsibility to make equipment safe through adequate risk reduction and it is the responsibility of the **user** to assess exposure of the **operator** in line with applicable health and safety regulations. Looking at projects providing single pieces of equipment or single installations, this clear division of responsibilities tends to blur, caused by inter alia

– development of the process (**normal operation**) through the **manufacturer** and **user**,

– shared definition of working procedures for the **operator** by the **manufacturer** and **user**,

– the scope of delivery often including all protective means,

– individual sales contracts where **users** require an assessment of exposure through the **manufacturer**.

Thus this standards provides information on exposure hazards and limits where relevant, well aware that this is exceeding the scope of a product standard.

SAFETY IN INSTALLATIONS FOR ELECTROHEATING AND ELECTROMAGNETIC PROCESSING –

Part 1: General requirements

1 Scope and object

1.1 Scope

This part of IEC 60519 specifies general safety requirements for industrial installations or equipment intended for **electroheating** (**EH**) and **electroheating** based treatment technologies as well as for **electromagnetic processing of materials** (**EPM**).

The requirements are applicable to industrial installations or equipment with the possible use as:

– equipment for direct and indirect resistance heating,
– equipment for electric resistance trace heating,
– equipment for induction heating,
– equipment using the effect of electromagnetic forces on materials,
– equipment for arc heating, including submerged arc heating,
– equipment for electroslag remelting,
– equipment for plasma heating and plasma surface treatment,
– equipment for microwave heating,
– equipment for dielectric heating,
– equipment using electron guns,
– equipment for infrared radiation heating,
– equipment for laser heating.

NOTE The list presents typical examples of equipment and its applications and is not exhaustive.

The overall safety requirements for the various types of **EH** or **EPM equipment** and **installations** result from the joint application of the General Requirements specified in this standard and Particular Requirements covering specific types of installations or equipment (guidelines are given in Annex G). If no Particular Requirement is covering a specific installation or equipment, the General Requirements are applicable as such.

This standard does not apply to equipment and appliances within the scope of:

– IEC 60079 series – i.e. equipment or installations intended for use in potentially explosive atmospheres;
– IEC 60335 series, – i.e. household, commercial and similar electrical appliances, including room heating;
– IEC 60601 series – i.e. medical electrical equipment,
– IEC 60974 series – i.e. arc welding equipment,
– IEC 61010 series – i.e. equipment for laboratory use.

1.2 Object

The requirements refer to the complete life cycle of the installation or equipment from design through commissioning, operation, maintenance, inspection, to decommissioning. They cover

the safety of persons and protection of the environment during **normal operation** and under single-fault condition.

This standard presumes that the installation or equipment is operated and maintained only by personnel consisting of **skilled** or **instructed persons**.

This standard is intended for verifying that the **EH** or **EPM equipment** or **installation** meets the requirements of this standard through design, site acceptance tests, routine tests or inspection.

This standard is not providing requirements for type testing.

NOTE Industrial equipment covered by this standard is typically produced as a single unit or a very small number of units.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60071-1, *Insulation co-ordination – Part 1: Definitions, principles and rules*

IEC 60204-1:2005, *Safety of machinery – Electrical equipment of machines – Part 1: General requirements*
IEC 60204-1:2005/AMD1:2008

IEC 60204-11:2000, *Safety of machinery – Electrical equipment of machines – Part 11: Requirements for HV equipment for voltages above 1 000 V a.c. or 1 500 V d.c. and not exceeding 36 kV*

IEC 60228, *Conductors of insulated cables*

IEC 60335-1:2010, *Household and similar electrical appliances – Safety – Part 1: General requirements*
IEC 603355-1:2010/AMD1:2013

IEC 60335-2-24, *Household and similar electrical appliances – Safety – Part 2-24: Particular requirements for refrigerating appliances, ice-cream appliances and ice makers*

IEC 60335-2-89, *Household and similar electrical appliances – Safety – Part 2-89: Particular requirements for commercial refrigerating appliances with an incorporated or remote refrigerant unit or compressor*

IEC 60364-1:2005, *Low-voltage electrical installations – Part 1: Fundamental principles, assessment of general characteristics, definitions*

IEC 60364-4-41, *Low-voltage electrical installations – Part 4-41: Protection for safety – Protection against electric shock*

IEC 60364-4-42, *Low-voltage electrical installations – Part 4-42: Protection for safety – Protection against thermal effects*

IEC 60364-4-44, *Low-voltage electrical installations – Part 4-44: Protection for safety – Protection against voltage disturbances and electromagnetic disturbances*

IEC 60364-5-53, *Electrical installations of buildings – Part 5-53: Selection and erection of electrical equipment – Isolation, switching and control*

IEC 60364-5-54, *Low-voltage electrical installations – Part 5-54: Selection and erection of electrical equipment – Earthing arrangements and protective conductors*

IEC 60398:—[1], *Installations for electroheating and electromagnetic processing – General performance test methods*

IEC 60417, *Graphical symbols for use on equipment* (available from: http://www.graphical-symbols.info/equipment)

IEC 60445, *Basic and safety principles for man-machine interface, marking and identification – Identification of equipment terminals, conductor terminations and conductors*

IEC 60529, *Degrees of protection provided by enclosures (IP Code)*

IEC 60664-1, *Insulation coordination for equipment within low-voltage systems – Part 1: Principles, requirements and tests*

IEC 60825-1, *Safety of laser products – Part 1: Equipment classification and requirements*

IEC 60865-1, *Short-circuit currents – Calculation of effects – Part 1: Definitions and calculation methods*

IEC 60909-0, *Short-circuit currents in three-phase a.c. systems – Part 0: Calculation of currents*

IEC 60990:1999, *Methods of measurement of touch current and protective conductor current*

IEC 61000-3-3, *Electromagnetic compatibility (EMC) – Part 3-3: Limits – Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems, for equipment with rated current ≤ 16 A per phase and not subject to conditional connection*

IEC TS 61000-3-5, *Electromagnetic compatibility (EMC) – Part 3-5: Limits – Limitation of voltage fluctuations and flicker in low-voltage power supply systems for equipment with rated current greater than 75 A*

IEC TR 61000-3-6, *Electromagnetic compatibility (EMC) – Part 3-6: Limits – Assessment of emission limits for the connection of distorting installations to MV, HV and EHV power systems*

IEC 61000-3-11, *Electromagnetic compatibility (EMC) – Part 3-11: Limits – Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems – Equipment with rated current ≤ 75 A and subject to conditional connection*

IEC 61000-6-2, *Electromagnetic compatibility (EMC) – Part 6-2: Generic standards – Immunity for industrial environments*

IEC 61000-6-4, *Electromagnetic compatibility (EMC) – Part 6-4: Generic standards – Emission standard for industrial environments*

[1] To be published.

IEC 61010-1:2010, *Safety requirements for electrical equipment for measurement, control, and laboratory use – Part 1: General requirements*

IEC 61082-1, *Preparation of documents used in electrotechnology – Part 1: Rules*

IEC 61310 (all parts), *Safety of machinery – Indication, marking and actuation*

IEC 61326-3-1, *Electrical equipment for measurement, control and laboratory use – EMC requirements – Part 3-1: Immunity requirements for safety-related systems and for equipment intended to perform safety-related functions (functional safety) – General industrial applications*

IEC 61508 (all parts), *Functional safety of electrical/electronic/programmable electronic safety-related systems*

IEC 61672-1, *Electroacoustics – Sound level meters – Part 1: Specifications*

IEC 61672-2, *Electroacoustics – Sound level meters – Part 2: Pattern evaluation tests*

IEC 61786-1, *Measurement of DC magnetic, AC magnetic and AC electric fields from 1 Hz to 100 kHz with regard to exposure of human beings – Part 1: Requirements for measuring instruments*

IEC 61786-2[2] *Measurement of DC magnetic fields, AC magnetic and electric fields from 1 Hz to 100 kHz with regard to exposure of human beings – Guidance for measurements*

IEC 61936-1, *Power installations exceeding 1 kV a.c. – Part 1: Common rules*

IEC 62061, *Safety of machinery – Functional safety of safety-related electrical, electronic and programmable electronic control systems*

IEC 62471:2006, *Photobiological safety of lamps and lamp systems*

IEC 82079-1, *Preparation of instructions for use – Structuring, content and presentation – Part 1: General principles and detailed requirements*

CISPR 11, *Industrial, scientific and medical equipment – Radio-frequency disturbance characteristics – Limits and methods of measurement*

IEC Guide 104, *The preparation of safety publications and the use of basic safety publications and group safety publications*

ISO/IEC Guide 51, *Safety aspects — Guidelines for their inclusion in standards*

ISO 3746, *Acoustics – Determination of sound power levels and sound energy levels of noise sources using sound pressure – Survey method using an enveloping measurement surface over a reflecting plane*

ISO 3864-1, *Graphical symbols – Safety colours and safety signs – Part 1: Design principles for safety signs and safety markings*

ISO 6385, *Ergonomic principles in the design of work systems*

---

2 To be published.

ISO 7000, *Graphical symbols for use on equipment – Registered symbols*

ISO 12100:2010, *Safety of machinery – General principles for design – Risk assessment and risk reduction*

ISO 13577-1, *Industrial furnaces and associated processing equipment – Safety – Part 1: General requirements*

ISO 13577-2, *Industrial furnaces and associated processing equipment – Safety – Part 2: Combustion and fuel handling systems*

ISO 13732-1*, Ergonomics of the thermal environment – Methods for the assessment of human responses to contact with surfaces – Part 1: Hot surfaces*

ISO 13849 (all parts), *Safety of machinery – Safety-related parts of control systems*

ISO 13850, *Safety of machinery – Emergency stop – Principles for design*

ISO 13855, *Safety of machinery – Positioning of safeguards with respect to the approach speeds of parts of the human body*

ISO 13857, *Safety of machinery – Safety distances to prevent hazard zones being reached by upper and lower limbs*

ISO 14119, *Safety of machinery – Interlocking devices associated with guards – Principles for design and selection*

ISO 14120, *Safety of machinery – Guards – General requirements for the design and construction of fixed and movable guards*

ISO 14159, *Safety of machinery – Hygiene requirements for the design of machinery*

ISO 19353, *Safety of machinery – Fire prevention and protection*

3 Terms, definitions and abbreviations

For the purposes of this document, the terms and definitions given in IEC Guide 104, ISO/IEC Guide 51 and ISO 12100, as well as the following apply.

NOTE General definitions are given in IEC 60050, the International Electrotechnical Vocabulary. Terms relating to industrial electroheating are defined in IEC 60050-841.

3.1 General concepts

3.1.1
electroheating
EH
DEPRECATED: electroheat
conversion of electric energy into thermal energy for useful purposes

Note 1 to entry: This note applies to the French language only.

[SOURCE: IEC 60050-841:2004, 841-21-22, modified — **electroheating** is the preferred term instead of electroheat, new synonym **EH** has been added and the definition has been shortened.]

3.1.2
electromagnetic processing of materials
EPM
interaction between electromagnetic energy or forces and materials for useful purposes

Note 1 to entry: The EPM can or cannot include heating.

Note 2 to entry: This note applies to the French language only.

3.1.3
electromagnetic field
EMF
electric or magnetic or a combination of electric and magnetic time varying field

Note 1 to entry: In the context of this standard, **EMF** is caused by a source being part of the installation or equipment.

Note 2 to entry: This note applies to the French language only.

3.1.4
electromagnetic radiation
propagating **electromagnetic field** transporting energy

EXAMPLE Microwave radiation or optical radiation (infrared, visible and ultraviolet).

3.1.5
electromagnetic nearfield
non-propagating **electromagnetic field**

3.1.6
manufacturer
producer of the **EH** or **EPM equipment** or **installation** responsible for compliance with this standard

Note 1 to entry: The **manufacturer** in the sense of this standard can also be a supplier, distributer, importer or agent.

Note 2 to entry: From the perspective of the **user**, the **manufacturer** is a party responsible for the design, manufacture, supply and commissioning of the equipment or installation.

3.1.7
user
party responsible for the operation and maintenance of the **EH** or **EPM equipment** or **installation**, from putting into service to de-commissioning

3.1.8
skilled person
person with suitable education, knowledge and experience to perceive risks and to avoid hazards which can be relevant for the type of installation or equipment, including supervision of the **instructed persons**

3.1.9
instructed person
person advised or supervised by **skilled persons**, able to perceive risks and to avoid **hazards** which an installation or equipment can create

3.1.10
operator
skilled person or **instructed person** performing one or more tasks during operation, adjustment, maintenance, repair or disassembly of an installation or equipment

3.1.11
ordinary person
person not able to perceive risks and avoid hazards**,** who can be harmed by exposure to lower limits than **operators**

EXAMPLE A member of the general public including pregnant, elderly or disabled persons, but not children.

3.2 Equipment and state of equipment

3.2.1
electrical equipment
set of items used to generate, convert, transmit, distribute or utilize electric energy, such as converters, transformers, capacitors, switchgear and control gear, measuring instruments, **protective devices** and wiring systems

[SOURCE: IEC 60050-826:2004, 826-16-01, modified — The word "electrical" is used instead of "electric"; the definition has been editorially improved.]

3.2.2
electroheating equipment
EH equipment
DEPRECATED: electroheat equipment
equipment in which electric energy is converted into thermal energy for useful purposes

[SOURCE: IEC 60050-841:2004, 841-22-01, modified — **electroheating equipment** is the preferred term instead of electroheat equipment becoming its synonym, new synonym **EH equipment** has been added, in the definition heat has been replaced by thermal energy]

3.2.3
equipment for electromagnetic processing of materials
EPM equipment
equipment in which electromagnetic energy or electromagnetic force is provided for the **electromagnetic processing of materials**

3.2.4
electroheating installation
EH installation
DEPRECATED: electroheat installation
installation composed of **EH equipment**, **electrical equipment** and mechanical equipment needed for its operation and use

[SOURCE: IEC 60050-841:2004, 841-22-02, modified — **electroheating installation** is the preferred term instead of electroheat installation becoming its synonym, and a new synonym, **EH installation***,* has been added.]

3.2.5
installation for electromagnetic processing of materials
EPM installation
installation composed of **EPM equipment**, **electrical equipment** and mechanical equipment needed for its operation and use

3.2.6
normal operation
operation of the installation or equipment as specified by the **manufacturer** and agreed with the **user**

3.2.7
workload
object or material being processed

Note 1 to entry: The term "load" has a different meaning. Load is used and defined accordingly in some Particular Requirements.

3.3 Parts and accessories

3.3.1
enclosure
housing affording the type and degree of protection suitable for the intended application

[SOURCE: IEC 60050-195:1998, 195-02-35]

3.3.2
window
part of an **enclosure** that allows passage of some kind of radiation

3.3.3
barrier
protective barrier
physical object limiting access to equipment or the **enclosure** of that equipment, which can only be removed with the use of a tool or is interlocked

Note 1 to entry: A **barrier** can be physically separated from the equipment, but is a part of the installation.

3.3.4
guard
barrier that is a part of the equipment

3.3.5
obstacle
item impeding access,which is secured to prevent unintentional removal but is removable without a tool or key

3.3.6
protective device
device other than a **guard** or **enclosure** that reduces a risk

EXAMPLE Two-hand control, pressure sensitive mat or edge, trip bar and wire, light curtain, laser scanner.

3.3.7
screen
shield, en US
device intended to reduce the penetration of an electric, magnetic or **electromagnetic field** into a given region

[SOURCE: IEC 60050-151:2001, 151-13-09]

3.3.8
interlock
mechanical or electrical **protective device** or system that prevents an action which can create a hazard

3.3.9
thermal cut-out
temperature protector
device switching off the equipment when the pre-determined temperature is exceeded

Note 1 to entry: Thermal cut-outs are resettable; temperature protectors are not resettable and are replaced each time they have operated.

3.3.10
photocoupler
optocoupler
optoelectronic device designed for the transfer of electrical signals by utilizing optical radiation to provide coupling while the output is isolated from the input

Note 1 to entry: This device can provide immunity against electromagnetic influences as well as independence of the distance of two voltage system levels.

[SOURCE: IEC 60050-521:2002, 521-04-45, modified — The note has been added.]

3.4 Safety related concepts

3.4.1
live part
conductor or conductive part intended to be energized in **normal operation**, including a neutral conductor, but by convention not a PEN conductor or PEM conductor or PEL conductor

Note 1 to entry: This concept does not necessarily imply a risk of electric shock.

[SOURCE: IEC 60050-195:1998, 195-02-19]

3.4.2
hazardous-live part
live part which, under certain conditions, can give a harmful electric shock

[SOURCE: IEC 60050-195:1998, 195-06-05]

3.4.3
high-voltage hazard zone
HV hazard zone
area limited by the minimum clearance around **hazardous-live parts** of high voltage equipment without complete protection against direct contact

Note 1 to entry: Entering the **high voltage hazard zone** is considered the same as touching **hazardous-live parts.**

3.4.4
touch voltage
voltage between conductive parts when touched simultaneously by a person or an animal

Note 1 to entry: The value of the effective **touch voltage** may be appreciably influenced by the impedance of the person or the animal in electric contact with these conductive parts.

[SOURCE: IEC 60050-195:1998, 195-05-11]

3.4.5
leakage current
DEPRECATED: earth current
electric current in an unwanted conductive path under normal operating conditions

3.4.6
induced electric shock
physiological effect caused by an induced electric field inside the human body

Note 1 to entry: The electric field is usually induced by an **electromagnetic nearfield** and does not necessitate contact to a conductor.

Note 2 to entry: The effects of **induced electric shock** are essentially the same as those of electric shock caused through contact to a conductor, for example burn or nerve reaction. Conditions for ventricular fibrillation are in practice excluded.

3.4.7
emergency switching-off
operation intended to switch-off any electric power from an electrical installation to avert or alleviate a hazardous situation

Note 1 to entry: Some power can remain in function if that provides a less hazardous outcome than a complete switching-off.

[SOURCE: IEC 60050-826:2004, 826-17-03, modified — The words "opening operation of a switching device intended to remove electric power" have been replaced by "operation intended to switch off any electric power" and a note has been added.]

3.4.8
insulation
insulating materials ensuring proper operation of the equipment and protection against electric shock

Note 1 to entry: **Insulation** also refers to the action of insulating.

Note 2 to entry: Under certain circumstances, thermal insulating material can equally perform the function of the electrical **insulation**.

3.4.9
basic insulation
insulation of hazardous-live-parts which provides basic protection

Note 1 to entry: This concept does not apply to **insulation** used exclusively for functional purposes.

[SOURCE: IEC 60050-195:1998, 195-06-06]

3.4.10
galvanic separation
prevention of electric conduction between two electric circuits intended to exchange power and/or signals

Note 1 to entry: **Galvanic separation** can be provided e.g. by an isolating transformer or a **photocoupler**.

[SOURCE: IEC 60050-151:2001, 151-12-26]

3.5 Abbreviations

EH **electroheating**

ELV extra low voltage (below 50 V at mains frequency)

EMC electromagnetic compatibility

EMF **electromagnetic field**

EPM **electromagnetic processing of materials**

HV high voltage (above 1 000 V at mains frequency)

IR infrared (radiation)

LED light-emitting diode

LV low voltage (the range between 50 V and 1 000 V at mains frequency)

MW microwave

PE protective earthing conductor

PEL protective earthing conductor being a line conductor as well

PEM protective earthing conductor being a mid-point conductor as well

PEN protective earthing conductor being a neutral conductor as well

SAR specific absorption rate (of energy)

UV ultraviolet (radiation)

VIS visible (radiation)

4 Classification and sub-division

4.1 Classification by process frequency

EH and **EPM equipment** is classified by its process frequency, i.e. the frequency of the voltage, current or **electromagnetic field** used for the process. Table 1 lists the equipment types and their process frequency ranges as well as safety relevant frequency limits. An installation may include more than one type of equipment.

Table 1 – Equipment, process frequency and safety-relevant frequency limits

<table>
<tr><th>Equipment type</th><th>Frequency [a] range defining equipment type</th><th>Frequency range [b] used for safety limits</th><th>EMF relevant frequency range</th><th>Hazards associated with the frequency range</th></tr>
<tr><td>direct current [c] or stationary field</td><td>0 Hz</td><td colspan="2">0 Hz or no change in polarity</td><td>electric shock,
neural stimulus</td></tr>
<tr><td>low frequency</td><td colspan="2">>0 Hz to <60 Hz</td><td rowspan="3">0,1 Hz to 200 Hz</td><td rowspan="3">electric shock,
burn,
not let-go,
neural stimulus</td></tr>
<tr><td>mains frequency</td><td colspan="2">50 Hz or 60 Hz</td></tr>
<tr><td rowspan="2">medium frequency</td><td rowspan="2">>60 Hz to 100 kHz</td><td>>60 Hz to 200 Hz</td></tr>
<tr><td colspan="2">>200 Hz to 100 kHz</td></tr>
<tr><td rowspan="2">high frequency</td><td rowspan="2">>100 kHz to 0,3 GHz</td><td>>100 kHz to 6 MHz</td><td rowspan="2">>100 kHz to 0,3 GHz</td><td>burn, bodypart heating</td></tr>
<tr><td>>6 MHz to 0,3 GHz</td><td rowspan="2">bodypart heating</td></tr>
<tr><td>microwave</td><td colspan="3">>0,3 GHz to 300 GHz</td></tr>
<tr><td rowspan="3">infrared</td><td rowspan="3">(>300 GHz to 400 THz)
1 mm to 780 nm</td><td>1 mm to 3 000 nm</td><td rowspan="6">not applicable</td><td>burn of skin and cornea</td></tr>
<tr><td>3 000 nm to 1 400 nm</td><td rowspan="2">burn of skin and cornea, retina</td></tr>
<tr><td>1 400 nm to 780 nm</td></tr>
<tr><td>visible</td><td colspan="2">(>400 THz to 790 THz), 780 nm to 380 nm</td></tr>
<tr><td>ultraviolet</td><td colspan="2">(>790 THz to 30 PHz), 380 nm to 10 nm</td><td>burn of skin and cornea,
skin cancer</td></tr>
<tr><td>laser</td><td colspan="2">(>300 GHz to 30 PHz), 1 mm to 10 nm</td><td>burn of skin and cornea, retina</td></tr>
<tr><td colspan="5">[a] Rated process frequency.
[b] Values of the corresponding free space wavelengths are also given in case of optical radiation.
[c] Direct current type – equipment with no intended change of polarity, but including switch-on and switch-off.</td></tr>
</table>

4.2 Classification by voltage

Throughout all **electrical equipment** for industrial applications a division between

– extra low voltage (ELV) and low voltage (LV) is made at 50 V (rms) at mains frequency or 120 V direct current.

– low voltage (LV) and high voltage (HV) is made at 1 000 V (rms) at mains frequency or 1 500 V direct current.

NOTE The definitions of ELV and voltage band 1, LV and voltage band 2 and HV and voltage band 3 are identical. Voltages below 25 V mains frequency or 60 V direct current are seen as without **risk** for any **ordinary person**.

This distinction shall be made for the installation and for parts as defined in 4.3.1 and

a) depending on the supply and the output voltage, whichever is the higher value (internal voltages may be higher);
b) independently of the process voltage or internal voltage of the installation or equipment.

Different parts of one installation may be classified as ELV, LV or HV.

4.3 Sub-division of installation and equipment

4.3.1 Subdivision into parts

EH or **EPM installations** consist of diverse and specific parts. Figure 1 presents a block diagram of a typical installation for reference; it determines the boundary of installations and equipment, not all parts are found in every kind of **EH** or **EPM installation**.

