BS ISO 4529:2023

BSI Standards Publication

Industrial furnaces and associated processing equipment — Secondary steelmaking — Machinery and equipment for treatment of liquid steel

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National foreword

This British Standard is the UK implementation of ISO 4529:2023. It supersedes BS EN 14677:2008, which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee RHE/13, Liquid fuel firing.

A list of organizations represented on this committee can be obtained on request to its committee manager.

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Industrial furnaces and associated processing equipment — Secondary steelmaking — Machinery and equipment for treatment of liquid steel

Fours industriels et équipements associés — Sidérurgie secondaire — Machines et équipements pour le traitement de l'acier liquide

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 244, *Industrial furnaces and associated processing equipment*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

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Introduction

This document is a type-C standard as stated in ISO 12100.

This document is of relevance, in particular, for the following stakeholder groups representing the market players with regard to machinery safety:

— machine manufacturers (small, medium and large enterprises);

— health and safety bodies (regulators, accident prevention organisations, market surveillance etc.).

Others can be affected by the level of machinery safety achieved with the means of the document by the above-mentioned stakeholder groups:

— machine users/employers (small, medium and large enterprises);

— machine users/employees (e.g. trade unions, organizations for people with special needs);

— service providers, e.g. for maintenance (small, medium and large enterprises);

— consumers (in case of machinery intended for use by consumers).

The above-mentioned stakeholder groups have been given the possibility to participate at the drafting process of this document.

The machinery concerned and the extent to which hazards, hazardous situations or hazardous events are covered are indicated in the Scope of this document.

When requirements of this type-C standard are different from those which are stated in type-A or type-B standards, the requirements of this type-C standard take precedence over the requirements of the other standards for machines that have been designed and built according to the requirements of this type-C standard.

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Industrial furnaces and associated processing equipment — Secondary steelmaking — Machinery and equipment for treatment of liquid steel

1 Scope

This document:

— specifies the general safety requirements for secondary steelmaking machinery and equipment (SSME) as defined in 3.1 to treat liquid steel;

— deals with all significant hazards, hazardous situations and events pertinent to SSME, when used as intended and under conditions foreseen by the manufacturer, but also includes foreseeable misuse, faults and malfunctions;

— specifies the requirements to ensure the safety of persons which are to be met during the design, pre-assembly, transport, sites assembly, commissioning, operation, maintenance, decommissioning and dismantling/ disassembling of the equipment;

— assumes that SSMEs are operated and maintained by adequately trained and competent personnel. Manual intervention for setting, adjustment and maintenance is accepted as part of the normal use of the equipment.

This document applies to SSME involved in the treatment process of liquid steel under vacuum or atmospheric pressure and covers:

— LF, ladle furnace,

— VD, vacuum degassing,

— VOD, vacuum oxygen decarburization,

— RH (OB), Ruhrstahl Heraeus (oxygen blowing),

— process related interfaces/interactions (e.g. according to design, controls) to:

  a) process media,

  b) primary and secondary gas cleaning plant,

  c) material handling systems,

  d) transfer cars for steel ladle, and

  e) crane and ladle.

NOTE 1 Due to the variety of secondary metallurgical processes, there are other variants (e.g. VODC – vacuum oxygen decarburization converter, CAS, CAS - OB) in addition to the main processes discussed in this document. Most countries require that applicable safety requirements, specific to this equipment be implemented.

This document does not cover safety requirements for the following equipment:

— cranes;

— transfer cars, e.g. ladle transfer cars, tank cars, maintenance cars;

— fork lift trucks or other transporting equipment;

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— ladles;

— equipment for relining and preheating in the relining area;

— burners according to ISO 13577-2 (the burner lances for RH vessels are covered by ISO 13577-2 except for maximum main burner ignition time, see 5.2.26.2);

— cleaning and treatment of dust and fume exhaust systems;

— process media (e.g. air separation, boiler house, steam generation system);

— material handling systems.

