INTERNATIONAL STANDARD

ISO 4529

First edition
2023-03

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

Reference number
ISO 4529:2023(E)

ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: www.iso.org

Published in Switzerland

Contents

Page

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.

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.

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;

— 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*

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/

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

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

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.

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

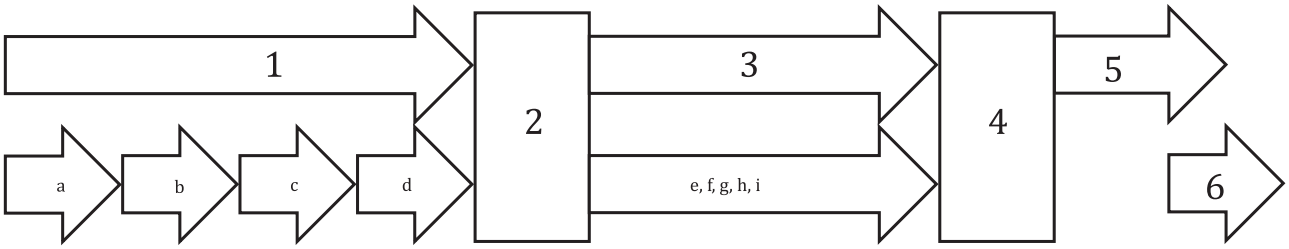
All the significant hazards, hazardous situations and events, as far as they are dealt with in this document, identified by risk assessment as significant for this type of machinery and which require action to eliminate or reduce the risk are listed in columns 1 and 2 of Table 1.

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).



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.

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.

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.

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.

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.

5.2.12 Access to and presence in danger zone

5.2.12.1 Guard-rails shall not be used as the sole measure for guarding hazardous areas except for slips, trips and falls. They may be used in conjunction with other means to exclude unauthorised persons from hazardous areas.

Unintentional access to danger zones (see also 5.2.12) shall not be possible; they shall be protected by physical barriers meeting the requirements of ISO 14120.

Some areas of the ground floor cannot be guarded, because authorized personnel needs free access to perform different operations.

In this area of access for authorized personnel there should be a full view over the danger zone (e.g. overview of the entire travel way). In case of semi/fully automatic movements, additional safety measures shall be applied (e.g. safety light barrier, safety laser scanner, safety bumper). Additional organisational measures are required (e.g. operating instructions, warning signs).

5.2.12.2 In order to allow authorized personnel safe access to and stay in areas protected by movable interlocked guards, adequate technical safety measures shall be applied as follows:

a) access conditions: all sources of energy causing a danger inside a danger zone shall be in a safe condition (e.g. movements and process media flows are stopped);

b) conditions for staying/working: hazardous movements inside a danger zone shall only be permitted with a hold-to-run control device and by using an enabling button and if necessary, at reduced speed;

c) conditions for restart: See 7.4.1.1.

5.2.12.3 Access to control desks, SSME control rooms, underground areas, inspection and service floors shall be in accordance with ISO 13857, ISO 14122-1, ISO 14122-2, ISO 14122-3 and ISO 14122-4.

5.2.12.4 Guard-rails shall be in accordance with 5.2.5.3.

5.2.12.5 Surfaces for walking or standing shall be so designed, that risks of slipping caused by scale, oil and/or lubricant are avoided or minimised.

5.2.12.6 The relevant category of safety systems for access to equipment shall be selected according to the specific risk assessment and shall consider the requirements of EN 1088 and ISO 13849-1.

5.2.12.7 Accessible rotating/moving parts like drive shafts, couplings, belts and chains, pulleys and sprockets, i.e. where the safety distances in ISO 13857 cannot be met, shall be guarded in accordance with ISO 14120. Rotating shafts should be marked so that it is visually evident when the shafts are in motion.

5.2.12.8 Safety signs shall be in accordance with 5.2.6.2.

5.2.12.9 Access to control desks, pulpits, underground areas, inspection and service floors shall be in accordance with EN 811 and ISO 14122-1, ISO 14122-2, ISO 14122-3 and ISO 14122-4. Where required, they shall be protected against heat radiation and designed to withstand moving material, tools and jets of high-pressure fluids or gases.

5.2.12.10 The manufacturer shall specify in the information for use the conditions under which access to the danger zones shall be permitted (7.4.1.1), including details about safe systems of working, as well as adoption of precautions like PPE, use of handling tools, etc.

5.2.13 Safety related control system

Safety related controls shall be selected in accordance with the risk assessment and as described in the ISO 13849 series. A minimum requirement is defined in B.2. For significant hazards requiring a safety related control system, the quality of such a system is provided as a combination of PLr and category (see Table 1). In cases where the supporting data for documentary proof of category from the manufacturer of such a component is not available, the fulfilment of the PLr is sufficient. For electro-mechanical components, for example, contactor, relay, etc., category 3 is mandatory where PLr = d is required.

5.2.14 Electrical power supply

The electrical power supply, comprising of the high-voltage switch gear, reactor (if applicable), furnace transformer, interconnecting bus bar systems and cables, shall meet the requirements as defined in IEC 60204-1.

5.2.15 Electrical low voltage supply

The electrical low voltage supply, comprising of low voltage switch gear, control system and low voltage cables, shall meet the requirements of IEC 60204-1.

5.2.16 Fluid systems carrying or containing fluids

Fluid systems exposed to process hazards, for example, high temperatures or impacts, shall be adequately protected if the damaged fluid systems can cause personal injuries.

Where the risk of fire is given emergency shut-off devices shall be provided. Emergency shut-off devices for the fluid system shall be:

— installed in a safe area outside the danger zone,

— easily accessible, and

— the location shall be clearly indicated.

The manufacturer of the SSME using fluid systems carrying or containing fluids which are likely to solidify and/or have high or low viscosity shall provide protection for all fluid components against temperature influence and fire.

Where the risk of spilling of fluids in case of leakage is given at permanent workplaces, coverings of flanges, fittings and hoses shall be provided.

Fluids which has to be discharged in special sumps shall be specified.

To avoid the risk of faulty installation and use, connections to media supplies (e.g. fittings, valves, flanges) shall be clearly identified by design and/or marking. Instructions shall be included in the information for use (see 7.2).

For ladle stirring with gases automatic coupling system should be used as far as technically feasible.

Instructions shall be included in the information for use for regular inspections of tanks, hotwells, pipes, hoses carrying harmful fluids (e.g. CO, O_2). This includes also inspection of rooms, pits, containers, vessels, etc.

5.2.16.1 Hydraulic, pneumatic, gas and lubrication systems

Hydraulic, pneumatic, gas and lubrication systems shall be designed to reduce risks from toxic effects, fire, explosion and noise (e.g. covering and routing of pipes).

The systems shall meet the safety requirements as defined in ISO 4413 or ISO 4414 and considering the requirements specified in Table 1.

In case of dangerous hydraulic oil leakage an indication to the operator shall be provided and the flow shall be stopped automatically.

Cylinders supporting equipment containing liquid steel shall be provided with hose rupture protection devices at the cylinders and the fluid flow shall be stopped automatically in case of hose rupture.

In case of leakage from hydraulic systems and LF-Transformer, respective pits or collectors shall be provided.

5.2.16.2 Cooling equipment

The design of any water-cooled equipment shall reduce the risks from reaction with liquid steel (e.g. water-cooled panels, lances, etc.).

In this context, a water leakage into the vacuum vessel/tank may not be necessarily dangerous in case it can be ruled out definitely that water can get below the liquid steel melt surface. This might be the case for small leakages in a greater distance to the liquid steel surface, because the water will evaporate as long as vacuum is maintained.

Because it is not possible to define a fixed flow rate of a water leakage as "dangerous", for example, by a physical calculation, water–cooled equipment in secondary steelmaking is classified in the following three groups.

a) Equipment parts (cooling of lances, e.g. for oxygen blowing; cooling of additional panels, e.g. splash shields) which have a high risk of leakages due to process conditions and that are quite close to the liquid steel surface. These parts shall be equipped with a differential flow monitoring including an automatic shut off for the water cooling (switching off lift gas / stirring gas, stop cooling water flow, switching off the blowing process and automatic initiation of treatment abort).

b) Equipment parts (cooling of, e.g. tank cover, ladle cover), which are located in a greater distance to the liquid steel and have a high cooling water consumption, shall be equipped with a differential flow monitoring, too. While an automatic shut off for the water cooling is recommended for bigger leakages, it is subject to an individual safety analysis for smaller leaks.

c) Equipment parts (cooling of cameras or sensors; cooling of integrated parts, e.g. slide gates, flaps or operation doors), which are located in a greater distance to the liquid steel and have a low cooling water consumption (≤5 m^3/h) do not need to be equipped with a differential flow monitoring including an automatic shut off for the water cooling. But at least flow, temperature and pressure measurements and monitoring are mandatory.

