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Industrial furnaces and associated processing equipment — Safety requirements for machinery and equipment for production of steel by electric arc furnaces

Fours industriels et équipements associés — Exigences de sécurité pour les machines et les équipements pour la production d'acier par four à arc électrique

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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 on 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 the following URL: www.iso.org/iso/foreword.html.

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

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 be 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 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 by these stakeholder groups through the use of this document:

— 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 machinery and equipment for production of steel by electric arc furnaces

1 Scope

This document specifies the general safety requirements for electric arc furnaces (EAF) to melt steel not containing radioactive material.

NOTE Radioactive material is considered to be detected in front of the steel plant entrance.

This document deals with significant hazards, hazardous situations and events as listed in Table 1 pertinent to EAF, when used as intended and under conditions foreseen by the manufacturer, and also includes foreseeable faults and malfunctions in case of misuse.

This document also specifies criteria for the plant and equipment integrated in the production process.

This document specifies the requirements to be followed during design to ensure the safety of persons, which are to be met during transport, assembly, commissioning, operation, maintenance and decommissioning of the equipment.

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

This document covers the following equipment (see Annex B, Tables B.1 and B.2, and Annex C, Figures C.1 and C.2):

— EAF with alternating current (AC) technology;

— EAF with direct current (DC) technology;

— scrap preheating technology;

— associated equipment/devices (e.g. inert gas stirring, carbon and oxygen injection systems).

The following equipment is not covered by this document:

— induction furnace;

— resistance-arc furnace (e.g. submerged arc furnace);

— electron beam furnace;

— plasma furnace;

— other electrical furnaces used in secondary steelmaking, e.g. ladle furnace.

This document does not specify safety requirements for the following equipment, which can be an integral or complementary part of the equipment covered by the scope:

— cranes;

— shell lifting cross beam;

— scrap basket, steel ladle and slag pot;

— transport cars for scrap baskets, steel ladles and slag pots;

— dedusting system;

— “dog house” and “elephant house” (furnace enclosures for environmental reasons);

— alloying system;

— separate scrap drying equipment;

— furnace transformer and high-voltage system;

— robots/manipulators (e.g. for temperature measurement and sampling).

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 3864-2, *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, *Acoustics — Declaration and verification of noise emission values of machinery and equipment*

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 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/TR 11688-1, *Acoustics — Recommended practice for the design of low-noise machinery and equipment — Part 1: Planning*

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

ISO 13574, *Industrial furnaces and associated processing equipment — Vocabulary*

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

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

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

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)*

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

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

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 61310-3, *Safety of machinery — Indication, marking and actuation — Part 3: Requirements for the location and operation of actuators*

IEC 61511-1, *Functional safety — Safety instrumented systems for the process industry sector — Part 1: Framework, definitions, system, hardware and application programming requirements*

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

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 12100 and 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 http://www.iso.org/obp

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

3.1
heat cycle
tap-to-tap time period between two consecutive tappings with defined power-on and power-off time

3.2
ladle
vessel to collect, transport and charge/discharge hot metal/steel

3.3
workstation
predefined locations for personnel conducting control, production or *maintenance* (3.18) activities

Note 1 to entry: The main workstations are *EAF control room* (3.3.1), *local control stands* (3.3.2), and *portable wireless control box* (3.3.3).

3.3.1
EAF control room
main control room in which the control consoles and monitoring facilities for an EAF are located

Note 1 to entry: A location where operating personnel are required permanently during the production process.

3.3.2
local control stand
control units usually situated adjacent to the equipment

Note 1 to entry: A location where operating personnel are required temporarily during the production process, e.g. during tapping.

3.3.3
portable wireless control box
mobile control units connected to the control system

Note 1 to entry: A portable wireless control box can be used, e.g. to position the equipment more precisely.

3.4
tilting
movement of the furnace to discharge molten steel or slag from foreseen openings

3.5
blocking device
device to block the equipment in the desired position

3.6
gantry
structure used for lifting and swinging roof and columns/electrode arms

3.7
high-voltage switch gear
furnace breaker to connect and disconnect the EAF to/from electrical high-voltage supply

3.8
reactor
device to increase the reactance of the EAF system

3.9
furnace transformer
device for the transformation of the high-voltage electrical supply to arc voltage

3.10
alloying system
device to store and feed any metallic and non-metallic materials to/into the EAF

3.11
electrode nippling system
device in which electrode strands can be stored or new electrode sections are added

3.12
dog house
furnace enclosure inside the EAF building close to the EAF

Note 1 to entry: Serves as an indirect fume extraction system and minimizes noise propagation. It is not covered by the scope of this document.

3.13
elephant house
furnace enclosure as part of the EAF building

Note 1 to entry: Serves as an indirect fume extraction system and minimizes noise propagation. It is not covered by the scope of this document.

3.14
gas cleaning system
equipment for the collection and processing of created off-gas

3.15
high current system
high current connection-line between transformer and electrode

3.16
trained personnel
persons 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

3.17
authorized personnel
trained persons who are nominated by the user to perform a specific task on a specific equipment

3.18
maintenance
activities carried out outside the production process

3.18.1
inspection
basic checks (e.g. visual) of equipment

3.18.2
service
periodic exchange of lances, cleaning (e.g. lance, slag door area), lubrication, adjustment of limit switches

3.18.3
repair
mending or exchange of damaged components accompanied with complete shutdown (i.e. isolation of energy)

3.19
safety layout
graphic overview of the EAF with arrangement of safety-related elements and details

3.20
manufacturer
natural or legal person declared as responsible for compliance with the requirements of the design and/or manufacture 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.

3.21
safety access
access into a danger zone by using interlocking guards or trip devices and monitored by the safety control

Note 1 to entry: Definition of interlocking guard and trip device according to ISO 12100:2010, 3.27.4 and 3.28.5.

Note 2 to entry: In general, all hazardous movements are stopped.

3.22
enabling button
additional manually actuated device used in conjunction with a start control which, when continuously actuated, permits machine function

[SOURCE: ISO 12100:2010, 3.28.2, modified — The definition has been revised.]

3.23
hold-to-run control device
control device which initiates and maintains machine functions only as long as the control device is actuated

[SOURCE: ISO 12100:2010, 3.28.3, modified — The term "control (actuator)" has been changed to "control device".]

4 Abbreviated terms

AC alternating current

DC direct current

EAF electric arc furnace

EBT eccentric bottom tap-hole

DRI direct reduced iron

HBI hot briquetted iron

HMI human machine interface

CCTV closed circuit television

5 Significant hazards

The identified significant hazards and hazardous situations are listed in columns 1 and 2 of Table 1 and are based on a risk assessment, which applies to the equipment listed in the scope. Due to the different designs of EAFs, an individual risk assessment shall be carried out in any case, taking into account the specific characteristics of the EAF in question and the interface between the EAF and other equipment and/or parts of buildings.

6 Safety requirements and/or measures

6.1 General

6.1.1 General design requirements

EAF and equipment conforming to this document shall comply with the safety requirements and/or measures of this subclause.

This document assumes that machinery is used with adequate workplace lighting conforming to ISO 8995-1 or to local regulations.

The manufacturer shall undertake and record design calculations of the structural assembly according the intended use, e.g. for steel sections, auxiliaries.

Safety devices shall be protected against damage to fulfil the intended function during continuous operation in the respective area.

In particular, the design shall include requirements and constructional details with respect to the following:

— accessibility;

— guards and protection;

— maintenance openings and clearance gaps for cleaning;

— escape routes;

— movement of machinery and material;

— safety during operation;

— safety devices, e.g. hold-to-run control, emergency stop;

— requirements for media systems;

— slag area, e.g. heat protected;

— emergency pit for liquid steel being able to contain the steel volume of the EAF;

— potential environmental conditions, e.g. seismic activities.