NOTE 2 Significant hazards and hazardous situations due to transporting/positioning of heavy components, e.g. by cranes (e.g. ladles, vessels, covers) are considered in this document (see 5.2.3).

This document is not applicable to SSMEs and associated equipment manufactured before the date of its publication.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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

ISO 3864-3, *Graphical symbols — Safety colours and safety signs — Part 3: Design principles for graphical symbols for use in safety signs*

ISO 4413, *Hydraulic fluid power — General rules and safety requirements for systems and their components*

ISO 4414, *Pneumatic fluid power — General rules and safety requirements for systems and their components*

ISO 4871:1996, *Acoustics — Declaration and verification of noise emission values of machinery and equipment*

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

ISO 7731, *Ergonomics — Danger signals for public and work areas — Auditory danger signals*

ISO 8995-1, *Lighting of work places — Part 1: Indoor*

ISO 11064-1, *Ergonomic design of control centres — Part 1: Principles for the design of control centres*

ISO 11202, *Acoustics — Noise emitted by machinery and equipment — Determination of emission sound pressure levels at a work station and at other specified positions applying approximate environmental corrections*

ISO 11428, *Ergonomics — Visual danger signals — General requirements, design and testing*

ISO 11429, *Ergonomics — System of auditory and visual danger and information signals*

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

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

ISO 13849-1, *Safety of machinery — Safety-related parts of control systems — Part 1: General principles for design*

ISO 13850:2015, *Safety of machinery — Emergency stop function— Principles for design*

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ISO 13854, *Safety of machinery — Minimum gaps to avoid crushing 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 14122-1, *Safety of machinery — Permanent means of access to machinery — Part 1: Choice of fixed means and general requirements of access*

ISO 14122-2, *Safety of machinery — Permanent means of access to machinery — Part 2: Working platforms and walkways*

ISO 14122-3, *Safety of machinery — Permanent means of access to machinery — Part 3: Stairs, stepladders and guard-rails*

ISO 14122-4, *Safety of machinery — Permanent means of access to machinery — Part 4: Fixed ladders*

ISO 16069, *Graphical symbols — Safety signs — Safety way guidance systems (SWGS)*

ISO 20816-1, *Mechanical vibration — Measurement and evaluation of machine vibration — Part 1: General guidelines*

ISO 80079-36, *Explosive atmospheres — Part 36: Non-electrical equipment for explosive atmospheres — Basic method and requirements*

EN 811, *Safety of machinery — Safety distances to prevent danger zones being reached by the lower limbs*

EN 1088, *Safety of machinery — Interlocking devices associated with guards - Principles for design and selection*

EN 13463-1:2001, *Non-electrical equipment for potentially explosive atmospheres — Part 1: Basic method and requirements*

IEC 60079(all parts), *Explosive atmospheres*

IEC 60204-1:2016, *Safety of machinery — Electrical equipment of machines — Part 1: General requirements*

IEC 60519-4:2021, *Safety in electroheat installations — Part 4: Particular requirements for arc furnace installations*

IEC 60730-2-5, *Automatic electrical controls — Part 2-5: Particular requirements for automatic electrical burner control systems*

IEC 61310-1, *Safety of machinery — Indication, marking and actuation — Part 1: Requirements for visual, acoustic and tactile signals*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 12100:2010 and the following apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

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3.1
secondary steelmaking machinery and equipment
SSME
machinery and equipment for treatment of liquid steel under vacuum or atmospheric pressure

3.2
material addition equipment
equipment for storage, conveying and adding material into liquid steel

3.3
blowing equipment
equipment for blowing gas and/or powder on top or into liquid steel

EXAMPLE Chemical heating and desulphurization.

3.4
burner equipment
burner for atmospheric operation inside RH vessel

EXAMPLE To pre-heat refractory or maintain refractory temperature.

