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Industrial furnaces and associated processing equipment — Safety —

Part 1: General requirements

Fours industriels et équipements associés — Sécurité —

Partie 1: Exigences générales

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Contents

Page

Foreword

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

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

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

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

For an explanation on 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.

The committee responsible for this document is ISO/TC 244, *Industrial furnaces and associated processing equipment*.

This second edition cancels and replaces the first edition (ISO 13577-1:2012), which has been technically revised. The following changes have been made:

— reconfiguration of the scope (no technical change);

— elimination of the requirements related to the implosion hazard;

— reconfiguration of the requirements related to electrical safety as the following:

  — the referenced safety requirements for electrical equipment of industrial furnaces and associated processing equipment (TPE) are integrated to IEC 60204-1 (referencing IEC 60519 series was eliminated);

  — referencing ISO 13577-4 for the requirements of protective systems (safety related control systems) was introduced;

  — independent subclause for the electroheat installations where electrical energy is directly used as the heating energy was established;

  — associated changes were made in Table 1 in regards to the changes in 4.3;

— change of title of regional Annex E from "Requirements specific to Japan" to "Information specific to Japan" and modification of its content;

— addition of regional Annex H specific to Canada;

— other editorial changes.

A list of all parts in the ISO 13577 series can be found on the ISO website.

Introduction

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

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

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

Industrial furnaces and associated processing equipment (TPE) generally consists of the following components:

— processing chambers (e.g. steel construction with lining or without lining);

— heating systems;

— protective system;

— control and instrumentation system/operator-control level.

This document gives additional requirements for TPE in certain countries or regions. When applying the requirements specific to a country or region, which are given in the relevant annexes, it is essential that a level of safety be ensured that is at least equivalent to that provided for by the requirements of the main body of this document.

Industrial furnaces and associated processing equipment — Safety —

Part 1: General requirements

1 Scope

This document specifies the general safety requirements common to industrial furnaces and associated processing equipment (TPE).

This document deals with the significant hazards, hazardous situations or hazardous events relevant to TPE, as listed in Annex A, when TPE is used as intended and also under conditions of misuse that are reasonably foreseeable by the manufacturer.

Annex B provides a list of common industrial furnaces and associated processing equipment.

This document specifies the requirements intended to be met by the manufacturer to ensure the safety of persons and property during commissioning, start-up, operation, shut-down, maintenance periods and dismantling, as well as in the event of foreseeable faults or malfunctions that can occur in the equipment.

These general safety requirements apply to all TPE, unless an exception is given in other parts of ISO 13577 dealing with specific equipment. The provisions of other parts of ISO 13577 that directly apply to specific types of TPE take precedence over the provisions of this document.

This document is not applicable to blast furnaces, converters (in steel plants), boilers or equipment not covered under ISO 12100.

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

ISO 13577-2:2014, *Industrial furnaces and associated processing equipment — Safety — Part 2: Combustion and fuel handling systems*

ISO 13577-3[1)], *Industrial furnaces and associated processing equipment — Safety — Part 3: Generation and use of protective and reactive atmosphere gases*

ISO 13577-4, *Industrial furnaces and associated processing equipment — Safety — Part 4: Protective systems*

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

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

ISO 13854, *Safety of machinery — Minimum gaps to avoid crushing of parts of the human body*

1) Under preparation. Stage at the time of publication: ISO/FDIS 13577-3:2016.

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 14122-2, *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*

IEC 60079-0, *Explosive atmospheres — Part 0: Equipment — General requirements*

IEC 60204-1:2009, *Safety of machinery — Electrical equipment of machines — Part 1: General requirements*

IEC 60519 (all parts), *Safety in electroheat installations*

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

IEC 62598, *Nuclear instrumentation — Constructional requirements and classification of radiometric gauges*

EN 1547, *Industrial thermoprocessing equipment — Noise test code for industrial thermoprocessing equipment including its ancillary handling equipment*

3 Terms and definitions

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

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

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

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

4 Safety requirements and/or protective measures

4.1 General

4.1.1 Requirements

The TPE shall comply with the safety requirements and/or protective measures described in Clause 4 and shall be verified in accordance with Clause 5. In addition, the TPE shall be designed in accordance with the principles of ISO 12100 for relevant hazards, but not significant hazards, which are dealt with by this document.