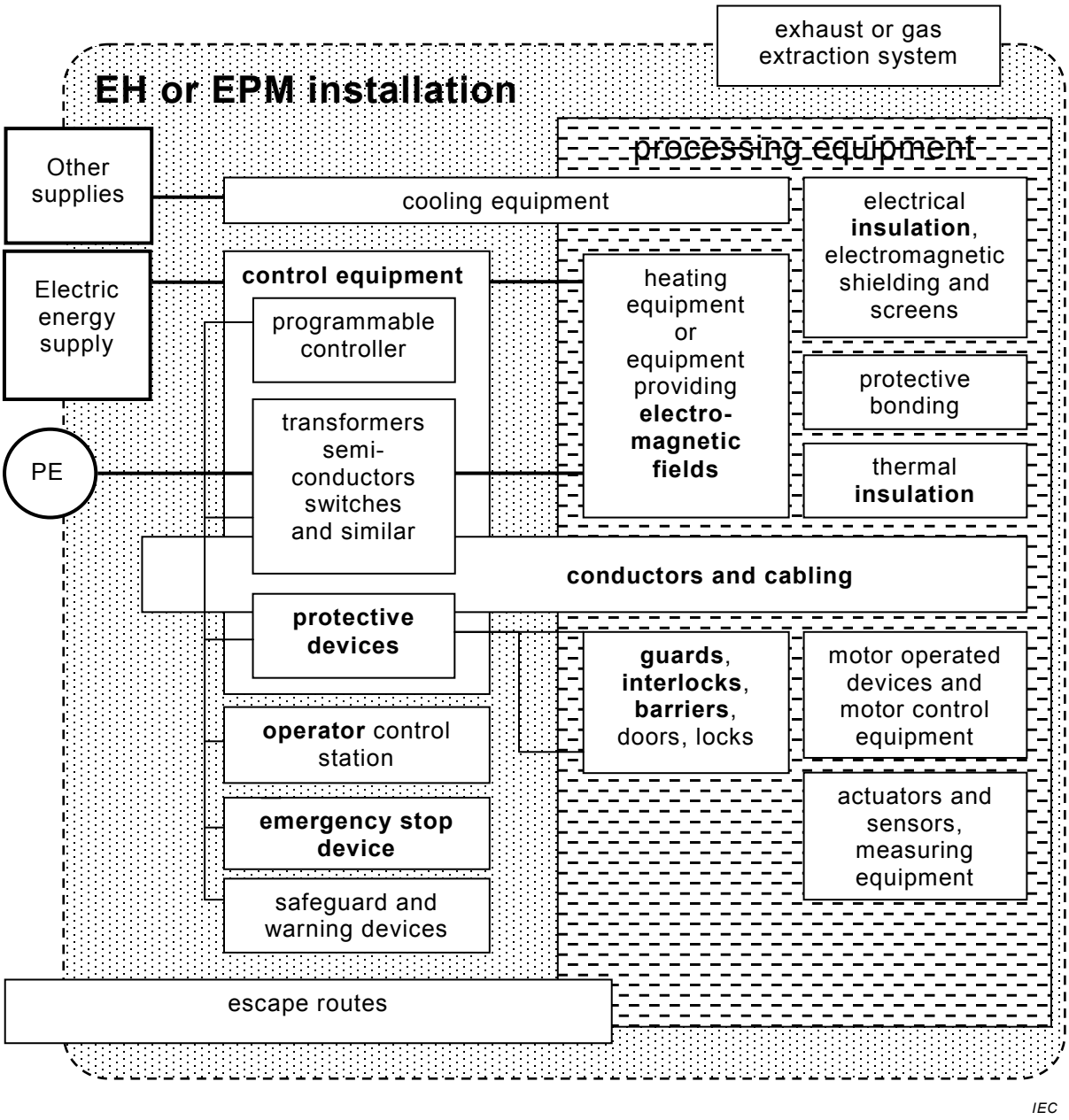


Figure 1 – Block diagram of a typical EH or EPM installation

Table 2 provides references to clauses of this standard or to other standards relevant to the parts identified in the above Figure 1.The requirements for **electrical equipment** outside the processing equipment are covered by IEC or ISO standards specified in Table 2. The basic sources of safety provisions for **electrical equipment** of **EH** or **EPM installations** are IEC 60204-1:2005 and IEC 60204-1:2005/AMD1:2008 for LV and IEC 60204-11:2000 for HV.

The safety requirements for the processing equipment are specific because of its extraordinary environment and conditions inside, where

a) extreme temperatures can interact with **electrical equipment**,

b) strong electric, magnetic or **electromagnetic fields** can interact with the **electrical equipment**,

c) thermal energy or electromagnetic forces can endanger the structural integrity of the equipment or of **insulation** and of protective means.

Table 2 – Typical EH or EPM installation – listing of parts and references

Part of installation or equipment – see Figure 1		Condition for which the reference is valid	Reference / source of provisions
Part	**Component / item**		
electric energy supply		LV, ≤ 200 Hz	IEC 60364-4-41, IEC 60364-4-42, IEC 60364-4-44, IEC 60364-5-53, IEC 60364-5-54 IEC 60445, IEC 60664-1
protective earth, PE			
protective bonding			
conductors and cabling at standard environment			
electric energy supply		HV, ≤ 200 Hz	IEC 61936-1, IEC 60071-1
protective earth, PE			
protective bonding			
conductors and cabling at standard environment			
electric energy supply		all other, ≤ 36 kV	Clause 7
protective earth, PE			
protective bonding			
conductors and cabling at standard environment		< 40 °C	IEC 60228
conductors and cabling exposed to non-standard environment		> 40 °C	6.4.2, 13.3
control equipment	switchgear and controgear	LV, ≤ 200 Hz	IEC 60204-1
		HV, ≤ 36 kV, ≤ 200 Hz	IEC 60204-11
		> 36 kV, ≤ 200 Hz	Particular Requirements
		> 200 Hz	Clause 7
	programmable controller	all	IEC 61508 series, IEC 62061, ISO 13849 series
	protective devices		
operator control station (same as switchgear and controlgear)		< 1 000 V, ≤ 200 Hz	IEC 60204-1
		>1 000 V, ≤ 200 Hz	IEC 60204-11
		all other	Clause 7 and 8
emergency stop device (same as switchgear and controlgear)		< 1 000 V, ≤ 200 Hz	IEC 60204-1
		> 1 000 V, ≤ 200 Hz	IEC 60204-11
		all other	ISO 13850
safeguard and warning devices (same as switchgear and controlgear)		< 1 000 V, ≤ 200 Hz	IEC 60204-1
		> 1 000 V, ≤ 200 Hz	IEC 60204-11
		all other	ISO 13850
other supplies – e.g. fluids, fuel, compressed air		all	Clause 12
gaseous or liquid fuels		all	ISO 13577-2
fluid extraction system		all	Clause 12
exhaust		all	ISO 13577-1
escape routes		all	IEC 60364-4-42

Part of installation or equipment – see Figure 1		Condition for which the reference is valid	Reference / source of provisions
Part	**Component / item**		
processing equipment	electrical heating equipment, usually **electroheating equipment**	see 6.4	Clauses 7, 8, 9, 10 Particular Requirements
	non-electric heating equipment		ISO 13577-1 ISO 13577-2
	equipment providing **electromagnetic fields**		Clause 7, 8, 9, 10 Particular Requirements
	thermal **insulation**		Clause 10 ISO 13577-1
	electrical **insulation**		Clauses 7, 8, 9, 10
	electromagnetic shielding		Clauses 7, 8, 9, 10
	actuators and sensors		IEC 61310 series
	measuring equipment		IEC 61010-1 Particular Requirements
	motor operated devices and motor control equipment		IEC 60204-1
	guards, **interlocks**, **barriers**, doors, locks		ISO 14119 ISO 14120 Particular Requirements
	cooling		Clauses 10 and 12

4.3.2 Hierarchy and structure of requirements

The following rules are a guideline especially with respect to the requirements on electromagnetic safety, which comprises electric shock, **induced electric shock**, touch currents and other effects of **electromagnetic fields**.

a) For all parts of an installation that fall under the scope of one of the standards listed in Table 2 that standard shall be used.

b) For equipment or parts outside the scope of any of the standards listed in Table 2, Clause 7 applies, i.e. for equipment with frequencies above 200 Hz or intended to be used at temperatures higher than 40 °C.

c) Equipment exceeding the voltage limit of 36 kV is dealt with in the Particular Requirements.

4.4 Classification of hazards and risks

4.4.1 Classification of hazards

Hazards are differentiated according to the following criteria:

a) hazards where the harm is immediate – i.e. any accident directly results in harm and

b) hazards where the harm depends on the exposure, accumulation or dose – for example on intensity, a field strength, an exposure time.

Examples of immediate hazards are electric shock, the ejection of objects, explosion, mechanical hazards like cutting or falling, toxic substances of potentially lethal dose.

Examples of exposure related hazards are exposure to optical or microwave radiation, exposure to electric or magnetic fields, exposure to sound or noise, exposure to ionizing radiation, toxic or radioactive substances.

Contact with hot surfaces or hot substances can be dose-related at low temperatures, or immediate, for example direct contact to liquid metals.

Hazards are differentiated as

c) sensed hazards – i.e. hazards creating adverse body reactions and

d) non-sensed hazards or non-perceivable hazards.

Examples of sensed hazards are temperature of material or of environment, intense visible radiation, fast moving parts, acceleration, vibration or noise.

Examples of non-sensed or non-perceivable hazards are UV radiation, ionising radiation or radioactive substances, toxic substances, microwave, magnetic or electric fields.

4.4.2 Classification of risks

Risks depending on exposure level, duration, intensity of the agent, but also depending on the exposed bodypart, awareness or sensing of the agent, experience or information about the type of hazard, and behavioural factors such as aversion or withdrawal are treated through a level categorisation of the risk, with non-perceivable hazards being categorised as requiring particular protective measures. Table 3 summarises this as a general approach.

Table 3 – Safety classification scheme for exposure risks

Risk Group		Restrictions and protective measures	Information and training
0	exempt	No restriction	No information needed
1	low risk	Restrictions like limitation of access or protective measures may be indicated depending on the result of a risk assessment	Information about hazards, risks and secondary effects to be provided by the **manufacturer**
2	moderate risk	Special restrictions and protective measures essential	Information about hazards, risks and secondary effects to be provided by the **manufacturer**. If specific training of the **operator** is deemed necessary by the **manufacturer**, he shall indicate this.
3	high risk	No access	Information about hazards, risks and secondary effects to be provided by the **manufacturer**.

Each spatial position or hazard zone shall be considered individually. **Normal operation** and single-fault condition shall be taken into account. Annex B and Annex C provide examples of risk group classifications.

4.4.3 Limits

Limits for significant hazards dealt with in this standard concern the following:

– electric, magnetic and **electromagnetic fields** including touch currents – information on hazards and applicable limits is provided in Annex B,

– optical radiation in the infrared, visible and ultraviolet – information on internationally recognised limits is provided in Annex C;

– acoustic fields – information on limits is provided in Annex D;

– hot ambient environment and objects – limits are given in ISO 13732-1, which corresponds to IEC Guide 117 (see also Clause 10).

It is in the responsibility of the **manufacturer** or **user**, as relevant, to take into account limit values specified by national regulations, if such exist. If not, the limits defined in this standard can be used.

5 Risk assessment

The risks associated with hazards relevant to the installation shall be assessed. This determines the adequate reduction of identified risks and the necessary protective measures, while still maintaining an appropriate performance of the installation.

This standard, in combination with the applicable Particular Requirements, assists the **manufacturer** during the process of risk assessment and risk reduction. This standard addresses the hazards specific and typical for **EH** and **EPM installations**. Annex A provides a list of significant hazards considered in this standard.

Implementation and methods of risk assessment and risk reduction are specified in ISO 12100 and apply.

6 General provisions

6.1 Basic considerations

6.1.1 Any **EH** or **EPM installation** or **equipment** shall be suitable for its intended use, it shall be designed to be operated, adjusted and maintained without putting persons at **risk** during **normal operation** or single-fault condition**.** Design and construction shall ensure adequate reduction of the **risks** at the state of the art and for the foreseeable lifetime of the installation or equipment.

It shall not cause any risk through the **workload** that is foreseeable to the **manufacturer**.

6.1.2 Any **EH** or **EPM installation** or **equipment** shall be designed to prevent or to reduce the possibility of any misuse or fault condition.

6.1.3 Any **EH** or **EPM installation** or **equipment** shall not pose a risk of the immediate or non-perceivable types, unless the intended use is otherwise impossible to achieve. Additional protective measures, warnings and instructions shall be provided in such cases.

6.1.4 The **manufacturer** shall in the following order

a) eliminate risks to achieve an inherent safe installation or equipment,

b) provide protective measures for those risks that are not eliminated,

c) provide all necessary information to the **user** about residual risks, indicate necessary training and personal protective equipment.

Even though an inherently safe design seems out of reach for most **EH** or **EPM installations** or equipment, the **manufacturer** shall attempt to achieve this where possible.

6.1.5 Protective measures are a combination of measures incorporated at the design stage and measures being indicated as to be implemented by the **user**. The **manufacturer** shall incorporate all measures identified to be necessary according to Clauses 5 through 17 when applicable.

6.1.6 If a specific hazard is in risk group 1 or 2 as defined in Table 3 and cannot be reduced further by the **manufacturer**, the **manufacturer** shall provide detailed information for the **user** including

a) a graphical description or plan of the installation indicating the position and extent of areas belonging to zones with risk group 1 or 2;

b) information on signalling and warning devices – see 19.3;

c) necessary marking and warning – see 19.4;

d) indication of necessary restrictions and protective measures to be taken by the **user** – see 19.5;

e) indication of the necessary information for the **operators** – see 19.5;

f) indication of working procedures that are safe or reduce the risk.

6.1.7 If a specific hazard is in risk group 3 as defined in Table 3 and cannot be reduced further by the **manufacturer**, the **manufacturer** shall provide detailed information for the **user** including

a) a graphical description or plan of the installation indicating the position and extent of areas belonging to zones with risk group 3;

b) information on signalling and warning devices – see 19.3;

c) necessary marking and warning – see 19.4;

d) indication of the necessary information for the **operators** – see 19.5.

6.1.8 Adequate risk reduction shall not be confused with the reduction of exposure to levels near exposure limits. Adequate risk reduction eliminates a hazard, or if this is impossible, reduces exposure to the technical limit. The adequate use of exposure limits is in the responsibility of the **user**.

6.2 Significant hazards

Provisions for protection against various types of identified significant hazards are specified in Clauses 6 to 17. Annex A provides a list of significant hazards relevant for the application of this standard.

Verification of compliance with the provisions of this standard shall be done according to Clause 18.

6.3 Physical environment and operating conditions for the installation as such and electrical equipment outside the processing equipment

6.3.1 The **EH** or **EPM installation** and its **electrical equipment** not placed inside the processing equipment shall be suitable for the physical environment and operating conditions of its intended use.

When special conditions apply or the limits specified in 6.3 are exceeded, an agreement between the **manufacturer** and **user** may be necessary. In this case, 4.1 and Annex B of IEC 60204-1:2005 and IEC 60204-1:2005/AMD1:2008 are applicable for LV installations and 4.1 and Annex B of IEC 60204-11:2000 are applicable for HV installations.

6.3.2 The installation shall not generate electromagnetic disturbances above levels that are appropriate for its intended operating environment. In addition, the equipment shall have a level of immunity to electromagnetic disturbances so that it can operate in its intended environment. Requirements are identified in Annex E.

6.3.3 The installation shall be capable of operating safely in the intended ambient air temperature. The minimum requirement for all **electrical equipment** is safe operation at air temperatures between 5 °C and 40 °C.

6.3.4 The installation shall be capable of operating safely when the relative humidity does not exceed 50 % at a maximum temperature of 40 °C. Higher relative humidity is permitted at lower temperatures (e.g. less than 90 % at 20 °C). The installation shall either be able to

operate safely if condensation happens occasionally or the **manufacturer** shall avoid condensation by design of the equipment or, where necessary, by additional measures (e.g. built-in heaters, air conditioners or drain holes).

6.3.5 The installation shall be capable of operating safely at air pressure expected at up to 1 000 m altitude and under a wide range of climate and weather conditions. The low ambient pressure limit shall be 85 % of normal sea-level atmospheric pressure.

For equipment to be used at higher altitudes or lower air pressure, it is necessary to take into account the reduction of the dielectric strength, the switching capability of the devices and the cooling effect of the air.

6.3.6 The **electrical equipment** of the installation shall be adequately protected against the ingress of solids and liquids according to 11.3 of IEC 60204-1:2005 for LV equipment. It shall be adequately protected against contaminants (e.g. dust, acids, corrosive gases or salts) that can be present in the physical environment for which it is intended.

6.3.7 When equipment is exposed to radiation (e.g. MW, UV, laser or X-ray), additional measures shall be taken to avoid malfunctioning of the equipment, accelerated deterioration of the **insulation**, metal degradation or corrosion due to radiation induced effects.

6.3.8 Undesirable effects on the installation caused by vibration, shock and bump (including those generated by the installation and its associated equipment and those created by the physical environment) shall be avoided by the selection of suitable equipment, by mounting it away from the equipment creating the vibration or shock, or by provision of anti-vibration or anti-shock mountings.

6.4 Physical environment and operating conditions for electrical equipment inside the processing equipment

6.4.1 **Electrical equipment** placed inside or near the processing equipment shall be suitable for the physical environment and operating conditions of its intended use.

Physical conditions inside or near the processing equipment cover an extremely wide range of different environments, it may be necessary for the **manufacturer** and **user** to agree on these conditions.

6.4.2 The **electrical equipment** shall be capable of operating correctly under **normal operation** and single-fault condition

a) at the intended temperature levels inside or near the processing equipment;

b) at the humidity levels inside or near the processing equipment (extreme humidity levels or strong condensation can be expected as well as total immersion);

c) at intended atmospheric conditions and pressures inside or near the processing equipment;

d) under prevalent electric and magnetic fields inside or near the processing equipment.

6.4.3 **Electrical equipment** shall be adequately protected against the ingress of solids and liquids, in particular against contaminants (e.g. dust, acids, corrosive gases or salts) that are expected to be present inside or near the processing equipment.

6.4.4 When **electrical equipment** inside the processing equipment is exposed to radiation (e.g. MW, UV, laser or X-ray) additional measures shall be taken to avoid malfunctioning of the equipment and accelerated deterioration of the **insulation**.

6.4.5 Undesirable effects on the installation caused by vibration, shock and bump generated by the processing equipment and those created by the physical environment shall

be avoided by selection of suitable **electrical equipment**, by mounting it away from the processing equipment, or by provision of anti-vibration mountings.

6.5 Power supply

6.5.1 The installation shall be designed to operate correctly under **normal operation** with the conditions of the **supply network**:

– as specified below, or

– as otherwise specified by the **user** and acknowledged by the **manufacturer**, or

– as specified by the **manufacturer** in the case of a special source of supply such as an onboard generator.

For mains frequency supplies the following applies, unless otherwise explicitly agreed on by the **manufacturer** and the **user**:

a) steady state voltage in the range of 90 % to 110 % of nominal voltage;

b) frequency in the range of 0,99 to 1,01 of nominal frequency continuously; according to IEC 60204-1, 0,98 to 1,02 short time (no excessive temperature rise in components due to an abnormal current).

For special supply systems such as onboard generators, the limits given may be exceeded provided that the equipment is designed to operate correctly under those conditions.

6.5.2 In case of failure or fault of the electric supply, the installation or equipment

a) shall not go into unsafe mode of operation or into single-fault condition, especially shall not start unexpectedly, shall not be prevented from stopping if the stop command has been given, shall not eject or let fall any part or **workload** unless protection is provided for this case;

b) shall not lose the setting of the switchgear, controlgear or programmable controller necessary for safe operation;

c) shall be able to keep all **protective devices** fully operational or let them give a stop command;

d) shall be able to cool down without causing a hazard.

6.6 Access

6.6.1 The installation or equipment shall allow safe access to all areas where intervention is necessary during operation or maintenance. The equipment shall be so designed and installed that all devices and components that are intended to be accessible, observed or seen by the **operator** are accessible or visible to the **operator.**

6.6.2 Risks shall be reduced by limiting or preventing the access to the hazard or to the hazard zone. Limitation of access to surfaces or parts that can cause a hazard or of access for entering a hazard zone depends on the hazard itself, its type (immediate or exposure dependent) and the strength of the source of the hazard (e.g. the temperature of a surface or the voltage of a **live part**).

6.6.3 Protection against unintentional access to **hazardous-live parts** or against unintentional entering the hazard zone shall be provided in all cases where either there are no **barriers** or **enclosures**, or where **barriers** or **enclosures** are to be removed to gain access to devices requiring manual operation or to components requiring replacement.

6.6.4 The access path to the device and the space needed for its operation shall be such that protection against unintentional contact with **hazardous-live parts** or against unintentionally entering the hazard zone is provided by an appropriate distance.

Obstacles protecting against unintentional contact shall be provided if the access path or space has less than the appropriate distance from **hazardous-live parts**.

6.6.5 The degree of protection shall be not less than IPXXB (also complied with by IP2X) of IEC 60529 from the direction of approach to the device or component, and not less than IPXXA (also complied with by IP1X) of IEC 60529 from other directions.

6.7 Ergonomic aspects

The physical and physiological stress faced by the **operator** during **normal operation** and intended environmental conditions shall be reduced to a possible minimum. In this regard, the main objectives are the following:

a) avoid a work rate determined by the installation only,

b) avoid monitoring of the installation or its control unit that demands lengthy concentration,

c) allow for the variation in the strength, stamina or physical dimensions of different **operators**,

d) allow for sufficient space for the movements of the **operator**,

e) adapt the control unit and other interfaces to the foreseeable variation in characteristic of **operators**.

Provisions of ISO 6385 apply.

6.8 Transport and storage

Electrical equipment shall be designed to withstand the effects of transport and storage at temperatures within a range from -25 °C to 55 °C and for short periods not exceeding 24 h at up to 70 °C. Otherwise, suitable precautions shall be taken to protect **the electrical equipment** against such effects. Suitable means shall be provided to prevent damage from humidity, vibration and shock.

NOTE **Electrical equipment** susceptible to damage at low temperatures includes PVC insulated cables, certain electrolytic capacitors or equipment using cooling water.

6.9 Provisions for handling

6.9.1 **EH** or **EPM installation** or **equipment** shall be capable of being handled and assembled safely.

6.9.2 Any part of an installation or equipment that cannot be moved by hand shall be fitted with attachments for lifting.

6.9.3 All parts shall be easily assembled by use of appropriate provisions or lifting gear.

6.10 Consumables and replaceable parts

Consumable or replaceable parts that are intended to be replaced by the **operator** shall be integrated or mounted in a way that replacement is uncomplicated and safe with regard to correct and unambiguous mounting and to electrical connection.

7 Protection against electric shock

7.1 General

Clause 7 applies

a) for the processing equipment, if this is not covered by the scope and the environmental limits of the IEC 60204 series, i.e. exceeding 40 °C and

b) for equipment of **EH** or **EPM installations** with an electrical frequency exceeding 200 Hz.

Clause 7 does neither apply for equipment covered by the IEC 60204 series, nor for equipment with a voltage exceeding 36 kV, which is covered by the Particular Requirements.

NOTE Electrical hazards are associated with electric charges and currents between frequencies of 0 Hz and up to about 100 kHz. Conventional electric shock phenomena gradually change or disappear at the upper limit; protective means like equipotential bonding cease to operate reliably.

7.2 Fundamental rule of protection

Hazardous-live parts shall not be accessible and accessible conductive parts shall not be hazardous-live either during **normal operation**, or under single-fault condition. For HV installations or equipment, entering the **HV hazard zone** is considered the same as touching a **hazardous-live part**.

