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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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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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.

ISO 13577-1 was prepared by Technical Committee ISO/TC 244, *Industrial furnaces and associated processing equipment*.

ISO 13577 consists of the following parts, under the general title *Industrial furnaces and associated processing equipment — Safety*:

— *Part 1: General requirements*

— *Part 2: Combustion and fuel handling systems*

It is intended that generation and use of protective gases will form the subject of a part 3 and protective systems will form the subject of a part 4.

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 part of ISO 13577 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 part of ISO 13577.

Industrial furnaces and associated processing equipment — Safety —

Part 1: General requirements

1 Scope

This part of ISO 13577 specifies the general safety requirements common to industrial furnaces and associated processing equipment (TPE). This part of ISO 13577 details significant hazards associated with TPE (see Annex B), and specifies the appropriate preventive measures for reduction or elimination of these hazards.

This part of ISO 13577 gives general principles and general safety requirements for the reduction of risks associated with TPE.

The general safety requirements apply to the other parts of ISO 13577 dealing with specific equipment, unless an exception is stated in the relevant part. The general principles are used to establish the specific technical measures in the relevant parts dealing with safety requirements for particular equipment.

For TPE covered by this part of ISO 13577, the provisions of the part of ISO 13577 directly applicable to that type of TPE, if available, take precedence over the provisions of this part of ISO 13577.

This part of ISO 13577 is not applicable to the risks associated with:

a) quenching;

b) vacuums;

c) salt baths;

d) liquid phase treatment, e.g. ladle refining;

e) protective or reactive atmospheres.

NOTE For similar TPE not covered by another specific part of ISO 13577, this part of ISO 13577 can be used to assist in the reduction of risk for the hazards identified in Annex A.

Safety requirements in this part of ISO 13577 cover furnaces that are heated by any source, but does not cover the safety requirements related to solid fuels and electrical heating as a source. For safety requirements related to electrical heating as a source, see IEC 60519 (all parts).

For a more detailed list of these categories, see Annex B.

This part of ISO 13577 is not applicable to blast furnaces, converters (in steel plants), boilers or equipment not covered under ISO 12100. This part of ISO 13577 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 which can occur in the equipment.

This part of ISO 13577 specifies the safety requirements at stages in the life of the equipment, and its design, ordering, construction, use and disposal. This part of ISO 13577 specifies safety requirements for maintenance, provision for indicators and inspection. It deals with the following significant hazards, hazardous situations or

hazardous events relevant to TPE, when it is used as intended and under conditions of misuse which are reasonably foreseeable by the manufacturer:

— mechanical hazards, movement of machinery and material, ejection of parts, material or liquids and gases, implosion and structural failure;

— electrical hazards;

— thermal hazards: explosion, fire, scalds, contact with hot parts, gases and flames;

— noise and vibration;

— thermal, optical and ionizing and non-ionizing radiation;

— harmful by-products and hazardous substances, poisoning, biological and micro-biological contamination, pollution and environmental discomfort.

2 Normative references

The following referenced documents are indispensable for the application 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, *Safety of machinery — General principles for design — Risk assessment and risk reduction*

ISO 13574, *Industrial furnaces and associated thermal 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 13850, *Safety of machinery — Emergency stop — Principles for design*

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

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, *Safety of machinery — Electrical equipment of machines — Part 1: General requirements*

IEC 60364-4-41, *Low-voltage electrical installations — Part 4-41: Protection for safety — Protection against electric shock*

IEC 60364-4-43, *Low-voltage electrical installations — Part 4-43: Protection for safety — Protection against overcurrent*

IEC 60364-4-44, *Low-voltage electrical installations — Part 4-44: Protection for safety — Protection against voltage disturbances and electromagnetic disturbances*

IEC 60364-5-53, *Electrical installations of buildings — Part 5-53: Selection and erection of electrical equipment - Isolation, switching and control*

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.

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 and be verified in accordance with Clause 5. In addition, the TPE shall be designed in accordance with the principles of ISO 12100 for hazards relevant, but not significant, which are dealt with by this part of ISO 13577.

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 standards, see Annexes E, F and G.

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) which form part of the TPE shall be stable, suitable for function and the intended use.

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

— 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;

c) flashback in the pipework.

The safety devices shall:

— be suitable for the range of adjustment required for the regulation of the TPE;

— 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, which 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 to which personnel require to have access 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 4.2.11). 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 build up of toxic gases).

