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Industrial furnaces and associated processing equipment — Safety requirements for steel converter and associated equipment

Fours industriels et équipements associés — Prescriptions de sécurité pour les convertisseurs et d'équipement associés

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Foreword

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

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

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

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

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

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

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

Introduction

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

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

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

Where for clarity an example of a preventive measure is given in this document, this should not have been considered as the only possible solution. Any other solution leading to the same risk reduction is permissible if an equivalent level of safety is achieved.

This document assumes that

- the steel converter is operated and maintained by adequately trained personnel (see 3.13 and 7.5);
- manual intervention for setting, adjustment and maintenance is accepted as part of the intended use of the steel converter;
- the steel converter is used with adequate workplace lighting conforming to e.g., ISO 8995-1.

This document assumes that the input materials do not contain the following hazardous components:

- radioactive scrap;
- explosives;
- entrapped water/ice; <https://standards.iteh.ai/catalog/standards/sist/1b1bf6ca-2170-4470-ba09-d3ecc2edfda9/iso-fdis-23495>
- closed containers;
- oversized scrap which can lead to water leakage due to collision with lances (see 7.3.5).

The charging should be done to avoid/minimize risk of explosion.

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 organizations, 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.

Industrial furnaces and associated processing equipment — Safety requirements for steel converter and associated equipment

1 Scope

This document applies for new steel converter and its associated equipment (hereinafter referred to as converter plant) used in the process of carbon or stainless steel making as defined in [3.1](#) and illustrated in [Annex B](#).

This document deals with significant hazards, hazardous situations and events relevant to the converter plant. It covers the intended use and foreseeable misuse.

This document specifies the safety requirements to be met during design, pre-assembly, transport, site-assembly, commissioning, operation, maintenance (as described in [Clause 5](#)) and decommissioning/dis-assembly of the equipment.

Assembly does not include erection because national regulations, e.g., national civil engineering laws and regulations or occupational health and safety regulations contain such information.

This document applies to:

Steel converter and its associated equipment (see [Annex B](#), [Figure B.1](#) for the oxygen steelmaking process

- from charging hot metal/liquid steel and scrap;
- via oxygen refining and stirring;
- temperature measurement and sampling equipment;
- up to tapping including slag retaining device;
- cooling systems;
- maintenance devices (e.g., relining device, tap hole repair device, device for cleaning the converter mouth);
- process related interfaces/interactions (e.g., according to design, controls) to
 - process media,
 - primary and secondary gas cleaning plant,
 - material feeding systems and ladle alloying systems,
 - transfer cars for steel ladle and slag pot, and
 - charging/tapping equipment, e.g., crane, scrap chute, ladles and slag pots.

This document does not cover safety requirements for:

- usage of process media other than oxygen, nitrogen, argon and compressed air;
- primary and secondary gas cleaning plants;
- measuring devices with radioactive sources;
- material feeding systems and ladle alloying systems;

- transfer cars for steel ladle and slag pot;
- charging/tapping and de-slagging equipment, e.g., crane, scrap chutes, ladles and slag pots;
- auxiliary winches and hoists.

For variations of converter process where other gases and process media, e.g., hydrocarbons, fuels, steam, etc. are used, additional safety measures shall be considered which are not covered in this safety standard.

NOTE In case of revamping, this document can be used as a guideline for the specific parts to be revamped.

This document is not applicable to steel converter 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 3864-1:2011, *Graphical symbols — Safety colours and safety signs — Part 1: Design principles for safety signs and safety markings*

ISO 3864-2, *Graphical symbols — Safety colours and safety signs — Part 2: Design principles for product safety labels*

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 4871:2009, *Acoustics — Declaration and verification of noise emission values of machinery and equipment*

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

ISO 7010, *Graphical symbols — Safety colours and safety signs — Registered safety signs*

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

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

ISO 11202:2010, *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 13849-1:2015, *Safety of machinery — Safety-related parts of control systems — Part 1: General principles for design*

ISO 13849-2:2012, *Safety of machinery — Safety-related parts of control systems — Part 2: Validation*

