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Foundry machinery — Safety requirements for molding and coremaking machinery and associated equipment

Machines de fonderie — Prescriptions de sécurité pour les machines et équipements associés de moulage et de noyautage

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Foreword

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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).

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

This document was prepared by Technical Committee ISO/TC 306, *Foundry machinery,* in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 202, *Foundry machinery,* in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

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

Introduction

This document is a type C standard as stated in ISO 12100:2010.

This document is of relevance, in particular, for the following stakeholder groups representing the market players with regard to machinery safety:

— machine manufacturers (small, medium and large enterprises);

— health and safety bodies (regulators, accident prevention organizations, market surveillance, etc.).

Others can be affected by the level of machinery safety achieved with the means of the document by the above-mentioned stakeholder groups:

— machine users/employers (small, medium and large enterprises);

— machine users/employees (e.g. trade unions, organizations for people with special needs);

— service providers, e. g. for maintenance (small, medium and large enterprises);

— consumers (in case of machinery intended for use by consumers).

The above-mentioned stakeholder groups have been given the possibility to participate at the drafting process of this document.

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

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

Foundry machinery — Safety requirements for molding and coremaking machinery and associated equipment

1 Scope

This document deals with foreseeable significant hazards, hazardous situations and events relevant to molding and coremaking machinery and associated equipment when used as intended and under conditions of misuse which are reasonably foreseeable by the manufacturer (see Clause 5). It provides the requirements to be met by the manufacturer to ensure the safety of persons and property during the life-cycle phases in accordance with ISO 12100:2010, 5.4, as well as in the event of foreseeable failures or malfunctions that can occur in the equipment.

This document applies to the following equipment:

a) machinery constructed to condition and/or reclaim foundry sands for mold and coremaking (including related moldable granular materials);

b) molding machinery;

c) coremaking machinery;

d) knock-out equipment;

e) other directly associated equipment.

This document does not apply to:

— ladles and pouring equipment;

NOTE This equipment is covered within the European Union (EU) by EN 1247:2010.

— wax and lost foam pattern production and wax removal equipment;

— additive manufacturing equipment;

— dust and/or gaseous emissions reduction equipment;

— crane installations;

— winches;

— continuous conveyors or handling systems which can be an integral part of the equipment covered by this document;

— sand and casting separation systems.

This document does not explicitly deal with electrical hazards. These hazards are covered by IEC 60204-1: 2016.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 3864-1:2011, *Graphical symbols — Safety colours and safety signs — Part 1: Design principles for safety signs and safety markings*

ISO 4413:2010, *Hydraulic fluid power — General rules and safety requirements for systems and their components*

ISO 4414:2010, *Pneumatic fluid power — General rules and safety requirements for systems and their components*

ISO 6184-1:1985, *Explosion protection systems — Part 1: Determination of explosion indices of combustible dusts in air*

ISO 7010:2019, *Graphical symbols — Safety colours and safety signs — Registered safety signs*

ISO 7731:2003, *Ergonomics — Danger signals for public and work areas — Auditory danger signals*

ISO 11428:1996, *Ergonomics — Visual danger signals — General requirements, design and testing*

ISO 11429:1996, *Ergonomics — System of auditory and visual danger and information signals*

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

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

ISO 13732-1:2006, *Ergonomics of the thermal environment — Methods for the assessment of human responses to contact with surfaces — Part 1: Hot surfaces*

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

ISO 13851:2019, *Safety of machinery — Two-hand control devices — Principles for design and selection*

ISO 13854:2017, *Safety of machinery — Minimum gaps to avoid crushing of parts of the human body*

ISO 13857:2019, *Safety of machinery — Safety distances to prevent hazard zones being reached by upper and lower limbs*

ISO 14119:2013, *Safety of machinery — Interlocking devices associated with guards — Principles for design and selection*

ISO 14120:2015, *Safety of machinery — Guards — General requirements for the design and construction of fixed and movable guards*

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

IEC 61310-1:2007, *Safety of machinery — Indication, marking and actuation — Part 1: Requirements for visual, auditory and tactile signals*

IEC 62061:2013, *Safety of machinery — Functional safety of safety-related electrical, electronic and programmable electronic control systems*

EN 1299:1997+A1:2008, *Mechanical vibration and shock - Vibration isolation of machines — Information for the application of source isolation*

EN 12198-3:2003+A1:2008, *Safety of machinery — Assessment and reduction of risks arising from radiation emitted by machinery — Part 3: Reduction of radiation by attenuation or screening*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 12100:2010 and the following apply.