3.5
positioning equipment
equipment for positioning of components

3.6
stirring equipment
equipment for homogenisation of liquid steel

3.7
vacuum pump
equipment to reduce pressure with respect to atmospheric conditions

3.8
vacuum vessel equipment
equipment to enable a treatment of liquid steel under vacuum conditions

3.9
media handling equipment
equipment to store, supply and return process media

3.10
electrical heating equipment
electrical equipment to provide thermal energy to liquid steel

3.11
temperature measurement and sampling equipment
manual or automatic equipment for temperature measurement and taking samples of liquid steel and slag

3.12
high-voltage switch gear
furnace breaker
device to connect and disconnect the ladle furnace to/from the electrical high voltage supply

3.13
safety layout
graphical description of plant-related equipment regarding safety

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3.14
hazard zone
danger zone
any space within and/or around machinery in which a person can be exposed to a hazard

[SOURCE: ISO 12100:2010, 3.11]

3.15
take-over-point
point where the *secondary steelmaking machinery and equipment (SSME)* (3.1) is connected to incoming/ outgoing material (e.g. liquid steel), process media, electricity (e.g. power supply and communication like input/output parameters)

Note 1 to entry: For example, ladle take-over-point: point where overhead cranes or other transport systems deposit or remove ladles.

3.16
safeguard
guard or protective device

[SOURCE: ISO 12100:2010, 3.26]

3.17
competent personnel
person who can demonstrate a combination of knowledge and skills to effectively, efficiently, and safely carry out specified tasks

Note 1 to entry: Competence is usually specified by activity [e.g. design, selection of equipment, installation, operation, *maintenance* (3.20), testing, *inspection* (3.20.1), *repair* (3.20.3)].

3.18
authorized personnel
competent personnel (3.17) who has the permission to perform a specific task under defined requirements on a specific equipment

3.19
trained personnel
person with the knowledge of systems, background, experience and ability to operate and/or maintain the equipment in the intended use and proper operation of the machinery/ equipment

Note 1 to entry: Background experiences are intended to be specific for the type of equipment.

3.20
maintenance
activities carried out outside the production process

3.20.1
inspection
basic checks (e.g, visual) of equipment

3.20.2
service
periodic exchange of lances, cleaning (e.g. lance), lubrication, adjustment of limit switches

3.20.3
repair
physical action taken to restore the intended function of faulty equipment

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3.20.4
reconditioning
measure to return to the nominal condition

Note 1 to entry: Foreseeable measures can be to replace worn parts or parts having expired the foreseen lifetime (could require dismantling/disassembling). These parts will normally meet manufacturers' original specification.

3.20.5
functional test
checking the functionality of the exchanged or repaired parts

Note 1 to entry: It can be required to carry out adjustment work, e.g. test runs, verifying safety functions.

3.21
alloying material
ferrous and/or non-ferrous metallic additions

3.22
chimney effect
suction power caused by the thermal updraft of hot gases expanding

3.23
control room
main room in which the control desk and monitoring facilities for a *secondary steelmaking machinery and equipment (SSME)* (3.1) are located

Note 1 to entry: It is a location where operating personnel is required permanently during the production process.

3.24
local control stand
control units usually situated adjacent to the equipment

Note 1 to entry: It is a location where operating personnel is required temporarily during the production process.

3.25
portable control box
mobile control units connected to the control system, wired or wireless

Note 1 to entry: For example, to position equipment more precisely.

3.26
ignition source
source of energy that initiates combustion

3.27
manual control
control device which is manually operated

3.27.1
hold-to-run control
control device which initiates and maintains machine functions only as long as the *manual control* (3.27) (actuator) is actuated

Note 1 to entry: Release of the button/device stops the function (e.g. movement) immediately.

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3.28
operating mode
state of the control system allowing to operate the *secondary steelmaking machinery and equipment (SSME)* (3.1) under defined conditions

Note 1 to entry: Such conditions (modes) could include production, safe stop, enabling, adjustment, inspection.

Note 2 to entry: The safety level of the operating mode(s) is defined as result of the risk assessment.

3.29
slack rope and overload protection
device to detect slack rope and overload of winch systems

3.30
manufacturer
natural or legal person declared as responsible for compliance with the requirements of the design and/or manufacturing of machinery

Note 1 to entry: The process of design and construction of machinery may involve several individuals or companies, but one is declared as the manufacturer.