6.1.2 Electrical melting power supply

The electrical melting power supply, comprising of the high-voltage switch gear, reactor (if applicable), furnace transformer, AC/DC converters (if applicable) and interconnecting high current systems and cables, shall meet the requirements as defined in IEC 60519-4.

6.1.3 Electrical low-voltage supply and control system

The electrical low-voltage supply, comprising of low-voltage switch gear, control system and low-voltage cables, shall meet the requirements as defined in IEC 60204-1 Edition 6.0.

6.1.4 Bonding and grounding of mechanical furnace parts

To prevent potential differences between mechanical furnace parts, all of these parts shall be bonded and grounded in accordance with IEC 60519-4.

6.1.5 Hydraulic, pneumatic, cooling and lubrication systems

Hydraulic and pneumatic fluid systems and their components shall meet the requirements as defined in ISO 4413 and ISO 4414.

Instruction shall be given in the information for use about systems filled with fluids, which are likely to solidify and/or change viscosity under extreme environmental temperatures and which may cause hazardous situations.

The design of cooling systems, hydraulic and lubrication systems shall consider risks created by temperature and pressure, ignition sources, including fire and toxic effects, as well as gas/dust reactions.

Instructions shall be given how to deal with small and large water leakages inside the furnace. In case of large leakages, indications of the water flow measurement shall be given to the control system to initiate further actions, e.g. stop water flow.

Media, which need to be discharged into dedicated sumps, shall be specified. Equipment which is needed for discharge shall be provided. Instructions for discharge shall be given in the information for use.

6.1.6 Molten material

Slag from furnace shall be guided to slag area (e.g. slag pot, slag pit).

Water and/or moisture shall be avoided at slagging and tapping area. Foundation shall be walled by refractory lining. Instruction shall be given; see 8.4.1.2.

6.1.7 Linked equipment

Equipment linked to the EAF, such as

— alloying system (tanks/vessels, structures, discharge/conveyor devices, etc.),

— gas cleaning system,

— dog house or elephant house,

— injection systems,

— electrode nippling system,

— temperature and sampling equipment,

— auxiliary equipment,

— cranes,

— transport cars for scrap baskets, steel ladles and slag pots,

— furnace transformer and high-voltage system,

shall be described in the documentation. Data and safety device information, with respect to take over points, shall be provided (see Figure B.1 and 8.4.1.3.5).

6.1.8 Ergonomic principles

6.1.8.1 General

Ergonomic principles shall be taken into account in designing EAF to reduce mental or physical stress and strain of the operator. These principles shall be considered when allocating functions to operator and EAF in the basic design. See EN 614-1.

All elements of an HMI such as controls, signalling or data display elements, shall be designed to be easily understood so that clear and unambiguous interaction between the operator and EAF is possible. See ISO 9355-1, ISO 9355-2, ISO 9355-3 and ISO 11064-1.

Particular attention shall be paid to the following.

a) Due to heat process, the equipment for sampling and temperature measuring shall be provided with a long balanced lever.

b) All areas where personnel have to work shall be easy to reach and easy to evacuate.

c) Dedicated lifting aids or anchoring points for common lifting devices shall be provided whenever frequent lifting or heavy tooling of machines is required.

d) Eyebolts or similar aids shall be fitted to heavy components to allow lifting equipment to be used if their mass is sufficiently high. Should manual handling be suitable or necessary, a sufficient number of handles, hand-holds or grips (e.g. more than one person may be required) with a slip-resistant (e.g. knurled) surface shall be provided.

e) Work areas used for manual handling of components shall be so designed that they are free of obstructions so that the operator is not hindered in his/her movements. The work area shall be sufficiently spacious to handle manual loads close to the body.

f) Where components require periodical maintenance, access shall be provided, according to 6.1.10.

g) Slip-resistant surfaces according to 6.1.10.5.

h) Vibration protection according to 6.1.24.

i) Heat protection according to 6.1.22.

6.1.8.2 Particular ergonomic requirements during installation and maintenance

Supporting structures provided to enable machinery parts to be assembled on site shall be designed and fabricated to ensure stability and minimize manual handling.

The positioning of electric junctions, fluid power and electrical connections and similar, can adversely affect a workers' posture during installation and subsequent maintenance. The location of such items shall so far as practicable be between 400 mm and 1 600 mm above the workers standing level and be in accordance with ISO 13857 for upper limbs.

The placement for hand wheels, levers, etc., should be between 700 mm and 1 600 mm above the workers standing level to minimize physical effort.

6.1.9 Leakage from hydraulic system and EAF transformer

Pits, collectors or other means shall be provided. Measures shall be taken to prevent the ignition of the collected leakage. Design of the pits shall include containment in the event of fire.

6.1.10 Access

6.1.10.1 Access to a danger zone shall be restricted and therefore shall be protected by guards.

Exceptions are as follows.

a) Guards preventing/hindering traffic cannot be installed on EAF working platform because trained personnel requires access free from obstacles to perform different operations.

b) Guards cannot be installed on ground floor in the EAF area because trained personnel requires access to perform different operations.

6.1.10.2 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: Prevent access until all sources of energy causing a danger inside a danger zone are in a safe condition (e.g. movements and media flows have stopped).

b) Conditions for staying/working: Movements shall not start until the interlocked guards have been closed or replaced. If hazardous movements inside a danger zone are required (e.g. for maintenance, adjustment) by overriding an interlocked guard, it shall be by means of a hold-to-run control device and by using an enabling button and, as far as practicable, at reduced speed. Changing from normal operation (overriding interlocking) to hold-to-run control shall be by means of a key-operated switch or similar means.

6.1.10.3 Access to EAF control room, control desks, 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.

6.1.10.4 Guard-rails shall be in accordance with ISO 14122-3.

6.1.10.5 Surfaces of walkways and stairs shall have slip-resistant surfaces according ISO 14122-3.

6.1.10.6 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.

6.1.10.7 Safety signs shall be in accordance with 6.1.21.2.

6.1.10.8 Where the risk of electric shock exists, access (e.g. on furnace roof/gantry, see Table 1) during power-on shall be prevented.

6.1.11 Safety-related control system

Safety-related controls shall be selected in accordance with the risk assessment and as described in ISO 13849 (all parts).

Wherever it is necessary to use SIL certified equipment in accordance with IEC 61511-1, for safety systems in accordance with ISO 13849 (all parts), the following procedure should be used.

a) By selecting the lambda values (λd, λdd, etc.), given in the safety data sheet of the equipment, the probability of dangerous failure per hour (PFHd) shall be calculated, considering the hardware fault tolerance, as well as the system architecture, given in IEC 62061.

b) With the calculated value, the corresponding performance level shall be selected by using ISO 13849-1:2015, Table 3.

6.1.12 Danger zone

For areas with residual risk of ignition, toxic effects, gas/dust accumulation or suffocation, information for use shall specify specific actions [e.g. fresh air exchange, removal of dust, personal protective equipment (PPE)].

For areas with the risk of unexpected flame propagation or splashing of molten material, the information for use shall specify specific actions.

In case of access to lower floor levels (e.g. pit, tank, closed room), information for use shall specify specific instructions.

6.1.13 Blocking device for tilting platform

The tilting platform of the EAF shall be blocked in horizontal position during gantry movements. If the tilting cylinder is used as blocking device, a check valve shall be fixed directly to the tilting cylinder(s) to protect against hose failure. Status (position) of blocking devices shall be indicated to the operator at the control room.

6.1.14 Gantry movement

Prior to gantry movement, the following interlocks shall be provided by a safety control system in accordance with ISO 13849-1:

a) tilting platform locked in horizontal position;

b) electrodes locked and in a position higher than the upper shell;

c) roof locked in upper position;

d) gantry unlocked;

e) EAF power supply switched off.