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

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

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

3.1
molding machinery
machinery used to make sand molds

Note 1 to entry: There are various machinery types which compact granular *molding materials* (3.19) including but not limited to:

— jolt molding machines (compaction by jolting the molding machine deck);

— squeeze molding machines (compaction by squeezing the pattern equipment and the molding sand together);

— jolt and squeeze molding machines;

— shoot-, blow-, fluidization- and squeeze-molding machines;

— impulse molding machines (the molding sand is compacted by a compression wave which acts on the top of the sand fill);

— air-flow-squeeze molding machines (similar to impulse-molding machines, except that the compressed air escapes through nozzles in the pattern plate);

— dynamic squeeze molding machines (compensating pressure squeeze pistons act on the top of the sand fill);

— suction and squeeze molding machines (the pressure differential between the molding box and the pattern draws in the molding sand);

— vacuum-molding machines (unbonded sand is compacted by vacuum);

— sand slingers (the molding sand is flung into the molding box by the centrifugal force of a rotating wheel).

3.2
molding line
equipment used to make ready-to-pour sand molds

Note 1 to entry: A molding line consists of molding stations (automatic molding machines for complete molds) or several molding machines (molding group) that produce the molding parts separately. It can also include lines for core setting, mold closing, weighting or clamping, pouring, cooling, knocking-out of the mold parts and emptying of the boxes as well as integral transfer systems linking the various stations and lines.

3.3
coremaking machinery
machinery used to make solid and/or hollow cores

3.4
core shooter
machine where compressed air is rapidly expanded via the sand reservoir into the sand

Note 1 to entry: After expanding, the sand is then fluidized by the airstream and the sand–air-mix is transported into the core box. Typically used for cold box, hot box and inorganic *binder* (3.20) systems.

3.5
coremaking line
equipment used to make ready-to-use single cores and/or core assemblies

Note 1 to entry: A line can consist, for example, of a sand preparation equipment, *coremaking machinery* (3.3), equipment for handling, deflashing, assembling, *coating* (3.22) and drying of cores.

3.6
sand mixer
machine in which the sand with bonding agents are mixed and conveyed to the discharge gate either batch or continuous type

Note 1 to entry: Typically, in the continuous type, the mixing takes place by screw-type mixing principles.

Note 2 to entry: Typically, in the batch type, the mixer consists of a circular container in which rotating ploughs and/or mill wheels (mullers) are mounted.

3.7
reclamation equipment
equipment including storage and conveying facilities used for the reclamation of used sands by mechanical and/or thermal processing means

Note 1 to entry: Machines used to destroy the *binder* (3.20) by thermal and/or mechanical and/or chemical/physical means.

3.8
sand lump crusher
machine used to break down lumps of used sand by mechanical means

3.9
magnetic separator
machine used to separate ferro-magnetic material from the used sand

3.10
gassing equipment
central supply systems and equipment used to produce and/or condition reactive gasses and supply them to the gassing station or into the sand mixture

Note 1 to entry: Typical processes (*binder* (3.20) system/reactive gas) are:

— silicate/CO_2;

— urethane (coldbox)/amine;

— furane resin; peroxide or epoxy resin; peroxide/SO_2;

— alkaline resin/methyl-formate;

— inorganic binders/hot air (as dehydration assistance).

3.11
knock-out equipment
equipment used to separate castings from the molding box, the mold and/or cores from castings

Note 1 to entry: Typical principles are vibrations on grids and trays.

3.12
punch-out equipment
equipment used to separate the mold and castings from the molding box by vertical or horizontal movement of a punch-out piston

3.13
set-up control mode
one or more groups of interlinked machines operated in set-up mode, where all steps within a process can be initiated separately and manually in any sequence

Note 1 to entry: Initiation of individual movements by hold-to-run without interlocked movements. Set-up control mode can enable certain functions of the machinery to be controlled with guards open or with protective devices muted or by means of a special control device such as a pendant control or a remote-control device, instead of the control devices used for *normal operation* (3.14) by *trained personnel* (3.17) which is authorised for this special task.

3.14
normal operation mode
normal operation
one or more groups of interlinked machines operated in normal mode during a period (e.g. an eight-hour shift) of regular production and directly production-related human interactions

Note 1 to entry: Directly production-related human interactions are defined as interactions done at least once per shift and does not include *repair* (3.16).