3.31
material handling system
equipment for storage, conveying and adding bulk material

4 Significant hazards and risk assessment

All the significant hazards, hazardous situations and events, as far as they are dealt with in this document, identified by risk assessment as significant for this type of machinery and which require action to eliminate or reduce the risk are listed in columns 1 and 2 of Table 1.

In addition, the manufacturer shall carry out a plant-related risk assessment, including interfaces to auxiliary equipment, according to ISO 12100:2010, Clause 4 to identify any other significant hazard of the machine/equipment. Significant hazards identified in this plant-related risk assessment but not dealt with in this document shall be reduced by applying the principles of ISO 12100.

5 Safety requirements

5.1 General

The manufacturer of SSMEs shall take into account that different life cycle phases have to be considered with regard to safety and the need for risk reduction. In general, the following life cycle phases are common for SSMEs (see Figure 1).

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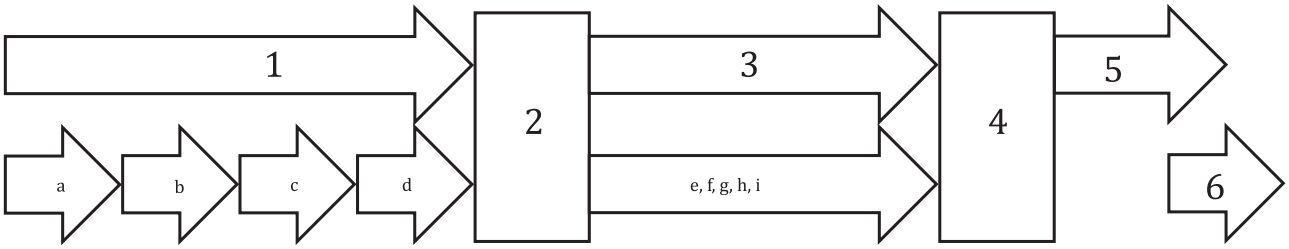

Key

1	design, manufacturing and installation by the manufacturer	c	On site assembly.
2	handover to and putting into service (first use for its intended purpose) by the operator	d	Testing and commissioning.
3	operation	e	Normal operation (production, intended use) including production changes and capacity changer.
4	putting out of service	f	Emergency and fault operation.
5	disassembly	g	Maintenance and repair.
6	disposal and recycling	h	Troubleshooting.
a	Design, manufacturing, pre-assembly.	i	Special operation modes (if applicable).
b	Transport/shipping to the construction site.		

Figure 1 — Schematic representation of the life phases of an SSME

5.2 General requirements for design and risk assessment

5.2.1 General

SSME plants conforming to this document shall comply with the safety requirements and/or measures set out in Clause 5 together with those set out in Annexes A and B for a typical installation, and the information for use as defined in Clause 7.

Special consideration shall be given to CO emission for vacuum treatment equipment due to process transients and/or equipment failure.

In general, risks and associated hazards are production- and plant-related. The variety of different plants (i.e. different combinations of equipment, different boundary conditions) could not be covered in all details in this document. To deal with this fact, an individual risk assessment of the SSME in question shall be carried out (see Clause 4) considering the safety requirements of this document.

The manufacturer shall include in the information for use all details required for a safe operating process under normal operating conditions. The manufacturer shall also describe the specific safety measures in case of special conditions, e.g. maintenance and adjustment work.

If in addition to the technical measures further measures for risk reduction by organizational precautions according to ISO 12100:2010, Clause 5 are necessary, the manufacturer shall include in the information for use details of these measures and the necessary information considering the residual risks.

Machinery shall comply with the safety requirements and/or protective/risk measures of this clause. In addition, the machine shall be designed according to the principles of ISO 12100:2010 for relevant but significant hazards which are not dealt with by this document.