5.2.17 Harmful areas

For areas with the risk of ignition, toxic effects, gas/dust accumulation or asphyxiation, specific action shall be taken (e.g. ventilation, removal of dust, fixed, mobile gas monitoring devices or waste gas burner). The requirements of ISO 14123-1 and ISO 14123-2 shall be considered.

Special consideration shall be taken where oxygen is provided for operation (e.g. VOD, RH-processes, see Annex C).

For areas with the risk of unexpected flame propagation or splashing of molten material, specific instruction shall be provided.

For areas where the risk of artificial optical radiation (e.g. infrared, laser) exists, specific information shall be given in the information for use, based on an individual risk assessment according to ISO 12100:2010.

Specific instruction shall be provided in case of access to lower floor levels, e.g. pit, tank, closed rooms.

Based on the risk assessment and the specific layout of the SSME, fixed and personal detection equipment shall be used to detect hazards caused, for example, by lack of oxygen, and to warn the personnel working with the SSME.

Personnel should wear mobile gas and oxygen level detectors as appropriate.

NOTE Some areas cannot be covered by fixed detectors.

5.2.18 Exchange of lances

For exchange of lances (e.g. media supplies, clamping, transportation) safe working conditions (e.g. zone of reach, and, if applicable, PPE) shall be provided and described in the information for use. In case of automatic exchange of lances access to danger zones shall be guarded (see 5.2.12).

5.2.19 Surface temperatures, heat radiation

Surfaces which are hot in operation and where the risk to be touched is present, shall be designed, positioned or provided with, e.g. thermal guards, so that the burn threshold is not exceeded concerning the contact time and material as specified in ISO 13732-1.

Where a risk of injury by heat radiation is present during operation, protection walls/shields with isolating material shall be provided.

5.2.20 Temperature measurement and sampling equipment

The risk of burns is given during manual temperature measurement and operation. Therefore, an automatic system should be installed. Manual temperature measurement and sampling shall only be used if an automatic system cannot be installed because of technical restrictions.

5.2.21 Electrode clamp

The electrodes shall be clamped mechanically by spring force. Unintentional opening of the electrode clamp shall be avoided. To activate the release of the clamp, the high-voltage switch gear (furnace breaker) shall be switched-off and interlocked by a key switch. To avoid unintentional opening, this key shall be used to operate the clamp release and to operate the high-voltage switch gear (furnace breaker). For access to the danger zone see 5.2.12.

5.2.22 Electrode exchange

Due to consumption of electrodes these have to be exchanged periodically. Therefore, an electrode nippling stand and storage stand has to be foreseen. Nippling is allowed manually or by use of pneumatic or hydraulic tools.

Suitable devices for transportation shall be used.

5.2.23 Grounding of mechanical ladle furnace parts

To prevent potential differences between mechanical ladle furnace parts, all of these parts shall be connected to each other and grounded according to IEC 60519-4:2021, 7.6.

5.2.24 Emergency stop

Emergency stops shall be:

a) easily identifiable according to ISO 13850;

b) located at control desk(s) and other necessary locations identified in the risk assessment;

c) marked to indicate the area of the plant affected by their operation(s) (see ISO 13850:2015, 4.1.1.1);

d) readily accessible (see ISO 13850) and

e) provided with means of locking in their pushed position.

When an emergency stop device has been operated, a restart:

1) shall only be possible from safe positions outside the protected hazardous area and with a clear view of the danger zone; and

2) shall only be possible after release of the emergency stop button and after confirmation, that the dangerous situation is clarified.

5.2.25 Fire protection

The necessity for installing a fire protection system at the SSME (e.g. SSME control room, hydraulic/electric rooms) shall be reviewed considering the process conditions (e.g. use of lubricants); the result shall be communicated to the user. For detailed information, see ISO 19353.

Hydraulic systems exposed to liquid steel shall be provided with separate systems for fire protection (e.g. covers, small tanks, fire-resistant fluids) or other means shall be provided to reduce the risk of fire.

National regulations and the requirements of insurance companies can apply.

5.2.26 Special requirements for explosion prevention and protection

5.2.26.1 General

Where combustible dusts or flammable gases (heating gas, CO, H_2) necessary for or produced by the SSME may create potentially explosive atmospheres, the following specific requirements shall apply.

Equipment shall be designed and constructed according to good engineering practice and if the hazard assessment shows that the explosive atmosphere can occur in normal operation, the equipment shall be protected in accordance with the IEC 60079 series and ISO 80079–36.

All equipment subject to ignition, and all parts of it shall be subjected to a formal documented hazard analysis. This analysis that identifies the potential sources of ignition and the measures shall be applied to prevent ignition as detailed in ISO 80079-36.

Protective measures/types of protection shall be considered and/or applied in the following order:

— ensure that ignition sources cannot arise;

— ensure that ignition sources cannot become effective;

— prevent explosion atmosphere reaching the ignition source;

— prevent flame propagation, e.g. flame arrestor in accordance with ISO 16852.

The risk of ignition of potentially explosive atmospheres of gas, vapour, mist and dust shall be prevented by suitable electrical and non-electrical equipment.

Ducts, hoses and pipes used for exhausting flammable dusts, gases, vapours or mist shall be conductive and electrostatically grounded (resistance < 10^6 Ω). Respective reference shall be made in the instruction handbook.

5.2.26.2 Burners, multifunction lances

For wall temperature in the RH-vessel ≤ 750 °C the main burner is started by a pilot burner equipped with a dedicated flame safeguard.

Direct ignition of main burner requires a separate safety analysis.

For high-temperature operation (≥750 °C) the temperature shall be detected redundantly in the refractory of the RH-vessel.

For ignition gas rate and ignition time shall be limited.

The safety-times according to ISO 13577-2 can be increased due to the length of the heating gas line to the lance tip in order to ensure the ignition and to detect the flame. The flame safeguard shall be type tested according IEC 60730–2-5.

The maximum gas rate and corresponding safety-time shall be plant-related determined. A safety calculation shall verify that the maximum allowable energy density (energy per volume) is not exceeded.

The pre-purge time shall be such as to ensure that the concentration of any combustible products in any part of the combustion chamber is below 25 % of the lower flammability limit (LFL) of the fuel gas.

If a draught is established from the RH gas cooler to the snorkels this can be calculated with the combustion chamber/connected spaces defined as the RH-vessel including hot-offtake.

In general, five (5) complete volume changes of the combustion chamber/connected spaces will be sufficient.

When the combustion chamber is proved to be at a temperature above 750 °C pre-purge may be omitted.

5.2.27 Ergonomics

Ergonomic design principles shall be considered, see ISO 14738. Particular attention shall be paid to the following:

a) dedicated lifting aids or anchoring points for common lifting devices shall be provided whenever frequent lifting or heavy tooling of machines is required;

b) eyebolts or similar aids shall be fitted to heavy components to lift them; they shall also be fitted with handles, hand-holds or grips with a slip-resistant (e.g. knurled) surface;

c) work areas where manual handling of components have to be carried out frequently shall be designed so that they are free of obstructions and that the operator is not hindered in her/his movements;

d) the ideal placement for hand wheels, levers, etc. to minimise physical effort is between 700 mm and 1 600 mm above the worker's standing level;

e) for regular maintenance: spatial arrangement of electric junctions, electrical connections and devices shall be in accordance with IEC 60204-1. For fluid connections/junctions (e.g. valves) the location should be at best between 400 mm and 1 800 mm above operators standing level;

f) slip-resistant surfaces shall be as defined in 5.2.5.1;

g) vibration protection shall be as defined in 5.2.28;

h) heat protection shall be as defined in 5.2.16;

i) lighting of the permanent working areas shall be in accordance with ISO 8995-1;

j) access to components requiring a regular maintenance shall be in accordance to 5.2.12.