The positions of the equipment above shall be monitored and indicated to the operator at the control position.

6.1.15 Loss of energy

In case of loss of energy (hydraulic, pneumatic, electric), it shall be possible to move all furnace components, especially shell, roof and electrodes, into stable position by manual operation without supply of external energy.

Provisions, e.g. a nitrogen accumulator, shall be provided to move the tilting platform into horizontal position.

Where necessary, emergency cooling water shall be provided.

Where necessary, an emergency power supply shall be provided.

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

6.1.16 Electrode clamp

The electrodes shall be clamped mechanically by spring force.

Unintentional opening of the electrode clamp shall be avoided.

An interlock shall be provided to

a) prevent the release of the clamp before the furnace breaker is switched-off,

b) prevent unintended release of the electrode clamp by use of a key-operated switch.

6.1.17 EAF control room

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

Good view from the operators' position to the EAF shall be ensured (direct or using CCTV).

The operators' position shall be designed that frequently used controls are located in a zone of comfort reach. Occasionally used controls can be located in a zone of reach.

The EAF control room shall be as follows:

a) air conditioned;

b) thermal insulated;

c) noise protected;

d) equipped with heat-reflecting windows;

e) equipped with special coloured glass areas to protect operators' eyes against high radiation light (arc);

f) protected against external impact by, e.g. slag and steel splashes;

g) positioned away from high current system.

6.1.18 Local control stand

A local control stand shall be in accordance with IEC 60204-1 Edition 6.0.

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

6.1.19 Portable wireless control box

A portable wireless control box (i.e. a temporary work place) shall be in accordance with IEC 60204-1 Edition 6.0:2016, 9.2.7.

6.1.20 Personal protective equipment (PPE)

The manufacturer shall give instruction in the information for use manual (see 8.4.1.2) on the required type of personal protective equipment.

6.1.21 Warnings

6.1.21.1 Visual and audible danger signals

a) Audible warning signals shall be in accordance with ISO 7731.

b) General requirements, design and testing of visual danger signals shall be in accordance with ISO 11428.

c) System of auditory and visual danger and information signals shall be in accordance with ISO 11429.

d) Electrical requirements for visual, acoustic and tactile signals shall be in accordance with IEC 61310-1.

e) Electrical requirements for indication, marking and actuation shall be in accordance with IEC 61310-2.

f) Electrical requirements for the location and operation of actuators shall be in accordance with IEC 61310-3.

The information for use shall contain instructions for maintenance of such devices; see 8.4.2 g).

6.1.21.2 Safety signs

a) Safety signs shall be in accordance with ISO 7010.

b) Design principles for safety signs shall be in accordance with ISO 3864-1.

c) Design principles for product safety labels shall be in accordance with ISO 3864-2.

d) Design principles for graphical symbols for use in safety signs shall be in accordance with ISO 3864-3.

e) Safety way guidance systems (i.e. possibility of escape) shall be in accordance with ISO 16069.

6.1.22 Surface temperatures and heat radiation

Surfaces outside restricted areas that are accessible and could be touched shall have temperatures not exceeding the burn threshold for contact time and material specified in ISO 13732-1. Where these limits cannot be kept, additional technical measures shall be applied, e.g. insulation, distance guard. These measures shall be supplemented by warning instructions and wearing of PPE, if necessary.

6.1.23 Noise

6.1.23.1 Noise reduction at source by design

When designing a machine, technical measures for reducing noise at source at the design stage shall be considered in accordance with ISO/TR 11688-1.

Examples for general measures which should be considered are the following:

— reduce power of impact (e.g. by attenuated impact);

— reduce oscillation amplitude or vibration frequency (e.g. by reducing unbalance, increasing mass);

— reduce noise of gas flow (e.g. sound absorbers);

— use materials with high internal damping (e.g. cast instead of steel plate structures, sandwich plate).

Noise emission from electric arc furnaces is particularly high during charging of scrap and melt down procedure. No technical measures are known to reduce the noise at the source during scrap charging and melting procedure.

NOTE ISO/TR 11688-2 gives useful information on noise generation mechanisms in machinery.

6.1.23.2 Noise reduction by protective measures

A sound insulated EAF control room has to be provided to protect the operators. In general, a sound attenuation of more than 40 dB to 50 dB shall be achieved to ensure an average noise level of less than 80 dB(A) inside a control room.

NOTE 1 National legislation often determines the maximum noise level for industrial workplaces.

NOTE 2 An elephant house or a dog house can be used to reduce noise propagation of the EAF.

Protective measures shall be provided, for example:

— access to the control room via isolated vestibule (e.g. two-door-system);

— enclosures (e.g. hydraulic pump station, transformers);

— screens (e.g. at local control stands);

— silencers (e.g. valves of the pneumatic system);

— increased distance between source and EAF control room.

NOTE 3 The efficacy of such protective measures can be estimated, e.g. by using ISO 11546 (all parts) (for enclosures), ISO 11691 and ISO 11820 (for silencers) and ISO 11821 (for screens).

6.1.23.3 Noise reduction by information

If noise reductions at source and/or by protective measures are not sufficient, further protection of the operator is necessary. The user shall be informed about these facts, e.g. use of hearing protection [see 8.4.1.2 e)], installation of sound absorbing material lining on room surfaces [see 8.4.1.2 e)].

6.1.24 Vibrations

Vibrations shall be considered at the design stage; see EN 1299.

Harmful hand-arm vibration at EAF during the process is not expected.

Where the risk of whole-body vibration exists, measurement shall be made; see EN 14253.

NOTE 1 Experience has shown that the magnitude of hand-arm vibration of this equipment is in general significantly below 2,5 m/s^2.

NOTE 2 This single whole-body vibration emission value determined under particular operating condition is not representative for the various conditions in accordance with the indented use of the machinery. Consequently, this single whole-body vibration emission value declared by the manufacturer in accordance with this document is not intended to determine the whole-body vibration exposure to the operator of the machinery.

NOTE 3 Information to the uncertainty of vibration measurement and the declaration of verification of vibration values are given in EN 12096.

6.1.25 Special requirements for explosion prevention and protection

Where combustible dusts or flammable gases necessary for or produced by the melting process may create potentially explosive atmospheres external to the furnace vessel, the following specific requirements shall apply.

Risk assessment of hazardous situations leading to explosion and design and construction measures appropriate for the required safety shall be implemented. For details about basic concept and methodology of explosion prevention and protection, see EN 1127-1. For ignition hazard assessment of non-electrical equipment, see EN 13463-1:2011, 5.2.

NOTE 1 If the ignition hazard assessment ensures that the equipment does not contain any effective ignition source in normal operation, the furnace equipment can be classified in accordance with EN 13463-1 as category 3 equipment.

Protective measures/types of protection shall be 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. covering hydraulic hoses.

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

NOTE 2 EN 13463-1 and EN 13463-5 specify requirements for non-electrical equipment.

NOTE 3 IEC 60079-0 specifies requirements for electrical equipment.

Ducts, hoses and pipes used for exhausting flammable dusts, gases, vapours or mist shall be bonded and grounded (see 6.1.4). Information shall be given in the instruction handbook.

6.1.26 Safety layout

The manufacturer shall prepare a safety layout document of the EAF. The safety layout shows the spatial arrangement of safety-related elements and areas around the EAF and shall include a key.

The safety layout shall be part of the information for use. An unambiguous relationship shall be established between the information provided in the safety layout and the information for use.

NOTE Specific issues, in particular interfaces like escape routes (of the plant/building) or fire extinguishing devices, will be jointly clarified between manufacturer and user.

Where applicable, the following shall be shown:

a) danger zones (related to single and/or interconnected machinery);

b) areas with specific residual risks, e.g. influence of asphyxiant gases, due to CO_2-extinguishing installation;

c) safeguards;

d) safety access;

e) means of escape;

f) local control devices or stands with safety-related functions;

g) emergency stop devices;

h) warning devices and safety signs.