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5.2.2 Design requirements

The manufacturer, in consultation with the user, should conduct a design layout review to ensure proper placement of the SSME. To ensure safe operation the following elements shall be included:

— operating procedures;

— accessibility;

— movement of parts of the equipment and material;

— position of emergency systems;

— maintenance and cleaning;

— prevention of hazardous conditions, caused by, e.g. emissions, heat, liquid steel;

— physical and ergonomic requirements;

— fire safety and evacuation.

Depending on the design of the SSME, the different operating modes shall be considered by the manufacturer. All these operating modes shall be assessed and considered in the risk assessment, except special operation modes if they are not foreseen by the manufacturer.

5.2.3 Structural assembly

The manufacturer shall undertake and record design calculations to show that the structural assembly (e.g. steel sections, auxiliaries) which forms part of the equipment is adequate to withstand the load under intended use.

5.2.4 Safety layout

A safety layout shall be prepared. The aim of the safety layout is to give information (normally by means of one or more drawings) about the physical position of safety related elements at the SSME.

It is recommended to involve the user of the equipment, e.g. regarding escape routes, fire extinguishing systems, etc.

If applicable, the following shall at least be illustrated:

— areas where the risk of injury due to contact with liquid metal or slag including spraying is given;

— emergency stop buttons;

— escape and access routes (if necessary, e.g. for large plants);

— areas influenced by low oxygen and/or harmful gases (e.g. CO or asphyxiating gases);

— visible/audible warning devices;

— safety related marking;

— safety signs;

— fixed guards (e.g. fences);

— moveable guards (e.g. safety doors);

— light barriers or safety scanners.

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The safety layout shall be part of the information for use, see 7.4.1.1.

NOTE 1 If an engineering partner provides just basic engineering or basic data, he/she will be able to provide only basic information for the final safety layout.

NOTE 2 A safety layout can be based on or built upon a digital twin of the system.

A safety layout shall be provided by the manufacturer together with the information for use.

5.2.5 Safety devices and protective measures

5.2.5.1 Safety devices

Safety devices and devices with safety function (e.g. limit switches, locking devices) shall be accessible for maintenance. These devices shall be protected against damage and the possibility of defeating or circumventing in a foreseeable manner (for further details, see ISO 14119 and ISO 13849-2:2012, D.1 and D.2).

All relevant energy isolating devices, either main or local, shall include facilities to apply one or more padlocks (see ISO 14118).

5.2.5.2 Guards

Guards used to prevent access to danger zones shall be selected as appropriate for the degree and frequency of access to be permitted, e.g. an enclosing guard or distance guard, fixed or movable with interlock. This selection shall be made according to ISO 14120. Interlock systems shall meet the requirements of ISO 14119 and ISO 13849-1 (see 5.2.13). The requirements of the guards shall conform to ISO 14120, ISO 13857 and ISO 13854.

As an exception to the requirements of ISO 14120, there is no necessity for attaching (e.g. by screws) guards or guarding (e.g. covers) which could be removed only by auxiliary devices (e.g. cranes) due to the heavy weight.

With regard to the safety distances the minimum height of distance guards shall be at least 1 400 mm.

NOTE ISO 13857 provides guidelines for establishing guard heights and safety distances to prevent hazard zones being reached by upper and lower limbs.

5.2.5.3 Guard-rails

Guard-rails are to be considered as means to deter or impede access to hazardous areas, i.e. a physical obstacle which only reduces the probability of access (but does not totally prevent it), offering an obstruction to free access (see ISO 12100).

Therefore, guard-rails are not permitted as the sole measure of safeguarding hazardous areas in case of significant risks (e.g. from moving machinery or processed product). Guard-rails may only be used for cases where the hazards of slips, trips and falls are involved.

Guard-rails can be used as a measure to prevent unintentional access of unauthorised personnel to zones where residual risks exist after more effective risk reduction measures have been used (e.g. zones where equipment with potentially dangerous movements can be operated only in manual mode by means of hold-to-run devices from operating stations with full overview of the driven elements, see 5.2.17). Such zones are described in Table 1.

Guard-rails shall conform to ISO 14122-3.