Anticipated significant hazards are listed in Table A.1.

For ease of reference, Table A.1 also indicates the corresponding preventive measures and should be used in conjunction with Clauses 4, 5 and 6.

Where particular requirements of the other parts of ISO 13577 apply, they shall supplement or modify these general safety requirements.

For regional requirements, see Annexes E, F, G, H and I.

4.1.2 General design and construction requirements

The manufacturer shall maintain evidence that all safety requirements of the design have been fulfilled.

The structural assembly, steel sections, auxiliaries and services (utilities) that form part of the TPE shall be stable and suitable for function and the intended use.

In particular, the design shall include solutions and constructional details relating to the following:

— static stability of the TPE, including structures intended for containing the processed materials and the materials entering and leaving the TPE;

— accessibility;

— maintenance and cleaning clearances;

— movement of material and machinery;

— safety in operation;

— health and safety at the workplace;

— protection against fire and prevention of explosion;

— emissions from the process;

— protection against earthquakes where seismic intensity exceeds 325 gal, as determined by the seismic zone.

Cut-off, regulating and measuring devices, pipework and tanks carrying or containing fluids, which are likely to solidify and/or have high viscosity, shall be protected against the effects of solidification and subsequent blockage.

If internal parts of the TPE require frequent inspection, they shall be either provided with lighting appropriate to the structure and the nature of the process or the user shall be advised to install suitable lighting.

The design of the TPE and the action of the regulating and safety devices shall prevent

a) unintended release of flammable or hazardous fluids to the outside of the TPE,

b) a backflow of flammable or hazardous fluids to pipes not intended for such fluids, and

c) flashback in the pipework.

The safety devices shall

— be suitable for the range of adjustment required for the regulation of the TPE, and

— not cause one device inadvertently to over-ride another.

Safety devices shall be fitted in such a manner that they are accessible and protected against harmful effects. In particular, they shall withstand continuous operation in the area in which they are to be used. Auxiliary fluids, such as lubricants, dielectric, diathermic and dynamic fluids, shall be selected to minimize the hazard of their products of combustion resulting from a fire.

Drains that form part of the TPE shall discharge into a suitably isolated sump. Means shall be provided for the collection and removal of such discharges.

Pipework distribution systems forming part of the TPE shall be designed to withstand corrosion.

Pipework distribution systems that form part of the equipment and can become dangerous if subjected to extreme temperatures or pressures, wide variations in temperature or pressures, or voltage shall be marked.

4.1.2.1 Stability

The TPE structures shall be designed to withstand their static and dynamic loads. The TPE shall be designed for normal and foreseeable accidental thermal static and dynamic working stresses, including those resulting from overpressurization or operation below atmospheric pressure.

The design shall also take account of vibration, wind pressure, impact and other foreseeable external forces, including earthquakes.

4.1.2.2 Access

All parts of the TPE that need to be accessed by personnel for operation and maintenance shall be served by adequate means of access, preferably fixed. Stairways, platforms and service floors shall be safe and shall be equipped with adequate safeguards (see 4.2.10). Inspection and service floors of the TPE shall be safe, well lit, well ventilated, protected against heat radiation and be fire-resistant (see 4.4.3.1).

Account shall be taken of the need for emergency escape routes to avoid the trapping of personnel in the event of hazardous situations (such as fire or the buildup of toxic gases).

4.1.2.3 Roofs and covers

Where the roofs or covers of the TPE (e.g. ceramic kilns or melting TPE) have been designed to be walked on, they shall be accessible by a safe means.

Roofs or covers to which access is not intended shall be marked and designated as not accessible and shall be adequately guarded to prevent access.