Note 2 to entry: Production-related human interaction during normal operation of *molding lines* (3.2) includes, but is not limited to:

— pattern change;

— removal of dropped cores and filters;

— core, filter and riser setting;

— cleaning of tools and/or machinery, if applicable;

— spraying *release agent* (3.23) and blow cleaning;

— visual *inspection* (3.15.2) of mold and pattern.

Note 3 to entry: Production-related human interaction during normal operation of *coremaking lines* (3.5) includes, but is not limited to:

— tool change, e.g. core box, robot gripper, deflashing templates;

— removal of dropped cores;

— cleaning of tools;

— spraying release agent and blow cleaning;

— visual inspection of tools;

— core unloading.

3.15
maintenance
combination of *service* (3.15.1) and *inspection* (3.15.2) of the equipment

3.15.1
service
measure to maintain the nominal condition

Note 1 to entry: The nominal condition can be maintained in general without dismantling/disassembling major parts of the equipment, e.g. cleaning, lubrication of the work equipment as well as addition or replacement of agents or by replacing tools or operational changing parts.

3.15.2
inspection
measure to observe and assess the current condition as well as fault finding

Note 1 to entry: Measures, e.g. measuring, testing, diagnostics, troubleshooting including the determination of the causes of wear or damage and the derivation of the necessary consequences for the continued use.

3.16
repair
non-regular work, not foreseeable, required to re-establish the nominal condition

Note 1 to entry: Measure to replace damaged parts, requires in general dismantling/disassembling.

3.17
trained person
trained personnel
skilled person with system knowledge, background knowledge, experience and/or ability to perform a specific task and are aware of the hazards related to their duties

3.18
remote access
machine control mode where faults can be diagnosed, parameters changed, and machine functions can be initiated from a remote location

Note 1 to entry: Collecting data or monitoring machine parameters is not considered as remote access.

Note 2 to entry: Diagnosis by means of passive monitoring of machine parameters is not considered as remote access. Diagnosis by means of active intervention is considered as remote access.

3.19
molding material
basic granular material for making cores and molds (sand) and powder additives

Note 1 to entry: Sand can contain, e.g. silica, chromite, zircon, syntetical sands.

Note 2 to entry: Powder additives can contain, e.g. bentonite, coal dust, starch, iron oxide, wood flour, silica derivate.

3.20
binder
liquid component for making cores and molds and powder additives

3.21
catalyst
gase or liquid component for making cores and molds

Note 1 to entry: Catalysts can contain, e.g. amines, SO_2, methylformiate.

3.22
coating
liquid or powder component to be added to the surface of cores and molds

3.23
release agent
liquid component to be added to the surface of patterns or core boxes

3.24
noise emission
airborne sound radiated by a well-defined noise source (e.g. the machine under test)

4 Significant hazards and risk assessment

4.1 General

The hazards, hazardous situations and events identified by risk assessment as significant for the machinery covered by the scope and which require action to eliminate or reduce the risk are listed in Clause 5 (in particular in Tables 1 to 5).

In general, risks and associated hazards are production and line related. The variety of machinery/lines cannot be covered in all details in a standard. To deal with this fact, an individual risk assessment of the machinery/line in question shall be carried out considering the safety requirements of this document.

Significant hazards identified in this individual risk assessment but not dealt with in this document shall be avoided or reduced by applying the principles of ISO 12100:2010.

If combinations of machines and/or machine functions described at different parts of this document are located in the same danger zone, the different measures shall be considered together.

4.2 Interfaces to the linked/integrated equipment

The individual risk assessment shall include the interfaces to the linked/integrated equipment. For this equipment respective instructions and safety measures including control requirements for interfaces shall be given in Clause 7.

5 Safety requirements and/or protective/risk reduction measures

5.1 General

5.1.1 Fixed guards

These guards shall be designed in accordance with ISO 12100:2010, ISO 13857:2019 and ISO 14120:2015.

These guards shall also be designed to contain processed materials, fluids or parts that can foreseeable be ejected or to contain emissions of substances or noise.

Where practical, these guards shall be fixed to the machine structure.

Fixing elements for guards, e.g. screws should stay with the guards or the machine after removal of the guards.