Non-accessible parts are all **hazardous-live parts** or hazard zones beyond the limits of reach – i.e. contact is not possible as defined in ISO 13857 during **normal operation** or in single-fault condition.

Protection during **normal operation** is provided by basic protection (7.4), and protection in single-fault condition is provided by fault protection (7.5). Protection by enhanced protective provision as defined in 5.3 of IEC 61140:2001 is not sufficient for any installation or equipment under the scope of this standard.

7.3 General provisions

7.3.1 All conductive parts which are not separated from **hazardous-live parts** by at least **basic insulation** shall be treated as if they were **hazardous-live parts**. This also applies to conductive parts which are separated by **basic insulation** but are connected to **hazardous-live parts** through components, which are not designed to sustain the same electric stress as specified for **basic insulation**.

7.3.2 Exposed conductive parts of the installation or equipment shall be connected to the protective bonding terminal. This includes all parts which are covered only by paints, varnishes, lacquers and similar products. Not included are conductive parts which can be touched but are separated from **hazardous-live parts** by protective separation.

7.3.3 If the installation or equipment is not completely covered with conductive parts, the following applies to accessible parts of insulating material. Accessible surfaces of parts of insulating material which

– are designed to be gripped, or
– are likely to come into contact with conductive surfaces which can distribute hazardous potential, or
– can come into significant contact (area more than 50 mm × 50 mm) with a part of the human body, or
– are to be used in areas where the pollution is highly conductive

shall be separated from **hazardous-live parts** by

a) double or reinforced **insulation**, or
b) **basic insulation** and protective screening, or
c) a combination of these provisions.

All other accessible surfaces of parts of insulating material shall be separated from **hazardous-live parts** by at least **basic insulation**. For all equipment intended to be part of the installation, the **basic insulation** shall be provided during assembly and installation either

by the **manufacturer** or by the **user** as indicated by the **manufacturer** in the information for use.

These requirements are deemed to be complied with if

– the accessible parts of insulating material provide the required **insulation** and their temperature does not exceed the limits defined in Clause 10;
– the switchboard is made from metal and driving axles of switches, turn-knobs or similar are effectively brought to earth potential in all positions.

7.3.4 The design of the installation or equipment shall restrict access to **HV hazard zones**. The need for operational and maintenance access by **operators** shall be taken into account. Where safe distances cannot be achieved, permanent protective shielding shall be installed.

Warning labels shall be displayed on all access doors, **guards**, **barriers**, and be in compliance with 19.4.

7.3.5 If it is not feasible for operating reasons to prevent the following LV parts being both accessible and **hazardous-live**, they are permitted to be accessible by an **operator** during **normal operation**:

a) parts of lamps and lamp sockets after lamp removal;
b) parts intended to be replaced and which can be hazardous-live during the replacement or other **operator's** action, but only if they are accessible with a tool and have a warning marking – see 19.4.

If any of the parts mentioned in a) and b) receive a charge from an internal capacitor, they shall not be hazardous-live 10 s after interruption of the supply.

7.4 Basic protection

7.4.1 All installations or equipment under the scope of this standard shall be provided with basic protection.

a) For LV installations or equipment, in the absence of a specific standard listed in Table 2, all basic protection shall be in compliance with IEC 60364-4-41.
b) For HV installations or equipment, in the absence of a specific standard listed in Table 2, all basic protection shall be in compliance with 7.4.

7.4.2 Basic protection shall consist of one or more provisions that at least during **normal operation** prevent contact with **hazardous-live parts**.

7.4.3 Where solid **basic insulation** is used, it shall prevent contact with **hazardous-live parts**.

In case of HV installations and equipment, a voltage can be present on the surface of solid **insulation** and further precautions may be necessary.

Where **basic insulation** is provided by air, access to **hazardous-live parts** or entering the hazard zone shall be prevented by **obstacles**, **barriers** or **enclosures** as specified in 7.4.4 and 7.4.5 or by placing them out of arm's reach according to ISO 13857.

Where a conductive **obstacle** is separated from **hazardous-live parts** by **basic insulation** only, it is an exposed conductive part and measures for fault protection shall be applied.

7.4.4 **Barriers** or **enclosures** preventing access to **hazardous-live parts** or entering the hazard zone shall provide a degree of protection of at least IPXXB (also complied with by IP2X) of IEC 60529.

Barriers or **enclosures** shall have sufficient mechanical strength, stability and durability to maintain the specified degree of protection, taking account of all relevant influences from the environment and from inside the **enclosure** – ISO 14119 and ISO 14120 shall be used for their design.

Where the design or construction allows for the removal of **barriers**, the opening of **enclosures** or the removal of parts of **enclosures**, access to **hazardous-live parts** or entering the hazard zone shall only be possible

– with the use of a key or tool, or
– after isolation of **hazardous-live parts** from the **supply network** where the **enclosure** would no longer provide protection, restoration of the supply shall become possible only after replacement of **barriers** or parts of **enclosures** or after the closing of doors, or
– where an intermediate **barrier** still maintains the required degree of protection, such **barrier** being removable only by the use of a key or tool.

Barriers or **enclosures** shall be made from such material that no hazardous induced currents can be created in them.

7.4.5 In the case of HV installations and equipment, substantial inequalities of electric field strength in or along an insulator or **insulation** shall be reduced to a safe level or avoided through constructional measures or through potential grading. This shall prevent the **operator** from hazardous step and **touch voltages**.

NOTE Potential grading is typically used for electrical installations, where high earth currents occur.

7.4.6 At frequencies exceeding 200 Hz potential grading of the circuit shall be controlled by the following means:

a) If earthing is necessary for reasons of equipment design, any constructional parts of the installation shall not be relied upon. A separate low reactance conductor forming path between the generator and the processing applicator shall be provided instead.
b) The voltage drop shall not exceed 5 V rms over any distance of the installation that can be touched by a person at once, if the conductor currents exceed 500 A unless access is hindered to the installation by sufficient **barriers** or **enclosures** (refer to 7.4.4).

NOTE This limitation of the geometric extent is due to electromagnetic waves and their propagation to result in unreliable earthing continuity at frequencies above approximately 100 kHz.

7.5 Provisions for single fault protection

7.5.1 Fault protection shall consist of one or more provisions independent of and additional to those for basic protection. Individual provisions for fault protection are specified in 7.5.2 to 7.5.7.

7.5.2 Single-fault conditions shall be considered, if they can cause

a) an accessible, non-**hazardous-live part** to become a **hazardous-live part**, or
b) an accessible conductive part which is not live during **normal operation** to become hazardous-live, or
c) a **hazardous-live part** to become accessible.

7.5.3 To meet the fundamental rule under single-fault condition, fault protection shall be achieved by a further protective provision, independent of that for basic protection (7.3.4). The independent single fault protection shall be provided

– for LV installations or equipment, in the absence of a specific standard listed in Table 2, in compliance with IEC 60364-4-41.
– for HV installations or equipment, in the absence of a specific standard listed in Table 2, in compliance with 7.5.

7.5.4 Each of the two independent protective provisions shall be designed so that a failure is unlikely under environmental conditions specified in 6.3 or 6.4 and under **normal operation** or single-fault condition.

The two independent protective provisions shall have no influence on each other.

NOTE Simultaneous failure of the two independent protective provisions is unlikely and is not normally taken into consideration. Reliance is placed on one of the protective provisions remaining effective.

7.5.5 Requirements for protective equipotential bonding are defined in 7.6 and apply independently.

7.5.6 Protective screening shall consist of a conductive **screen** interposed between **hazardous-live parts** of an installation or equipment and the part being protected. The protective **screen** shall be connected to the protective equipotential bonding system of the installation or equipment; it shall itself comply with the requirements for protective equipotential bonding according to 7.6.

7.5.7 Simple separation between a circuit and other circuits or earth shall be achieved by **basic insulation** throughout, rated for the highest voltage present.

If any component is connected between the separated circuits, that component shall withstand the electric stresses specified for the **insulation** which it bridges and its impedance shall limit the prospective current flow through the component to the steady-state touch current values indicated in Annex B.

7.5.8 Supplementary insulation shall be dimensioned to withstand the same stresses as specified for **basic insulation**.

7.6 Protective equipotential bonding

7.6.1 The protective equipotential bonding system shall consist of one or a suitable combination of two or more of the following elements:

a) means for protective equipotential bonding in equipment;

b) earthed protective-equipotential bonding in the installation;

c) protective conductor (PE);

d) protective conductor being a neutral conductor as well (PEN);

e) protective screening;

f) earthed point of the source;

g) earth electrode (including earth electrodes for potential grading);

h) earthing conductor.

Specific considerations apply for frequencies well above mains frequency and are given in the Particular Requirements.

All parts of the protective bonding circuits shall be so designed that they are able to withstand the highest thermal and mechanical stress, which can be caused by earth-fault currents, flowing in any part of the protective bonding circuits. For the assessment of short circuit currents IEC 60909-0 shall be used, for effects of short circuit currents IEC 60865-1 is applicable.

Any structural part of the electrical installation or equipment may be used as part of the protective bonding circuit, in case an earth fault monitoring system is installed.

7.6.2 The equipotential bonding system of a HV installation or equipment shall be connected to earth because of the special risks, which can be present, for example the danger of high touch and step voltage and of exposed conductive parts becoming live due to an electrical discharge. The impedance to earth of the earthing arrangement shall be rated so that no hazardous **touch voltage** can occur (refer to Clause 18 in connection with Annex B). Exposed conductive parts, which can become live under fault conditions, shall be connected to the earthing arrangement.

7.6.3 Accessible conductive parts which could acquire a hazardous effective **touch voltage** in the event of a failure of basic protection, i.e. exposed conductive parts and any protective **screen**, shall be connected to the protective equipotential bonding system.

7.6.4 The protective equipotential bonding system shall be of sufficiently low impedance to avoid hazardous potential difference between parts in case of an **insulation** failure and, if necessary, be used in association with a **protective device** operated by the fault current.

This can necessitate consideration of the relative impedance values of the different elements of a protective equipotential bonding system. The difference in potential need not be considered if the impedance of the circuit limits the steady-state touch current in the case of a single fault so that it cannot exceed 3,5 mA rms for frequencies up to 100 Hz or 10 mA for direct current applications when measured in accordance with Clause 18. In some environments or situations, e.g. highly conductive locations or wet areas, the limiting values shall be lower.

NOTE IEC TS 60479-1 can provide relevant data on impedance.

7.6.5 All parts of the protective equipotential bonding shall be so dimensioned that thermal and dynamic stresses which are likely to occur due to a fault current do not impair the characteristics of the protective equipotential bonding system as a consequence of a failure or bridging of **basic insulation**. Some local damage, not impairing safety, e.g. of a sheet metal part of an **enclosure**, may be accepted at the place where the fault occurs.

7.6.6 All parts of the protective equipotential bonding shall be capable of withstanding all internal and external influences (including mechanical, thermal and corrosive) which can occur during the expected lifetime of the installation.

If parts need to be checked regularly or maintained, the **manufacturer** shall indicate this in the information for use.

Movable conductive connections, e.g. hinges and slides, shall not be considered to be parts of a protective equipotential bonding system unless compliance with the requirements in 7.6 is maintained.

Where a component of an installation or equipment is intended to be removed, the protective equipotential bonding for any other part of the installation or equipment shall not be interrupted when removing the component unless the electrical supply to the other part is disconnected first.

No element of the protective equipotential bonding shall contain any device which could reasonably be expected to break the electrical continuity or to introduce significant impedance, with the exception of components intended to be removed. This requirement may be dispensed only temporarily for the verification of the continuity of protective conductors or for the measure of the current of the protective conductor – see Clause 18.

7.6.7 Where elements of the protective equipotential bonding can be interrupted by the same coupler or plug-and-socket-outlet device as the relevant supply conductors, the protective equipotential bonding shall not be interrupted earlier than the supply conductors. The protective equipotential bonding shall be re-established not later than when the supply

conductors are reconnected. These requirements do not apply when interruption and reconnection are only possible with the equipment in de-energized condition.

7.6.8 In HV installations and equipment, the protective equipotential bonding shall not be interrupted before the main contact has reached an isolating distance which can withstand the equipment rated impulse withstand voltage.

7.6.9 Conductors of the protective equipotential bonding, whether insulated or bare, shall be readily distinguishable by shape, location, marking or colour, except those conductors which cannot be disconnected without destruction, e.g. in wire-wrap and similar wiring in electronic equipment and tracks on printed wiring boards. If identification by colour is used, it shall be in accordance with IEC 60445.

7.6.10 In LV equipment, the protective conductors or the continuity of the protective bonding system shall be in accordance with 8.2 of IEC 60204-1:2005. This includes the requirements on the exclusion of switching devices, parts that need not be connected, and interruption.

Protective connector connection points, protective bonding in installations with earth **leakage current** exceeding 10 mA, and functional bonding, shall be in accordance with 8.2 and 8.4 of IEC 60204-1:2005.

7.6.11 In LV equipment, track rails may be used as a return circuit, provided that under fault conditions, the impedance of the circuit is sufficiently low to limit the step and contact voltages between the rails and the adjacent earth to values not exceeding 25 V rms.

7.6.12 The earth, protective conductors, sheaths and structures shall not be used as part of an active circuit, unless specified otherwise in the Particular Requirements.

7.6.13 Earthing of secondary circuits shall be avoided unless improving overall safety of the installation. If secondary circuits are earthed they shall only be accessible, if the voltage of the secondary circuit is so low that the touch current limits are met – refer to 7.9 for details.

7.6.14 The means of connection, except for plug-and-socket connections, shall be clearly identified either using symbol IEC 60417-5019 (2006-08) (see Annex F), or with the letters PE, or by the bicolour combination of green and yellow. The indication shall not be placed on or fixed by screws, washers or other parts which could be removed when conductors are being connected.

For cord-connected equipment, the protective conductor in the cord shall, in case of failure of the strain-relief mechanism, be the last conductor to be interrupted.

7.7 Additional provisions for fault protection for frequencies above 200 Hz

7.7.1 Fault protection shall consist of one or more of the following measures independent of and additional to those for basic protection.

7.7.2 Parts of **electrical equipment** operating at higher frequencies than 200 Hz shall be capable of operating correctly in consideration of skin and proximity effects under **normal operation** and single-fault condition.

7.7.3 Any supplementary **insulation** shall be dimensioned to withstand the same stresses as specified for the **basic insulation**. In addition, insulating materials shall have sufficiently low dielectric loss factors at the working temperature and frequency so that the **insulation** is not impaired by dielectric heating of the materials.

7.7.4 All high frequency circuits shall be galvanically separated from the mains frequency earthing system. Failure of the **galvanic separation** between the circuit and the mains frequency earthing system which could result in accessible parts acquiring a hazardous

effective **touch voltage** shall be detected by a **protective device** operated by the fault voltage and result in disconnecting and deenergising the circuits.

High frequency earthing may be directly connected to the mains frequency earthing system, if this reduces the associated risks compared with a **galvanic separation**; details are provided in the Particular Requirements.

7.7.5 The separated low resistance conductors constituting the main current path from the circuit frequency source to the processing applicator or similar

a) shall be capable of withstanding all internal and external influences (including mechanical, thermal, corrosive, glow discharge) which can be expected;

b) shall comply with the highest occurring voltage under any single-fault condition, if the conductor is accessible during maintenance; its electric **insulation**, and its current-carrying capacity shall be such that it does not overheat during any foreseeable single-fault condition; if excessive currents can occur with such duration under any foreseeable single-fault condition that overheating occurs, a current-sensing device that permanently switches off the equipment before the conductor properties are compromised shall be installed;

c) shall be not removable without the use of a tool;

d) if it is necessary for reasons of equipment design to include a separable disconnection of the main circuit conductor for maintenance, its plug and socket shall be mechanically combined with a safety circuit preventing energising of the main circuit during disconnection and there shall be a latching or similar device incorporated in the plug and socket system, as well as sufficient **insulation** to the exterior for non-hazardous disconnection; these requirements do not apply if separation is needed only during installation and decommissioning and then with the use of tools;

e) the connection of the separable circuit conductor shall be re-established not later than when the supply conductors are reconnected; this requirement does not apply when interruption and reconnection are possible only with the equipment in de-energized condition;

f) the circuit electrical connections at the ends shall be separated and thus not be combined with any other electrical connection or the protective equipotential bonding for any other part of the installation or equipment.

7.8 Protective conductor currents

7.8.1 Measures shall be taken in the installation or equipment to prevent excessive protective conductor currents impairing safety or **normal operation** of the installation. Compatibility shall be ensured for currents of all frequencies supplied to and produced by the equipment.

7.8.2 The following limits are applicable to equipment supplied at mains frequency:

a) For plug-in current using equipment fitted with a single or multiphase plug and socket-outlet system rated up to and including 32 A: less than 2 mA for rated current below 4 A, less than 5 mA for rated current exceeding 10 A and 0,5 mA/A in between.

b) For current-using equipment for permanent connection and current using stationary equipment, both without special measures for the protective conductor, or plug-in current using equipment fitted with a single phase or multiphase plug and socket-outlet system, rated more than 32 A: less than 3,5 mA for rated current below 7 A, less than 10 mA for rated current exceeding 20 A and 0,5 mA/A in between.

If residual current devices are provided in the installation, the protective conductor current shall be compatible with the protective measures provided.

In **normal operation**, mains frequency equipment shall not generate current with a direct current component in the protective conductor which could affect the proper functioning of residual current devices or other equipment.

7.8.3 For current-using equipment intended for permanent connection and having a protective conductor current higher than 10 mA, provision shall be made for a secure and reliable connection with earth such as described in IEC 60364-5-54.

7.9 Touch current and touch voltage

7.9.1 Touch current hazards are caused by currents flowing through the human body (this current is not necessarily equal to the current flowing through a protective conductor). The effect of electric current on a human body is causing some distinct responses which need to be considered. These are

a) perception of a current or a spark up to pain;

b) a physical reaction caused by the perception or pain, this physical reaction can be uncontrolled;

c) hindering of let-go;

d) electric burn, either small scale at the touch point or large scale due to overheating of bodyparts of high resistivity.

Each of these body responses has a unique threshold level and there are significant differences in the manner in which some of these thresholds vary with frequency.

7.9.2 Touch currents causing harm shall be avoided. No part or surface that can cause harm when touched shall be within arm's reach. Annex B informs about limits for touch currents and **touch voltages**.

NOTE IEC TS 60479-1 and IEC TS 60479-2 provide additional information for risk assessment as well as Annex A of EN 50445:2008.

7.9.3 If parts that can cause non-harmful touch currents need to be touched in **normal operation**, the **manufacturer** shall

a) apply warnings and markings according to Annex F;

b) indicate in the information for use specific handling procedures for the **operator** if appropriate; such procedures may include grasping to avoid harm for touch currents below the let-go threshold.

7.10 Conductors and insulations at high temperature

7.10.1 The effect of decreasing conductivity with temperature of conductor materials and thus increasing Joule heating of undersized conductors shall be taken into account. IEC 60364-4-42 applies.

7.10.2 All conductors shall be able to operate at their maximum expected environmental temperature without overheating and shall be made from conductive material that does not degrade at the stationary conductor temperature.

7.10.3 The effect of increasing conductivity with temperature of most insulating materials shall be considered as this can lead to hazardous **leakage currents**.

7.10.4 If the insulating material at the maximum expected temperature does not provide sufficient **insulation**, secondary insulating means shall be introduced.

7.11 Non-electric faults

Such single-fault condition shall be taken into account, where a fault of mechanical or thermal origin leads to parts becoming live – for example the destruction of non-conducting **insulation**, the flow of liquid metals into non-conductive **insulation**, or a dislocated conducting charge connecting conductive elements.

8 Protection against hazards caused by electric or magnetic nearfields

8.1 General

8.1.1 Clause 8 specifies provisions for frequencies between 0 Hz and 6 MHz concerning hazards caused by magnetic, electric or **electromagnetic nearfields**. Provisions for higher frequencies and for propagating fields are provided in the Particular Requirements.

8.1.2 The **EH** and **EPM** processing equipment shall be designed and operated so as to protect the **operator** and the environment from harmful effects of magnetic or electric nearfields and from **EMF**.

Secondary phenomena such as the creation of ozone by discharges, induced currents or induced voltages shall also be taken into account.

8.1.3 Direct contact between the hand or fingers and live conductors shall be hindered, as for protection against electric shock in Clause 7.

8.1.4 Access by hands, arms, head and torso to regions with field intensities exceeding the limits or characteristics resulting in efficient induction of electric fields shall be prevented by the same geometric restrictions as for **live parts** – refer to Clause 7.

8.2 Magnetic fields

8.2.1 The equipment shall be so designed that the maximum accessible magnetic field level and characteristics do not cause a risk. **Barriers** or **screens** shall hinder exposure to hazardous fields and be designed as defined in 8.4.

8.2.2 All zones where risk group 1 conditions exist during **normal operation** or in single-fault condition shall be indicated by the **manufacturer** in the information for use and a warning symbol defined in Annex F shall be provided outside the zone.

8.2.3 In case of static magnetic fields, the **manufacturer** shall indicate in the information for use safe behaviour for maximum allowed accessible B value level exceeding the limit for risk group 1. This includes specifying slow bodypart movement in and out of the field – time for full entry into the static magnetic field shall exceed a time of 1 s.

8.2.4 Exceptional exposure can be allowed for **operator** not carrying or wearing any metal objects and not having implants of any kind, if optical or audible warning devices are in place and the following requirement is met.

8.2.5 The **manufacturer** shall indicate to the **user** if applicable

a) the need for slow movements in static magnetic fields, especially to slow the bodypart movement into and out of the field to a time being longer than 1 s, if the maximum accessible B value level exceeds 200 mT;

b) the necessity to instruct and warn persons carrying any metal objects or having metallic implants of any kind not to enter regions exceeding occupational limits.

8.3 Local electric fields

8.3.1 Clause 7, especially 7.9 applies. **HV hazard zones** shall be non-accessible by any bodyparts.

8.3.2 The continuity of the earthing of all conductive accessible parts shall be provided in **normal operation** and single-fault condition.

8.3.3 Ionization phenomena, which can occur at high temperatures under high electric fields, shall be taken into account in design of **insulation** distances along surfaces or in air. Particular care shall be taken in case of metallic vapour emission, splashes, pollution, or similar, according to IEC 60664-1.

8.3.4 Corona discharges at high field intensities can create hazardous ozone concentrations and shall be limited. At a given field intensity, the corona effect increases with frequency.

NOTE Limits of maximum ozone concentrations over time can be found in national regulations.

8.3.5 If fires or explosions can result from ignition of flammable materials by sparks caused by induced fields, contact currents, or spark discharges, Clause 11 applies.

8.4 Requirements related to barriers and screens

8.4.1 Non-conductive, non-magnetic b**arriers** are not considered as protective other than hindering access, like **obstacles**.

8.4.2 Conductive **screens** guiding or absorbing the field and being protected from direct touch shall have sufficient conductivity and be located in a way that they cannot overheat in **normal operation** or in single-fault condition. They shall under these conditions neither cause a hazard due to excessive heat nor shall their integrity of protection be compromised. If heating exceeding the limits for safe touch is expected, Clause 10 applies.

8.4.3 Conductive **screens** which are accessible for direct touch shall have sufficient conductivity and be located in such a manner that they cannot overheat in **normal operation** or in single-fault condition. They shall under these conditions neither exceed the limits for touchable surfaces as defined in Clause 10 nor shall their integrity of protection be compromised.