NOTE There are areas and activities in which the ergonomic principles can be implemented only partially (e.g. change of ladle roof).

5.2.28 Vibrations

Mechanical vibrations shall be considered at the design stage for permanent working places, e.g. control rooms.

Harmful hand-arm vibration at SSMEs cannot be expected.

Where the risk of whole-body vibration is given, measures according to ISO 20816-1 shall be taken.

5.2.29 Noise reduction as a safety requirement

5.2.29.1 General

Noise emitted by a plant is a significant hazard.

Noise can arise from several sources in a plant. Means shall be applied to reduce the noise levels by design, by protective measures and by information (protection of operator).

Noise emission measurement requirements shall be in accordance with Annex A.

NOTE ISO/TR 11688-1 provides additional examples for noise reduction measures.

5.3 List of significant hazards, hazardous situations, safety requirements and/or protective/risk reduction measures

Table 1 is developed to allow the designer and manufacturer of the equipment to apply a logical approach for checking the design against the list of significant hazards with respect to SSME.

Table 1 is structured as follows.

Column 1 identifies the significant hazards.

Column 2 describes the hazardous situations.

Column 3 specifies the safety requirements and/or measures to avoid or minimise the hazards and hazardous situations; they are shown as combined measures or as options.

Column 4 makes reference to the relevant clauses or standards defining the measures. All references shown are applicable to each of the measures except where this is otherwise indicated.

When implementing safety requirements and/or measures it should be considered that different hazards may appear at the same time.

NOTE 5.3 contains special safety requirements or measures for explosion prevention and protection and for noise reduction.

Column 5 identifies the verification methods to be used to demonstrate conformity; the abbreviations V, T, M and D are defined as follows:

V: visual inspection verifies the required features of the components;

T: a test/check is required to verify that the features provided perform their function in such a way that the requirement is met;

M: measurements are needed to verify that requirements are met to the specified limits;

D: drawings and/or calculations verify that the design characteristics of the components provided meet the requirements.

Table 1 — List of significant hazards

Significant hazard	Hazardous situation	Safety requirements and/or protective/risk reduction measures	Reference	Verification
5.3.1 General				
1 Fire	1.1 Contact of liquid steel with hydraulic fluids.	1.1.1 Measures to avoid hydraulic system exposure to liquid steel.	5.2.25	D, V
	1.2 High thermal radiation.	1.2.1 Hydraulic system exposed to high thermal radiation shall be protected.	5.2.19	D, V, T
2 Explosion	2.1 Reaction between water and molten steel or slag.	2.1.1 Operating/maintenance instruction: avoid presence of water in pits underneath ladle.	7.4.1	
3 Noise	3.1 Exposure to noise.	3.1.1 Noise reduction at control room.	5.2.29 Annex A	D, T, M
4 Vibration	4.1 Exposure to hand-arm and whole-body vibration.	4.1.1 Vibration reduction at control room.	5.2.28	D, T, M
5.3.2 Material addition equipment				
1 Crushing, drawing in	1.1 Risk of crushing in the following areas:			
	1.2 Conveyors.	1.2.1 Provide measures according C-type-standard, e.g. enclosing guard, pull cord emergency switch.	ISO 1819, ISO 7149	D, V, T
	1.3 Swivelling chutes and/or travelling conveyor belts.	1.3.1 Full overview over the danger zone, e.g. direct or indirect.	5.2.9	V, D
		1.3.2 Provide guards.	5.2.5.2	D, V, T
		1.3.3 Operating/maintenance instructions: definition of hazardous areas, e.g. caused by swivelling of the conveyor.	7.4.1	V
2 Cutting, severing or entanglement, stabbing or puncture	2.1 Feeding wire into the ladle: — coil storage; — wire feeder; — wire guidance.	2.1.1 Provide guards.	5.2.5.2 5.2.24	D, V
		2.1.2 Provide warning signs.	5.2.6	D, V
		2.1.3 Operating/maintenance instructions: PPE, information about residual risk in case of access.	5.2.7 5.2.11 7.4.1	V

Table 1 *(continued)*

Significant hazard	Hazardous situation	Safety requirements and/or protective/risk reduction measures	Reference	Verification
3 Drawing in	3.1 Movement of traversing or lifting devices (e.g. chain-driven), such as: — lance adjusting devices; — roof lifting and traversing devices; — torch and burner equipment; — rotary operating mechanisms.	3.1.1 Provide fixed guards.	5.2.5.2	V, D
		3.1.2 For maintenance purposes, provide local control device.	5.2.9.3 5.2.10	V, D, T
		3.1.3 Operating/maintenance instructions: definition of hazardous areas, e.g. caused by rotary operating mechanism.	7.4.1	V
4 Ejection or dropping of parts	4.1 Running conveyors.	4.1.1 Material guide plates, and/or enclosures for discharging hoppers.	ISO 1819, ISO 7149	V, D
		4.1.2 If necessary, protection against falling material or parts.		
	4.2 Belt leaving its intended path.	4.2.1 Indication and drive-stop in case of belt going askew.	5.2.13	V, D, T
5 Electrostatic phenomena	5.1 Transport and storage of fine-grained and dusty substances.	5.1.1 Earthing of all plant parts where electrostatic charging occurs.	5.2.23 IEC 60204-1	D, T, M
		5.1.2 Inert gas for pneumatic transportation and storage.		D
6 Hot work environment	6.1 Heat radiation from open ladles.	6.1.1 Heat radiation protection walls/shields with isolating material.	5.2.19	V, D
		6.1.2 Operating/maintenance instruction: PPE.	7.4.1	V

Table 1 *(continued)*

Significant hazard	Hazardous situation	Safety requirements and/or protective/risk reduction measures	Reference	Verification
7 Harmful gases, mists, fumes, dusts	7.1 Reduced oxygen content in the air due to accumulation of gases and dust in the following areas, e.g. — addition of alloying agents in the open ladle; — points of material transfer; — floor hoppers/bins.	7.1.1 Select a firefighting system without asphyxiant gas, if possible.	5.2.25	D
		7.1.2 Provide sufficient ventilation.	5.2.12 5.2.17	D, M, T
		7.1.3 Dust extraction points.		
		7.1.4 Operating/maintenance instruction: PPE (O_2 min detector).	7.4.1	V
8 Exothermic reaction	8.1 Thermal reaction as a consequence of moisture in the addition alloying material, e.g. lime.	8.1.1 Operating/maintenance instruction: storage and supply of dry addition materials.	7.4.1	V
	8.2 Fire as a consequence of air in the addition of special alloying material (e.g. sponge Ti).	8.2.1 Provide protective atmosphere for storage.		
		8.2.2 Select a firefighting system corresponding to the alloying material.	5.2.25	
9 Failure of fittings	9.1 Faulty installation at machines, equipment and plants (e.g. power connections and other mechanical components).	9.1.1 Different sizes and/or connection types for different media.	5.2.16	V, D
		9.1.2 Clear marking of components.	5.2.6.2	V, D
		9.1.3 Operating/maintenance instruction.	7.4.1	V
10 Unexpected movements	10.1 Unexpected movement of vertical and inclining conveyors due to drive failure.	10.1.1 Unintentional movement shall be avoided by a brake system.	ISO 1819, ISO 7149	T, D
5.3.3 VD and VOD				
5.3.3.1 Oxygen blowing equipment				
1 Crushing	1.1 Movement of manipulator or lance.	1.1.1 Provide guards with safety access.	5.2.12	V, D
		1.1.2 In case of safety access: — provide safe stop of movement: PLr = c in conjunction with category 1 according to ISO 13849-1:2015;	5.2.12.6 5.2.13	T, D
		— provide manual remote control with full view over the danger zone.	5.2.10 5.2.12.1	V

Table 1 *(continued)*

Significant hazard	Hazardous situation	Safety requirements and/or protective/risk reduction measures	Reference	Verification
2 Burns, shearing	2.1 Handling the blowing-lance during maintenance.	2.1.1 Provide devices with safe access and for safe handling, e.g. storage rack, lifting device, manual or automatic clamping device.	5.2.18	V, D, T
		2.1.2 Operating/maintenance instructions: PPE; safe handling; cleaning.	7.4.1.1	V
	2.2 Touching hot surfaces during maintenance.	2.2.1 Operating/maintenance instructions: PPE.	7.4.1.1	V
3 Fire	3.1 Fire caused by leakage or other failures of oxygen supply, e.g. at oxygen lances, valve stations.	3.1.1 Systems and components for oxygen supply shall be tight.	5.2.17	V, T
		3.1.2 Special consideration shall be taken to the flow speed in relation to the material of pipes, hoses and valves.	5.2.17	T, D
		3.1.3 Operating/maintenance instructions: all parts shall be kept free from oil and grease.	7.4.1.1	V