- ISO 13850:2015, *Safety of machinery — Emergency stop function — Principles for design*
- ISO 13857, *Safety of machinery — Safety distances to prevent hazard zones being reached by upper and lower limbs*
- ISO 14118, *Safety of machinery — Prevention of unexpected start-up*
- 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 14122-3, *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 14123-1, *Safety of machinery — Reduction of risks to health resulting from hazardous substances emitted by machinery — Part 1: Principles and specifications for machinery manufacturers*
- ISO 14123-2, *Safety of machinery — Reduction of risks to health resulting from hazardous substances emitted by machinery — Part 2: Methodology leading to verification procedures*
- IEC 60204-1:2006, Edition 5.1:2009, *Safety of machinery — Electrical equipment of machines — Part 1: General requirements*
- IEC 61310-1, *Safety of machinery — Indication, marking and actuation — Part 1: Requirements for visual, acoustic and tactile signals*
- IEC 61310-2, *Safety of machinery — Indication, marking and actuation — Part 2: Requirements for marking*
- IEC 61511-1, *Functional safety — Safety instrumented systems for the process industry sector — Part 1: Framework, definitions, system, hardware and software requirements*
- IEC 62061:2005, *Safety of machinery — Functional safety of safety-related electrical, electronic and programmable electronic control systems (Note: To be replaced by IEC 44/788/CD (2017-02))*
- ISO 13854, *Safety of machinery — Minimum gaps to avoid crushing of parts of the human body*
- IEC 60529:1989, *Degrees of protection provided by enclosures (IP Code) (IEC 60529:1989/ AMD2:2013/ COR1:2019)*
- ISO/TR 11688-1, *Acoustics — Recommended practice for the design of low-noise machinery and equipment — Part 1: Planning*

3 Terms, definitions and abbreviated terms

For the purpose of this document, the terms and definitions given in ISO 12100, ISO 13574 and the following apply.

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

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <http://www.electropedia.org/>

NOTE Definition used in ISO standards referred to in this document are also valid for this document.

3.1

steel converter

tiltable unit for the production of carbon or stainless steel

Note 1 to entry: This tiltable unit is mainly consisting of a vessel with refractory lining, trunnion ring, vessel suspension system, tilting drive, etc.

3.2

associated equipment

additional equipment for the production of carbon steel or stainless steel by means of a *steel converter* (3.1)

Note 1 to entry: For associated equipment, e.g., lances, see [Figure B.1](#).

3.3

refining

conversion of hot metal to carbon steel or stainless steel by elimination of (mainly) carbon (and other unwanted elements like silicon, phosphor) using oxygen supply

Note 1 to entry: Refining processes differ in oxygen supply from top, bottom or a combination of both; and optional gas stirring

3.4

production process

all production-related activities between charging to tapping

3.5

maintenance devices

devices to maintain the converter

Note 1 to entry: Such devices are, e.g., relining device, tap hole repair device, clean-up device for converter mouth

3.6

manual mode

every single function/movement will be individually triggered by the operator

3.7

special control modes

dedicated modes activated by a specific device, to carry out operations

Note 1 to entry: e.g., like skull removal or slag splashing

3.8

maintenance

all activities carried out outside the *production process* (3.1)

3.8.1

inspection

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

3.8.2

service

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

3.8.3

repair

repair or exchange of damaged components accompanied with complete shutdown (i.e. isolation of energy)

3.8.4**relining**

all activities from shut down of converter for relining up to end of pre-heating (including converter vessel exchange or parts of it, refractory breakout)

3.8.5**skull removal**

special procedure for removing the skull inside the converter by using the blowing lance

3.9**ladle**

vessel with refractory lining to collect, treat, transport and charge/discharge hot metal/steel

3.10**slag pot**

vessel to collect, treat and transport slag

3.11**scrap chute**

scrap charging container used to charge scrap into the converter

3.12**work stations**

predefined locations for personnel used for production or maintenance

3.12.1**converter control room**

main control room in which the control desk and monitoring facilities for a steel converter are located

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

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3.12.2**local control stands**

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, e.g., during charging or tapping.

3.12.3**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.