8.4.4 All conductive **screens** shall have a material thickness d that exceeds the energy penetration depth by a factor of 3 and thus fulfilling the following formula:

$$d = \frac{3}{\sqrt{4\pi \cdot f \cdot \sigma(f) \cdot \mu_0 \cdot \mu_r}} \quad (1)$$

where

$\mu_0 = 4\pi\ 10^{-7}$ is the magnetic constant in Ω s m^{-1};

μ_r is the relative permeability;

f is the frequency in Hz;

$\sigma(f)$ is the material and temperature dependent conductivity in Ω^{-1} m^{-1}.

NOTE Some magnetic field leaks through if the plate is thinner. It can be difficult to fulfil the requirement for frequencies below 100 kHz and it is typically impossible below about 10 kHz.

8.4.5 The geometric extent of a conductive **screen** shall be such that no hazardous field extends over its reach.

8.4.6 Other measures for stray field control may be indicated, these can be

– a field filtering **window** for visible access to the working area or

– an array of well placed magnetic objects of sufficient permeability.

8.5 Requirements related to objects worn, carried or held by persons

8.5.1 Metallic objects near the processing equipment can be heated by strong induced currents, even if the requirements of 8.3 and 8.4 are complied with. Ferromagnetic materials such as in tools can be strongly heated by the magnetic field.

8.5.2 The hazard of heated up metallic or semiconducting parts shall be considered. Information on relevant fields is provided in Annex B. The **manufacturer** shall indicate hazard zones to the **user** and proper warning for this region shall be provided in the information for use and and proper warning signs shall be provided outside the zone.

8.5.3 Magnetic objects can be exposed to strong mechanical forces and cause a hazard in or near strong static magnetic fields and field gradients. Annex B provides information for static fields. All zones where such risk can exist during **normal operation** or in single-fault condition shall be indicated by the **manufacturer** in the information for use and proper warning signs shall be provided outside the zone.

8.5.4 **Hazards** related to pacemakers in strong static or time-variable magnetic fields as well as nuisance related to watches and other electronic equipment such as radios are inevitable. Information on relevant fields is provided in Annex B. The **manufacturer** shall indicate this problem to the **user** and proper cautions for this region shall be provided in the information for use.

8.5.5 The **manufacturer** shall indicate in the information for use with respect to static magnetic fields

a) if very strong forces are expected when fields are varied, especially when the field is switched on or off;

b) that **operators** or **ordinary persons** carrying any metal objects or having implants of any kind (i.e. metallic or medical electronic devices) or wearing any metal objects shall only attend any zone of risk group 1, if they are instructed about the need of slow movements and if a special optical or audible warning device is in operation indicating the existence of such a field.

8.5.6 The **manufacturer** shall indicate in the information for use with respect to static and alternating magnetic fields

a) that **operators** or **ordinary persons** carrying any metal objects or having implants of any kind (i.e. metallic or medical electronic devices) or wearing any metal objects shall not attend any zone of risk group 2. Sufficient marking and and proper warning signs shall be provided outside the zone;

b) that **operators** or **ordinary persons** attending any zone of risk group 1 or higher shall never wear objects like metal necklaces, bracelets, rings, objects that are magnetisable or objects made from silicon, carbon or similar.

9 Protection against hazards from radiation

9.1 General

9.1.1 The installation shall provide protection against effects of internally generated ultraviolet, ionizing, visible, infrared and microwave radiation, including radiation from laser sources.

This standard does not differentiate between different sources of radiation (e.g. emitter, **workload** or wall) with respect to classification or emission. Different phases of the life cycle of the equipment can cause different levels of radiation emission and shall be treated separately.

9.1.2 The following effects shall be taken into account as they can lead to unintended hazardous exposure:

– emission of radiation through the openings for entrance and exit of **workload** belonging to the continuously operating processing equipment;

– emission of radiation through the doors of the batch processing equipment which are either opened or stay open during the process;

– emission of radiation when the doors of the processing equipment are opened and the inside of the processing equipment, the **workload** or heating elements have not cooled down in advance;

– emission of radiation by a very hot **workload** after leaving the installation;

– during access for maintenance, commissioning or testing;

– if heating elements are operated outside the processing equipment;

– if reflectors, refractors or reflective walls inside the installation cause zones of intense irradiation outside the installation;

– if hot walls inside the processing equipment cause zones of intense irradiation outside the installation.

9.2 Installation or equipment generating ionizing radiation

9.2.1 In the case of equipment not intended to emit ionizing radiation, the effective dose rate of unintended stray radiation at any accessible point 100 mm from the outer surface of the equipment shall not exceed 1 μSv/h unless a national regulation stipulates a different dose.

9.2.2 The equipment shall be so constructed that compartments in which electrons are accelerated by voltages exceeding 5 kV cannot be opened without the use of a tool. Sufficient information for use shall be supplied by the **manufacturer**.

9.2.3 Specific provisions for equipment intended to emit radiation are given in the Particular Requirements.

NOTE Equipment that emits ionizing radiation is in most countries regulated by national authorities. These regulations usually address both the emissions of radiation from the equipment and the cumulative dose of radiation that can be received by the **operator** or **ordinary person**. Examples of regional or national regulations are Directive 96/29/EURATOM for the European Union and document 29 CFR 1910.1096 for the USA.

9.3 Ultraviolet radiation

9.3.1 Effects of ultraviolet (UV) radiation include the destruction of biological cells and the degradation of materials of **enclosures** or **insulation**s made from plastic. UV radiation can start chemical reactions and fire. These effects shall be taken into account.

9.3.2 The assessment of UV hazards for lamps is detailed in IEC 62471, but that approach shall be used for any UV radiation source without limiting its validity.

All processes where hot reactive gases or surfaces exceeding 2 500 °C are not completely shielded from the outside and all processes involving or employing a plasma being not completely enclosed are defined as intended to emit UV radiation.

9.3.3 Equipment emitting unavoidable stray radiation though not designed to provide external UV illumination shall not permit unintentional escape of UV radiation that could cause a hazard.

9.3.4 In the case of equipment intended to emit UV radiation, the **manufacturer** shall reduce the radiation and irradiation levels to safe levels that either cause a possible exposure hazard to **operators**, or cause equipment not suited to exposure to intense UV radiation to levels that can destroy such equipment preliminary. Measures can include **screens**, **barriers**, locked doors, filtered **windows** and warning markings. The **manufacturer** shall indicate to the **user** in the information for use the need for personal protective equipment if hazardous exposure is possible.

9.4 Visible and infrared radiation

9.4.1 All equipment or installations under the scope of this standard shall be so designed and constructed that any emission of infrared (IR) or visible (VIS) radiation is limited to the extent necessary for their operation and that their effects on exposed persons are non-existent or reduced to non-hazardous levels.

9.4.2 The following effects shall be taken into account:

– effects of intense VIS radiation can cause hazards for the human eye;

– intense VIS radiation can reduce the ability to see and react to signal lights or warning signs;

– effects of intense IR radiation include hazards to the human eye and the hazard of burning of skin;

– intense VIS or IR radiation can ignite flammable materials and fluids;

– surfaces or **windows** acting as optical elements can locally increase the intensity of irradiation.

9.4.3 The assessment of visible light and infrared hazards for lamps is detailed in IEC 62471, but that approach shall be used for any visible or infrared radiation source without limiting its validity.

EH equipment where hot reactive gases or surfaces exceeding 600 °C are not completely shielded from the outside and **EH equipment** employing hot plasma being not completely shielded are defined as intended to emit infrared radiation. Intense visible radiation is usually caused by thermal emitters exceeding 1 500 °C surface temperature, but hazards depend on the size and emissivity of the source.

9.4.4 No exclusive reduction or exclusive filtering of visible radiation shall be done, as a reduction of the visual stimulus of radiation increases risk to persons, refer to Annex C.

9.5 Laser sources

Equipment employing laser sources shall meet the requirements of IEC 60825-1.

10 Protection against hazards from thermal influences

10.1 General

10.1.1 Aside from electrical hazards, high temperature and thermal energy are the most important hazards to consider during all stages of design and manufacture of **EH** and **EPM**

installations or **equipment**. Indirect aspects of thermal energy are treated throughout this standard:

– provisions concerning hazards caused by radiation are given in Clause 9 – as bodies at elevated temperature cause radiation;

– provisions concerning fire hazards are given in Clause 11;

– provisions concerning fluids including hot fluids are given in Clause 12.

10.1.2 **EH** or **EPM installations** or **equipment** shall be so designed, installed and operated that no hazard due to thermal energy or elevated temperature is likely to occur for the **operator** or the environment, even in case of unattended operation or inadvertent switching.

10.1.3 The general rule for **normal operation** is that

a) all materials used shall at least withstand the influence of thermal energy exposed to during **normal operation** over the designed lifetime of that part;

b) if the designed lifetime of a part is shorter than the lifetime of the installation or equipment a maintenance cycle shall be part of the information for use indicating replacement cycle.

10.1.4 The general rule for single-fault condition is that

a) all material used shall at least withstand the influence of thermal energy reasonably expected during single-fault condition over a reasonable period when safety of the installation or equipment or any part of it depends on its structural integrity;

b) this reasonable time period shall be at least the time necessary for detection and removal of that single-fault condition and cooling down of the installation;

c) if any materials or parts are exchanged after being exposed to thermal energy higher than that foreseen for **normal operation,** this shall be indicated in the information for use.

10.2 Surface temperature limits for protection against burn

All surfaces intended to be touched for operation of the installation or equipment shall not exceed the temperature limits as set in ISO 13732-1 during **normal operation** or in single-fault condition unless national regulations provide other limits.

All other surfaces that are in reach of the **operator**

a) shall either not exceed the limits as set in ISO 13732-1, or

b) a **barrier** shall be placed to prevent accidental touching, or

c) shall be marked accordingly and the risk including possible measures to reduce the risk be indicated in the information for use.

10.3 Hazards caused by working conditions

The exposure of the **operator** to thermal stress, hazard of overheating or dehydration shall be avoided as far as possible. If the **operator** is to be exposed to excessive heat during **normal operation** or single-fault condition, the **manufacturer**

a) shall indicate the need for taking this hazard into account in the information for use;

b) shall indicate the need for a risk assessment by the **user** based on the working procedures, e.g. following ISO 15265.

10.4 Heat resistance of components

10.4.1 All structural parts and **enclosures** shall be made from material that is sufficiently heat resistant at all temperatures they are exposed to during **normal operation** or prolonged single-fault condition.

10.4.2 **Enclosures** made from plastics or other non-metallic material shall only be used when, during **normal operation** or single-fault condition, their temperature never reaches

– the limit of flammability,

– the limit of structural deformation or

– the limit of decomposition.

10.4.3 All **insulation** shall be made from materials that are sufficiently heat resistant at all temperatures it is exposed to during **normal operation** or prolonged single-fault condition, including effects from fault currents inside the insulated conductor.

10.4.4 Clearance distances between conductive parts shall be sufficient for temperatures expected during **normal operation** or single-fault condition.

10.4.5 Creepage distances between conductive parts shall be made to incorporate any increase of conductivity of insulating materials used due to temperatures expected during **normal operation** or single-fault condition.

10.4.6 Mechanical stress from thermal expansion shall not cause deformations which could cause a hazard.

NOTE Such mechanical stress is often caused by temperature differences in the equipment structure or by mismatch of the coefficient of thermal expansion of different materials. Both can lead to serious failure.

10.4.7 Any parts or accessories of the processing equipment shall be mounted in such a way that they are not subjected to temperatures exceeding the temperature for which they are designed.

10.4.8 General protective measures against thermal influences on or from the **electrical equipment** shall be provided according to IEC 60364-4-42.

10.4.9 In the absence of limits supplied by the **manufacturer** of parts the maximum increase of temperature as defined in Table 3 of IEC 60335-1:2010/AMD1:2013 applies to materials and parts or components of the installation.

10.5 Cooling

10.5.1 Where forced cooling of components is employed and lack of cooling can cause a hazard, provisions shall be made for monitoring the cooling action. If the cooling becomes insufficient, an alarm shall be given and the equipment shall be switched into a safe state.

10.5.2 If a liquid cooling agent is used and insufficient cooling due to bubble formation of boiling can cause a hazard,

a) either the temperature shall be kept sufficiently below boiling point or other means shall assure that no bubbles are formed inside the cooling circuit, reducing heat transfer,

b) or the cooling system shall be designed to operate safely with liquid and gas mixtures.

10.5.3 Released hot cooling liquid or vapour shall not pose a hazard itself.

10.5.4 Where **live parts** are liquid-cooled, the quality of the coolant, the length of the hoses and the material used for tubes and hoses shall be such that the **touch voltage** resulting from **leakage currents** does not impair safety.

NOTE A closed cooling circuit reduces the risk of environment pollution and loss of coolant.

10.6 Over-temperature protection

10.6.1 In order to ensure the necessary degree of safety in the case of single-fault condition in the temperature control circuit, appropriate **protective devices** and measures shall be applied as defined in Table 4.

Table 4 – Thermal protective measures

Class	Scope of protection	Extent of protection	Protective device	Protective measure
0	Processing equipment and environment thereof	–	–	Attended operation with non-hazardous workload only
				Overheating precluded by constructional measures
1	Processing equipment and environment thereof	In the case of a fault no hazard caused by the processing equipment	Thermal cut-out, temperature protector or comparable	Depending on utilization and site of installation
2	Processing equipment, environment thereof and workload	In the case of a fault no hazard caused by processing equipment or workload	Pre-selected temperature controllers, or comparable	

The **manufacturer** shall for the case of attended operation indicate reasonably limited intervals at which the installation is to be checked by the **user**; the applicable class as defined in Table 4 shall be indicated to the **user**.

10.6.2 If a single fault in a temperature control system, heater, cooling means, circulating pump or fan, agitator, or other part could cause a hazard through overheating of any part of equipment or of the **workload**, a non-self-resetting **thermal cut-out** or system meeting the requirements of 14.7 shall de-energize the heating means and any other parts which could cause a hazard.

10.6.3 If an insufficient quantity of heat-transfer liquid – for example cooling water – could cause a hazard, a non-self-resetting liquid-level device shall de-energize the heating means and any other parts which could cause a hazard.

10.6.4 In **EH** and **EPM equipment** or **installations** any hazards arising from overheating of the **workload** or overheating of heat-transfer media (e.g. heating baths) as well as from over-temperature of parts of the processing equipment itself shall be taken into account.

10.6.5 In some cases, a fall in the temperature of a heated medium – for example liquid in a bath or air in an oven or heating cabinet – could cause a hazard. If this can occur as a result of the operation of an over-temperature protection device or a **thermal cut-out** after failure of the temperature control system, a second temperature control system shall be fitted to maintain a safe temperature without the over-temperature device operating.

10.6.6 For equipment designed to contain flammable materials, either for **normal operation** or for heat-transfer, over-temperature protection devices or systems shall ensure that the liquid cannot exceed in **normal operation** or single-fault condition

a) the flash point temperature of the liquid being exposed to air, or

b) a temperature 25 K below the fire point when in contact with any heating element.

10.6.7 If no over-temperature protection device is used, a controlled and limited amount of energy supplied to the **workload** can be used to protect against over-temperature.

10.6.8 If the **workload** can ignite or cause damage after an emergency stop or in single-fault condition**,** measures shall be taken in compliance with Clause 11 or as defined in the Particular Requirements. The following effects shall be considered:

a) residual heat stored in the equipment can be released over a long period after switching off, and

b) surface temperature can increase even after switch off due to the release of stored heat.

11 Protection against hazards from fire

This Clause 11 applies for the installation in general and the processing equipment. Protection against fire hazards for **electrical equipment** shall be according to the relevant standards identified in Table 2.

Basic concepts and methodology of technical fire-prevention and protective measures to be taken at the design and construction phase shall be according to ISO 19353.

In case of equipment designed to contain controlled combustion processes, ISO 13577-2 shall apply.

NOTE 1 Hot surfaces, intense optical radiation, arcs, plasmas, hot gases or liquids are to be expected near or inside **EH installations**. Plasma or static electrical discharges can occur in **EPM installations**.

NOTE 2 Plasmas, discharges and other electric phenomenon can provide extra energy thus lowering the flame point or lead to ignition.

12 Protection against hazards from fluids

12.1 General

12.1.1 The **manufacturer** shall take into account protection against hazards from fluids encountered in **normal operation** and single-fault condition.

12.1.2 ISO 13577-2 applies for combustion and fuel handling systems. For all other fluid systems the provisions 12.1.3 through 12.1.9 apply.

12.1.3 If, in **normal operation** or single-fault condition, fluid is likely to be spilt into the equipment,

a) the equipment shall be designed so that no hazard is possible – for example as a result of the wetting of **insulation** or of internal **hazardous-live parts**;

b) no corrosion leading to a hazard is possible – for example as a result of the contact of potentially aggressive substances with parts of the equipment;

c) suitable means below the equipment able to collect the spill shall be positioned.

If in **normal operation** or single-fault condition, potentially aggressive substances (such as corrosive, toxic or flammable liquids) are likely to be spilt on parts of the equipment, the possibly affected surfaces shall be made from material not affected by the aggressive substance.

12.1.4 The maximum pressure to which a part of the equipment can be subjected in **normal operation** or single-fault condition shall not exceed the rated maximum working pressure for the part. The maximum pressure shall be considered to be the highest of the following:

a) the rated maximum supply pressure specified for an external source;

b) the pressure setting of an overpressure safety device provided as part of the assembly;

c) the maximum pressure that can be developed by a pressure generating device that is part of the assembly, unless the pressure is limited by an overpressure safety device.

12.1.5 Fluid-containing parts shall not cause a hazard through rupture or leakage. No leakage is allowed from fluid-containing parts intended for toxic, flammable, or otherwise hazardous substances.

12.1.6 Fluid-containing parts of refrigeration systems shall meet the relevant pressure-related requirements of IEC 60335-2-24 or IEC 60335-2-89 as applicable.

12.1.7 Leakage from fluid-containing parts at pressures lower than ambient shall not cause a hazard.

12.1.8 Liquid overflowing from any container in the equipment which can be overfilled shall not cause a hazard during **normal operation**, for example as a result of the wetting of **insulation** or of internal parts that are **hazardous-live**.

Equipment likely to be moved while a container is full of liquid shall be protected against liquid surging out of the container.

12.1.9 Any cleaning, decontamination or disinfection process indicated by the **manufacturer** shall not cause degradation of the equipment or any foreseeable hazard.

12.2 Poisonous and injurious gases and substances

12.2.1 Equipment shall not liberate dangerous amounts of poisonous or injurious gases or substances in **normal operation** or single-fault condition.

12.2.2 If such gases or substances are likely to be liberated, they shall be drawn into an extraction system.

12.2.3 If released gases can pose a hazard due to their temperature or impulse they shall be diverted from the installation and from the **operator**.

12.2.4 Hazard zones shall be marked and **barriers** or **obstacles** shall limit accessibility.

12.2.5 Equipment drawing in air for any purposes shall not draw in exhaust gases unless necessary for the process or for energy recuperation needs.

12.2.6 The **manufacturer** shall indicate necessary personal protective equipment for such substances or gases that can be liberated during **normal operation** or single-fault condition.

12.3 Explosion and implosion of pressurised parts

12.3.1 Components liable to burst or explode if overheated or overcharged shall be provided with a pressure release device.

12.3.2 Protection of **operators** by **enclosures** shall be incorporated in the equipment to protect them from debris or expelled parts.

13 Specific requirements for components and subassemblies

13.1 General

All components and devices

a) shall be suitable for their intended use;

b) shall conform to relevant IEC or ISO standards where such exist;

c) shall be applied in accordance with their information for use.

13.2 Electrical equipment and conductors

13.2.1 The **electrical equipment** of the installation shall satisfy the safety requirements identified by the **manufacturer**.

Depending upon the installation, its intended use and its **electrical equipment**, the designer may select parts of the **electrical equipment** of the installation that are for LV in compliance with relevant parts of the IEC 61439 series and for HV parts in compliance with relevant parts of the IEC 62271 series – see also Annex E of IEC 60204-1:2005 and IEC 60204-1:2005/AMD1:2008.

NOTE The IEC 61439 series specifies requirements for equipment covering a wide range of possible applications of LV switchgear and controlgear assemblies. The IEC 62271 series specifies requirements for equipment covering a wide range of possible applications of HV switchgear and controlgear assemblies.

13.2.2 The dimensioning of electrical conductors depending on maximum current and temperature shall follow IEC 60228 for intended temperatures of the conductors up to 40 °C.

13.2.3 The proximity and the skin effect shall be taken into account when dimensioning conductors for higher frequencies, as the penetration depth of the current decreases with increasing frequency. This affects cross sectional area of the conductor and surface to volume ratio.

NOTE Tables of cable current-carrying values relevant for mains frequency (50 Hz/60 Hz) are generally not applicable for installations working at higher frequencies.

13.3 Connection to the electrical supply network and internal connections

13.3.1 The connection to the electrical supply network depends on the type and the voltage of the supply system according to Clause 312 of IEC 60364-1:2005. The conductors shall be in accordance with Clause 12 of IEC 60204-1:2005 for LV and in accordance with Clause 12 of IEC 60204-11:2000 for HV. The conductors shall be identified according to IEC 60445.

13.3.2 The incoming supply conductor shall be in accordance with 5.1 of IEC 60204-1:2005 for LV and in accordance with 5.1 of IEC 60204-11:2000 for HV.

13.3.3 Interconnecting conductors shall be designed and arranged so that in **normal operation** they do not undergo abnormal mechanical stresses, e.g. due to bending, tension, flexing, torsion, friction or vibration, or effects of radiation, heat, moisture or vapours liable to damage them. Single-fault condition shall be considered as well.

13.3.4 **Enclosures** of conductors shall ensure:

– protection of **insulation** of conductors against abrasion and laceration;

– protection of conductors against tension and torsion.

Enclosures and devices adopted to avoid tensile stress in fixed electrical connections shall not be hazardous-live. They shall also be so designed that any damage of the conductor to be protected from abnormal tensile stresses is prevented.

13.3.5 Equipment which is not permanently connected to the **supply network** shall meet the following requirements:

a) it shall have a permanent fixed flexible connecting conductor which can only be removed with the use of a tool;

b) connections using a sliding contact shall be inaccessible, both when connected and disconnected but live;

c) **live parts** of plug-and-socket devices shall be inaccessible when connected or disconnected but live;

d) removable connecting lines shall contain necessary active and protective conductors clearly identified and laid-up together;

e) when several plugs are used, an erroneous connection shall be prevented by shape or distinct marking of the plugs.

13.3.6 All flexible wiring shall meet the following requirements:

a) it shall be provided with protective sheaths, measures taken to ensure protection against tensile stress and torsion shall be readily recognizable;

b) it shall be protected against excessive flexing at the points of entry, protective sheathing shall be sufficiently long to avoid any damage through bending;

c) it shall be fixed securely or other means shall avoid any hazard through their position in or near the installation.

13.4 Isolation and switching

13.4.1 **Isolation**, **switching-off for maintenance**, **emergency switching off**, and **functional switching** shall be provided and be in accordance with the relevant standards, for example IEC 60364-4-41, IEC 60364-5-53 as well as IEC 60204-1 for LV and IEC 60204-11 for HV, respectively.

13.4.2 Examples of control and auxiliary circuits which, depending on the application, need not to be switched off, are:

a) lighting and socket-outlet circuits for the connection of repair and maintenance tools, for example lamps or drills (irrespective of their voltage);

b) circuits supplying under-voltage trips and circuit-breaker closing and tripping devices which are operated at mains voltage, but are not used for control purposes;

c) auxiliary circuits with ELV;

d) other auxiliary circuits supplying essential components, for example pumps, fans and drives, which shall not be switched off during the period of interruption of the mains supply.

In the case of LV or HV, the above-mentioned circuits shall employ cables or insulated conductors segregated from those following the supply disconnecting switch. They shall be connected via separate specially enclosed terminals and shall be provided with a separate disconnecting switch.