Table 1 *(continued)*

Significant hazard	Hazardous situation	Safety requirements and/or protective/risk reduction measures	Reference	Verification
4 Explosion	4.1 Water or moisture in the piping system (e.g. as a result of water pressure testing).	4.1.1 Operating/maintenance instructions: piping system shall be dried by compressed air or inert gas (free of oil and water).	7.4.1.1	V
	4.2 Ignition caused by leakage or other failures of oxygen supply, e.g. at valve stations.	4.2.1 Special consideration shall be taken to the flow speed in relation to the material of pipes, hoses and valves.	5.2.17	T, D
	4.3 Water leakage of oxygen lance.	4.3.1 Detection of water leakage by differential water flow. Provide safe control with at least: PLr = d in conjunction with category 3 according ISO 13849-1:2015.	5.2.13 5.2.16.2	V, T, D
		4.3.2 Isolate the water source. Provide safe control: PLr = d in conjunction with category 3 according to ISO 13849-1:2015.	5.2.13 5.2.16.2	V, T, D
		4.3.3 Isolate the oxygen source. Provide safe control: PLr = d in conjunction with category 3 according to ISO 13849-1:2015.	5.2.13 5.2.16.2	V, T, D
		4.3.4 Stirring shall be stopped. Provide safe control: PLr = d in conjunction with category 3 according to ISO 13849-1:2015.	5.2.13 5.2.16.2	V, T, D
		4.3.5 Restart of water cooling shall only be possible in manual mode after repair.	5.2.5.1 5.2.13 5.2.24	T, D
		4.3.6 Operating/maintenance instructions.	7.4.1.1	V
	4.4 Water leakage due to loss of power.	4.4.1 Provide emergency lifting for oxygen lance.	5.2.8 5.2.14	D, T, M
5.3.3.2 Stirring equipment				

Table 1 *(continued)*

Significant hazard	Hazardous situation	Safety requirements and/or protective/risk reduction measures	Reference	Verification
1 Burns	1.1 Touching the ladle during the manual connection/disconnection of the purging-gas pipes to the ladle.	1.1.1 Operating/maintenance instruction: PPE; communication between crane operator and person in charge of connecting/disconnecting in case of manual coupling; filling instructions, e.g. freeboard.	7.4.1.1	V
	1.2 Splashing of liquid steel due to connection of the purging-gas pipes to the ladle.	1.2.1 Provide safe position, e.g. protection shield.	5.2.19	V, D
		1.2.2 Operating/maintenance instruction.	7.4.1.1	V
	1.3 Ladle leakage due to porous plug failure.	1.3.1 Provide emergency draining channels and emergency pit.	5.2.5.4	V, T, D
2 Radiation	2.1 Electromagnetic fields due to electromagnetic stirring.	2.1.1 Warning signs.	5.2.6.2	V, D
		2.1.2 Operating/maintenance instruction.	7.4.1.1	V
5.3.3.3 Vacuum tank equipment				
1 Crushing	1.1 Movements of tank equipment.	1.1.1 Guards for the moving area of the tank equipment including corresponding devices.	5.2.12	V, D
		1.1.2 Secure the lifted equipment in parking position (e.g. by bolts/ brackets).	5.2.5.1 5.2.13	T, D
		1.1.3 Safety distances shall be considered to avoid crushing.	ISO 13857, ISO 13854	M, D
		1.1.4 Acoustic and visual signals before and during movements.	5.2.6	V, T, D
		1.1.5 Operating/maintenance instruction.	7.4.1.1	V
2 Shearing	2.1 Gap between stationary and moving platforms.	2.1.1 Safety distances shall be considered to avoid shearing.	5.2.12.1 ISO 13857	M, D
		2.1.2 Interlocked access to danger zones.	5.2.12.2	V, T, D
		2.1.3 Good visibility shall be insured during movement.	5.2.12.1	V

Table 1 *(continued)*

Significant hazard	Hazardous situation	Safety requirements and/or protective/risk reduction measures	Reference	Verification
3 Drawing in by vacuum force, noise	3.1 Imploding inspection glasses under vacuum conditions.	3.1.1 High-temperature and vacuum resistant glass (double glasses with space between them).		D
		3.1.2 Distance guards in front of inspection glasses for safe observation.	5.2.12	V, D
		3.1.3 Provide sufficient distance for reflex movement (e.g. backward) of the operator in case of an implosion of the inspection glass.	5.2.4	V, D
	3.2 Drawing in of clothes or parts of the body into vacuum flooding valves or other valves in conjunction with all processes under vacuum.	3.2.1 Vacuum flooding openings shall be installed outside the accessible areas of platforms and galleries, etc.	5.2.12.1	V, D
		3.2.2 Grilles or shrouds in order to cover the vacuum flooding openings.	5.2.12.6	V, D
	3.3 Noise propagation during flooding.	3.3.1 Operating/maintenance instruction: PPE.	5.2.7 5.2.29 7.4.1.1	V

Table 1 *(continued)*

Significant hazard	Hazardous situation	Safety requirements and/or protective/risk reduction measures	Reference	Verification
4 Water leakage	4.1 Water penetration in vacuum tank and/or generation of steam.	4.1.1 Flow, temperature and pressure measurements and monitoring in supply and return lines.	5.2.5.1 5.2.6 5.2.13	T, M, D
		4.1.2 Detection of water leakage by differential water flow for consumers > 3 m^3/h. Provide safe control with at least: PLr = c in conjunction with category 1 according ISO 13849-1:2015.	5.2.13 5.2.16.2	V, T, D
		4.1.3 Isolate the water source. Provide safe control: PLr = c in conjunction with category 1 according to ISO 13849-1:2015.	5.2.13 5.2.16.2	V, T, D
		4.1.4 Stirring shall be stopped. Provide safe control: PLr = c in conjunction with category 1 according to ISO 13849-1:2015.	5.2.13 5.2.16.2	V, T, D
		4.1.5 Restart of water cooling shall only be possible in manual mode after repair.	5.2.5.1 5.2.13 5.2.24	T, D
		4.1.6 Operating/ maintenance instruction.	7.4.1.1	V
	4.2 Water leakage of water-cooled splash shield.	4.2.1 Detection of water leakage by differential water flow. Provide safe control with at least: PLr = d in conjunction with category 3 according ISO 13849-1:2015.	5.2.13 5.2.16.2	V, T, D
		4.2.2 Isolate the water source. Provide safe control: PLr = d in conjunction with category 3 according to ISO 13849-1:2015.	5.2.13 5.2.16.2	V, T, D
		4.2.3 Stirring shall be stopped. Provide safe control: PLr = d in conjunction with category 3 according to ISO 13849-1:2015.	5.2.13 5.2.16.2	V, T, D
		4.2.4 Restart of water cooling shall only be possible in manual mode after repair.	5.2.5.1 5.2.13 5.2.12	T, D
5 Inhalation of gases	5.1 Reduced oxygen content in the air due to accumulation of gases (e.g. argon) in vacuum tank.	5.1.1 Operating/maintenance instruction: Before entering vacuum tank for maintenance, O_2 measurement is required; forced ventilation is required.	5.2.17 7.4.1.1	V, T, D