6.2 List of significant hazards, hazardous situations, safety requirements and/or 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 EAF.

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 minimize 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.

— 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 verifies that the features provided perform their function in such a way that the requirement is met.

M: Measurement verifies 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.

When implementing safety requirements and/or measures, simultaneous hazards shall be considered.

Table 1 — Significant hazards, hazardous situations, safety requirements and/or measures

Significant hazard	Hazardous situation	Safety requirement and/or measure	Reference	Verification
General requirements				
Combination of hazards	Unauthorized access	Restrict access to authorized personnel	6.1.1 6.1.10	V, D
		Provide warning signs and visible and/or audible signals	6.1.21	V, D, T
		Provide devices to give clear view to critical areas not visible from EAF control room	6.1.17	V, D
		Operating/maintenance instruction: advice on the use of safe working procedures, e.g. use of safety locks, access only for authorized persons	8.4.1.2	V
Slips, trips and falls	On or from stairs, ladders, platforms or walkways	Open sides of platforms and walkways shall be fitted with, e.g. guard-rails and toe boards	6.1.10	V, D
		Stairways shall be provided with a handrails or equivalent protection	6.1.10	V, D

Table 1 *(continued)*

Significant hazard	Hazardous situation	Safety requirement and/or measure	Reference	Verification
		Treads of stairs, walkways and platforms shall be constructed to prevent slipping and to be easily cleaned of oil, grease, etc.	6.1.10	V, D
EAF including scrap preheating				
Mass and stability	— Shell tilting position (imposed, not forced) during scrap loading, slagging off and tapping — Loss of control of shell movement (uncontrolled mass motion) — Loss of control may cause loss of liquid steel and damage structures	Blocking devices to avoid uncontrolled shell movements	6.1.13	V, D, T
Parts under voltage	Electric shock, caused by approaching live parts, i.e. electrode arms, electrodes during inspection/ maintenance of roof and gantry	Provide interlock device to prevent access on furnace roof/gantry during power on	6.1.10 6.1.11 6.1.14	V, D, T
	Potential difference on furnace	Levelling of the potential difference of different furnace equipment (e.g. shell, roof, gantry)	6.1.4	V, D, M
Electromagnetic fields	Magnetic fields causing interference with, e.g. implants, pacemakers	Provide warning signs	6.1.21	V, D
		Operating/maintenance instruction: e.g. danger for “pacemaker holders”, personnel with implants should not work in this area	8.4.1.2	V
Water leakage	Small water leakage inside the furnace, with direct evaporation	Operating/maintenance instruction	8.4.1.2	V
	Large water leakage inside the furnace	Provide devices to monitor cooling water parameters, e.g. temperature, pressure, flow rate	6.1.5 6.1.11	V, D, T, M
		Provide devices, e.g. automated valves, to shut-off the water circuit from EAF control room initiated by the operator	6.1.5 6.1.11	V, D, T
		Operating/maintenance instruction: No furnace movement prior all water is evaporated, actions to be taken in case of emergency	8.4.1.2	V
	Reaction between water and molten steel or slag	Water in pits underneath furnace shall be prohibited	6.1.6	V
		Drainage of cooling water away from the EAF into containment	6.1.5	V, D
		Operating/maintenance instruction	8.4.1.2	V

Table 1 *(continued)*

Significant hazard	Hazardous situation	Safety requirement and/or measure	Reference	Verification
Gas/particle reactions	Gas reactions inside fume ducts	In case of failure of the off-gas system, the EAF shall be switched off automatically	6.1.11 6.1.25	V, D, T
		Operating/maintenance instruction	8.4.1.2	V
Unexpected reactions	— Chemical reaction within liquid steel, slag — Overflow of steel slag from EAF or ladle	Tapping and de-slagging area shall be designed as delimited and free of water pooling, walled by refractory lining	6.1.6	V, D
		Operating/maintenance instruction: Only dry alloy and other material to be charged into liquid steel	8.4.1.2	V
Combination of hazards	Contact between roof and electrodes during movement, ejection of heated parts or material	Uncontrolled movement of equipment (sequential processes steps and electrical interlocks) shall be prohibited	6.1.11 6.1.15	V, D, T
		Roof and electrodes shall be lifted prior roof swivelling	6.1.11 6.1.15	V, D, T
		End positions shall be monitored	6.1.11 6.1.15 6.1.17	V, D, T
		Operating/maintenance instruction: Clamp electrodes with correct length	8.4.1.2	V
	Working in the tapping area	Operating/maintenance instruction: Access to the area during operation and presence of persons should be prohibited	6.1.10 8.4.1.2	V
	De-slagging	Operating/maintenance instruction: Access to the slag pit area during de-slagging should be prohibited	6.1.10 8.4.1.2	V
	Working in de-slagging area	Tilting the EAF in de-slagging position shall not be possible	6.1.11	V, D, T
		Provide an entrance concept for access to the de-slagging area NOTE In general, this is applicable for green field projects. For revamping, the user is responsible.	6.1.10	V, D, T
		Operating/maintenance instruction: Access to the area and presence of unauthorized persons should be prohibited	6.1.10 8.4.1.2	V
Restart of energy supply after interruption	Uncontrolled movement of roof, shell, blocking device and tap-hole device	Provide safety control system	6.1.11 6.1.15	D, T
		Operating/maintenance instruction: Presence of unauthorized persons should be prohibited	6.1.10 8.4.1.2	V

Table 1 *(continued)*

Significant hazard	Hazardous situation	Safety requirement and/or measure	Reference	Verification
Failure of power supply	Failure of power supply (hydraulic, pneumatic, electric) causing uncontrolled movement of the equipment	Ensure safe conditions, particularly all EAF components, especially shell, roof and electrode shall go into stable position by manual operation with or without supply of external energy	6.1.11 6.1.15 6.1.17	D, T
		Operating/maintenance instruction	8.4.1.2	V
Accidental release of electrode	Drop of electrode	Prevent clamp release due to failure of control system or power supply	6.1.11 6.1.16	D, T
		No release command during normal operation condition (e.g. key switch)	6.1.11 6.1.16	D, T
Contact with gases, fumes and dust	Exposure to fume, gas and dust	Fume, gas and dust shall be evacuated from plant	6.1.12	V, D, T
		In case of failure of the off-gas system the EAF shall be switched off automatically	6.1.11	D, T
		Operating/maintenance instruction	8.4.1.2	V
Falling objects, slag and steel splashing	Presence of persons during scrap charging via scrap bucket	Provide protective equipment during scrap charging (e.g. housing for crane operator)	6.1.18 6.1.20	V, D
		Operating/maintenance instruction: Presence of persons in the hazardous area should be prohibited during charging activities	6.1.10 8.4.1.2	V
	Presence of persons during scrap charging via skip elevator	Provide protective equipment during scrap charging (e.g. guards or covered walkways) and	6.1.10	V, D
		Operating/maintenance instruction: Presence of persons in the hazardous area should be prohibited during charging activities	6.1.10 8.4.1.2	V
EAF control room and local control stands				
Slip, trip, fall	Escape in case of danger	Provide safe escape with proper marking	6.1.1 6.1.21.2 6.1.26	V, D
		Escape ways only built with straight staircases (not spiral staircases) and wide enough for handling a rescue stretcher	6.1.1 6.1.10	V, D
		Slip-resistant flooring material	6.1.10.5	V, D
Heat, cold, draught	Hot or cold work environment Draught conditions at local control stands	Thermal isolation in accordance with ISO 11064-1	ISO 11064-1	V, D
		Heat-reflecting windows in accordance with ISO 11064-1	ISO 11064-1	V, D
		Air conditioning in accordance with ISO 11064-1	ISO 11064-1	D, T, M
Combination of hazards	Ejection of parts	Provide fixed or movable protection walls	6.1.1	V, D
		Location at a safe distance	6.1.1	D
		Impact resistant glass/adequate material and walls	6.1.17	V, D