In the case specified under item b), this disconnecting switch may not be applied. The circuits, which are not disconnected by the supply-disconnecting switch, shall be clearly indicated in the technical documentation.

13.4.3 Switching of direct current or mains frequency currents at HV through the use of circuit breakers is permissible for supply, disconnection and isolation, providing the following conditions exist:

a) an isolating distance is provided and visible – for example a disconnecting switch or a withdrawn circuit-breaker;

b) facilities are provided to prevent closing of the isolating switches and providing connection to earth of the outgoing cables or busbars.

13.5 Sensors and actuators safeguarding moving parts

ISO 13855 and ISO 13857 apply.

13.6 Motors

Clause 14 of IEC 60204-1:2005 for LV and Clause 14 of IEC 60204-11:2000 for HV installations or equipment apply.

13.7 Non electric-heating means

Combustion based heating means shall conform to ISO 13577-2, if applicable.

13.8 Lighting

13.8.1 If the ambient lighting is not sufficient to prevent risks – for example areas of shadow or dazzle – the installation shall be designed with integrated lighting. Parts requiring frequent maintenance, inspection or adjustment and not illuminated sufficiently by the ambient light shall be provided with integrated lighting.

13.8.2 The equipment shall be designed and constructed so that there is no area of shadow likely to cause nuisance, that there is no irritating dazzle and that there are no dangerous stroboscopic effects on moving parts due to the lighting.

13.9 Structural parts and stability

13.9.1 The installation or equipment and all its parts shall be sufficiently stable to avoid break-up or collapse during **normal operation** or single-fault condition.

13.9.2 The installation or equipment shall be sufficiently designed or anchored to avoid tripping, overturning, falling or any uncontrolled movements during **normal operation** or single-fault condition.

13.10 Doors, windows and other openings

Subclauses 11.4 and 11.5 of IEC 60204-1:2005 apply for LV installations or equipment.

14 Control of the installation or equipment

14.1 General

The need for **operator** intervention shall be limited. If intervention is necessary it shall be conducted easily and safely.

Subclauses 14.2 through 14.7 define requirements based on this general concept.

NOTE The decision to use functional safety concepts is beyond the scope of this standard. ISO 13577-4 provides an illustration, when the application of IEC 61508 and ISO 13849-1 becomes necessary.

14.2 Operator control unit

14.2.1 Any operator control unit

a) shall be clearly visible and identifiable, using pictograms where appropriate,
b) shall be positioned in such a way as to be safely operated without hesitation or loss of time and without ambiguity,
c) shall be located outside a hazard zone – the sole exception being emergency stops;
d) shall be positioned in such a way that the operation cannot cause additional risks.

14.2.2 Any operator control unit or the control system

a) shall be positioned in a way that enables the **operator** to ensure that no one is in the hazard zones,
b) shall assure that starting is prevented while someone is in the hazard zones,
c) shall give acoustic, visual or a combination of both warnings before the installation is started; exposed persons shall have sufficient time to leave the hazard zone or prevent starting.

14.2.3 The provisions of Clause 10 of IEC 60204-1:2005 for LV and those of Clause 10 of IEC 60204-11:2000 for HV installations or equipment for operator control units and operator machine interfaces apply.

14.2.4 If there are more than one operator control unit, the control system shall assure that the use of one of them precludes the use of the others, except for stop controls and emergency stops. Each operator control unit shall be provided with all the required control devices without the **operators** hindering or putting each other into a hazardous situation. For details refer to 9.2.5.1 of IEC 60204-1:2005 for LV installations or equipment. Each unit shall be provided with controls to stop some or all of the functions of the equipment or installation, depending on the existing hazards, so that safety is ensured during and after the stop.

The sequence of emergency stopping operations (e.g. fan and conveyor motors in relation to main processing circuits) shall be taken into account by the **manufacturer** during design and shall be specified in the information for use.

14.2.5 Any operator control unit shall be designed or protected in such a way that the desired effect, where a hazard is involved,

a) can only be achieved by a deliberate action,

b) manufactured to withstand foreseeable forces;

c) particular attention shall be paid to emergency stop devices as these are liable to be subjected to considerable forces in case of an emergency.

14.3 Emergency stop

The design of the emergency stop shall be according to ISO 13850. All emergency stop devices shall be clearly identifiable, clearly visible and quickly accessible. Once the active operation of the emergency stop has ceased following a stop command, that command shall be sustained by engagement of the emergency stop device until that engagement is specifically overridden. It shall not be possible to engage the device without triggering a stop command. It shall be possible to disengage the device only by an appropriate operation, and disengaging the device shall not restart the equipment but only permit restarting. Emergency stop devices shall be in accordance with 10.8 of IEC 60204-1:2005 for LV installations or equipment.

14.4 Control systems and their functions

14.4.1 Control systems shall be designed and constructed in such a way as to prevent hazardous situations. In particular, they shall be designed and constructed in such a way that:

– they can withstand the intended operating stresses and external influences,

– a fault in the hardware or the software of the control system does not lead to hazardous situations,

– errors in the control system logic do not lead to hazardous situations,

– reasonably foreseeable human error during operation does not lead to hazardous situations.

This may be reached through suitable functional safety as defined in the IEC 61508 series or ISO 13849-1.

14.4.2 Start functions shall initiate the energizing of the relevant circuit and shall not be automatic if this can create a hazard. In case push-buttons are used, separate push-buttons for “Start” and “Stop” shall be provided.

14.4.3 **Interlocks** shall be provided to secure correct sequential starting.

14.4.4 Stop functions shall override related start functions. The installation shall not be prevented from stopping if the signal has been given.

Where more than one control station is provided, stop command from any control station shall be effective.

14.4.5 For operating modes, 9.2.3 of IEC 60204-1:2005 applies.

14.4.6 For suspension of safety functions or protective measures, 9.2.4 of IEC 60204-1: 2005 applies with the addition, that “motion” shall include “heating” or “processing”.

14.4.7 The emergency stop signal shall stop the hazardous process as quickly as possible, without creating additional risks. It can trigger or permit the triggering of safeguarding actions. The emergency stop function shall be available and operational at all times, regardless of the operating mode. Emergency stop devices shall be a back-up to other safeguarding measures, they shall not be a substitute for them.

14.4.8 For emergency operations, 9.2.5.4 of IEC 60204-1:2005 applies.

14.4.9 For cableless control, 9.2.7 of IEC 60204-1:2005 applies.

14.4.10 For control functions in the event of failure, 9.4 of IEC 60204-1:2005 and IEC 60204-1:200/AMD1:2008 applies.

14.5 Controlgear

14.5.1 Sensors of any physical quantity and actuators shall be selected and mounted taking into account all conditions during **normal operation** and single-fault condition – for example temperature, mechanical action or electromagnetic phenomena.

14.5.2 Push-buttons shall be in accordance with 10.2 of IEC 60204-1:2005.

14.5.3 Indicator lights and displays shall be in accordance with 10.3 of IEC 60204-1:2005.

14.5.4 Control circuits shall comply with 9.1 of IEC 60204-1:2005.

14.5.5 Control circuits can be supplied from a network of type TN or TT – refer to 312.2 of IEC 60364-1:2005.

14.5.6 In control circuits supplied via a transformer

a) with one end of the secondary winding connected to the earth, short-circuit protection shall be provided in the unearthed conductor of the secondary side. Such protection is not required if short-circuit protection elements on the primary side ensure equivalent safety;
b) with earthed centre tap of the secondary winding, protection against short circuits shall be provided in both poles of the secondary side of the control circuits.

14.5.7 When **photocouplers** are used as a means of **galvanic separation**, e.g. in semi-conductor converters, clearance and creepage distances shall be specified as minimum values, based on the principles

– of IEC 60071-1 for the upstream or power network side and
– of IEC 60664-1 for the downstream or converter side.

14.5.8 An earth fault on any control circuit operating below 200 Hz shall neither cause inadvertent switching on nor prevent switching off the **EH** or **EPM installation** or a part of it.

a) In order to fulfil this requirement, it is recommended that one side of the control transformer(s) be earthed and coils and contacts be connected accordingly. Unearthed control circuits fed from the transformer shall be provided with an insulation-monitoring device, which either indicates an earth fault or interrupts the circuit automatically after an earth fault. The direct current internal resistance of the insulation-monitoring device shall be at least 15 kΩ. For certain electronic devices much higher values of this resistance may be necessary.

b) In the case of control transformers with an earthed centre tap, a differential current circuit-breaker shall be used.

c) For control circuits, in which single-pole earthing is required for operational reasons, the **manufacturer** shall provide for earthing. Such operational reasons can be, e.g. the use of electromagnetic clutches having an internal earth or of control circuits with electronic components. In this case, separate control transformers or one control transformer with several isolated secondary windings shall be used.

14.5.9 In case of earthed control circuit supplies, the common conductor is connected to the protective bonding circuit at the point of supply. All contacts, solid state elements and other parts, which are intended to operate an electromagnetic or other device (for example, a relay or indicator light) are inserted between one side, the switched conductor of the control circuit supply and one terminal of the coil or device. The other terminal of the coil or device (preferably always having the same marking) is connected directly to the common conductor of the control circuit supply without any switching elements – refer to Figure 3 of IEC 60204-1:2005.

The following exceptions to this rule are allowed:

a) contacts of protective relays, for example overload relays, may be connected between the side connected to the protective circuit and the coils, if the conductors between such contacts and the coils of the control devices, on which the relay contacts operate, are inside the same control **enclosure**;

b) in special cases, where a different arrangement of the contacts leads to a simplification of the external control accessories (e.g. trolleys, cable winders, multiple plugs), if the requirements of the first paragraph of 9.4.3.1 of IEC 60204-1:2005 are met. In this case, a very careful design is required, to avoid a hazard in case of an earth fault – refer to 9.4.3.1 of IEC 60204-1:2005.

14.6 Protective devices

14.6.1 **Protective devices** including **interlocks** used to protect **operators** from **hazards** shall prevent an **operator** from being exposed to the hazard before the hazard is removed and shall meet the following requirements specified in 14.6.2 through 14.6.7.

14.6.2 **Protective devices** shall not obstruct the **normal operation** or the view onto the installation or equipment as being necessary for safe operation.

14.6.3 Only after the action which caused the **protective device** to give a stop command has been reversed or cancelled, shall the **protective device** and equipment be reactivated by use of a tool.

14.6.4 A **protective device** for the protection of **operators** shall ensure that a single-fault condition in the **protective device** is either unlikely to occur during the expected life of the equipment, or cannot cause a hazard – i.e. any fault of the **protective device** is a fault to safety. In most cases this implies that any **protective device** shall give a stop command if it is not fully effective.

14.6.5 **Protective devices** shall not easily be bypassed or made non-operational.

14.6.6 **Protective devices** shall be adjustable only by means of an intentional action.

14.6.7 **Protective devices** reacting in case of any short-circuit shall be adequately sized for the switching elements in the control circuits.

14.7 Over-temperature protective device

14.7.1 Over-temperature **protective devices** and systems designed to operate in single-fault condition shall be

a) designed and tested to ensure reliable function;

b) rated to interrupt the maximum voltage and current of the circuit in which they are employed;

c) rated so that components or materials whose temperatures are intended to be limited by the device do not exceed the relevant temperature limits of Clause 10 or other defined limits.

14.7.2 If necessary, means shall be provided for the **operator** to check that a device or system will function in the case of single-fault condition. The information for use shall specify the method and how often the check is required.

a) For adjustable devices or systems the check can normally be made by setting the over-temperature device to a lower temperature than that of the temperature control system.

b) For non-adjustable devices or systems it may be necessary to provide a self-resetting means to override the temperature control system temporarily.

14.7.3 Over-temperature **protective devices** shall be separated from any temperature control system. This applies not only to the temperature sensing means but also to all disconnecting devices in the circuits to be de-energised.

14.7.4 Adjustable over-temperature and liquid-level devices and systems shall be adjustable only with the use of a tool.

14.7.5 **Normal operation** includes the correct setting of any adjustable over-temperature device. Incorrect setting of a device by the use of a tool is a single-fault condition.

14.7.6 Liquid-level devices used to protect against over-temperature shall meet the same requirements as over-temperature **protective devices** and systems.

14.8 Overpressure safety device

An overpressure safety device shall not operate in **normal operation**. It shall conform to the following requirements.

a) It shall be connected as close as possible to the fluid-containing parts of the system that it is intended to protect.

b) It shall be installed so as to provide easy access for inspection, maintenance and repair.

c) It shall not be capable of being adjusted without the use of a tool.

d) It shall be located so that a discharge does not cause hazard to **operators**, especially shall it have its discharge opening so located and directed that the released material is not directed towards the **operator**.

e) The installation or equipment shall be designed such that no pressure release device is obstructed.

f) It shall have its discharge opening located and any discharge directed so that operation of the device does not deposit material on parts, if that could cause a hazard.

g) It shall have adequate discharge capacity to ensure that the pressure cannot exceed the rated maximum working pressure of the system.

h) There shall be no shut-off valve between an overpressure safety device and the parts that it is intended to protect.

15 Protection against mechanical hazards

15.1 With respect to mechanical hazards, the **manufacturer** shall refer to ISO 13577-1, if applicable. In all other cases, the requirements 15.2 through 15.12 apply.

15.2 No accessible part of the installation or equipment shall have rough surfaces, sharp edges or angles posing a hazard.

15.3 Any moving part that poses a hazard shall be prevented from becoming a risk through **guards** or **protective devices**. ISO 14120 applies for design and construction, assuring the mechanical stability of **guards**.

15.4 Sufficient precautions shall be implemented to prevent any hazardous situation from expelled parts or **workload**.

15.5 It shall either be impossible that an **operator** gets trapped inside any part of an installation or equipment or, if this is impossible to achieve, means to summon help shall be installed.

15.6 If an **operator** can be trapped inside the installation, sufficient means for escape or emergency stop from the inside shall be installed.

15.7 Zones where a human body or bodyparts can be exposed to trapping, crushing, shearing, impact, cutting, entanglement, drawing in, stabbing or abrasion shall be inaccessible or, if this is impossible for **normal operation**, one of the following or other measures shall prevent the risk:

a) such a hazard zone is considered not to present a mechanical hazard if the gaps of the zone comply with the dimensions specified in Tables 13 and 14 of IEC 61010-1:2010;
b) such a hazard zone is considered not to present a mechanical hazard if the distances separating the **operator** from the hazard zone exceed the values specified in ISO 13857;
c) such a hazard zone is considered not to present a mechanical hazard if **guards** and protective measures prevent access.

15.8 Protective measures shall be designed and incorporated into the control system so that

a) moving parts cannot start to move while they are in the reach of **operators**;
b) once the equipment has started to move, the hazard zone cannot be reached, or, if this hazard zone is reached, system movement shall stop. No hazard or damage shall result from the system stop;
c) if in single-fault condition of the protective measure, an unacceptable risk could arise, one or more emergency stopping devices in the equipment shall be provided;
d) the absence or failure of one of their components prevents starting or stops the moving parts.

Protective measures include **protective devices** for mechanical hazards.

15.9 The speed of movement of any part of the equipment that can come into contact with the **operator**, and where contact of the **operator** with the equipment can result in a hazardous situation, shall be limited so that the **operator** can adequately react to the moving part without resulting in an unacceptable risk.

15.10 Controls shall be so positioned, recessed, or protected by other means so that they cannot be accidentally actuated, resulting in unacceptable risk.

The risk due to overtravel (past range limits) of equipment parts shall be reduced to an acceptable level. End stops or other stopping means shall be provided to act as the ultimate

travel limiting measure in both **normal operation** and in single-fault condition. Such means shall have the mechanical strength to withstand the intended loading.

The overtravel (stopping distance) of such movement, occurring after operation of a control to stop the movement, shall not result in an unacceptable risk.

15.11 When a part of the equipment has been stopped, any drift away from the stopping position, for whatever reason other than action on the control devices, shall be prevented or shall be such that it does not cause a hazard.

15.12 If **operators** are supposed to move about or stand on the installation or equipment, sufficient means to prevent slipping, tripping or falling shall be implemented.

16 Protection against hazards resulting from use

16.1 Particular hazards in processing of food, feed, cosmetics and similar intended for human or animal consumption

16.1.1 Hygiene hazards differ from other hazards because they are hazardous for consumers of the **workload** being processed. This does usually not pose a hazard for the **operator**. Hygiene risks are associated with the ability of the equipment to be freed from product debris and micro-organisms, and thus preventing product contamination.

16.1.2 Particular hygienic and contamination hazards exist in the processing of **workloads** like food, beverages, animal feed, pharmaceuticals and cosmetics and shall be considered. The equipment shall in that case fulfil the relevant requirements of ISO 14159 and applicable national regulations. Furthermore, such **workloads** shall not be contaminated during pasteurization, sterilization or other processing, resulting in hazardous products.

16.1.3 Interaction of cleaning or disinfection agents or their residuals with the processing equipment shall be considered. The **manufacturer** shall include information on safe to use agents in the information for use. The **manufacturer** shall indicate cleaning or disinfection agents that are not safe to use.

16.2 Radio frequency interference

CISPR 11 shall be adhered to, if applicable.

16.3 Particular hazards in electroheating and electromagnetic processing

Other particular hazards unique to specific installation sites or equipment use are to be covered by the Particular Requirements and may be agreed between the **manufacturer** and **user** – for example, external conditions such as earthquakes.

16.4 Combination equipment

If the equipment is intended to be used in combination with other equipment, any hazard due to the combination shall be considered.

17 Protection against other hazards

17.1 General

Complementary to the potential hazards addressed in previous clauses, hazards according to ISO 13577-1 and Annex B of ISO 12100:2010 shall be evaluated by the **manufacturer** at the design stage, and the relevant requirements of these standards shall be fulfilled, if applicable. Furthermore, the specific hazards addressed in 17.2 shall be considered.

17.2 Sonic, infra- and ultra-sonic pressure

The equipment or installation shall not cause a hazard from sonic, infra- and ultra-sonic pressure.

Installation instructions shall specify how the **user** can ensure that the sound pressure level from equipment, at its point of use after installation, does not reach a value which could cause a hazard. These instructions shall identify readily available and practicable protective materials or measures which can be used, including the fitting of noise-reducing baffles or hoods.

18 Verification and testing

18.1 General

Compliance of the safety requirements or protective measures shall be verified by one or combinations of the following methods:

a) examination of drawings or calculations,

b) visual inspection,

c) measurement,

d) functional test,

e) numerical modelling.

Table 5 lists the recommended methods of verification with respect to the specific requirements of this standard. The methods and results of the verification shall be reported.

Table 5 – Methods for the verification of requirements

Sub-clause	Requirement or measure relating to	Verification done by				
		examination	visual inspection	measurement	functional test	numerical modelling
		18.4	18.5	18.6	18.7	18.8
6.4	Physical environment and operating conditions for electrical equipment inside the processing equipment	✓	✓	✓		
6.5	Power supply	✓	✓			
6.6	Access	✓	✓			
6.7	Ergonomic aspects	✓	✓			
6.8	Transport and storage	✓	✓			
6.9	Provisions for handling	✓	✓			
6.10	Consumables and replaceable parts	✓	✓			
7.3	General provisions	✓	✓	✓	✓	
7.4	Basic protection	✓	✓			
7.5	Provisions for single fault protection	✓	✓			
7.6	Protective equipotential bonding	✓	✓			
7.7	Additional provisions for fault protection for frequencies above 200 Hz	✓	✓			
7.8	Protective conductor currents	✓	✓			

Sub-clause	Requirement or measure relating to	Verification done by				
		examination	visual inspection	measurement	functional test	numerical modelling
		18.4	18.5	18.6	18.7	18.8
7.9	Touch current and touch voltage	✓	✓	✓	✓	✓
7.10	Conductors and **insulations** at high temperature	✓	✓	✓		
7.11	Non-electric faults	✓	✓			
8.2	Magnetic fields	✓	✓	✓	✓	✓
8.3	Local electric fields	✓	✓	✓	✓	✓
8.4	Requirements related to barriers and screens	✓	✓			
8.5	Requirements related to objects worn, carried or held by persons	✓	✓			
9.2	Installation or equipment generating ionizing radiation	✓	✓	✓		
9.3	Ultraviolet radiation	✓	✓	✓	✓	✓
9.4	Visible and infrared radiation	✓	✓	✓	✓	✓
9.5	Laser sources	✓	✓	✓	✓	✓
10.2	Surface temperature limits for protection against burn	✓	✓	✓		
10.3	Hazards caused by working conditions		✓			✓
10.4	Heat resistance of components	✓	✓			
10.5	Cooling	✓	✓			
10.6	Over-temperature protection	✓	✓			
11	Protection against hazards from fire	✓	✓			
12.2	Protection against hazards from fluids – Poisonous and injurious gases and substances	✓	✓			
12.3	Protection against hazards from fluids – Explosion and implosion of pressurised parts	✓	✓			
13.2	Electrical equipment and conductors	✓	✓	✓	✓	
13.3	Connection to the electrical supply network and internal connections	✓	✓		✓	
13.4	Isolation and switching	✓	✓		✓	
13.5	Sensors and actuators safeguarding moving parts	✓	✓	✓	✓	
13.6	Motors	✓	✓			
13.7	Non electric-heating means	refer to ISO 13577-1				
13.8	Lighting	✓	✓			
13.9	Structural parts and stability	✓	✓			
13.10	Doors, windows and other openings	✓	✓			
14	Control of the installation or equipment	✓	✓		✓	
15	Protection against mechanical hazards	✓	✓	✓		
16.1	Particular hazards in processing of food, feed, cosmetics and similar intended for human or animal consumption	✓	✓	✓		
16.2	Radio frequency interference			✓	✓	
17.2	Sonic, infra- and ultra-sonic pressure			✓	✓	

18.2 Performing measurements and tests

18.2.1 Accuracy of measuring equipment and measurement methods shall conform to IEC 60398:—[3], as relevant.

18.2.2 This standard defines some tests at cold state and other tests under **normal operation** conditions. Test conditions of **normal operation** shall be most unfavourable conditions causing the maximum expected stress to the installation and highest probability or strength of hazards.

18.2.3 This standard does not define tests under single-fault condition as these can result in serious damage to the installation.

NOTE IEC 61010-1 can be used in combination with this standard to develop verification means for single-fault conditions or for type testing.

18.2.4 For all installations under the scope of ISO 13577-1, that standard applies with respect to verification with the exception of electrical, magnetic and radiation hazards and requirements, for which Clauses 7 through 10 of this standard are applicable.

18.3 Verification of conformity with limits for electric or magnetic fields

If the measured or calculated value exceeds reference levels or comparable values set in a national regulation, it does not necessarily follow that the applicable basic restriction is exceeded and that an **operator** can be exposed to hazardous levels of electric or magnetic fields. However, whenever a reference level is exceeded, it is an indication of a possible hazard and it becomes necessary to verify compliance with the applicable basic restriction. This can be done through improved screening where possible or through using one of the following methods:

a) assessment of human exposure to magnetic or electric fields (for example according to IEC 62311 or EN 50413 covering the range from 0 Hz to 300 GHz);

b) assessment of human exposure to magnetic or electric fields according to the IEEE C95 series;

c) use of the numerical calculation of the electric or magnetic fields according to the IEC 62226 series for low and intermediate frequency range;

d) numerical assessment of the interaction between the processing equipment and exposed persons;

e) or by use of any other method, that will provide with comparable accuracy, if the basic restrictions are met.

18.4 Examination of drawings or calculations

The examination of drawings and calculations is to verify if all parts of the **EH** or **EPM installation** comply with the requirements.