Table 1 *(continued)*

Significant hazard	Hazardous situation	Safety requirements and/or protective/risk reduction measures	Reference	Verification
6 Falling from height	6.1 Access to VD cover.	6.1.1 Operating/maintenance instruction: PPE (safety harness).	5.2.7 7.4.1.1	V
		6.1.2 Provide safe stand, e.g. steps, walkway if necessary.	5.2.12.5 5.2.27	V, D
5.3.4 RH-OB				
5.3.4.1 Blowing equipment				
1 Crushing	1.1 Movement of manipulator or lance.	1.1.1 Provide guards with safety access.	5.2.12	V, D
		1.1.2 In case of safety access: — provide safe stop of movement: PLr = c in conjunction with category 1 according to ISO 13849-1:2015;	5.2.12.6 5.2.13	T, D
		— provide manual remote control with full view over the danger zone.	5.2.10 5.2.12.1	V
2 Burns, shearing	2.1 Handling the blowing-lance during maintenance.	2.1.1 Provide devices with safe access and/or safe handling, e.g. storage rack, lifting device, manual or automatic clamping device.	5.2.18	V, D, T
		2.1.2 Operating/maintenance instruction: PPE; safe handling; cleaning.	7.4.1.1	V
	2.2 Touching hot surfaces during maintenance.	2.2.1 Operating/maintenance instruction: PPE.	7.4.1.1	V
	2.3 Chimney effect in case of replacement of RH-vessel or RH-vessel parts during maintenance, e.g. replacement of camera, oxygen lance, burners.	2.3.1 Provide manual operated valve for supply of inert gas, e.g. nitrogen.	5.2.17	D
		2.3.2 Warning signs.	5.2.6.2	V, D
		2.3.3 Operating/maintenance instruction: flooding with inert gas before replacement of parts.	7.4.1.1	V
3 Fire	3.1 Fire caused by leakage or other failures of oxygen supply, e.g. at oxygen lances, valve stations.	3.1.1 Systems and components for oxygen supply shall be tight.	5.2.17	V, T
		3.1.2 Special consideration shall be taken to the flow speed in relation to the material of pipes, hoses and valves.	5.2.17	T, D
		3.1.3 All parts shall be free from oil and grease.	5.2.17	V
		3.1.4 Operating/maintenance instruction.	7.4.1.1	V

Table 1 *(continued)*

Significant hazard	Hazardous situation	Safety requirements and/or protective/risk reduction measures	Reference	Verification
4 Explosion	4.1 Grease, oil, water or moisture in the piping system (e.g. as a result of water pressure testing).	4.1.1 Operating/maintenance instruction: Piping system shall be dried by compressed air or inert gas (free of oil and water).	5.2.16.1 5.2.17	T, D
	4.2 Ignition caused by leakage or other failures of oxygen supply, e.g. at valve stations.	4.2.1 Special consideration shall be taken to the flow speed in relation to the material of pipes, hoses and valves.	5.2.17	T, D
	4.3 Water leakage of oxygen lance.	4.3.1 Detection of water leakage by differential water flow. Provide safe control with at least: PLr = d in conjunction with category 3 according ISO 13849-1:2015.	5.2.13 5.2.16.2	V, T, D
		4.3.2 Isolate the water source. Provide safe control: PLr = d in conjunction with category 3 according to ISO 13849-1:2015.	5.2.13 5.2.16.2	V, T, D
		4.3.3 Isolate the oxygen source. Provide safe control: PLr = d in conjunction with category 3 according to ISO 13849-1:2015.	5.2.13 5.2.16.2	V, T, D
		4.3.4 Stop steel circulation (lift gas). Provide safe control: PLr = d in conjunction with category 3 according to ISO 13849-1:2015.	5.2.13 5.2.16.2	V, T, D
		4.3.5 Restart of water cooling shall only be possible in manual mode after repair.	5.2.5.1 5.2.13 5.2.24	T, D
		4.3.6 Operating/ maintenance instructions.	7.4.1.1	V
5 Electrostatic phenomena	5.1 Dusty substances in blowing equipment.	5.1.1 Earthing of all plant parts where electrostatic phenomena occurs.	5.2.23 IEC 60204-1	D, T, M
		5.1.2 If applicable, inert gas for pneumatic transportation.		D
5.3.4.2 Burner lances/multifunction lances				

Table 1 *(continued)*

Significant hazard	Hazardous situation	Safety requirements and/or protective/risk reduction measures	Reference	Verification
1 Crushing	1.1 Movement of manipulator or lance.	1.1.1 Provide guards with safety access.	5.2.12	V, D
		1.1.2 In case of safety access: — provide safe stop of movement: PLr = c in conjunction with category 1 according to ISO 13849-1:2015;	5.2.12.6 5.2.13	T, D
		— provide manual remote control with full view over the danger zone.	5.2.10 5.2.12.1	V
2 Burns, shearing	2.1 Handling the blowing-lance during maintenance.	2.1.1 Provide devices with safe access and for safe handling, e.g. storage rack, lifting device, manual or automatic clamping device.	5.2.18	V, D, T
		2.1.2 Operating/maintenance instruction: PPE; safe handling; cleaning.	7.4.1.1	V
	2.2 Touching hot surfaces during maintenance.	2.2.1 Operating/maintenance instruction: PPE.	7.4.1.1	V
	2.3 Chimney effect in case of replacement of RH-vessel or RH-vessel-parts during maintenance, e.g. replacement of camera, oxygen lance, burners.	2.3.1 Provide manual operated valve for supply of inert gas, e.g. nitrogen.	5.2.17	D
		2.3.2 Warning signs.	5.2.6.2	V, D
		2.3.3 Operating/maintenance instruction: flooding with inert gas before replacement of parts.	7.4.1.1	V
3 Fire	3.1 Fire caused by leakage or other failures of oxygen supply, e.g. at oxygen lances, valve stations.	3.1.1 Systems and components for oxygen supply shall be tight.	5.2.17	V, T
		3.1.2 Special consideration shall be taken to the flow speed in relation to the material of pipes, hoses and valves.	5.2.17	T, D
		3.1.3 All parts shall be free from oil and grease.	5.2.17	V
		3.1.4 Operating/maintenance instruction.	7.4.1.1	V

Table 1 *(continued)*

Significant hazard	Hazardous situation	Safety requirements and/ or protective/risk reduction measures	Reference	Verification
4 Explosion	4.1 Burner start-up.	4.1.1 For ignition gas rate and ignition time shall be limited.	5.2.26.2	D, T, M
		4.1.2 The maximum gas rate and corresponding safety-time shall be plant-related determined. A safety calculation shall verify that the maximum allowable energy density (energy per volume) is not exceeded.	5.2.26.2	D, T, M
		4.1.3 The pre-purge time shall be such as to ensure that the concentration of any combustible products in any part of the combustion chamber is below 25 % of the lower flammability limit (LFL) of the fuel gas.	5.2.26.2	D, T, M
	4.2 Air (oxygen)/ gas ratio outside safe operating range.	4.2.1 The correct air (oxygen) / gas ratio is controlled by mechanical, pneumatic or electric systems. Provide safe control: PLr = d in conjunction with category 3 according to ISO 13849-1:2015.	5.2.13	D, T
	4.3 Explosive mixture of gases, e.g. heating gas and air due to leakage in valve rack.	4.3.1 Outside the equipment can be classified as no-explosive-zone if the valve rack is designed as durably technically leakproof and ventilation shall be ensured.	5.2.26.1	V, T, D
5 Inhalation of gases, mists, fumes and dusts	5.1 CO gas.	5.1.1 Provide sufficient ventilation.	5.2.17	V, T, D
		5.1.2 Provide mobile CO gas detectors and indicators in danger zones.	5.2.7	V, T
		5.1.3 Warning signs in danger zones.	5.2.6.2	V, D
		5.1.4 Operating/maintenance instruction.	7.4.1.1	V
5.3.4.3 RH-vessel and related equipment				
1 Crushing	1.1 Movements of vessel equipment.	1.1.1 Guards for the moving area of the vessel including corresponding devices.	5.2.12	V, D
		1.1.2 Secure the lifted equipment in parking position (e.g. by bolts/ brackets).	5.2.5.1 5.2.13	T, D
		1.1.3 Safety distances shall be considered to avoid crushing.	ISO 13857	M, D