Table 1 *(continued)*

Significant hazard	Hazardous situation	Safety requirement and/or measure	Reference	Verification
	Impact by vehicles, cranes or travelling load	Select a safe location	6.1.1	D
		Collision protection (e.g. by fencing, bollards) robustly fixed in position	6.1.1	V, D
		Firm fixture to the building structure	6.1.1	V, D
		Operating/maintenance instructions: crane passage with load prohibited above control stand	8.4.1.2	V
Impact	Projection of parts to EAF control room or control stand	Design to resist external impact (e.g. protective screen, impact-resistant glass)	6.1.17	D
Noise	Hearing impairment: Accidents due to disturbance of speech communication and non-perception of acoustic signals:			
	— EAF control room	Reduce noise by design, e.g. provide sound insulated control room	6.1.23.1 6.1.17	D, M
	— Local control stand	Provide measures to reduce noise by design (e.g. sound-reducing capsule)	6.1.23.2	V, D
		Operating/maintenance instructions: Wearing of special PPE (ear protection) at local control stands	6.1.20 8.4.1.2	V
Vibration	Transmission of vibrations	Control rooms shall be isolated from vibration source	6.1.24	D, M
Impaired vision	Operator error caused by insufficient lighting or dazzle	Provide sufficient lighting	6.1.1 6.1.17	V, D, M
		Arrangement of light sources or selection that glare is avoided/ minimized	6.1.17	V, D
		Provide tinted glass/adequate material to prevent dazzle from outside	6.1.17	V, D
		Operating/maintenance instructions: Maintenance of the lighting system	8.4.1.2	V
Visible, infrared and ultraviolet light	High radiation light, influencing operator's eyes	Special coloured glass shall be provided at EAF control room and control stand	6.1.17	V, D

Table 1 *(continued)*

Significant hazard	Hazardous situation	Safety requirement and/or measure	Reference	Verification
Mental overload, fatigue of the operator, decrease in concentration	Excessive stress and strain	Workplace design, taking account of ergonomic principles	6.1.8	V, D
	Overstressing caused by excessive number of screens and controlling instruments	Automatic operation where possible	6.1.11	D
		All safety-related information requiring action by the operator shall be indicated at the main monitor	6.1.8	V, D
		Information that have to be observed permanently by the operator shall be shown on only one or two monitors	6.1.8	V, D
	Overstressing caused by too much information shown on one monitor	Ergonomic visualization of monitor contents	6.1.8	V, D
Ergonomic problems	Influence on performance of personnel at work stations	Provide ergonomic concepts, e.g. inside EAF control room: Visual display of controls, good direct visibility to EAF or via CCTV, air condition	6.1.8 6.1.17	V, D

7 Verification of the safety requirements and/or measures

It is necessary to verify that all requirements of this document have been incorporated in the design and manufacturing of the EAF.

The verification required is defined in Table 1, column 5.

Verification of electrical safety shall be made in accordance with IEC 60204-1 Edition 6.0 and IEC 60519-4.

Verification of noise shall be made in accordance with the noise test code given in Annex A to verify the effectiveness of the measures taken at the design stage.

Verification shall be carried out at the latest prior to putting into service.

If partial disassembly is necessary for verification, e.g. to gain access, it shall not affect the function being verified. Safety devices put out of operation for verification shall be restored before verification is completed.

8 Information for use

8.1 General

Information for use is an integral part of the design of an EAF. It shall comply with the requirements of ISO 12100:2010, 6.4 and the requirements of this document. Information for use shall consist of communication links, such as texts, words, signs, signals, symbols or diagrams, used separately or in combination to convey information to the user.

8.2 Warning devices and safety signs

Warning devices and safety signs shall be in accordance with 6.1.21.

8.3 Minimum marking

The following information shall be attached clearly and durably, e.g. in the EAF control room:

a) name and address of manufacturer and, where applicable, the name and address of the authorized representative;

b) designation of series or type, if any;

c) mandatory marking;

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

d) serial number/machine number, if any;

e) year in which the manufacturing process was completed.

In accordance with IEC 60204-1 Edition 6.0, the auxiliary electrical equipment shall be fitted with durable plates containing data, including casing protection grade.

8.4 Accompanying documents

8.4.1 Instruction handbook

8.4.1.1 General

An instruction handbook for each machinery/equipment shall be provided by the manufacturer. In this manual, the characteristics and measures to the specific machine/equipment shall be designated. The following items describe exemplarily the structure and content of an instruction handbook and shall be completed or extended in consideration of the specific equipment.

8.4.1.2 Machine/equipment declaration

The following information shall be given:

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

b) technical documents (circuit diagrams, data sheets, information/reference for spare parts);

c) for intended use, details to interfaces of additional/optional machinery;

d) for non-intended use (e.g. forbidden use of specific auxiliary equipment, prohibition of specific materials);

e) noise emission values determined according to Annex A and, where necessary, recommendation to e.g. wear hearing protection;

f) description of auxiliary equipment and the installation of the control system of these (e.g. emergency stop, effect of the safety devices);

g) information about molten material (e.g. slag guidance, avoidance of water/moisture, etc.).

8.4.1.3 Detailed information/instructions

8.4.1.3.1 Safety layout

See 6.1.26 for details about safety layout.

8.4.1.3.2 Instructions for transportation and assembly of the equipment

Instructions for transportation, setting up and installation shall be given, especially:

a) instructions for safe lifting (e.g. transport rig, ring bolt, centre of gravity);

b) transportation weight;

c) transport safety devices and removal of these before commissioning;

d) instructions for correct connection of take-over-points;

e) prohibition of unauthorized reconstruction and modification;

f) plant layout/installation conditions (e.g. foundation plan, requirements of the building);

g) 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;

h) details on the fume and dust emission and arrangements provided for connection to extraction system.

8.4.1.3.3 Information about commissioning and dismantling of the equipment

Detailed information shall be given concerning associated significant risks and necessary remedial measures. In particular, it shall include the following details:

a) energy supplies (electric, hydraulic, pneumatic);

b) filling amounts;

c) specification of fluids;

d) fitting of special devices;

e) safe starting, operation and shut-down;

f) inspection and proofing of safety devices before commissioning;

g) unauthorized reconstruction and modification;

h) residual risks in areas surrounded by guards and guard-rails;

i) reference for disabling (e.g. disposal of high pressure fluids, emptying instructions, handling of radioactive materials);

j) reference to qualification of operation personnel;

k) instruction for flooding in case of leakage;

l) information concerning the need of PPE and its use.

8.4.1.3.4 Equipment-related operation instructions

The following operation instructions shall be given:

a) available safety devices;

b) instruction on safety devices;

c) regular inspection of safety devices;

d) significant hazards (e.g. electrical current, hydraulic, especially reference to setting up and re-commissioning after setting up);

e) processing materials which generate fume or dust hazardous to human health including cleaning requirements;

f) description of safety-related control systems;

g) references about the qualification level of operators;

h) instruction and training to be given to the operator how to operate the machine;

i) action in the event of faults or irregularities and abnormal operation;

j) references to hazards due to:

   1) non-relieved pressures,

   2) malfunction of programmable electronic systems,

   3) fire,

   4) noise,

   5) hot surfaces in the working area,

   6) ejection of material,

   7) ejection of fluids,

   8) areas surrounded by guards and guard-rails;

k) references to particular hazards when occasional access is required (e.g. maintenance, trouble-shooting) shall be identified in the instruction handbook and on the machine by markings/symbols referring to the nature of hazard. If protective devices are not operational during this action, the necessary actions shall be indicated (see e.g. 6.1.10.2).