Roofs or covers that have to be walked on for operating, maintenance and inspection purposes and that are more than 1 m above floor level shall be accessible through safe ascents and shall be fitted with railings to prevent falls. Where the heat source is located in the roof, for example in the ceramics or glass industry, one escape route shall be available in front of, and one behind, the firing zone, one of which shall be a stairway. For design requirements, see 4.1.2.4.

4.1.2.4 Access channels and stairs

In general, the design of access channels and stairs shall be in accordance with ISO 14122-2 and ISO 14122-3. For channels intended for repair purposes below tunnel furnaces or kilns, the unobstructed passage way shall be at least 1,80 m high by 0,70 m wide, and shall be accessible through two stairways, one of which shall be in front of, and the other behind the firing zone. If the stairways are in the area of the firing zone, emergency exits shall be available in front of, and behind, the firing zone.

4.2 Mechanical safety

4.2.1 General

The design shall be such as to avoid injury by movement of the machinery parts of the TPE, by crushing, shearing, entanglement, drawing-in or impact. It shall also prevent hazardous situations arising where high-pressure fluids are used or where parts of the TPE and processed material are liable to be ejected. The stability of the TPE during operation and the safety of the access areas around the TPE shall also be considered.

Where the construction of the TPE includes

— corners and projections,

— passages of reduced height, and

— manhole covers, drains, etc.

they shall be protected and marked in such a way as to minimize the hazard.

Emergency stop devices shall be in accordance with ISO 13850.

4.2.2 Crushing

The design shall incorporate means to minimize hazard to personnel arising from

— movement of materials and machinery,

— automation,

— suspended loads,

— falling materials, and

— moving parts.

All moving machinery that can present a hazard shall be guarded wherever practicable. Where guarding is not practicable, audible and/or visual signals shall be provided. Strategically positioned emergency stop mechanisms shall be provided to stop potentially hazardous moving machinery.

Guarding, where provided, shall comply with ISO 14119 and ISO 14120.

Any traversing part of the TPE or material carried by it shall not be closer to any fixed structure than the safety distance requirements given in ISO 13854.

The design of the TPE shall take account of the minimum distance requirement. See ISO 13854, ISO 13857, ISO 15534-1 and/or ISO 15534-2.

4.2.3 Shearing

Where possible, shear traps shall be eliminated by

a) filling the gaps or reducing the maximum clearance between the moving parts, such that parts of the body cannot enter the gap, and

b) increasing the minimum clearance between the shearing parts, such that parts of the body can enter the gap safely (see ISO 13854 and ISO 15534-1).

Where it is not possible to avoid the creation of a shear trap, adequate guarding shall be used (see ISO 14119 and ISO 14120).

Means shall be provided to prevent unintentional closure or opening of moving parts (e.g. doors, conveyors and elevators) during operation and maintenance.

4.2.4 Entanglement

Design measures shall be taken, or suitable guards shall be provided, to prevent entanglement by rotating shafts, conveyors and transmission machinery (see ISO 14120).

4.2.5 Drawing-in

Design measures shall be taken, or suitable guards shall be provided, to avoid drawing-in (see ISO 14120).

4.2.6 Impact

NOTE Impact hazards are caused by objects that act against the inertia of the body but do not penetrate.

The speed, force or torque, and inertia of the moving parts shall be kept to a minimum by the designer, in order to reduce the possibility of injury. Where this is not practicable, adequate guarding or safety devices shall be provided. Where guarding or safety devices cannot be provided, a perimeter fence shall be provided.

4.2.7 High-pressure fluid ejection

In order to minimize the risk of injury caused by the ejection of fluids, such as compressed air, steam and high-pressure hydraulic oil or water

— all components within the system shall be operated within their manufacturer's specifications and all parts of the system shall be protected against overpressure,

— verification of leak tightness shall be achieved by pressure testing to at least the intended operating pressure, and

— any pressure relief device shall be verified by testing in accordance with the manufacturer's instructions.

Piping should be permanent. Where the use of flexible hoses is unavoidable, equipment suitable for the most arduous duty and operating conditions likely to be experienced shall be used. If flexible hoses are used for hydraulic oil, they shall be shielded from ignition sources (e.g. hot surfaces). Replacement intervals shall be defined in the instruction handbook.