4.1.2.3 Roofs and covers

Where the roofs or covers of 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 or shall be adequately guarded to prevent access.

Roofs or covers, which have to be walked on for operating, maintenance and inspection purposes and which 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 4.1.3.4.

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 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 machinery parts of 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 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,

— 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;

— moving parts.

All moving machinery which 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 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;

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

Impact hazards are caused by objects which 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 leaktightness shall be achieved by pressure testing to at least the intended operating pressure;

— 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.

ISO 13577-2:—, 5.2.1.5, shall be used for gas and ISO 13577-2:—, 5.3.1.4, for liquids. Special care shall be taken to guard against flexing or twisting during movement, and thermal damage.

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 ejected unexpectedly or accidentally, adequate guarding shall be provided (see ISO 14120).

4.2.9 Implosion

All parts of the TPE, which operate at pressures lower than atmospheric pressure, shall be constructed in such a way that implosions are avoided.

Suitable devices shall be provided to neutralize the pressure within the TPE before a door can be opened.

NOTE An interlocked double release device ensures detaching of the door before it is completely open.

4.2.10 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 which remain 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.

4.2.11 Falls

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

4.2.12 Transport

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

4.3 Electrical safety

4.3.1 General

Electrical components and installations for any TPE and services located in the same unit(s) up to the defined TPE limits shall be suitable for their function and intended use.

The following requirements shall be considered:

a) safety of electrical Installation;

b) the design and operation of electroheat installations shall be in accordance with IEC 60519 (all parts);

c) the design and operation of electric installations in other equipment shall comply with IEC 60364-4-41, IEC 60364-4-43, IEC 60364-4-44 and IEC 60364-5-53 or IEC 60204-1;

d) the energy supply to moving parts of the installation shall be shut off in case of emergency.

An assessment of the electrical installation shall be made, including the following elements:

— electrical power-carrying capacity and insulation characteristics of the conductors in the installed positions;

— temperature rise of conductors and the ambient temperature environment;

— the suitability of connectors and terminations;

— minimization or elimination of undesirable induction heating effects;

— estimated temperature of operation of devices in their installed position;

— minimizing electrical induction or interference between power and control cables, sensors, etc.;

— protection of cables, groups of cables, devices or motors against overload and short circuit;

— prevention of damage to conductors from heat, shearing, trapping, cutting, crushing, fluids or other contamination;

— prevention of, or protection against, ground faults (short circuits).

— prevention of, or protection against electric arcs;

— safe access or prevention of access to live circuits;

— adequate warning signs (see 6.4.3);

— adequate identification of devices, cables, fuses and distribution boards;

— adequate electrical schematic drawings, cable schedule drawings, software programs and their adequate provision to TPE engineering, operation and maintenance operatives;

— protection of conductors connecting to movable equipment or protection against cut-off from cycle fatigue.

Verification of preventive measures shall be carried out in accordance with IEC 60204-1 or IEC 60364-4-41, IEC 60364-4-43, IEC 60364-4-44 and IEC 60364-5-53, as well as with IEC 60519 (all parts), if applicable.

Piping conveying 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.

4.3.2 Direct or indirect contact

Measures against direct or indirect contact with live conductors/terminations shall be taken for electroheat installations in accordance with IEC 60519 (all parts), as appropriate, and for other thermoprocessing equipment in accordance with IEC 60364-4-41.

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

4.3.3 Electrostatics

Suitable grounding (e.g. earthing and/or bonding) or other means shall be provided to minimize hazards caused by electrostatic effects.

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.

4.3.4 Effects of electrical overload

Measures shall be taken to prevent electrical overload in electroheat installations in accordance with IEC 60519 (all parts) and for other thermoprocessing equipment in accordance with IEC 60364-4-43.

4.3.5 Thermal radiation and heat flow

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

4.3.6 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 part of ISO 13577 and are intended to be dealt with in contract with/among the supplier, agent importers and/or users of the TPE.

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 part of ISO 13577 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 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 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 6.4). 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., which are at elevated temperatures, requirements for protective clothing shall be included in the instruction handbook.

4.4.3 Fire/explosion

4.4.3.1 Fire

TPE shall be designed to minimize the fire hazards due to overheating or inherent in operating at elevated temperatures of the TPE itself.

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 workpieces.

Where the TPE is heated by gaseous, liquid or solid fuel, the fuel circuits shall be designed to prevent leakage. In addition, the fuel circuits 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.

Where 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 which 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;