18.5 Visual inspection

18.5.1 Visual inspection of the **EH** or **EPM installation** shall be done after mounting and during commissioning prior to any hot state tests, to compare the erected installation with the drawings. This visual inspection shall ensure that

a) the installation has been erected as defined in the drawings;

b) all markings and warnings have been affixed;

c) all **barriers**, **obstacles, guards** and similar protective means are in place;

---

3 To be published.

d) all **barriers, guards** and similar protective means intended to be removed with a tool are only removable with the use of a tool;

e) all protective measures are adequate and exist and that all earthing provisions and equipotential connections are in accordance with the drawings.

18.5.2 Further visual inspection shall be carried out after finishing all hot state tests of commissioning. This visual inspection shall ensure that the parts of the **EH** or **EPM installation** subject to heat, **EMF**, intense radiation or to other influences causing wear are still in their intended state. Especially linings, heating elements, thermal **insulation** and refractories, **barriers**, doors, **gates**, **windows**, lips, systems for transporting or positioning the **workload** shall be inspected with the focus on drop-out, crack, distortion, unusual abrasion, burn-through, oxidization and creepage.

18.6 Measurements

18.6.1 Insulation resistance measurement up to 200 Hz

For the insulation resistance measurement up to 200 Hz, 18.3 of IEC 60204-1:2005 applies with the addition that the tests shall be performed in the cold state.

18.6.2 Measurement of electric or magnetic fields

IEC 61786-2[4] applies for measurements of electric or magnetic fields and IEC 61786-1 for measuring equipment for frequencies up to 100 kHz.

Measurements above 100 kHz are under consideration.

18.6.3 Touch current measurement

The measurement of touch currents shall adhere to IEC 60990 with the exception of the use of the circuit for high frequencies.

The high frequency test method in IEC 60990 is recommended here only with the following alterations: to determine the frequency variation of skin capacitances with increasing frequency – skin being a significant part of the current circuit and being most sensitive due to its small volume and cross section for burns – the capacitance shall instead be applied in series and set to $A \cdot 0{,}01$ μF, where A is the skin area in cm^2. For normal gripping and 10 kHz to 10 MHz a series capacitance of 0,45 μF and a skin impedance of $A \cdot f^{-1} \cdot 3 \cdot 10^6$ Ω is recommended, where f is the frequency in Hz.

NOTE 1 In Figure 3 of IEC 60990:1999, R_s respresents the skin and C_s the skin capacitance where C_s is probably by a factor of 10 too large.

NOTE 2 The recommended gripping contact area represented in IEC 60990 is 200 cm^2. This surface area is unususally large and commonly 50 cm^2 are used instead.

18.6.4 Ionising radiation measurement

Conformity is checked by measuring the amount of radiation emitted in most unfavourable conditions, when maximum ionising radiation occurs. The method of determining the amount of radiation shall be effective over the range of possible radiation energies. Equipment containing cathode-ray tubes is tested while displaying a pattern from each beam not exceeding 30 mm × 30 mm or the smallest possible display, whichever is larger. Equipment containing X-ray sources is set to produce the maximum possible level of radiation. Displays are positioned so as to produce maximum radiation.

4 To be published.

18.6.5 Measurement of non-coherent optical irradiation

18.6.5.1 For the measurement of non-coherent optical radiation Clause 5 of IEC 62471:2006 applies with the following amendments.

18.6.5.2 Separated locations of the installation, like separate doors or **windows** can belong to different risk classes. They shall be assessed and verified separately.

18.6.5.3 Usually no controlled environment is possible to achieve. Thus the measurement conditions and an assessment of the influence of measurement conditions on the quality of the measured data shall be part of the measurement report. Measurement conditions shall be reported as part of the evaluation and the assignment of risk classification.

18.6.5.4 To maintain stable output during the measurement process and provide reproducible results, the **EH** or **EPM installation** shall be seasoned for an appropriate period of time prior to measurement. During the initial period of operation the output characteristic will change as components oxidise, age, or come otherwise to a state of near equilibrium. If measurements are taken with unseasoned installations, the variations within the measurement period and between measurements can be significant. The necessary ageing period depends on the specific installation and the environment. It varies with different types of installations and it can be impossible to reach sufficient ageing for assessment during commissioning. In this case measurement shall be done again at a later stage of equipment lifetime.

18.6.5.5 Careful checks shall ensure that other sources of radiation like nearby equipment or ovens, hot **workload**, hot shields, or reflections do not add significantly to the measured signal.

18.6.5.6 All measuring equipment for non-spectrally resolved measurement of irradiance or radiance shall be of class 3.0 or better. The measuring equipment shall have a flat or constant spectral response between 400 nm and 10 μm, a flat response between 200 nm and 20 μm is preferred. The measuring equipment shall be sufficiently stabilised to avoid any drift exceeding the limits.

NOTE This can be a thermally stabilised pyroelectric detector.

18.6.5.7 Annex B of IEC 62471:2006 applies for spectrally resolved measurements. The accuracy of the measurement results shall be calculated and stated. Measurement inaccuracy should not exceed 30 % of the lowest classification limit in absolute values.

18.6.6 Measurement of coherent optical radiation including emission from LEDs

All measurements of radiation from laser or LED sources shall adhere to IEC 60825-1.

18.6.7 Surface temperature measurement

Verification of accessible surfaces shall be done according to ISO 13732-1.

18.6.8 Sound level measurement

Conformity is checked by measuring the maximum A-weighted sound pressure level at the **operator** position and if necessary, calculating the maximum A-weighted sound power level produced by the equipment, as specified in ISO 3746. Measurement is performed during **normal operation** and with the combination of **workload** and other operating conditions (for example, pressure, flow or temperature) which create the maximum sound pressure level.

Sound level meters used in the measurement shall conform either to class 1 of IEC 61672-1 or, if an integrating sound level meter, to class 1 of IEC 61672-2.

18.7 Functional tests

18.7.1 Protection by automatic disconnection of supply

Subclause 18.2 of IEC 60204-1:2005 and IEC 60204-1:2005/AMD1:2008 applies.

18.7.2 Voltage test

For LV installations or equipment, the test of 18.4 of IEC 60204-1:2005 applies.

18.7.3 Dielectric test

Clause 13 of IEC 60335-1:2010 and IEC 60335-1:2010/AMD1:2013 applies.

18.7.4 Accessibility of live parts

Inaccessibility of any **live parts** shall be checked by tests defined according to IEC 60529.

18.8 Numerical modelling

18.8.1 General

The accuracy of any calculation shall at least be comparable to the achievable accuracy of measurements. This defines the needed accuracy of the implemented geometrical setup and minimum grid resolution or number of cells, surface elements, time resolution, bands or rays used as well as the used physical or thermochemical data.

The use of calculated data instead of measurements shall be stated in the technical documentation. The documentation of the calculation shall include

a) the geometrical setup used;

b) all relevant modelling data and a description of the models used;

c) the software and version used;

d) set parameters of the software that influence the result;

e) the method used for verification of the accuracy of the used models and the calculation itself;

f) all results used for classification.

It shall be possible, from the data stored, to implement the models again and to make the calculation again on another system or with another software.

Relevant data of the measurements shall be kept at the **manufacturer** of the **equipment**. It shall be kept either over the expected lifetime of the **equipment** or over a time defined by national regulations.

18.8.2 Numerical assessment of electric or magnetic fields

For complex geometries or applications where the assumptions for calculating the reference level are not sound a numerical assessment of the interaction between the processing equipment and exposed persons regarding electric or magnetic fields and induced electric fields in bodyparts may be used to assess the induced currents in bodyparts if the calculation reaches a sufficient accuracy.

The use of computational electrodynamics for assessing external fields, internal electric field, specific absorption rate (SAR) or contact current is a numerical experiment and accuracy depends inter alia on

– the model of the source, of the installation and of the human body,

– the calculation method used,
– the spatial and temporal resolution.

The documentation of the calculation shall in addition to the list of 18.8.1 include

a) the geometry of conductors and all bodies relevant to the calculation;
b) the grid and resolution.

18.8.3 Numerical assessment of optical radiation

The assessment of exposure and subsequent classification can be based on ray tracing calculation of irradiance and radiance at all positions relevant instead of measurements, if a comparable accuracy is reached by the calculation.

As ray tracing is a numerical experiment, the demands on position and orientation of virtual detectors are the same as for physical detectors during measurements.

The calculation of radiance or irradiance, depending on the defined spatial angles or angular subtenses shall follow the same procedure as for measurements defined in 18.6.5 or 18.6.6.

The documentation of the calculation shall in addition to the list of 18.8.1 include

a) all relevant modelling data and a description of the models used for involved surfaces, their scattering behaviour, diffuse or specular reflection;
b) set parameters of the software that influence the result, like splitting of rays, maximum number of split rays followed, minimum amount of energy in a single ray, randomisation method;
c) number of rays used, energy lost due to numerical effects.

19 Information for use

19.1 General requirements

19.1.1 The **manufacturer** shall provide information for use of the equipment consisting of communication links such as texts, words, signs, signals, symbols or diagrams, used separately or in combination to convey information to the **user**.

Information about the intended use of the equipment shall be provided, taking into account its operating modes, measures required to ensure intended and correct use of the equipment, in particular information on residual risks.

The information shall include:

a) details of the required training;
b) personal protective equipment requirements;
c) additional details of the **guards** or **protective devices**.

19.1.2 The information for use shall cover separately or in combination transport, assembly and installation, commissioning, use (setting, teaching/programming or process changeover, operation, cleaning, fault finding and maintenance) of the equipment, and if applicable de-commissioning, dismantling and disposal.

19.2 Location and nature of the information for use

The **manufacturer** shall decide whether the information or parts of it are given

a) in or on the installation itself;

b) in accompanying documents;

c) on the packaging;

d) by other means such as signals and warnings outside the equipment.

The decision shall be based on the risk, the time when the information is needed and the design of the installation.

19.3 Signalling and warning devices

Visual signals (e.g. flashing lights) or acoustic signals (e.g. sirens) shall be used to warn **operators** or **ordinary persons** of an impending hazardous event – e.g. start-up of the equipment or over-temperature. The following requirements shall be met:

a) signals shall be emitted before the occurrence of the hazardous event,

b) signals shall be unambiguous and shall be clearly recognized by **operators**,

c) signals shall be clearly perceived and differentiated from all other signals used.

If warning devices are used, they shall be designed and located such that checking for proper operation is easy. The information for use shall determine procedures for verifying proper operation of warning devices.

The **manufacturer** shall consider the risk of "sensorial saturation" when designing the warning devices. This risk results from too many visual or acoustic signals which can lead to ignoring or defeating the warning devices by **operators**.

19.4 Markings, pictograms, written warnings

19.4.1 The installation and its equipment shall be marked on nameplate(s) at least with the following data in a visible and legible manner:

a) serial number, if any, or name of the equipment;

b) name and address of the **manufacturer**;

c) year of construction;

d) year of modification, if applicable;

e) number of phases and rated input voltage; when the equipment is intended to be used at different rated supply voltages, the association of the particular voltage and corresponding supply terminals as well as the type of connection shall be indicated on the nameplate;

f) type and value of rated input current;

g) rated input power; in case of installations for several voltage ranges, the maximum values for the power input pertaining to the voltage ranges shall be stated;

h) input frequency and rated process frequency or range, where appropriate, shall be stated;

i) class and group of the equipment according to CISPR 11.

19.4.2 The equipment shall be marked with all information that is necessary for its safe use, for example

– the maximum **workload** or output to be processed;

– the maximum operation temperature;

– the atmosphere to be used (e.g. non-flammable, explosive, toxic), if specific;

– the necessity to wear personal protective equipment;

– **guard** or **barrier** adjustment data.

19.4.3 Appropriate warnings shall be displayed, in particular against hazards which cannot be immediately perceived, such as HV, ionizing radiation, non-ionizing radiation or **electromagnetic fields**.

19.4.4 IEC 60204-1:2005, 16.2 shall be used for the marking of electrical features.

Control and signalling devices shall be identified by letters, words or symbols.

Identification of conductors shall be in accordance with 13.2 of IEC 60204-1:2005.

The electrical components and their references to the circuit diagram in the documentation shall be durably marked. The designation shall comply with the indications on the circuit diagram.

19.4.5 The installation shall bear all markings which are necessary to indicate its compliance with relevant requirements.

19.4.6 Information printed directly on the equipment shall be permanent and remain legible throughout the expected life of the equipment.

Markings shall be durable, legible and clearly visible. Markings shall be in the language of the country, in which the equipment is to be installed, unless agreed differently. Written warnings shall be drawn up in the language(s) of the country in which the equipment will be used for the first time and, on request, in the language(s) understood by **operators**.

Markings, symbols, signs and written warnings shall be readily understandable and unambiguous, especially as regards the part of the function(s) of the equipment to which they are related. Readily understandable pictograms should be used in preference to written warnings.

Graphical symbols shall conform to IEC 60417 or ISO 7000, if applicable. Signs, labels or signboards shall be designed according to ISO 3864-1. Annex F provides examples of relevant symbols and safety signs.

19.5 Instruction handbook(s) / installation, commissioning, operation, maintenance, and decommissioning manual(s)

19.5.1 The instruction handbook and technical documentation shall be provided in paper form; it may be accompanied by electronic data.

19.5.2 The instruction handbook or other written instructions shall conform with IEC 82079-1 and shall contain at least the following information relating to transport, handling and storage of the installation or equipment, including but not limited to:

a) storage conditions for the equipment or parts of it;

b) dimensions, mass value(s), position of the centre(s) of gravity;

c) indications for handling – for example, drawings indicating application points for lifting equipment.

19.5.3 The instruction handbook or other written instructions shall contain at least the following information relating to installing and commissioning of the equipment, including but not limited to:

a) fixing/anchoring and vibration dampening requirements, or foundations if necessary;

b) mandatory earth terminals in the vicinity of parts of the installation where it is necessary for maintenance and inspection that conductors and bare conductive parts are earthed after switching off the supply;

c) if the equipment is not sent assembled, specific instructions on unpacking of the equipment, checklist of parts, plan of the configuration, plan for installation of all parts and a connection schedule of parts (IEC 61082-1);

d) instructions for connecting the installation or equipment to water, hydraulic liquids, pressurized air, including permissible pressures;

e) instructions for connecting the installation or equipment to the power supply, especially tolerable voltage and frequency fluctuations, and including protection against electrical overloading;

f) test plan including all tests performed prior to connecting or operating the equipment;

g) assembly and mounting conditions;

h) space needed for use and maintenance of the equipment;

i) permissible conditions of the environment – for example temperature, moisture, vibration, **electromagnetic radiation**, intended atmosphere and atmospheric pressure;

j) recommendation about process waste removal or disposal, if applicable;

k) recommendation for the implementation of protective measures, safety distances, safety signs and signals by the **user**.

19.5.4 The instruction handbook or other written instructions shall contain information relating to the installation or equipment itself, such as

a) detailed description of the equipment, its fittings, **guards** and other **protective devices**;

b) the comprehensive range of applications for which the equipment is intended, including prohibited usages;

c) diagrams, especially schematic representation of safety functions in conformity with Clause 17 of IEC 60204-1:2005;

d) data on noise and vibration generated by the equipment, data on radiation, gases, vapours and dust emitted by it. If applicable including reference to the measurement methods used;

e) technical documentation of the **electrical equipment** in conformity with Clause 17 of IEC 60204-1:2005;

f) documents attesting that the installation or equipment complies with mandatory requirements;

g) explicit warning, if the emitted radiation can cause a hazard;

h) explicit warning if making the equipment live for the purpose of measurement and inspection causes excessive stress to electrical **insulation**, if applicable instructions for such tests and the maximum voltage to be applied.

19.5.5 The instruction handbook or other written instructions shall contain information relating to the use of the installation or equipment, such as that related to or describing

a) intended use;

b) manual controls (actuators);

c) setting, adjustment and the list of setting values and adjusting values of the equipment at the completion of the commissioning test;

d) modes and means for start-up, operation and stopping (for example emergency stop);

e) residual risks;

f) particular risks which can be generated by certain applications, by the use of certain fittings, and about specific safeguards necessary for such applications;

g) reasonably foreseeable misuse and prohibited applications;

h) procedure for fault identification, location and for repair;

i) safe procedure(s) for restarting after an intervention or after a fault;

j) personal protective equipment to be used;

k) required training.

19.5.6 The instruction handbook or other written instructions shall contain information for maintenance, such as

a) the nature and frequency of inspections for safety functions;

b) specification of the spare parts to be used, when these can affect the health and safety of the **operator**;

c) instructions relating to maintenance operations which require a definite technical knowledge or particular skills and hence need to be carried out exclusively by a **skilled person**;

d) instructions relating to maintenance actions, like replacement of parts, which do not require specific skills and hence can be carried out by the **operator**;

e) drawings and diagrams enabling the **operators** to carry out their tasks, especially during maintenance or fault finding;

f) maintenance items which can only be conducted by the equipment **manufacturer** or its designated representative;

g) instructions, drawings and diagrams related to maintenance;

h) necessary consumables, such as cleaning and disinfection agents or lubricants;

i) type and specific characteristics of fuses.

19.5.7 The instruction handbook or other written instructions shall contain information for maintenance of **electrical equipment** of the installation, such as

a) necessary testing of the resistance of earth circuits during maintenance;

b) mandatory testing of **equipotential bonding** and **insulation** resistance values of the conductors to earth and to each other during maintenance;

c) the procedure of discharging capacitors and checking the absence of voltage on capacitors, if applicable;

d) instructions on escape routes during maintenance;

e) procedures for maintenance work with equipment live – the voltage shall not exceed the LV limits;

f) preparation of the equipment for maintenance through switch off, connection to earth and short-circuiting;

g) instructions for maintenance in potentially flammable environments – no live circuit or the replacement of a lamp or fuse is usually tolerable under such conditions, or procedure for removing flammable atmospheres from the equipment;

h) instructions for maintenance in areas liable to contain toxic gases, or procedures for removing the toxic gases prior to work.

19.5.8 The instruction handbook or other written instructions shall contain information for de-commissioning, dismantling or disposal.

19.5.9 The instruction handbook or other written instructions shall contain information for emergency situations, such as

a) the operating procedure to be followed in the event of an accident or breakdown;

b) the type of fire-fighting equipment to be used;

c) warning of possible emission or leakage of hazardous substance(s) and, if possible, an indication of means for fighting their effects;

d) instructions on the application of first aid to the victims of accidents of electrical origin.

19.5.10 If the instruction handbook or other written instructions contain maintenance instructions provided for **skilled persons** and maintenance instructions provided for **instructed persons**, they shall appear clearly separated from each other.

19.5.11 The instruction handbook or other written instructions shall contain relevant information regarding EMC.

19.5.12 The instruction handbook or other written instructions shall contain relevant information concerning hazards to specific groups of persons – for example pregnant women or people wearing a pacemaker.

Annex A
(informative)

List of significant hazards

Table A.1 lists hazards that are significant for at least some types of installations covered by this standard. This list is intended for the use in risk assessment. Particular attention should be paid to the fact that this list

– lists mainly those hazards dealt with in this standard,
– does not list many hazards beyond the scope of this standard, as they are listed in Annex B of ISO 12100:2010, ISO 13577-1 or in other documents,
– is not exhaustive for specific installations or equipment for risk assessment purposes.

Table A.1 gives examples of hazardous situations or events that can occur.

Table A.1 – List of hazards dealt with in this standard

Hazard			Clause/subclause of this standard or reference
Origin	**Hazardous situation/event**	**Potential consequence**	
1 Mechanical			ISO 13577-1, ISO 12100
high pressure gases and liquids	bursting of vessel, ejection of (hot) gases, falling or ejection of objects, ejection of (hot) liquids	suffocation, impact, explosion, being thrown, crushing, slipping or tripping,	12.3
movable parts	getting caught by part, getting crunched between parts	shear, crunching,	15
vacuum	implosion of vessel, bursting of window	impact, injection or ejection	12.3
2 Electrical			
short-circuit arc live parts parts which have become live under fault conditions		electric shock, burn, shock, electrocution, falling or being thrown	7 and 8
		fire, chemical reaction, explosion, projection of molten particles	7, 10, 11
insufficient distance to live parts under HV – people/equipment	entering the HV hazard zone	electrical shock, fire, explosion	7, 10, 11
leakage current caused by hot **insulation** or through water or contamination	static electricity builds up on surface and ignites material	electric shock	7, 10, 12
prospective circuit breaker not fast enough		shock, any other (for example, mechanical, electrical) as a consequence of equipment failure or overheating	7, 14

Hazard			Clause/subclause of this standard or reference
Origin	**Hazardous situation/event**	**Potential consequence**	
prospective short circuit current		fire, any other (for example, mechanical, electrical) as a consequence of equipment failure or overheating	7, 10, 11
inrush current cause relays to weld and stick in 'on'		any other (for example, mechanical, electrical) as a consequence of equipment failure or overheating	7, 14
discharge into electric control or measuring equipment		any other (for example, mechanical, electrical) as a consequence of equipment failure or overheating	7, 14
onboard electrical source frequency variation		destruction of power source	6, 7, 14
overload	workload contacts heating means, foam formation	eruption or ejection of workload	10
undervoltage		any other (for example, mechanical, electrical) as a consequence of equipment failure	6.5
overvoltage	overheating of electric connections, melting of **insulation**	any other (for example, mechanical, electrical) as a consequence of equipment failure or overheating	6.5
magnetic field		projection or ejection of workload or other metallic parts, effects on medical implants, body heating, neural stimulus, any other (for example, mechanical, electrical) as a consequence of equipment failure or overheating	8
electromagnetic force		ejection of workload or projection of metallic parts, effects on medical implants, body heating, any other (for example, mechanical, electrical) as a consequence of equipment failure or overheating	8
electric field		ejection of workload or projection of metallic parts, effects on medical implants, body heating, any other (for example, mechanical, electrical) as a consequence of equipment failure or overheating	8
arc or plasma generating ozone		breathing harm, destruction of **insulations**	8
arc or plasma generating UV light		destruction of **insulations**	9
electrostatic phenomena causing arcs		electric shock, any other (for example, mechanical, electrical) as a consequence of equipment failure or overheating	7, 8

Hazard			Clause/subclause of this standard or reference
Origin	**Hazardous situation/event**	**Potential consequence**	
3 Thermal			
hot environment	prolonged stay near processing equipment	burn, dehydration, discomfort, dizziness, any other (for example, mechanical, electrical) as a consequence of a human error	9, 10, 11
flame			ISO 13577-2
explosion of gas, dust, aerosols	falling or ejection of objects, ejection of (hot) gases	any other (for example, mechanical, electrical) as a consequence of equipment failure	11, IEC 60079 series
projection or sudden eruption of material	falling or ejection of objects ejection of (hot) gases, ejection of (hot) liquids, thermal energy stored in workload projects hazard	burn, scald, impact, being thrown, crushing, slipping or tripping, explosion, any other (for example, mechanical, electrical) as a consequence of equipment failure	8, 10, 11, 15
failure of liquid cooling enclosure in contact with liquid workload		burn, scald, impact, being thrown, crushing, slipping or tripping, explosion, any other (for example, mechanical, electrical) as a consequence of equipment failure	12, ISO 13577-1
objects or materials with a high temperature	non-sufficient thermal strength of parts of the installation leads to break-up during operation	burn, ignition, explosion, radiation	10
hot liquids, hot liquid flowing out of a vessel, hot liquid flowing into water	falling or ejection of objects, ejection of hot liquids, liquid metal causes sudden steam eruption	burn, scald, poisoning, slipping or tripping, explosion, ejection, any other (for example, mechanical, electrical) as a consequence of equipment failure	11, 15
superheated hot liquids		burn, scald, poisoning, impact, being thrown, crushing, slipping or tripping, explosion, any other (for example, mechanical, electrical) as a consequence of equipment failure	10,12
hot high pressure gases		scald, burn	10, 12
hot high pressure liquids		scald, burn	10, 12
radiation from heat sources		see infrared radiation	9
4 Noise			17.2 ISO 12100
5 Vibration			ISO 13577-1 ISO 12100