Table 1 *(continued)*

Significant hazard	Hazardous situation	Safety requirements and/or protective/risk reduction measures	Reference	Verification
		1.1.4 Acoustic and visual signals before and during movements.	5.2.6	V, T, D
		1.1.5 Operating/maintenance instruction.	7.4.1.1	V
	1.2 Lifting device for vertical vessel or ladle lifting/lowering movements.	1.2.1 The platform shall be guarded.	5.2.12.1	V, D, T
2 Shearing	2.1 Gap between stationary and moving platforms.	2.1.1 Safety distances shall be considered to avoid shearing.	5.2.12.1 ISO 13857	V, D
		2.1.2 Interlocked access to danger zones or fixed guards with interlocked access.	5.2.12.2	V, T, D
		2.1.3 Good visibility shall be insured during movement.	5.2.12.1	V
	2.2 Lifting device	2.2.1 Enclosing guards around the danger zones.	5.2.12	V, D
		2.2.2 Acoustic and visual signals before start and during moving.	5.2.4	T, D
3 Combination of hazards	3.1 Uncontrolled movement of vessel or cover with mechanical or hydraulic lifting equipment.	3.1.1 Slack rope and overload protection for winch drives.	5.2.5.1	V, T, M, D
		3.1.2 Overload protection for hydraulic drives.	5.2.5.1 5.2.13 5.2.16.1	T, D
		3.1.3 Signal and indication.	5.2.6	V, T, D
		3.1.4 Automatic stop in case of overload or slack rope.	5.2.5.1 5.2.13	T, D
		3.1.5 Secure the lifted equipment in parking position (e.g. by bolts, brackets).	5.2.5.1 5.2.13	T, D
	3.2 Uncontrolled steel level during vacuum operation in case of ladle leakage.	3.2.1 Flooding to atmospheric pressure by a flooding valve.	5.2.5.4	T, D
		3.2.2 Operating/maintenance instruction.	7.4.1.1	V
	3.3 Uncontrolled movement of ladle.	3.3.1 Automatic flooding to atmospheric pressure by a flooding valve.	5.2.5.1 5.2.5.4 5.2.13	T, D
		3.3.2 Operating/maintenance instruction.	7.4.1.1	V

Table 1 *(continued)*

Significant hazard	Hazardous situation	Safety requirements and/or protective/risk reduction measures	Reference	Verification
4 Drawing in by vacuum force, noise	4.1 Imploding inspection glasses under vacuum conditions.	4.1.1 High-temperature and vacuum resistant glass (double glasses with space between them).		D
		4.1.2 Distance guards in front of inspection glasses for safe observation.	5.2.12.1	V, D
		4.1.3 Provide sufficient distance for reflex movement (e.g. backward) of the operator in case of an implosion of the inspection glass.	5.2.4	V, D
	4.2 Drawing in of clothes or parts of the body into vacuum flooding valves or other valves in conjunction with all processes under vacuum.	4.2.1 Vacuum flooding openings shall be installed outside the accessible areas of platforms and galleries, etc.	5.2.12.1	V, D
		4.2.2 Grilles or shrouds in order to cover the vacuum flooding openings.	5.2.12.6	V, D
	4.3 Noise propagation during flooding.	4.3.1 Operating/maintenance instruction: PPE.	5.2.7 7.4.1.1	V
5 Asphyxiation	5.1 Reduced oxygen content in the air as a result of accumulation of gases (such as argon, nitrogen, CO_2) in pits, containers and vessels and in plant areas with an insufficient level of natural ventilation and gas discharge.	5.1.1 Forced ventilation and gas discharge	5.2.17	V, T, D
		5.1.2 Acoustic and visual signals from stationary and mobile detectors for low oxygen content in the air.	5.2.5.1 5.2.6.1 5.2.13	V, T, D
6 Water leakage	6.1 Water penetration in vacuum vessel.	6.1.1 Automatic shut off water for consumers > 3 m^3/h when the limits of the above-mentioned measuring values are exceeded or fall below.	5.2.16	T, M, D
5.3.5 Positioning equipment (general)				

Table 1 *(continued)*

Significant hazard	Hazardous situation	Safety requirements and/or protective/risk reduction measures	Reference	Verification
1 Combination of mechanical hazards	1.1 Incorrect positioning of the ladle into the station by crane.	1.1.1 Provide mechanical guiding for correct positioning of the ladle.		V, T, D
	1.2 Incorrect positioning of the ladle by ladle car.	1.2.1 Control of the exact stop position (e.g. treatment position) and interlocking with other components (e.g. lifting equipment).	5.2.13	V, T, D
	1.3 Vertical ladle lifting/lowering movements.	1.3.1 Acoustic and visual signals before and during movement.	5.2.6.1	T, D
		1.3.2 Operating/maintenance instruction.	7.4.1	V
	1.4 Ladle movement by turret or car.	1.4.1 Acoustic and visual signals before and during movement.	5.2.6.1	D, T
	1.5 Transport equipment for vacuum vessel or vacuum covers.	1.5.1 Safety distances shall be considered to avoid crushing.	EN 294 EN 349 EN 811	M, D
		1.5.2 Acoustic and visual signals before and during movement.	5.2.6.1	T, D
		1.5.3 Secure the lifted equipment in parking position (e.g. by bolts, brackets).		T, D
	1.6 Movement of main machinery components (e.g. roof gentry, manipulator or lance.	1.6.1 Provide guards with safety access.	5.2.5.2	V, D
		1.6.2 In case of safety access: — provide safe stop of movement: PLr = c in conjunction with category 1 according to ISO 13849-1:2015; — provide restraining device; and	5.2.13	V, D
		— provide manual remote control with full view over the danger zone.	5.2.9.3	V
	1.7 Gap between stationary and moving platforms.	1.7.1 Safety distances shall be considered to avoid shearing.	5.2.5.2	M, D
		1.7.2 Interlocked access to danger zones.	5.2.5.2	V, T, D
		1.7.3 Fixed guards with interlocked access.	5.2.5.2	V, T, D
		1.7.4 Good visibility shall be insured during movement.	5.2.9	V

Table 1 *(continued)*

Significant hazard	Hazardous situation	Safety requirements and/or protective/risk reduction measures	Reference	Verification
2 Contact with parts being energized	2.1 Contact with none insulated power cables, bus bars or contact rings.	2.1.1 Guards around the danger zones.	5.2.5.2	V, D
3 Failure of energy supply	3.1 Loss of electrical power.	3.1.1 Provide emergency energy.	5.2.8 5.2.14 5.2.15	T, M, D
4 Downward movement of plant components	4.1 Uncontrolled downward movement of lances (e.g. oxygen lances water cooled).	4.1.1 Secure safe distance between the tip of the lance and the surface of the liquid steel (e.g. mechanical stopper).	5.2.13	T, M, D
		4.1.2 Operating/maintenance instruction: freeboard for steel level.	7.4.1	V
5.3.6 Vacuum pump/ventilation equipment (general)				
1 Gases	1.1 CO gas during decarburisation processes and maintenance.	1.1.1 Installation of flare stack.		V, T, D
		1.1.2 Installation of waste gas exhaust pipe at minimum height with respect to surrounding buildings.		V, D
		1.1.3 Avoid waste gas exhaust installation close to air inlets of, e.g. air conditioning equipment, ventilation equipment, windows or roof breather pipes, ventilation for hotwell tanks.	5.2.17	V, D
		1.1.4 Warning signs at the border of danger zones, e.g. MVP or CCW pump room.	5.2.6.2 5.2.12.8	V, D
		1.1.5 Acoustic and visual signals from stationary CO gas detectors.	5.2.6.1	V, T, D
		1.1.6 Indicators in danger zones.	5.2.6.1 5.2.17	V, D
		1.1.7 Operating/maintenance instruction: mobile CO gas detectors.	7.4.1.1	V
		1.1.8 All equipment with own ignition sources (e.g. mechanical vacuum pumps, watering pumps) shall be designed in compliance with EN 13463-1:2001, zone 1 inside (appliance group II2G with temperature class T1 and explosion group IIC).	5.2.26	D