NOTE For fuel gases and liquid fuel, ISO 13577-2 specifies requirements for piping including flexible tubing.

4.2.8 Ejection of parts

In order to minimize the risk that a body can be crushed or penetrated by material or parts of the equipment that have been ejected unexpectedly or accidentally, adequate guarding shall be provided (see ISO 14120).

4.2.9 Slip/trip

Working platforms shall be designed so as to provide a level standing space of adequate size, with a firm foothold. Walkways shall be made from materials that are as slip resistant as practicable under working conditions, and suitable guard rails, posts and toe boards shall be provided.

Where necessary, a fixed access ladder with handholds or a stairway with handrails or some other suitable means shall be provided to give safe and convenient access to all equipment needing adjustment, lubrication or maintenance.

4.2.10 Falls

Where the design of the TPE or the movement of the TPE requires floor openings that can constitute a hazard, automatic guards, safety warning devices (see 6.3) or barriers shall be provided.

4.2.11 Transport

Where applicable, TPE shall be designed for transport. Instructions for transport shall be provided.

4.3 Electrical safety

4.3.1 Electrical equipment of TPE

4.3.1.1 General

Electrical equipment of any TPE located in the same unit(s) up to the defined TPE limits shall be suitable for their function and intended use. A risk assessment shall be done for each emergency condition and the results shall determine the action to take on the electrical energy supply to the TPE.

Electrical equipment of TPE shall be in accordance with IEC 60204-1:2009. However, the requirement to meet IEC 62061 and/or ISO 13849 in IEC 60204-1:2009, 9.4.1 is not applicable where the requirements of the protective system specified in ISO 13577-4 apply.

The functional requirements to which the protective systems according to ISO 13577-4 apply are specified in the other parts of ISO 13577.

For electroheat installations where electrical energy is directly used as the heating energy, see 4.3.2.

Piping that conveys flammable fluids shall not be installed in channels, ducts, pipes or trenches carrying electrical conductors, unless an explosion-proof method is provided in accordance with IEC 60079-0 suitable for the applicable hazardous area.

Where it is necessary during commissioning, pre-commissioning, maintenance or fault-finding operations to gain access to live parts appropriate interlocks, protection systems or guarding shall be incorporated (see ISO 14119 and ISO 14120).

Where electrostatic effects can cause loss of normal control and present a hazardous situation, safety shut-down or stopping devices shall be fitted to those parts of the TPE affected.

Electrical conductors and devices shall not be located in areas affected by the discharge of hot components or openings, exhausts and vents for hot gases, vapours or fluids.

4.3.1.2 External influences

The TPE shall be designed to minimize hazards resulting from known external influences on the electrical power, controls and systems.

Disconnection and/or restoration of the electricity supply shall not cancel the safety and interlock conditions.

The electrical control system shall be suitably protected or guarded against mechanical damage from operations within the TPE environment.

NOTE Such influences can be beyond the boundaries defined within the scope of this document and are intended to be dealt with in contract with/among the supplier, agent importers and/or users of the TPE.

4.3.2 Electroheat installations/equipment

Electroheat installations/equipment as part of TPE under the scope of this document shall be suitable for their function and intended use. They shall be in accordance with the relevant parts of IEC 60519.

4.4 Thermal and cryogenic safety

4.4.1 General

The manufacturer shall design the TPE to prevent unintended contact with workpieces, flames, surfaces or devices, which can be at elevated temperatures or below ambient temperatures.

NOTE Such influences can be beyond the boundaries defined within the scope of this document and are intended to be dealt with in contract with/among the supplier, agent importers and/or users of the TPE.

4.4.2 Contact with hot/cold surfaces

Precautions shall be taken to prevent contact with operating controls at elevated or below ambient temperature either accidentally or while operating them.

Where it is not possible, for process reasons or other constraints, to maintain surface temperature at an appropriate level, steps should be taken to prevent hot operating controls from being touched. Wherever possible, this shall be by means of guards complying with ISO 14120.