3.13**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

3.14**authorized personnel**

trained person who is instructed by the user to perform a specific task on a specific equipment

3.15**doghouse**

enclosure around the converter vessel consisting of sidewalls, ceiling and movable doors (see [5.1.4.4](#))

Note 1 to entry: The primary purpose is to contain noise and dust during process and should protect the converter platform against steel or slag splashing.

3.16

skirt

movable water-cooled part of the gas cleaning system

Note 1 to entry: Located above the converter mouth

3.17

protection platform

(re-)movable platform above the converter

Note 1 to entry: Protecting lower areas from falling material.

3.18

danger zone

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

3.19

safety layout

graphical description of plant-related equipment with regard to safety

3.20

warning system

visible, audible warning devices or a combination of both

3.21

blowing lance

water cooled vertical lance used for blowing technical gases, mainly oxygen

3.22

sub-lance

water cooled vertical lance used for temperature measurement and sampling during production process

3.23

relining machinery/device

machine for manual or automatic installation of refractory lining inside the converter

Note 1 to entry: Associated lifting, lowering and travelling devices for material transport and access to the workplace are included.

3.24

fire-resistant hydraulic fluid

hydraulic fluid that is difficult to ignite and shows little tendency to propagate flame

[SOURCE: ISO 5598:2008; 3.2.271]

Abbreviated terms

AOD argon oxygen decarburization

BOF basic oxygen furnace

PPE	personal protective equipment
CCTV	closed circuit television
PLC	programmable logic control

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 [5.2](#), [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 standard shall be reduced by applying the principles of ISO 12100.

5 Safety requirements and/or measures

5.1 General

5.1.1 Introduction

Converter 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 [Annex A](#) and [C](#) for a typical installation as illustrated in [Annex B](#), and the information for use as defined in [Clause 7](#).

Special consideration shall be given to CO emission 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 such a document. To deal with this fact, an individual risk assessment of the steel converter 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. He 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 this 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 ISO 12100:2010 for relevant but not significant hazards which are not dealt with by this document.

5.1.2 Planning phase

The manufacturer shall undertake during planning phase together with the user a layout-check to ensure good placement and safe operation of the converter plant, in particular with regard to:

- position of physical emergency systems;
- accessibility;

- maintenance and cleaning;
- movement of parts of the equipment and material;
- prevention of emissions hazardous to health at the work stations (e.g., avoiding harmful emissions);
- considering ergonomic requirements;
- escape routes.

5.1.3 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 converter plant.

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 instruction for use.

5.1.4 Safety devices and protective measures

5.1.4.1 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; Annex 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).

5.1.4.2 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 13849-1:2015 (see 5.1.13). 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 described in ISO 13857, the minimum height of distance guards (e.g., perimeter fences, protective structures) shall be 1 400 mm.

5.1.4.3 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 12100:2010; 3.29).

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 [5.1.17](#) of this document).

Guard-rails shall conform to ISO 14122-3.

5.1.4.4 Doghouse

A doghouse shall be provided to reduce the environmental impact of the process in general (e.g., containing or guiding dust to the dust collection system). As a secondary effect, it also reduces the noise level and contains splashes.

It shall be noted that doghouse doors are not guards according to ISO 14119 and are not interlocked with the process. In the circumstances where the doghouse doors are not closed (e.g., due to process observation), further production can be continued temporarily if specific instructions and/or additional safety measures like temporary guards have been provided.

Where a doghouse cannot be installed, e.g., for "micro" AOD converters used in foundries (typical capacity less than 25 t), measures like sidewalls, protection shields and removable platforms with protection devices shall be provided.

5.1.4.5 Emergency pit

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

5.1.4.6 Hot metal ladle, steel ladle and slag pot

It shall be ensured that the ladle and slag pot shall be dry and free of snow/ice prior to filling with liquid metal/liquid slag to prevent dangerous steam build-up.

5.1.5 Hydraulic, pneumatic, gas, cooling and lubrication systems

Hydraulic, pneumatic, gas, cooling and lubrication systems shall be designed to reduce risks from toxic effects, fire, explosion and noise (e.g., covering and routing of pipes). It does not automatically lead to the usage of fire-resistant hydraulic fluids in general.

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