8.4.1.3.5 Linked equipment

Information about linked equipment and take over points shall be provided.

8.4.2 Maintenance manual

The maintenance manual shall contain the following instructions:

a) the testing to be carried out;

b) maintenance work;

c) criteria for repair work;

d) isolation, elimination or reduction of energy sources to a non-hazardous level;

e) protective measures against hazardous situations, e.g. periodical check of shell temperature and refractory conditions;

f) maintenance activities that require special knowledge or qualification;

g) a periodical inspection programme of the safety devices and the frequency of these inspections that shall be defined at the design stage according to the reliability, nature and importance of the device;

h) preventive measures (e.g. replacement of wear parts, lubrication, etc.);

i) error messages of the control system and the actions resulting from this;

j) which parts of the system(s) shall be switched off during repair work;

k) instructions on existing residual energy (hydraulic reservoir, etc.) and its reduction, where necessary;

l) electrical isolation and grounding required during maintenance and repair;

m) warning in case of hot surfaces;

n) references to residual hazards, for example:

   1) radiation,

   2) hot surfaces in the working area,

   3) stored energy,

   4) ejection of material,

   5) ejection of fluids,

   6) access to hazardous areas after removal of guards and guard-rails.

The maintenance manual shall contain the following:

— the safety layout;

— lists of spare parts with reference to drawings or circuit diagrams;

— fault lists indicating causes of malfunction and measures to be taken.

8.5 Training of personnel

The manufacturer of the equipment shall inform the user that specific training of personnel is needed to use the EAF safely.

Such a specific training program shall consider the entire life cycle of the equipment and specifically shall cover the following operation conditions:

— plant start-up;

— normal operation;

— operation under abnormal conditions;

— service and maintenance;

— shut down procedures.

In case of computerized process control, training program shall specifically include interactions between personnel and equipment in different modes of operation: manual, automatic, local and maintenance control.

The manufacturer shall inform the user that he/she should provide personnel with regular refresher training.

Annex A
(normative)

Noise test code

A.1 General

Electric arc furnaces are not standard machines and are tailored to satisfy customers' specifications. They are extremely noisy equipment. The present state of the art does not allow reducing noise emission at the design stage to low values. Therefore, working in the neighbourhood of an EAF is only possible if a well-chosen and efficient hearing protection is worn. Due to this, an EAF control room (see 6.1.17) is in any case necessary to operate the EAF.

The noise emission of an EAF depends on many parameters, in particular

— type and size of scrap including charging procedures,

— active power and secondary voltage,

— mode of operation (melt down, foamy slag operation, refining, etc.),

— use of non-electrical energy sources (oxygen injection, oxy-fuel burners, etc.), and

— powder and/or alloy injection.

These parameters cannot be standardized as they differ within each cycle and from user to user.

In order to ensure the traceability of noise emission values to the operating conditions of the EAF, so allowing the test to be repeated, it is necessary to know the values of the main operating parameters of the EAF during noise emission measurement. This is why this noise test code requires operating procedures to be recorded, reported and declared in detail.

EAF never operate at the manufacturers place. Noise emission measurement can only be carried out after commissioning.

This noise test code specifies all the information necessary to carry out efficiently and under defined conditions the determination, declaration and verification of the noise emission characteristics for electric arc furnaces.

The noise emission of a machine in general is described by two quantities: the A-weighted emission sound pressure level at the EAF control room (permanent workstation) and temporary workstations (e.g. local control stands, positions for sample taking and temperature measurement) and the A-weighted sound power level. They are used by the manufacturer to declare the noise emitted.

This noise test code gives information on the selection of suitable standards for noise measurement. The use of this document ensures the reproducibility of the determination of the noise emission characteristics within specified limits determined by the grade of accuracy of the basic noise measurement method used. Methods of grade 2 of accuracy (engineering method) shall be preferably used. Methods of grade 3 of accuracy (survey method) can be used, but the reason for not using a grade 2 method shall be reported.

NOTE For further information, see ISO 11200.

A.2 Determination of sound power level

There would be a need to determine the sound power level of an EAF because the A-weighted emission sound pressure level at the operators on the floor is much higher than 80 dB. However, access is limited for safety reasons (i.e. high current equipment/cables, tapping area, underneath direct gas cleaning system) around an EAF in operation and due to the presence of electromagnetic fields. Therefore, it is not possible to determine the sound power level. It is either not possible to measure at points on a path around an EAF.

A.3 Determination of emission sound pressure level

The A-weighted emission sound pressure levels shall be determined in accordance with ISO 11202. Due to the fact that there is one dominant noise source (electric arc during material melt-down) and depending on the value of the local environment correction K3, grade 2 or grade 3 results can be obtained.

The emission sound pressure level shall be determined at least at the following workstations:

a) 5 m from the slag door during melting and refining;

b) at the tapping stand prior and during tapping;

c) inside the EAF control room(s), at the operators' position(s).

At each workstation, measurements shall be carried out for three consecutive heat cycles. The declared value shall be the arithmetic average of the three values measured.

A.4 Measurement uncertainty

The total measurement uncertainty of the noise emission values determined in accordance with this document depends on the standard deviation of reproducibility of the measurement:

σ_{R0}

as given by ISO 11202 and the uncertainty associated with the instability of the operating and mounting conditions:

$\sigma\ omc$

The resulting total standard deviation, $\sigma\ tot$, is then calculated as shown in Formula (A.1):

$$\sigma\ tot^2 = \sigma_{R0}^2 + \sigma\ omc^2 \qquad \text{(A.1)}$$

The upper bound value of σ_{R0} is about 1,5 dB for the grade 2 measurement methods dealing with the determination of the emission sound pressure level or the sound power level.

NOTE 1 For more information on measurement uncertainty, see ISO 11202:2010, Annex C.

For machines with a rather constant noise emission, a value of 0,5 dB for $\sigma\ omc$ can apply. In general, converters have an instable noise emission, especially during the blowing process (e.g. different blowing conditions and different input materials). In this case, a value of 2 dB may be more appropriate. Methods to determine $\sigma\ omc$ are described in ISO 11202:2010, Annex C.

The expanded measurement uncertainty, U, in decibels, shall be calculated with $k = 2$, the coverage factor, for two-sided normal distribution at confidence level of 95 %, from Formula (A.2):

$$U = k\ \sigma\ tot \qquad \text{(A.2)}$$

NOTE 2 The expanded measurement uncertainty depends on the desired confidence level. For the purpose of comparing the result with a limit value, it is appropriate to apply the coverage factor for a one-sided normal distribution. In that case, the coverage factor k = 1,6 corresponds to a 95 % confidence level. Further information is given in ISO 4871. Note that the expanded measurement uncertainty, U, is denoted K in ISO 4871.

A.5 Operating conditions

Measurements shall be made under representative operating conditions agreed between manufacturer and user, considering the following:

— heat cycle number;

— type and size of scrap and/or other charging material (e.g. HBI, DRI, hot metal) including charging procedures;

— active power and secondary voltage;

— mode of operation (melt down, foamy slag operation, refining, etc.);

— use of non-electrical energy sources (oxygen injection, oxy-fuel burners, etc.);

— material injection.

The measurement shall be carried out with only one EAF in operation.

A.6 Information to be recorded and reported

At least the following information shall be recorded and reported:

a) manufacturer, kind of equipment/plant, boundary and technical data and sizes;

b) operating conditions under which noise is measured (see A.5);

c) measurement results:

   1) A-weighted emission sound pressure level at each workstation,

   2) possible deviations to this noise test code or to ISO 11202, with the justification for them;

d) position of workstations according to A.3, a) b) and c), measurement points and duration of measurement;

e) place and date of measurement, identifying information of the responsible person/body.