Table 1 *(continued)*

Significant hazard	Hazardous situation	Safety requirements and/or protective/risk reduction measures	Reference	Verification
2 Asphyxiation	2.1 Reduced oxygen content in the air as a result of accumulation of gases (such as argon, nitrogen, CO_2) in the pump room with an insufficient level of natural ventilation and gas discharge.	2.1.1 Forced ventilation and gas discharge.	5.2.17	V, T, D
		2.1.2 Acoustic and visual signals from stationary and mobile detectors for low oxygen content in the air.	5.2.6.1	V, T, D
3 Explosion	3.1 Explosive mixture of gases, e.g. CO and O_2 during decarborisation process.	3.1.1 Outside the equipment can be classified as no-explosive-zone if the piping is designed as durably technically leakproof and ventilation is ensured.	5.2.26	V, T, D
4 Burns	4.1 Touching hot surfaces (e.g. steam piping, exhaust gas piping).	4.1.1 Provide contact protection.	5.2.2	V, D
		4.1.2 Operating/maintenance instruction: PPE.	7.4.1.1	V
5 Drawing in by vacuum force	5.1 Drawing in of clothes or parts of the body into vacuum flooding valves or other valves in conjunction with all processes under vacuum.	5.1.1 Grilles, guards or shrouds in order to cover the vacuum flooding openings or other valves.	5.2.12.6	V, D
		5.1.2 Provide noise insulation.	5.2.29.1	V, D
		5.1.3 Vacuum flooding openings shall be installed outside the accessible areas of platforms and galleries, etc.	5.2.12.1	V, D
6 Noise	6.1 Noise propagation during pump operation.	6.1.1 Arrange mechanical vacuum pumps and watering pumps in a separate pump room.	5.2.29.1	V, D
		6.1.2 Operating/maintenance instruction: PPE.	5.2.7 7.4.1.1	V
5.3.7 Media handling equipment (general)				
1 Loss of cooling water supply	1.1 Failure of cooling water system.	1.1.1 Provide emergency cooling water for shut down under safe conditions.	5.2.5.1 5.2.13 5.2.16	D, T
2 Burns	2.1 Spilling over of liquid metal due to excessive gas pressure at the beginning of the purging process.	2.1.1 Operating/maintenance instruction: keep distance from equipment and wear PPE.	7.4.1.1	V

Table 1 *(continued)*

Significant hazard	Hazardous situation	Safety requirements and/or protective/risk reduction measures	Reference	Verification
3 Inhalation of gases, mists, fumes and dusts	3.1 Process steps with dust generation, e.g. injection of wire.	3.1.1 Install fume extraction system.	5.2.17	V, T, M, D
		3.1.2 Provide gas tight systems.	5.2.17	T, D
		3.1.3 Provide stationary and mobile CO gas detectors and indicators in danger zones.	5.2.17	V, T, M, D
		3.1.4 Warning signs in danger zones.	5.2.6.1 5.2.17	V, D
		3.1.5 Operating/maintenance instruction.	7.4.1.1	V
4 Failure of energy supply	4.1 Loss of electrical power.	4.1.1 Provide emergency energy.	5.2.8 5.2.14 5.2.15	T, M, D
5 Failure, malfunction of the control system	5.1 Control fault and/or unexpected media supply (e.g. gas, water) into the process cycle.	5.1.1 Provide safe control system.	5.2.5.1 5.2.13	T, D
6 Failure of fittings, faulty installations	6.1 Faulty installation of components (e.g. power connections media pipes).	6.1.1 Clear marking of components.	5.2.16	V
5.3.8 LF - Ladle furnace				
5.3.8.1 Stirring equipment				
1 Crushing	1.1 Movement of manipulator or lance.	1.1.1 Provide guards with safety access.	5.2.5.2	V, D
		1.1.2 In case of safety access: — provide restraining device;		V, D
		— provide manual remote control with full view over the danger zone.	5.2.9	V
2 Burns, shearing	2.1 Handling the stirring lance during maintenance.	2.1.1 Provide devices with good access and for safe handling, e.g. storage rack, lifting device, manual or automatic clamping device.	5.2.18	V, D, T
		2.1.2 Operating/maintenance instruction: Safe handling; cleaning.	7.4.1	V
	2.2 Touching hot surfaces during maintenance.	2.2.1 Operating/maintenance instruction: PPE.	7.4.1	V
3 Explosion	3.1 Grease, oil, humidity, water or moisture in the piping system (e.g. as a result of water pressure testing).	3.1.1 Operating/maintenance instruction: piping system shall be dried by compressed air or inert gas (free of oil and water).	7.4.1	

Table 1 *(continued)*

Significant hazard	Hazardous situation	Safety requirements and/or protective/risk reduction measures	Reference	Verification
4 Burns	4.1 Touching the ladle during the manual connection/disconnection of the purging-gas pipes to the ladle.	4.1.1 Operating/maintenance instruction: PPE; communication between crane operator and person in charge of connecting/disconnecting in case of manual coupling; filling instructions, e.g. freeboard.	7.4.1	
	4.2 Splashing of liquid steel due to connection of the purging-gas pipes to the ladle.	4.2.1 Provide safe position, e.g. protection shield.		
		4.2.2 Operating/maintenance instruction.	7.4.1	
	4.3 Ladle leakage due to porous plug failure.	4.3.1 Provide emergency draining channels and emergency pit.		
5 Radiation	5.1 Heat radiation.	5.1.1 Provide protection devices (e.g. protection walls, shields).	5.2.19	
	5.2 Electromagnetic fields due to electromagnetic stirring.	5.2.1 Warning signs.		
		5.2.2 Operating/maintenance instruction.	7.4.1	
5.3.8.2 LF roof				
1 Water leakage	1.1 Water penetration in ladle and/or generation of steam.	1.1.1 Flow, temperature and pressure measurements and monitoring in the main supply and the main return line.	5.2.6.2	T, M, D
		1.1.2 Detection of water leakage by differential water flow. Provide safe control with at least: PLr = c according ISO 13849-1:2015.	5.2.13	V, T
		1.1.3 Isolate the water source. Provide safe control: PLr = c according to ISO 13849-1:2015.	5.2.13	V, T
		1.1.4 Stirring shall be stopped. Provide safe control: PLr = c according to ISO 13849-1:2015.	5.2.13	V, T
		1.1.5 Restart of water cooling shall only be possible in manual mode after repair.		
		1.1.6 Automatic shut-off LF circuit breaker. Provide safe control: PLr = d according to ISO 13849-1:2015.	5.2.16.2 5.2.13	V, T
		1.1.7 Operating/maintenance instruction.	7.4.1	V
2 Downfall	2.1 Access onto the LF roof.	2.1.1 Operating/maintenance instruction: PPE (safety harness).		

Table 1 *(continued)*

Significant hazard	Hazardous situation	Safety requirements and/or protective/risk reduction measures	Reference	Verification
3 Combination of hazards	3.1 Contact between roof and electrodes during movement, ejection of hot material.	3.1.1 Avoid uncontrolled movement of equipment (sequential process steps and electrical interlocks).	5.2.13	T, D
		3.1.2 Roof and electrodes shall be lifted prior roof swivelling.	5.2.13	T, D
		3.1.3 Operation and maintenance positions shall be monitored.		V, T, D
		3.1.4 Operating/maintenance instruction: clamp electrodes with correct length.	7.4.1	V
	3.2 Drop of electrode, accidental release of electrode.	3.2.1 Provide spring-loaded clamping device.		
		3.2.2No release command during normal operation condition (e.g. key switch).		
4 Parts under voltage	4.1 Electric shock, caused by approaching live parts, e.g. electrode arms, electrodes during inspection/maintenance on electrode platform.	4.1.1 Provide guards with safety access.	5.2.5.2	
		4.1.2 Swith-off LF circuit breaker. Provide safe control: PLr = d according to ISO 13849-1:2015.	5.2.13	
	4.2 Potential difference on furnace, e.g. short circuit to earth.	4.2.1 Connection to earth.		
5 Visible, infrared and ultraviolet light	5.1 High radiation light, influencing operator's eyes.	5.1.1 Special coloured glass shall be provided at pulpit and control stand.	5.2.9	V, D
6 Inhalation of harmful gases, fume and dust	6.1 Exposure to fume, gas and dus.t	6.1.1 Provide fume extraction system.	5.2.7	V, T, D
7 Crushing	7.1 Changing of graphite electrodes.	7.1.1 Operating/maintenance instruction: clear communication (visible/audible) between crane operator and personnel; ensure proper electrode assembly.	7.4.1	V
8 Failure of power supply	8.1 Failure of power supply (hydraulic, pneumatic, electric) causing uncontrolled movement of the equipment.	8.1.1 Ladle cover and electrodes shall go into stable position without supply of external energy.	5.2.12 5.2.13	D, T
5.3.9 Temperature measuring and sampling equipment (general)				
1 Electric shock	1.1 Access to danger zones.	1.1.1 An automatic system should be installed.	5.2.20	V, T

Table 1 *(continued)*

Significant hazard	Hazardous situation	Safety requirements and/or protective/risk reduction measures	Reference	Verification
2 Crushing	2.1 Access to danger zones during automatic movement of lances.	2.1.1 Fixed guards with interlocked access.	5.2.5.2 5.2.9.3 5.2.13	V, T, D
3 Drawing in, crushing	3.1 Unintended opening of the vacuum slide gate during manual replacement of sleeves for measurement/sampling.	3.1.1 Vacuum slide gate, lance drive and door shall be interlocked during sleeve replacement.	5.2.12 5.2.13	V, T, D

6 Verification of safety requirements and protective/risk reduction measures

6.1 General

The verification procedure(s) shall be described in a verification plan (it should be observed that verification includes validation). To fulfil the above-mentioned requirements, the technical documentation shall contain all the necessary information. The elements and descriptions relevant to the verification shall be identifiable in the documents.