Hazard			Clause/subclause of this standard or reference
Origin	**Hazardous situation/event**	**Potential consequence**	
6 Electromagnetic fields below 300 GHz			
electric field		burn, dizziness, body heating.	8
magnetic field	Magnetic field interacts with installation and leads to break-up	any other (for example, mechanical, electrical) as a consequence of equipment failure or overheating	8
7 Radiation – electromagnetic fields above 300 GHz			
ionising radiation		effects on reproductive capability, mutation, cancer, burn, severe illness or death, any other (for example, mechanical, electrical) as a consequence of equipment failure	9.2
ultraviolet radiation		damage to eyes and skin, mutation, cancer of skin	9.3
visible radiation		damage to eyes and skin, burn	9.4
infrared radiation		burn, damage to eyes, any other (for example, mechanical, electrical) as a consequence of equipment failure or overheating	9.4
ignition of flammable substance by radiation		burn, explosion, noxious gases	9, 10, 11 IEC 60079 series
laser radiation		damage to eyes and tissue	9.5
8 Material or substance related			
aerosol, combustible, dust, explosive, fibre, flammable, fluid, fume, gas, mist, oxidizer		breathing difficulties, suffocation, cancer, corrosion, explosion, fire	ISO 12100, ISO 13577-1
9 Ergonomic			
access	moving into hazard zone	any as a consequence of a human being in the wrong place	6.7, 8, 9, 10, 12, 13, 14, 15
design or location of indicators and visual display units		any other (for example, mechanical, electrical) as a consequence of a human error	19.3
design, location or identification of control devices		any other (for example, mechanical, electrical) as a consequence of a human error	14, 19

Hazard			Clause/subclause of this standard or reference
Origin	**Hazardous situation/event**	**Potential consequence**	
flicker, dazzling, shadow, stroboscopic effect by the installation		discomfort, fatigue, stress, any other (for example, mechanical, electrical) as a consequence of a human error	13.8, 14
lighting in installation	tripping due to dim lighting not perceiving warning due to glare	any other (for example, mechanical, electrical) as a consequence of a human error	13.8
work process design	excessive effort, human errors, human misbehaviour (unintentional or deliberately induced by the design), Loss of direct visibility of the working area, Painful and tiring postures, Repetitive handling at high frequency	any other (for example, mechanical, electrical) as a consequence of a human error	14, 15
10 Associated with the environment in which the installation is used			
General			ISO 12100
electromagnetic disturbance	malfunction of the controls	any other as a consequence of the effect caused by the sources of the hazards on the equipment or parts of the equipment	Annex E
insufficient lighting	tripping due to dim lighting, not perceiving warning due to glare	any other (for example, mechanical, electrical) as a consequence of a human error	13.8, 19.2, 19.3, 19.5
flicker, dazzling, shadow, stroboscopic effect by other installations		discomfort, fatigue, stress, any other (for example, mechanical, electrical) as a consequence of a human error	19
11 Combination of hazards			
repetitive activity + effort + high environmental temperature		dehydration, loss of awareness, heat stroke	

Annex B
(informative)

Electric and magnetic fields, touch currents – limits of exposure hazards

B.1 Overview and motivation

B.1.1 General

This Annex B informs about limits for exposure to electric and magnetic fields as well as for touch currents and voltages. Meeting exposure limits is not to be confused with adequate risk reduction. The limits can be used if no applicable national regulations exist.

B.1.2 Basic concepts

Exposure limits are based on the physical quantity or quantities directly related to the established health effects and are termed basic restrictions, their values are for example defined in ICNIRP:2010 or in IEEE C95.1.

The induced electric field strength in exposed body parts is the physical quantity used by those sources and adhered to in this Annex B in the frequency range between 1 Hz and 100 kHz. It is this field that affects nerve cells and other electrically sensitive cells and causes an immediate reaction.

Reference levels are measurable values that are derived from the basic restrictions. Their calculation is usually based on very general worst case scenarios and includes generous safety margins. The implicit safety margin differs quite markedly between ICNIRP:1999, ICNIRP:2010 and IEEE C95.1. They can exaggerate the hazard by orders of magnitude. Meeting a reference level during verification shows that a position is safe; exceeding a reference level does not necessarily indicate that the same position is unsafe.

Values for the general public are kept in this Annex B as these are needed for the classification with respect to 4.4.

B.1.3 Hazard sources and hazard effects

This Annex B is concerned with hazards caused by

a) static magnetic fields and magnetic fields with a frequency below 1 Hz;
b) live conductors and charges on non-conducting surfaces causing touch currents including arcing;
c) electric or magnetic nearfields causing electric fields in body parts.

The basic physical quantity used for specifying electric, magnetic and current limiting values on electric shock effects is the internal tissue electric field strength in all cases where local bodypart heating is not the determining hazard, otherwise it is the localised specific absorption rate (SAR).

Painful local heating or burn caused by touch currents are considered as electric shock effects. Such heating effects can also be internal and caused by the product of the electric field and the current it causes in the tissue. There are no limiting values specified by international organisations or local authorities based on a quantification of the various factors to be considered. Thus skin heating effects are not included in this Annex B.

External wave propagation phenomena complicate the exposure scenario above some MHz as involved fields are no longer only nearfields. Effects that limit the energy penetration into the body occur above some MHz frequencies. A value of 6 MHz is set as the upper limit considered in this standard. Higher frequencies are dealt with in the applicable Particular Requirements.

All fields dealt with in this Annex B are quasistatic and non-propagating.

B.1.4 Frequency dependence

The assessment of hazards becomes more complicated for frequencies higher than 200 Hz due to

a) electric and propagating fields becoming significant to the human body with increasing frequency, as the induced electric field strength increases with the frequency;
b) any coupling between external magnetic fields and a bodypart causing an induced electric field, depends on the geometry and location of the bodypart in relation to the direction, curvature and strength;
c) strength of displacement currents, e.g. caused by touching an insulated conductor, increases with the frequency;
d) circuits do not remain as reliable as at low frequencies, due to skin and proximity effects;
e) conventional **electric shock** phenomena of nerve and muscle reflex reactions diminish with increasing frequency, skin burns and internal bodypart heating become significant instead.

Exposure to strong magnetic fields induces local electric fields in human bodyparts, and by that also currents and local heating of bodyparts. The electric field causes electric shock type effects which, however, diminish in the frequency range between 100 kHz and 6 MHz.

B.2 Static magnetic fields

Table B.1 provides the exposure limits to static magnetic fields according to

a) ICNIRP:2009 where static is defined as having a frequency of less than 1 Hz; the spatial peak limits are for people without medical implants made from ferromagnetic materials or including electronic equipment;
b) IEEE C95.6:2002 where static is defined as having a frequency of less than 0,153 Hz; these levels are derived from restrictions on induced internal electrical fields.

Table B.1 – ICNIRP and IEEE limits of exposure to static magnetic fields

Exposure characteristics	Magnetic flux density, spatial peak exposure and rms					
	general public		occupational		exceptional occupational	
	ICNIRP	IEEE	ICNIRP	IEEE	ICNIRP[a]	IEEE
Exposure of head and of trunk	0,4 T	0,118 T	2 T	0,353 T	8 T	n.a.
Exposure of limbs	0,4 T	0,353 T	8 T	0,353 T	8 T	n.a.

[a] For specific work applications, exposure up to 8 T can be justified, if the environment is controlled and appropriate work practices are implemented to control movement-induced effects.

Limits to safeguard personnel against the hazard of objects being accelerated in an inhomogeneous field are lower than the safety limits for the exposure of people, the variation of the magnetic field strength is usually limited to 0,3 T m^{-1} for any direction. For persons having medical electronic implants or devices in or on the body, the corresponding maximum value is usually 0,5 mT unless these devices are certified to withstand and operate reliably at higher values.

B.3 Time varying magnetic, electric and electromagnetic fields

B.3.1 Basic restrictions between 1 Hz and 100 kHz

Table B.2 summarises the ICNIRP basic restrictions on induced time-varying electric fields in body tissues over the frequency range from 1 Hz to 10 MHz; Table B.3 summarises the basic restrictions on induced time-varying electric fields in body tissues over the frequency range from 0,153 Hz to 3 GHz according to IEEE C95.1:2005 and IEEE C95.6:2002. From these values other limits and reference levels are derived.

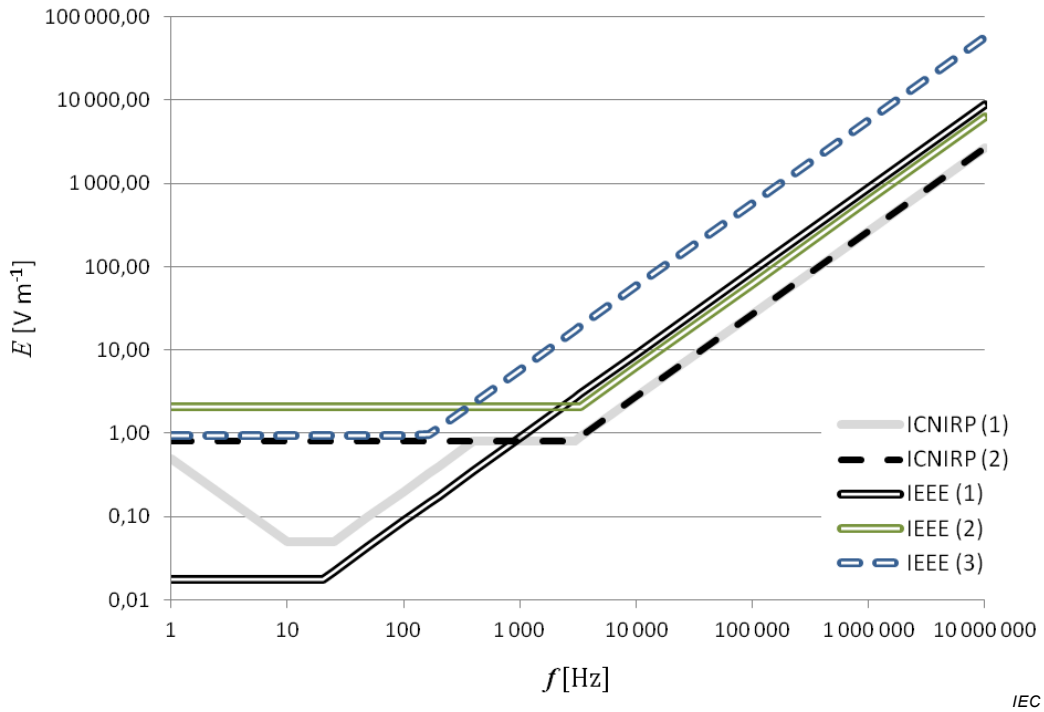
Table B.2 – ICNIRP basic restrictions for internal electric fields in human tissue in the frequency range between 1 Hz and 10 MHz

Exposure characteristic	Frequency range	Internal electric field in V m^{-1}	
		general public	occupational
Central nervous system (CNS) tissue of the head	1 − 10 Hz	$0{,}1 \times f^{-1}$	$0{,}5 \times f^{-1}$
	10 Hz − 25 Hz	0,01	0,05
	25 Hz − 400 Hz	$0{,}4 \cdot 10^{-3} \times f$	$2 \cdot 10^{-3} \times f$
	400 Hz − 3 kHz	0,4	0,8
	3 kHz − 10 MHz	$1{,}35 \cdot 10^{-4} \times f$	$2{,}7 \cdot 10^{-4} \times f$
All tissues of head and body	1 Hz − 3 kHz	0,4	0,8
	3 kHz − 10 MHz	$1{,}35 \cdot 10^{-4} \times f$	$2{,}7 \cdot 10^{-4} \times f$
NOTE f is the frequency in Hz; all values are rms.			

Table B.3 – IEEE basic restrictions for internal electric fields in human tissue in the frequency range between 0,153 Hz and 3 GHz

Exposure characteristic	Frequency range	Internal electric field in V m^{-1}	
		general public	occupational
Brain	< 20 Hz	0,005 89	0,017 7
	20 Hz − 3 GHz	$2{,}95 \cdot 10^{-4} \times f$	$8{,}85 \cdot 10^{-4} \times f$
Heart	< 167 Hz	0,943	0,943
	167 Hz – 3 GHz	$5{,}76 \cdot 10^{-3} \times f$	$5{,}76 \cdot 10^{-3} \times f$
Hands, wrists, feet and ankles	< 3 350 Hz	2,1	2,1
	3 350 Hz – 3 GHz	$6{,}27 \cdot 10^{-4} \times f$	$6{,}27 \cdot 10^{-4} \times f$
other tissue	< 3 350 Hz	0,701	2,1
	3 350 Hz – 3 GHz	$2{,}09 \cdot 10^{-4} \times f$	$6{,}27 \cdot 10^{-4} \times f$
NOTE f is the frequency in Hz; all values are rms.			

The data is illustrated in Figure B.1.



Key

(1) = central nervous sytem or brain tissue

(2) = all other tissue

(3) = heart tissue

f = frequency

E = induced internal electric field

Figure B.1 – Illustration of the basic restrictions from Tables B.3 and B.4

B.3.2 Basic restrictions between 100 kHz and 300 MHz

Table B.4 summarises the basic restrictions on SAR values and power flux densities due to exposure to time-varying electric, magnetic or **electromagnetic fields** in the frequency range between 100 kHz and 300 MHz according to ICNIRP:2010 and IEEE C95.1:2002.

Table B.4 – Specific absorption rate (SAR) and power flux density basic restrictions between 100 kHz and 300 MHz

<table>
<tr><th rowspan="2"></th><th rowspan="2">Frequency range</th><th colspan="2" rowspan="2">Whole-body average SAR [a] in W·kg^{-2}</th><th colspan="2" rowspan="2">Localized SAR [b] (head and trunk) in W·kg^{-2}</th><th colspan="2" rowspan="2">Localized SAR (limbs) in W·kg^{-2}</th><th colspan="2">Power flux density in W·m^{-2}</th></tr>
<tr><th>20 cm^2 average</th><th>1 cm^2 average</th></tr>
<tr><th></th><th></th><th>ICNIRP</th><th>IEEE</th><th>ICNIRP</th><th>IEEE</th><th>ICNIRP</th><th>IEEE</th><th>ICNIRP</th><th>ICNIRP</th></tr>
<tr><td rowspan="3">general public</td><td>100 kHz − 3 GHz</td><td rowspan="2">0,08</td><td>0,08</td><td rowspan="2">2</td><td>2</td><td rowspan="2">4</td><td>4</td><td rowspan="3">10</td><td rowspan="3">200</td></tr>
<tr><td>3 GHz − 10 GHz</td><td>n.a.</td><td>n.a.</td><td>n.a.</td></tr>
<tr><td>10 GHz − 300 GHz</td><td colspan="6">n.a.</td></tr>
<tr><td rowspan="3">occu-pational</td><td>100 kHz − 3 GHz</td><td rowspan="2">0,4</td><td>0,4</td><td rowspan="2">10</td><td>10</td><td rowspan="2">20</td><td>20</td><td rowspan="3">50</td><td rowspan="3">1 000</td></tr>
<tr><td>3 GHz − 10 GHz</td><td>n.a</td><td>n.a.</td><td>n.a.</td></tr>
<tr><td>10 GHz − 300 GHz</td><td colspan="6">n.a.</td></tr>
<tr><td colspan="10">[a] All SAR values are to be averaged over any 6-min period.
[b] Localized SAR averaging mass is any 10 g of continuous tissue; the maximum SAR so obtained should be the value used for the estimation of exposure.</td></tr>
</table>

B.3.3 Heated worn objects

Some objects worn in an electric or magnetic field can cause a risk; this includes ring shaped objects like necklaces, bracelets, rings as well as magnetisable objects or objects made from material of comparably poor conductivity, like carbon or silicon. No clear limits can be given.

B.4 Touch currents

Table B.5 summarises the ICNIRP:2010 reference levels for exposure to touch currents; one can instead derive sufficient safe levels from the basic restrictions for specific cases.

Table B.5 – ICNIRP reference levels for time-varying touch currents

Frequency range	Maximum contact current (mA)	
	general public	occupational
1 Hz − 2,5 kHz	0,5	1,0
2,5 kHz − 100 kHz	0,2 f	0,4 f
100 kHz − 10 MHz	20	40
NOTE f is the frequency in kHz.		

B.5 Touch voltages

B.5.1 Extra-low voltage (ELV) below 100 Hz

The following values define ELV circuits which can be touched without restrictions:

– A **touch voltage** of up to 120 V is accepted at 0 Hz.

– A **touch voltage** of up to 50 V rms value is accepted between 10 Hz and 100 Hz.

– For a composite of 0 Hz and alternating components up to 100 Hz, a peak value not exceeding 120 V and rms ripple not exceeding 12 V are accepted.

B.5.2 Extra-low voltage (ELV) above 100 Hz

Limits for **touch voltages** for higher frequencies would be determined from the touch current, for the actual configuration of the accessible live conductor and the touching part of the body.

IEC TR 60479-5 and IEC TS 61201 provide information on limitations at mains frequency. Limits at other frequencies are under consideration.

IEEE C95.1:2005 suggests 140 V as the upper limit to prevent arc formation between equipment and an exposed person in the frequency range 100 kHz to 100 MHz.

B.6 Classification of exposure

B.6.1 General

Following the approach of 4.4, the following risk groups are defined. A risk group describes the risk of exposure to a hazard for a specific spatial position or hazard zone. The classification applies for **normal operation** and single-fault condition.

B.6.2 Exempt group

Any equipment that does not pose any hazard caused by electric, magnetic or **electromagnetic field** is classified in the exempt group. This requirement is met by any **EH** or **EPM equipment** that does

– not pose a hazard to an **ordinary person**;

– not cause a static magnetic field exceeding the limit for the general public as defined in Table B.1,

– not cause an internal electrical field exceeding the limit for the general public as defined in Table B.2,

– not cause SAR exceeding the limit for the general public as defined in Table B.4;

– not cause a touch current exceeding the reference level defined for the general public as defined in ICNIRP.

This complies with equipment that either has been assessed using methods defined in Clause 18 or that does not cause an electric field strength, magnetic field strength, magnetic flux density or equivalent plane wave power density exceeding the reference level as defined in ICNIRP:2010, IEEE C95.1:2002 or IEEE C95.6:2005 for general public.

B.6.3 Risk group 1 (low risk)

Any equipment that does not pose a hazard for occupational exposure is classified in the low risk group. This requirement is met by any equipment that exceeds the limits for the exempt group but that does

– not pose a hazard for **operators**,

– not cause a static magnetic field exceeding the occupational limit as defined in Table B.1,

– not cause an internal electrical field exceeding the occupational limit as defined in Table B.2,

– not cause a SAR exceeding the occupational limits as defined in Table B.3,

– not cause a touch current exceeding the reference level defined for occupational use as defined in Table B.4.

This complies with equipment that either has been assessed using methods defined in Clause 18 or that does not cause an electric field strength, magnetic field strength, magnetic flux density or equivalent plane wave power density exceeding the reference level as defined in ICNIRP:2010, IEEE C95.1:2002 or IEEE C95.6:2005 for occupational exposure.

B.6.4 Risk group 2 (moderate risk)

Any equipment, that does not pose a hazard for short exposure duration is classified in the moderate risk group. This requirement is met by any kind of equipment that exceeds the limits for risk group 1 (low risk), but that does not cause

– a static magnetic field exceeding the occupational limit as defined in Table B.1 for specific work applications where the environment is controlled and appropriate work practices are implemented to control movement-induced effects;

– a touch current exceeding the level causing harm over a short time.

B.6.5 Risk group 3 (high risk)

Any equipment that can pose a hazard even for momentary or brief exposure, or which exceeds the limits for risk group 2 (moderate risk), is classified in risk group 3 (high risk).

Annex C
(informative)

Optical radiation – limits of exposure hazards

C.1 Non-coherent radiation limits

This Annex C informs about limits for exposure to non-ionising radiation. Meeting exposure limits is not to be confused with adequate risk reduction. The limits can be used if no applicable national regulations exist. Non-ionising radiation includes hazards from ultraviolet, from visible and from infrared radiation. The limits provided in Table C.1 and

Table C.2 comply with IEC 62471.

Table C.1 – Exposure limits in the ultraviolet, visible and infrared, irradiance based values

Hazard	Formula [a]	Wavelength range	Exposure duration	Limiting aperture	Exposure limit in terms of constant irradiance[b]
Actinic UV skin and eye	$E_S = \sum E_\lambda \cdot S(\lambda) \cdot \Delta\lambda$	200 nm – 400 nm	< 30 000 s	1,4 rad / 80°	$30/t$ W·m^{-2}
Eye UV-A	$E_S = \sum E_\lambda \cdot S(\lambda) \cdot \Delta\lambda$	200 nm – 400 nm	< 30 000 s	1,4 rad / 80°	$30/t$ W·m^{-2}
Eye infrared	$E_{IR} = \sum E_\lambda \cdot \Delta\lambda$	780 nm – 3 000 nm	≤ 1 000 s	1,4 rad / 80°	18 000/$t^{0,75}$ W·m^{-2}
Eye infrared	$E_{IR} = \sum E_\lambda \cdot \Delta\lambda$	780 nm – 3 000 nm	> 1 000 s	1,4 rad / 80°	100 W·m^{-2}
Skin thermal	$E_H = \sum E_\lambda \cdot \Delta\lambda$	380 nm – 3 000 nm	< 10 s	2π rad	20 000/$t^{0,75}$ J·m^{-2}
NOTE The exposure limit for the skin thermal hazard is a dose and not a power, thus it is stated in Joules (J) per area.					
[a] E is the spectral irradiance; λ is the wavelength; [b] t is the exposure time.					

Table C.2 – Exposure limits in the infrared, radiance based values

Hazard	Formula [a]	Wavelength range	Exposure duration	Limiting aperture	Exposure limit in terms of constant irradiance
Blue light	$L_B = \sum L_\lambda \cdot B(\lambda) \cdot \Delta\lambda$	300 nm – 700 nm	0,25 s – 10 s		
Retinal thermal	$L_R = \sum L_\lambda \cdot R(\lambda) \cdot \Delta\lambda$	380 nm – 1 400 nm	< 0,25 s	0,0017 rad	50 000/(α $t^{0,25}$) W·m^{-2}
Retinal thermal	$L_R = \sum L_\lambda \cdot R(\lambda) \cdot \Delta\lambda$	380 nm – 1 400 nm	0,25 s – 10 s	0,011 $\sqrt{t/10}$ rad	50 000/(α $t^{0,25}$) W·m^{-2}
Retinal thermal, weak[b] vis. stim.	$L_{IR} = \sum L_\lambda \cdot R(\lambda) \cdot \Delta\lambda$	780 nm – 1 400 nm	> 10 s	0,011 rad	6 000/α W·m^{-2}
NOTE The functions $B(\lambda)$ and $R(\lambda)$ are defined in IEC 62471:2006.					
[a] L is the spectral irradiance; [b] where a weak visual stimulus is inadequate to activate the aversion response.					

In the case of danger of burn caused by infrared radiation, the limit is defined as a dose, not by a specific irradiation. **Operators** can be exposed to a safe dose repeatedly, as the doses do not accumulate – in contrast to e.g. exposure to UV radiation.

For infrared radiation exceeding 3 000 nm, no limits are usually set, ICNIRP:2006 provides the necessary information.