A.7 Declaration and verification of noise emission values

For an EAF, only estimated values can be given as noise emission values before commissioning. Due to this, the noise emission shall be measured by the manufacturer *in situ* during commissioning and declared afterwards.

The declaration of the A-weighted emission sound pressure levels at the workstations (see A.3) shall be given in the instruction handbook. The dual-number format shall be used, i.e. measured values and associated uncertainty shall be declared separately.

If carried out, the verification of noise emission values shall be made

— using the same operation conditions as those used for the noise declaration, and

— in accordance with ISO 4871.

The noise declaration shall explicitly mention the fact that the noise emission values have been obtained according to the specifications of this noise test code and indicate that the measurements have been carried out in accordance with ISO 11202. If this statement is not true, the noise declaration shall indicate clearly what the deviations are from these specifications and/or ISO 11202.

Table A.1 shows an example of a dual-number noise declaration. The given values are only for illustration.

Table A.1 — Example of declared dual-number noise emission values

Type of EAF:	**AC**
Identification of EAF:	**EAF No. 2**
Capacity:	**120 t**
Measurement conditions:	
— heat cycle number:	00322
— type(s), size(s) and density/ies of scrap:	100 % HMS, 1 m maximum length, 0,7 t/m^3
— charging procedures:	two basket operation
— active power and secondary voltage:	70 MW, 700 V
— mode of operation:	melt down
— use of non-electrical energy sources:	oxygen injection
— material injection:	lime
DECLARED DUAL-NUMBER NOISE EMISSION VALUES	
A-weighted emission sound pressure level inside EAF control room:	
Measured value:	L_{pAeq} = 73 dB (re 20 µPa)
Uncertainty:	K_{pA} = 4 dB
A-weighted emission sound pressure level close to slag door (4 m distance):	
Measured value:	L_{pAeq} = 115 dB (re 20 µPa)
Uncertainty:	K_{pA} = 4 dB
A-weighted emission sound pressure level at tapping stand:	
Measured value:	L_{pAeq} = 105 dB (re 20 µPa)
Uncertainty:	K_{pA} = 4 dB
Values are determined according to the noise test code described in Annex A and noise measurement standard ISO 11202.	
NOTE The sum of a measured noise emission value and its associated uncertainty represents an upper bound of the range of values that can occur in measurements.	

Annex B
(informative)

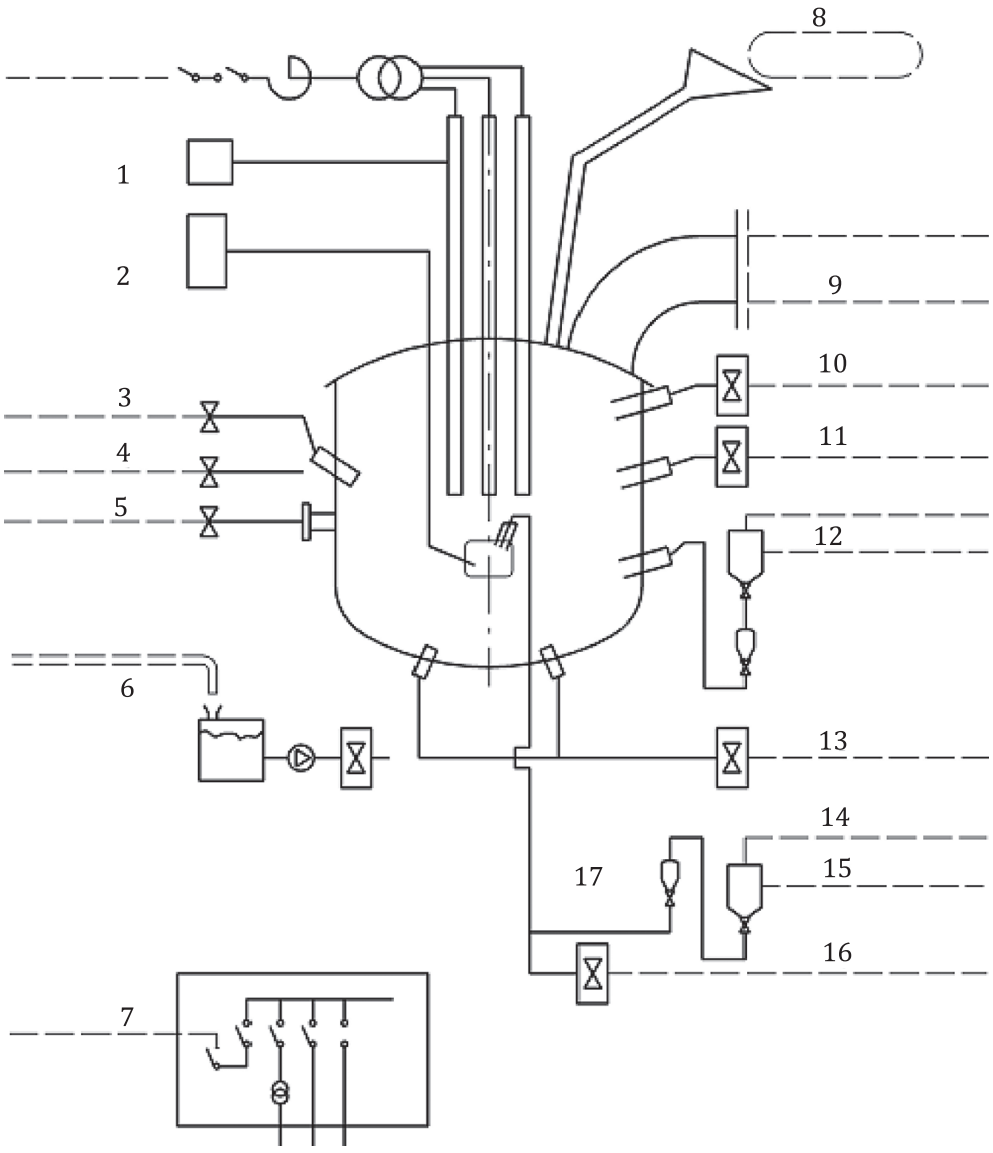
Equipment covered by this document

Table B.1 — EAF with AC technology

Vessel including upper shell with water cooled or refractory panels and refractory clad bottom with tapping system (e.g. spout, EBT, etc.)
Roof with roof support and water cooling system
Furnace tilting platform including cylinders
Integrated scrap preheating system (in case applicable)
High current system including water cooled cables and electrode arms
Electrode gantry including masts and cylinders
Electrode regulation system
Media distribution including shut-off valves

Table B.2 — EAF with DC technology

Vessel including upper shell with water cooled or refractory panels and refractory clad bottom with tapping system
Roof with roof support and water cooling system
Furnace tilting platform including cylinders
Integrated scrap preheating system (in case applicable)
High current including water cooled cables to electrode arm and bottom anode system
Electrode gantry including mast and cylinder
Electrode regulation system
Media distribution and shut-off valves