In addition to the scope and outcome of the checks, it shall be documented which technical documents (name, version) were used and who carried out these checks and when. For software or parameters, the version used during the checks shall be documented (e.g. using checksums).

Conducting verification and validation, the manufacturer shall comply with the requirements of relevant standards, e.g. ISO 12100, ISO 13849-1, ISO 13849-2.

NOTE An adequate time frame for conducting the on-site verification is normally agreed in the contract between the manufacturer, the client and other relevant parties.

6.2 Required verification D

During the design phase, the technical documentation (e.g. risk assessment, circuit diagram, calculations, safety layout) shall be cross-checked. The required verification D is given in Table 1. It shall be verified that:

a) the risk assessment covers all parts and functions of the line and all interfaces to linked/integrated machines or equipment;

b) the measures required by the risk assessment have been considered;

c) the selected components are suitable for the expected conditions (ambient conditions, IP-classification etc.) and the required functionality and purpose;

d) the selected components have been incorporated into the design according to the supplier's specification (mounting, preliminary fuse, system pressure etc.);

e) the safety functions fulfil the requirements from the risk assessment (required SIL or PL, including mathematical proof).

6.3 Required verification V, M and T

All the equipment and safety functions of an SSME which serve the purpose of reducing hazards (according to the risk assessment), shall be checked and documented prior putting into service (i.e. no further changes are made). The required verification V, M, T is given in Table 1.

If parts of the SSME are already pre-finished and inspected (e.g. sections of the line, components, control cabinets, software components), only the integration of these parts into the line has to be checked.

If a partial disassembly is necessary for checks, for example, to gain access, it shall not affect the function being checked. Safety devices put out of operation for checks shall be restored after the check is completed.

The following shall be checked at the place of erection based on the technical documentation:

a) at the place of erection: correspondence between the specific ambient conditions regarding the equipment and the presumptions listed in the technical documentation;

b) completeness, correct assembly and arrangement (e.g. safety distances) of all protective equipment (e.g. covers, fences, access doors, safety bolts, sensors, actuators, operating elements, warning signs);

c) correct wiring and piping (e.g. max. cable length, cable type, burst protection, tube type) of all elements involved in safety functions;

d) in case of safety-related application software (SRASW): correct integration (inputs, outputs, block calls, working cycle etc.) of all software blocks involved in safety functions;

e) in case of parameters: correct setting of parameter values involved in safety functions;

f) check of safety functions (including all interfaces to linked/integrated machines or equipment):

   1) do all safety functions fulfil their designated task (e.g. safe stop, safely limited speed)?

   2) do all initiating elements (access detections, e-stop buttons, enabling switches, etc.) operate as foreseen?

   3) do fault detection and fault reaction work as foreseen?

   4) does the interaction between safe and non-safe function work as foreseen (ramp down, restart in enabling mode, etc.)?

Safety functions in strip processing lines are realized in general by using standardized modules (e.g. safety relays) or program blocks [e.g. function blocks for safety programmable logic controls (PLC's)]. Due to this fact, the amount of checks for similar safety functions can be reduced:

— if already tested modules/program blocks or combinations of those are used. A test performing all theoretically possible combinations of input signals (e.g. black box test) is not required. It is sufficient to check the reactions upon all input conditions that are intended to initiate or reset a safety function;

— if for checks on fault detection and fault reaction a reference module/program block is available that already has been tested, no further tests are required if such a module/program block is implemented without changes. Such modules/program blocks have only to be checked for correct incorporation (e.g. parameter setting, connection of module/program blocks).

7 Information for use

7.1 General requirements

IEC/IEEE 82079-1 defines the general principles and requirements for the preparation of information for use. The operation handbook shall be designed according to ISO 20607 and ISO 12100.

The manufacturer shall provide all relevant information in all single phases of the development and operation, e.g. for installation and commissioning made by the user/operator. A set of the information for use shall be provided to the user/operator of the SSME latest at the time of hand-over.

In case of missing legal requirements, the date of hand over the full set of information for use should be defined in the contract.

7.2 Warning devices and safety labelling

Warning devices and safety labelling shall meet the requirements of 5.2.6.

7.3 Marking and labelling

According to ISO 12100:2010, 6.4.4, the following information shall be attached clearly and durably to the SSME (e.g. in the pulpit, at the main operation panel):

— name and address of manufacturer and where applicable the name and address of its authorized representative;

— designation of series or type, if any;

— mandatory marking[1)];

— serial number/machine number, if any;

— year in which the manufacturing process was completed.

The electrical equipment shall be marked with durable plates containing data in accordance with IEC 60204-1, if necessary, including casing protection grade.

The hydraulic and/or pneumatic equipment shall be marked with legible durable plates containing data in accordance with ISO 4413 and ISO 4414.

7.4 Accompanying documents

7.4.1 Instructions

7.4.1.1 General information

The manufacturer shall prepare an operation handbook to ensure the safe and intended use of the SSME. Necessary information for safe use of the equipment shall include elements identified through the risk assessment conducted in accordance with Clause 4. Individual technical and functional concepts of the SSME shall also be included.

NOTE ISO 20607 provides further information on the preparation, structure, and content of operation handbooks.

The manufacturer shall provide at least the following information together with the SSME:

— manufacturer, type of machinery, year of manufacturing, serial number (if any);

— intended use;

— identification of foreseeable misuse, including unauthorised reconstruction and modification;

— operation, including at least:

  — starting procedure (incl. preconditions after inspection or service), operating modes and stopping (e.g. quick stop, emergency stop);

  — operation modes;

1) For machines and their related products intended to be put on the market in EEA, CE marking is as defined in the European applicable directive(s), e.g. machinery, low voltage, explosive atmosphere, gas appliances.

  - putting the equipment out of operation and/or service;
  - safety relevant and operational details of any interfaces with additional/optional machinery;
- settings and adjustment;
- information/reference about operational changing parts and tools;
- fault detection and troubleshooting, including information about fault/warning messages, failure codes, irregularities, and abnormal operation;
- maintenance and repair, including at least:
  - preconditions for inspection and service (e.g. depressurizing/emptying instructions, switching off electrical circuits), the required tasks and relevant residual risks;
  - settings and adjustment;
  - preventive measures (e.g. replacement of wear parts, lubrication);
  - electrical isolation and grounding required (e.g. in classified areas);
- instructions for transport, handling and storage operations (e.g. transportation weight, transport rig, ring bolt, centre of gravity), where equipment or machine parts are regularly being transported (e.g. work rolls);
- instruction for transportation and assembly of the equipment, including if relevant:
  - instructions for safe lifting (e.g. mass, transport rig, ring bolt, centre of gravity);
  - transport safety devices and removal of these before commissioning;
  - instructions for correct (dis)connection of take-over-points;
- information about expected emissions, for example, noise, vibration, radiation, hazardous dusts, and where necessary, information about additional required measures, e.g.
  - designation of hazardous areas;
  - measures to be conducted by the personnel for work in hazardous areas;
- information about fume and dust emission provided for connection to extraction system;
- plant layout/installation conditions (e.g. foundation plan, requirements of the building);
- reference to installation/assembly of the machinery or single parts of the machine particularly where machine position or adjacent elements of the building require safeguards or risk reduction;
- safety layout plan (see 5.2.4);
- energy supplies (electric, hydraulic, pneumatic);
- instructions for correct connection of take-over-points;
- filling amounts;
- specification of fluids and information on handling (e.g. transport, storage, disposal) of hazardous substances (e.g. radioactive materials, acids, oils);
- unauthorised reconstruction and modification;
- safety devices, warning devices and labelling;
- instruction on safety and warning devices (e.g. maintenance, repair);