5.2.5.4 Emergency pit

An emergency pit with the minimum capacity of the entire charge (liquid steel, slag and additions) of the steel ladle shall be provided. It shall be ensured that this pit is kept clean, dry and free of snow/ice.

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5.2.6 Warning devices and safety labelling

5.2.6.1 Visual, acoustic, and tactile signals

The manufacturer shall consider during the risk assessment where warning signals are necessary.

Acoustic warning signals shall be designed and selected in accordance with ISO 7731.

Visual danger signals shall be designed and selected in accordance with ISO 11428.

The system of acoustic warning signals and visual danger information signals shall be in accordance with ISO 11429.

Visual, acoustic and tactile signals shall be designed and selected in accordance with IEC 61310-1.

The information for use shall contain the information on visual, acoustic and tactile signals (see 7.2)

5.2.6.2 Safety labelling

Safety labelling shall selected be in accordance with ISO 7010 and designed in accordance with ISO 3864-1 to ISO 3864-3.

Graphical symbols used on the equipment shall be selected in accordance with ISO 7000.

Safety way guidance systems (SWGS) shall be selected in accordance with ISO 16069.

The information for use shall contain information which safety labelling is used and what their meaning is (see 7.2).

5.2.7 Personal protective equipment (PPE)

The manufacturer shall give information in the information for use (see Clause 7) on the required type of personal protective equipment (PPE).

5.2.8 Loss of energy

In case of hazardous situations due to loss of energy (hydraulic, pneumatic, electric) all components shall go into or stay in a defined safe position and/or safe state.

In case of resupply of energy after interruption, any uncontrolled restart shall be avoided, see ISO 14118.

The control systems and devices shall meet the requirements of IEC 60204-1:2006, 7.5 and 9.4.3.2 as well as ISO 13849-1:2015, 5.2.8.

In case of loss of energy special instructions for actions to be taken shall be given in the information for use.

5.2.9 Operating stations for the SSME

5.2.9.1 General

Provide escape routes according 5.2.4.

The operating stations shall be designed so that frequently used controls are located in an ergonomic reach, in accordance with ISO 11064-1.

Visual displays shall be so arranged that they are unambiguous and free of reflections.

Good visibility, either direct or indirect, should be provided from the operator's position to the operating process.

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Control override from different control stands or devices shall be prevented (according IEC 60204-1:2016, 9.2.7.4).

5.2.9.2 SSME control room

The SSME control room shall be designed taking into consideration the ergonomic principles of ISO 11064-1.

If applicable, the SSME control room shall be

— equipped with automatically controlled air condition;

— thermal-insulated;

— sound-insulated;

— equipped with heat reflecting windows;

— equipped with special coloured glass areas to protect operators' eyes against radiation light;

— protected against external effects by, e.g. slag and steel splashes, where the risk is given.

5.2.9.3 Local control stand

A local control stand shall be in accordance with IEC 60204-1.

The local control stand (i.e. a temporary work place) shall be protected against radiated heat, external impact (e.g. by slag and steel splashes), dust and noise, if necessary.

5.2.10 Portable wired/wireless control box

A portable wireless control box shall be in accordance with IEC 60204-1:2016, 9.2.7.

A portable wired control box shall be treated as a local control stand when applying IEC 60204-1.

Where a direct view by the operator is required (e.g. because of moving equipment) and not possible from a fixed control stand, a portable control box shall be provided for use from an alternate safe location. The same result can be achieved by means of a fixed control stand in combination with a portable enable control.

Any interruption of the connection between the portable control box and the control system shall stop the movement/function immediately.

5.2.11 Hold-to-run control device and enabling button

5.2.11.1 Hold-to-run control device

A hold-to-run control device shall meet the requirements of IEC 60204-1. The operator using a hold-to-run control device shall have good visibility over the danger zone (see 5.2.12), e.g. by closed circuit television.

5.2.11.2 Enabling control device

An enabling button shall meet the requirements of IEC 60204-1. Release of an enabling button shall bring the movement to standstill. The performance level shall be corresponding to the related function.

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