Key

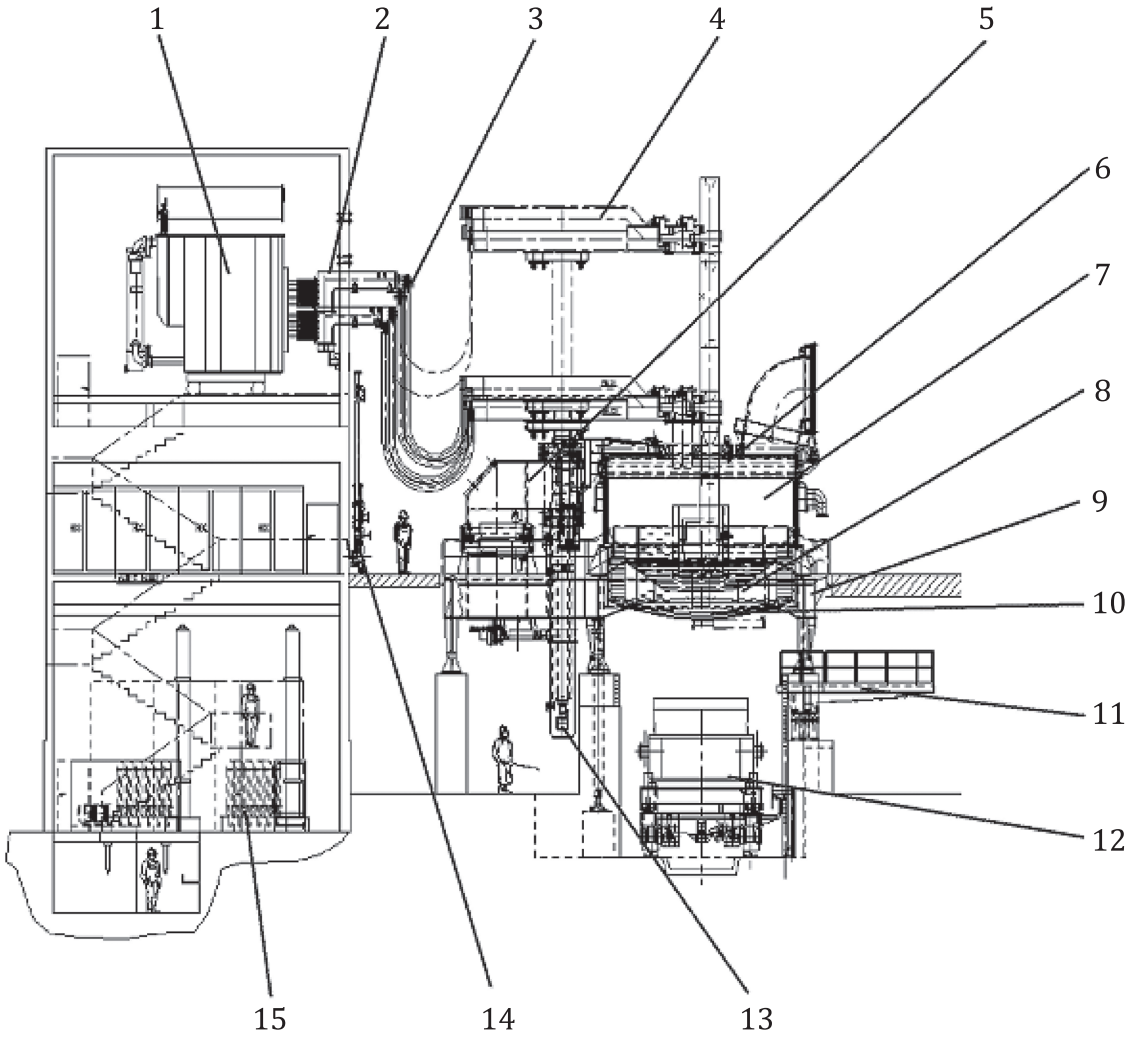
1	electrode controller	10	burner
2	temperature and sampling system	11	O_2 injector
3	post combustion (O_2)	12	carbon injector and nitrogen
4	compressed air	13	gas tuyeres or bottom stirring
5	cooling water	14	carbon (C)
6	hydraulic system	15	nitrogen (N_2)
7	low-voltage control system	16	oxygen (O_2)
8	additives	17	door manipulator
9	gas cleaning system		

NOTE Bottom tapping service system (walkways), shell lifting crossbeam and devices with respect to integrated scrap preheating are not shown in Figure B.1.

Figure B.1 — Specification of equipment covered by this document (solid line) and take over points of linked equipment (dashed line)

Annex C
(informative)

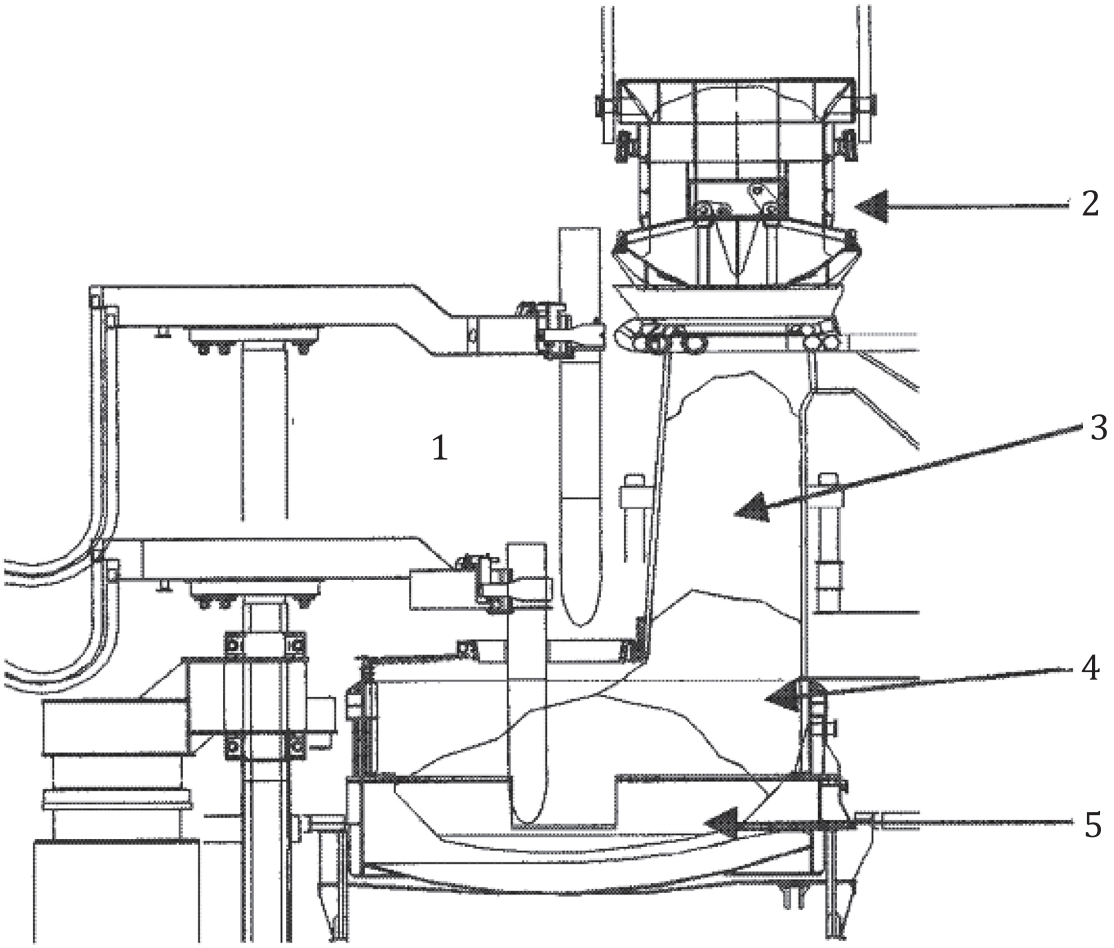
Examples of electric arc furnaces



Key

1 furnace transformer
2 furnace secondary bus bar system
3 fables, water cooled
4 electrode arms
5 roof and electrode gantry
6 roof, water cooled
7 shell, with panels, water cooled
8 bottom, refractory clad
9 tilting platform, incl. cylinder
10 bottom tapping system
11 bottom tapping, service
12 ladle on ladle car
13 electrode masts with hydraulic cylinders
14 cooling water supply including distribution
15 hydraulic system

Figure C.1 — Example of an EAF



Key

1 electrode arms
2 scrap basket (excluded, see Scope)
3 shaft
4 upper shell
5 lower shell

Figure C.2 — Example of an EAF: Single shaft furnace with scrap preheating system

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