If these measures are not practicable, areas of elevated temperatures shall be indicated by means of suitable marking, warning signs, etc. (see 6.3). In addition, attention shall be drawn in the technical documentation to the presence of such hazards.

Where it is not possible to avoid contact with controls, etc. that are at elevated or below ambient temperatures, requirements for protective clothing shall be included in the instruction handbook.

4.4.3 Fire/explosion

4.4.3.1 Fire

The TPE shall be designed to minimize fire hazards resulting from overheating or those inherent in the TPE from operating at elevated temperatures.

The design and construction of the TPE shall prevent the leakage of hot gases, combustion products and flames, other than via designed flues, vents and doors, etc.

In particular, the following shall be considered:

a) discharge of hot gases or flames from openings;

b) loading and unloading of work pieces.

Where the TPE is heated by gaseous or liquid fuel, the fuel pipework shall be designed to prevent leakage. In addition, the fuel pipework shall be capable of withstanding foreseeable mechanical damage. Further guidance for gaseous and liquid fuels is given in ISO 13577-2.

Where hydraulic oil-actuated components are used, piping and hydraulic equipment shall be protected from overheating. Any oil leakage shall be prevented from reaching hot parts by suitable design and location.

Heat-transfer fluids shall be non-toxic and shall not exceed the maximum temperature specified by the manufacturer. The humidity and oxygen content in the fluid shall not exceed levels specified by the manufacturer. These values shall be specified in the instruction handbook.

When considering the maximum level of the heat-transfer fluid, account shall be taken of its expansion during normal working conditions. The system shall be fitted with safety vents that are protected against the ingress of hazardous contaminants (e.g. moisture and air).

Heat-transfer fluid systems shall be provided with a safety device to prevent over-temperature.

Suitable safety devices shall be fitted where any one of the following parameters impact safety:

— pressure;

— temperature;

— level (of fluid);

— flow.

For further guidance, see ISO 13577-2.

Where used, fire extinguishing system(s) shall be installed on the TPE at positions where there is the greatest risk of fire occurring. Particular attention shall be paid to the selection of the type of extinguisher for use.

4.4.3.2 Explosion

The TPE shall be designed and constructed in such a way as to avoid any risk of explosion posed by the TPE itself or by gases, liquids, dusts, vapours and other substances produced or used by the TPE.

The design shall incorporate means to avoid the explosive co-existence of a flammable substance and an oxidizing agent (usually air) within the flammability limits with an ignition source (see ISO 13577-2).

Attention shall be given to work pieces that are not themselves flammable but that may, by design or otherwise, be coated with substances that can give rise to a flammable mixture.

Pressure relief(s) from an ignited flammable mixture shall be provided, unless it can be shown that the mixture cannot exceed 25 % of the lower flammability limit (LFL), the ignited flammable mixture is safely vented by other means or an ignited flammable mixture is safely contained.

Pressure reliefs shall be positioned such that they are unimpeded, both inside and outside the TPE, and shall discharge in such a manner that personnel are not subjected to hazards. The strength of the relief(s) shall be such as to relieve the pressure before serious damage is caused to the TPE.

Where doors are not designed as pressure reliefs, they shall be fastened in such a manner that they cannot be opened when subjected to an overpressure condition. Doors shall not open other than in their intended direction.

4.4.4 Ejection of hot particles, work pieces and process liquids

The TPE shall be designed to contain hot particles, work pieces or process liquids within its structure. Attention shall be paid to the loading/unloading areas. If additional guards or barriers are required, they shall comply with ISO 14120.

Where liquid metals, oils or salts are being heated, the introduction of moisture into the liquid shall be avoided.

4.4.5 Thermal stress and other physiological effects

The TPE shall be designed so that the effects of thermal stress on human beings are minimized (see ISO 7933). An estimation shall be made of temperatures that can be reached in areas to which operators have access. Preventive measures, such as ventilation and operating booths with cooling, shall be provided if necessary.