C.2 Radiation from laser sources and LEDs

Coherent non-ionising radiation is emitted from sources like lasers and LEDs. Table C.3 summarises the classification of equipment according to IEC 60825-1 and connects it with the classification conform to IEC 62471 and used in Clause 0.

Table C.3 – Risk group classification of equipment by emission of optical radiation

Class	Laser radiation Highest class IEC 60825-1	Non-coherent optical radiation Highest risk group
0	1, 1M	Exempt group – see C.3.2 Risk group 1 (low risk) – see C.3.3
1	2, 2M	Risk group 2 (moderate risk) – see C.3.4
2	3R, 3B, 4	Risk group 3 (high risk) – see C.3.5

C.3 Non-coherent optical radiation – risk groups

C.3.1 General

The classification as illustrated in Table C.3 depends for each single location on the highest single risk, summarised over all positions and all emission bands. A detailed description of risk groups for optical radiation is given in IEC 62471.

Risk groups simplify the task of assessment of exposure. They mirror specific aspects of behaviour or tasks of **operators**. They are derived from the exposure limits as given in Table C.1 and

Table C.2.

As radiation hazards are depending on the radiation itself, not on the cause or source, it is advisable to include all radiation from all sources of the installation into this classification.

C.3.2 Exempt group

Any equipment that does not pose any photobiological hazard is classified in the exempt group. This requirement is met by any **EH** or **EPM equipment** that

– does not pose an actinic ultraviolet hazard within 8 h of exposure;
– does not pose a near-UV hazard within 1 000 s;
– does not pose a retinal blue-light hazard within 10 000 s;
– does not pose a retinal thermal hazard within 10 s;
– does not pose an infrared radiation hazard for the eye within 1 000 s;

– emits infrared radiation without a strong visual stimulus (i.e. less than 10 cd·m^{-2}) and does not pose an IR-A retinal hazard within 1 000 s.

C.3.3 Risk group 1 (low risk)

Any equipment that does not pose a hazard due to normal behavioural limitations on exposure is classified in the low risk group. This requirement is met by any equipment that exceeds the limits for the exempt group but

– does not pose an actinic ultraviolet hazard within 10 000 s;

– does not pose a near ultraviolet hazard within 300 s;

– does not pose a retinal blue-light hazard within 100 s;

– does not pose a retinal thermal hazard within 10 s;

– does not pose an infrared radiation hazard for the eye within 100 s;

– emits infrared radiation without a strong visual stimulus (i.e. less than 10 cd·m^{-2}) and does not pose an IR-A retinal hazard, within 100 s.

C.3.4 Risk group 2 (moderate risk)

Any equipment, that does not pose a hazard due to the aversion response to very bright light sources or due to thermal discomfort is classified in the moderate risk group. This requirement is met by any kind of equipment that exceeds the limits for risk group 1 (low risk), but that

– does not pose an actinic ultraviolet hazard within 1 000 s exposure;

– does not pose a near ultraviolet hazard within 100 s;

– does not pose a retinal blue-light hazard within 0,25 s (aversion response);

– does not pose a retinal thermal hazard within 0,25 s (aversion response);

– does not pose an infrared radiation hazard for the eye within 10 s;

– emits infrared radiation without a strong visual stimulus (i.e. less than 10 cd·m^{-2}) and does not pose an IR-A retinal hazard within 10 s.

C.3.5 Risk group 3 (high risk)

Any equipment that can pose a hazard even for momentary or brief exposure, or which exceeds the limits for risk group 2 (moderate risk), is classified in risk group 3 (high risk).

C.3.6 Pulsed equipment

For the definition of risk groups for pulsed sources covered by this standard, 6.2 of IEC 62471:2006 applies.

Annex D
(informative)

Limits for exposure hazards – noise and vibration

D.1 General

This Annex D informs about limits for exposure to noise and vibration. Meeting exposure limits is not to be confused with adequate risk reduction. The limits can be used if no applicable national regulations exist.

D.2 Sonic noise

The physical parameters used as risk predictors are defined as follows:

a) peak sound pressure (p_{peak}): maximum value of the 'C'-frequency weighted instantaneous noise pressure;

b) daily noise exposure level (L_{EX},8 h) (dB(A) re. 20 μPa): time-weighted average of the noise exposure levels for a nominal eight-hour working day as defined by ISO 1999:2013, 3.6. It covers all noises present at work, including impulsive noise;

c) weekly noise exposure level (L_{EX},8h): time-weighted average of the daily noise exposure levels for a nominal week of five eight-hour working days.

The exposure limit values and exposure action values in respect of the daily noise exposure levels and peak sound pressures should not exceed:

– exposure limit values: L_{EX},8 h = 87 dB(A) and p_{peak} = 200 Pa (140 dB (C) in relation to 20 μPa) respectively;

– upper exposure action values: L_{EX},8 h 85 dB(A) and p_{peak} = 140 Pa (137 dB (C) in relation to 20 μPa) respectively;

– lower exposure action values: L_{EX},8 h = 80 dB(A) and p_{peak} = 112 Pa (135 dB (C) in relation to 20 μPa) respectively.

When applying the exposure limit values, the determination of the **operator**'s effective exposure should take account of the attenuation provided by the individual hearing protectors worn by **operators**. The exposure action values should not take account of the effect of any such protectors.

NOTE These limits are derived from Directive 2003/10/EC.

D.3 Ultrasonic pressure

Limit for exposure to ultrasonic pressure is 110 dB above the reference pressure value of 20 μPa, for frequencies between 20 kHz and 100 kHz.

D.4 Infrasound

Currently, there are no national regulations or international standards defining permissible exposure limits to infrasound. However, proposed limits with respect to the safety and preservation of the auditory system were provided by von Gierke and Nixon in " *Effects of Intense Intrasound on Man"* (1976): for 8 h of exposure the limit ranges from 136 dB at a low frequency of 1 Hz to 123 dB at the upper end of the infrasonic range at 20 Hz. The limits can be approximately adjusted for shorter or longer duration exposures using a 3-dB exchange rate, i.e. if the duration is halved, the level can be increased by 3 dB.

D.5 Vibration

Limiting values standardised to an eight-hour reference period and for hand-arm vibration are, where the values and assessment method are defined in ISO 5349-1:

a) the daily exposure limit value is 5 m/s^2;

b) the daily exposure action value is 2,5 m/s^2.

Limit values for whole-body vibration are, where the values and assessment method are defined in ISO 2631-1:

c) the daily exposure limit value is 1,15 m/s^2 or, a vibration dose value of 21 $m/s^{1,75}$;

d) the daily exposure action value is 0,5 m/s^2 or a vibration dose value of 9,1 $m/s^{1,75}$.

NOTE These limits are derived from Directive 2002/44/EC.

Annex E
(normative)

Provisions concerning EMC

E.1 General

Even as EMC is not inside the scope of this standard per se, EMC can cause serious risks concerned with control or safety circuits.

The equipment shall be designed for functional safety with regard to EMC, in accordance with IEC 61326-3-1. The methodology in IEC TS 61000-1-2 can be used for guidance.

Flicker and harmonics shall be taken into account, especially shall the short-circuit capacity of the supply system be taken into account in the evaluation of flicker and of harmonics.

E.2 Requirements

The requirements on maximum voltage fluctuation and flicker for equipment with a rated input current

– less or equal to 16 A given in IEC 61000-3-3,
– for greater than 16 A in IEC TS 61000-3-5 and
– less than or equal to 75 A in IEC 61000-3-11

shall be applied.

Guidelines on limits of fluctuating loads in medium-voltage and high-voltage power systems are provided in IEC TR 61000-3-7. Specific provisions of the local utility may apply.

The fluctuation and flicker are also related to the short-circuit capacity of the supply system. That in turn also influences the level of the possible hazard.

Electromagnetic disturbances created by **EH** and **EPM installations** or **equipment** shall be within the limits given in CISPR 11, as far as it applies.

Effects of harmonic currents shall be taken into account. The characteristics of the supply system shall then be taken into account for the evaluation of the type and levels of harmonics.

Requirements on emission shall comply with IEC 61000-6-4.

Guidelines on limitations of distorting loads in medium-voltage and high-voltage power systems are provided in IEC TR 61000-3-6 and apply.

Immunity to **electromagnetic fields** shall be taken into account, if necessary. Requirements on immunity for industrial equipment given in IEC 61000-6-2 apply.

Annex F
(normative)

Marking and warning

F.1 EMF hazard zones

All areas where exposure to hazardous electric or magnetic fields is expected shall be marked when they are class 1 or class 2 as defined in Annex B or national regulations indicate. This refers to risk group 2 (moderate risk) and risk group 3 (high risk). Examples of marking presented in Figure F.1 consist of graphical symbols registered in IEC 60417 (see Table F.4) and text labels, which state the kind of field, the class and the reference (this standard or a national regulation).

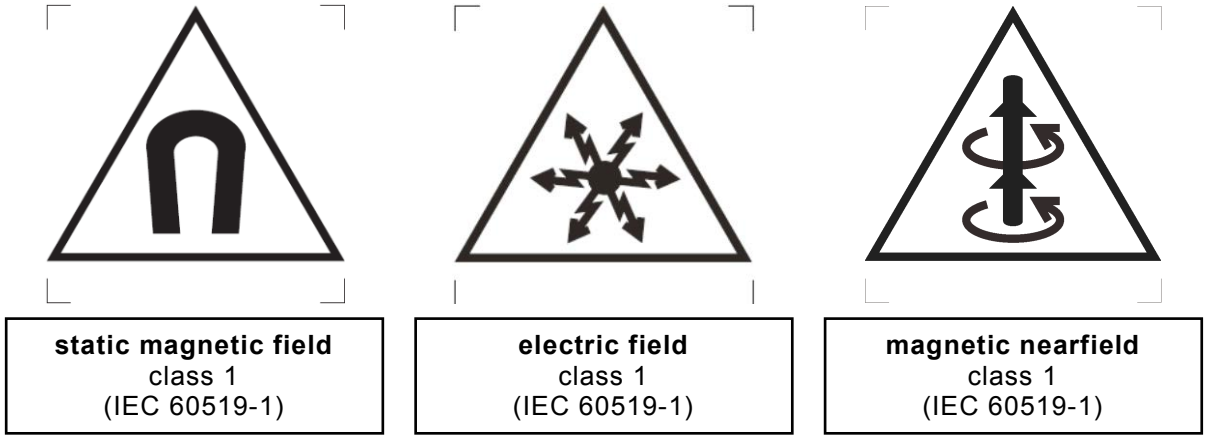


Figure F.1 – Examples of marking for magnetic and electric fields

F.2 Touch currents and surfaces

All surfaces where exposure to touch currents is expected shall be marked, when they are class 1 or class 2 as defined in Annex B or national regulations indicate. This refers to the risk group 2 (moderate risk) and risk group 3 (high risk). Examples of marking given in Figure F.2 consist of graphical symbols registered in IEC 60417 (see Table F.4) and text labels, which state the kind of hazard, the class and the reference (this standard or a national regulation).

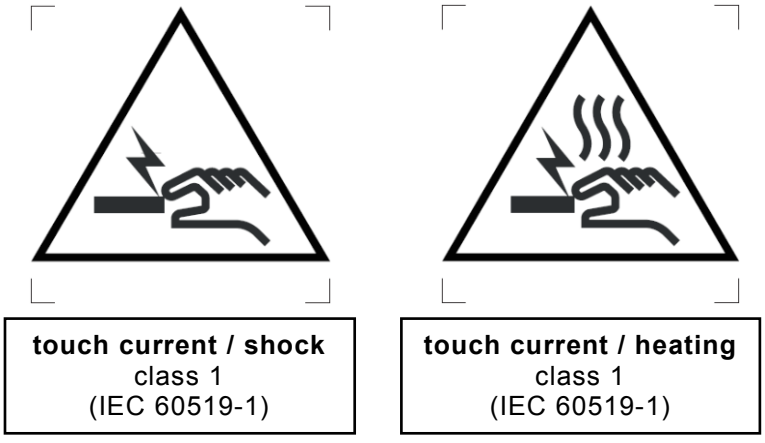
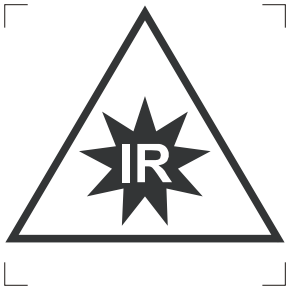


Figure F.2 – Examples of marking for touch current

F.3 Optical radiation hazards

All openings or areas where exposure to radiation is expected shall be marked, when they are class 1 or class 2 as defined in Annex C or indicated in national regulations. This refers to the risk group 2 (moderate risk) and risk group 3 (high risk). The example of marking given in Figure F.3 consists of a graphical symbol IEC 60417-6151 (2012-02) and a text label, which states the kind of radiation, the class and the reference (this standard or a national regulation).



Caution, infrared radiation
class 1
(IEC 60519-1)

Figure F.3 – Example of marking for infrared radiation

Laser radiation under the scope of IEC 60825-1 should be marked as defined in that standard.

F.4 Symbols and signs used for markings and warnings

In case of application of symbols in warning signs the rules according to ISO 3864-1 are recommended. Relevant symbols and signs registered in IEC 60417, ISO 7000 or ISO 7010 should be used, if applicable – some examples are given in Table F.4. Supplementary text signs or labels should be used to increase comprehension.

Relevant safety or warning signs and labels should be specified in the information for use according to 19.4.

Table F.4 – Examples of symbols and signs for use in EH or EPM installations

Symbol / sign	Reference	Description	Clause
	IEC 60417-5036 (2002-10)	Dangerous voltage	7
	IEC 60417-6042 (2010-11)	Caution, **risk** of electric shock	7
	IEC 60417-5019 (2006-08)	Protective earth; protective ground	7
	IEC 60417-6204 (2013-07)	Caution, static magnetic field hazard	8
	IEC 60417-6205 (2014-08)	Caution, alternating magnetic nearfield hazard	8
	IEC 60417-6206 (2013-07)	Caution, electric field hazard	8
	IEC 60417-6207 (2013-07)	Caution, touch current that can cause burns	8
	IEC 60417-6208 (2013-07)	Caution, touch current or voltage	8
	ISO 7010:2011 – P007	No access for people with active implanted cardiac devices	8
	ISO 7010:2011 – P014	No access for people with metallic implants	8
	ISO 7010:2011 – P008	No metallic articles or watches	8
	IEC 60417-6166 (2012-07)	Caution, non-ionizing **electromagnetic radiation**; Caution, microwave radiation	8, 9
	IEC 60417-5152 (2002-10)	Radiation of laser apparatus	9
	IEC 60417-6151 (2012-02)	Caution, infrared radiation	9
	IEC 60417-5041 (2002-10)	Caution, hot surface	10

Annex G
(informative)

Guidelines on using this standard

IEC 60519-1 gives a large number of general requirements that can or cannot be applicable to a particular **EH** or **EPM installation** or equipment. A simple reference without any qualification to IEC 60519-1 is therefore not sufficient. A **manufacturer** of an installation or equipment for which no Particular Requirement exists, should use IEC 60519-1

a) by selection of the most appropriate option(s) from the requirements given in the relevant clauses; and

b) by modification of certain clauses, as necessary, where the particular requirements for the installation or equipment are adequately covered by other relevant standards,

providing the options selected and the modifications made do not adversely affect the level of protection required for the installation.

When applying the principles listed above, it is recommended that

– reference be made to the relevant clauses and subclauses of this standard that are complied with, indicating where relevant the applicable option;

– reference be made to the relevant clauses and subclauses of this standard that have been modified or extended for the specific equipment requirements; and

– reference be made directly to the relevant standard, for those requirements for the electrical equipment that are adequately covered by that standard.

In all cases, expertise is essential to be able to:

– read and understand all of the requirements of IEC 60519-1;

– choose the applicable requirements from IEC 60519-1 where alternatives are given;

– identify alternative or additional particular requirements that differ from the requirements of IEC 60519-1 or are not included in the latter, and that are determined by the installation and its use; and

– specify precisely those particular requirements;

– use this standard for risk assessment purposes.

Figure 1 of IEC 60519-1 is a block diagram of a typical installation and can be used as the starting point of this task. The complementary Table 2 indicates the clauses and subclauses dealing with particular provisions or equipment. However, IEC 60519-1 is a complex standard and Table 2 can help identify the application options for a particular installation or equipment and gives reference to other relevant standards.

The primary responsibility of the **manufacturer** with respect to safety of **EH** or **EPM installations** or **equipment** is given in requirement 6.1.1. Subclause 4.4 provides assistance and introduces helpful concepts. Some of the concepts given as well as the information provided on exposure limits in Annex B, Annex C and Annex D do exceed the core responsibility of a **manufacturer** in view of 6.1.1. These aspects can become part of his work as is argued in the Introduction.

Annex H
(informative)

Connection with ISO 13577 series

The ISO 13577 series of standards developed by ISO/TC 244 (Industrial furnaces and associated processing equipment) addresses the safety of industrial furnaces and of associated processing equipment. These standards cover thermal processing equipment (TPE) that is using different kinds of fuels and electric energy. The scope of that series and the IEC 60519 series overlap in parts, therefore reciprocal references are used, when practicable.

Both ISO 13577-1 and this standard are product safety publications and they cover all safety aspects of one or more products within the scope of a single product TC. Both standards reference the other where appropriate and in an unambiguous way. This is detailed in Clause 4 of this standard for the approach where this standard is used as the primary document.

In the case a **manufacturer** uses ISO 13577-1 as basic standard (type-C standard with respect to ISO 12100), he will be referred to IEC 60519-1 for requirements concerning electrical safety, **electroheating**, direct or indirect contact to **hazardous-live parts** and effects of electrical overload. It can then be possible to make use only of Clauses 7 and 8 as well as parts of Clauses 13 and 14 including the related annexes of this standard.

Bibliography

IEC 60050 (all parts), *International Electrotechnical Vocabulary* (available at http://www.electropedia.org)

IEC 60079 (all parts), *Explosive atmospheres*

IEC 60204 (all parts), *Safety of machinery – Electrical equipment of machines*

IEC 60335 (all parts), *Household and similar electrical appliances – Safety*

IEC TS 60479-1, *Effects of current on human beings and livestock – Part 1: General aspects*

IEC TS 60479-2, *Effects of current on human beings and livestock – Part 2: Special aspects*

IEC TR 60479-5, *Effects of current on human beings and livestock – Part 5: Touch voltage threshold values for physiological effects*

IEC 60601 (all parts), *Medical electrical equipment*

IEC 60974 (all parts), *Arc welding equipment*

IEC TS 61000-1-2, *Electromagnetic compatibility (EMC) – Part 1-2: General – Methodology for the achievement of functional safety of electrical and electronic systems including equipment with regard to electromagnetic phenomena*

IEC TR 61000-3-7, *Electromagnetic compatibility (EMC) – Part 3-7: Limits – Assessment of emission limits for the connection of fluctuating installations to MV, HV and EHV power systems*

IEC 61140:2001, *Protection against electric shock – Common aspects for installation and equipment*
IEC 61140:2001/AMD1:2004

IEC TS 61201:2007, *Use of conventional touch voltage limits – Application guide*

IEC 61439 (all parts), *Low-voltage switchgear and controlgear assemblies*

IEC 62226 (all parts), *Exposure to electric or magnetic fields in the low and intermediate frequency range – Methods for calculating the current density and internal electric field induced in the human body*

IEC 62271 (all parts), *High-voltage switchgear and controlgear*

IEC 62311, *Assessment of electronic and electrical equipment related to human exposure restrictions for electromagnetic fields (0 Hz – 300 GHz)*

IEC Guide 117, *Electrotechnical equipment – Temperatures of touchable hot surfaces*

ISO 1999:2013, *Acoustics – Estimation of noise-induced hearing loss*

ISO 2631-1:1997, *Mechanical vibration and shock – Evaluation of human exposure to whole-body vibration – Part 1: General requirements*

ISO 5349-1:2001, *Mechanical vibration – Measurement and evaluation of human exposure to hand-transmitted vibration – Part 1: General requirements*

ISO 7010, *Graphical symbols – Safety colours and safety signs – Registered safety signs*

ISO 13577-4, *Industrial furnace and associated processing equipment – Safety – Part 4: Protective systems*

ISO 15265:2004, *Ergonomics of the thermal environment – Risk assessment strategy for the prevention of stress or discomfort in thermal working conditions*

EN 50413, *Basic standard on measurement and calculation procedures for human exposure to electric, magnetic and electromagnetic fields (0 Hz – 300 GHz)*

EN 50445:2008, *Product family standard to demonstrate compliance of equipment for resistance welding, arc welding and allied processes with the basic restrictions related to human exposure to electromagnetic fields (0 Hz – 300 GHz)*

IEEE C95.1:2005, *IEEE standard for safety levels with respect to human exposure to radio frequency electromagnetic fields, 3 kHz to 300 GHz*

IEEE C95.6:2002, *IEEE standard for safety levels with respect to human exposure to radio frequency electromagnetic fields, 0–3 kHz*

Council Directive 96/29/EURATOM of 13 May 1996 laying down basic safety standards for the protection of the health of workers and the general public against the dangers arising from ionizing radiation - http://ec.europa.eu/energy/nuclear/radioprotection/doc/legislation/9629_en.pdf

Directive 2002/44/EC of the European parliament and of the council of 25 June 2002 on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (vibration) - http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:02002L0044-20081211&from=EN

Directive 2003/10/EC of the European parliament and of the council of 6 February 2003 on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (noise) - http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2003:042:0038:0044:EN:PDF

US Department of Labour, Occupational Safety and Health Administration (OSHA), 29 CFR 1910.1096, *Occupational Safety and Health Standards – Toxic and Hazardous Substances – Ionizing radiation* http://www.gpo.gov/fdsys/search/pagedetails.action?st=29+CFR+1910.1096&granuleId=CFR-2011-title29-vol6-sec1910-1096&packageId=CFR-2011-title29-vol6

ICNIRP (International Commission on Non-Ionizing Radiation Protection) *Guidelines for limiting exposure to time-varying electric, magnetic and electromagnetic fields (up to 300 GHz)*. health physics 74 (4): 494-522; 1998 (available at http://www.icnirp.org/en/publications/index.html)

ICNIRP (International Commission on Non-Ionizing Radiation Protection): *Revision of guidelines on limits of exposure to LASER radiation of wavelengths between 400 nm and 1.4 μm* – Health Physics 79 (4): 431-440; 2000 (available at http://www.icnirp.org/en/publications/index.html)

ICNIRP (International Commission on Non-Ionizing Radiation Protection): *ICNIRP Statement on far Infrared Radiation Exposure.* Health Physics 91 (6), 630-645, (2006) (available at http://www.icnirp.org/en/publications/index.html)

ICNIRP (International Commission on Non-Ionizing Radiation Protection): *Guidelines on limits of exposure to static magnetic fields.* Health Physics 96 (4): 504-514; 2009 (available at http://www.icnirp.org/en/publications/index.html)

ICNIRP (International Commission on Non-Ionizing Radiation Protection): *Guidelines for limiting exposure to time-varying electric and magnetic fields (1 Hz – 100 kHz).* Health Physics 99 (6): 818-836; 2010 (available at http://www.icnirp.org/en/publications/index.html)

ICNIRP (International Commission on Non-Ionizing Radiation Protection): *ICNIRP guidelines on limits of exposure to incoherent visible and infrared radiation.* Health Physics 105 (1), 74-91 (2013)

H.E. von Gierke, C.W. Nixon: *Effects of Intense Intrasound on Man,* in W. Tempest [ed.]: *Infrasound and Low Frequency Vibration*. Academic Press, New York: 1976, pages 115-150

[Blank page]

standard@evs.ee
www.evs.ee

EESTI STANDARDIKESKUS
ESTONIAN CENTRE FOR STANDARDISATION