If floor mounted, these guards shall be securely fixed and have a minimum height of 1,4 m and be positioned at a sufficient distance from the danger zone in accordance with ISO 13857:2019, Table 1.

The installation of fixed covers is sufficient for safeguarding danger zones when there is no need to reach in or walk in during normal operation.

5.1.2 Movable guards

a) Detection, monitoring and emergency escape

Movable guards in danger zones with fixed cycle intervention or access (e.g. during loading and unloading of parts), set-up activities (setting), required periodical manual cleaning or spraying or troubleshooting, shall incorporate guard interlocking according to ISO 14119:2013.

When the guard is open, the drive power supply for the relevant hazardous movements shall be disconnected according to 5.1.6.

If trapping can occur behind a movable guard, an emergency escape shall be possible, e.g. providing panic handle.

b) Interlocking guard with guard locking

An interlocking guard with guard locking effective within the hazardous period shall be used when the stopping time of the hazardous movement is greater than the access time of a person in reaching the danger zone.

c) Closing the guards

Closing the guards shall not initiate operation of hazardous movements. If movement was interrupted by opening of an interlocked guard, the restart shall be performed by actuation from outside the guard.

d) Power operated guards

Power operated guards shall not create a danger of injury by its own movement. Either the power provided shall be insufficient to cause injury when contacting the operator, or the guard shall be provided with a safety trip device to prevent injury.

Actuation of the safety trip device shall stop or reverse the direction of movement of the movable guard.

Power operated guards shall be positioned so that persons cannot remain in the danger zone and initiate a machine cycle. If trapping behind these guards cannot be avoided, additional detection devices shall be installed (e.g. contact mat, horizontal ESPD).

5.1.3 Electro-sensitive protective devices (ESPD)

Electro-sensitive protective devices (see IEC 61496-1:2020) shall meet the following requirements:

a) the control system of the machine shall be able to interrupt the hazardous movement in time when it receives the output signal from such a protective device;

b) they shall switch on if the control system of the machine is connected,

c) they shall be tested at each machine cycle;

d) they shall not act as control devices;

e) they shall not be adjustable neither in the vertical nor in the horizontal direction;

f) they shall be interlocked with the hazardous movements of the machine;

g) the output-signals of such devices shall be independent of the electronic control system of the machine or shall be connected to failsafe PLC or safety relays;

h) the protective field of such devices shall cover the access area;

i) they shall be positioned so that persons cannot remain between the protective field of the device and the danger zone and initiate a machine cycle;

j) their position, in relation to the danger zone, shall take into account the machine stopping time, the approach speed of the operator and the initiation time of the device (see ISO 13855:2010).

5.1.4 Several persons at the same time being present at hazardous zones

When machinery require frequent intervention (i.e. for feeding and/or removing of parts) and if several persons are being present at the same time at the relevant hazardous zone, each person shall be protected, e.g. by electro-sensitive protective devices, so that they will not be mutually endangered during that intervention.

5.1.5 Control systems

The safety related parts of the control system (SRP/CS) shall comply with the requirements (performance level) of ISO 13849-1:2015.

Where access to a defined danger zone is required during normal operation the SRP/CS of the equipment shall be in accordance with required performance level PLr e according to ISO 13849-1:2015.

Where access to a defined danger zone is required for maintenance and general cleaning (i.e. outside normal production), the electric/electronic components of the safety related control systems of the equipment shall be at least performance level PLr d according to ISO 13849-1:2015.

Where access to a defined danger zone is required where movements take place resulting not in a significant hazard, the equipment shall be in accordance with at least required performance level PLr b according to ISO 13849-1:2015.

If these tasks can only be performed whilst the protective device is muted, lockable mode selection switches shall be provided for the muting of the protective device and the simultaneous transition to setting mode. Hazardous movements shall be interrupted immediately when the manual control actuator(s) (see IEC 60204-1:2016, 9.2.3.9 and 10.9) is released. Unsecured movements of dangerous parts shall be prevented, e.g. gravity fall. When safely reduced speed of such movements is used to permit maintenance the control system in this mode shall comply with performance level PLr d according to ISO 13849-1:2015.

When accessing a defined danger zone by opening an interlocked guard or through an AOPD (Automatic Optoelectrical Protective Device) (see ISO 13855:2010), hazardous moving parts shall be brought to a standstill before a dangerous situation can occur. The time required to bring the hazardous moving parts to standstill can be derived from ISO 13855:2010. The safety related parts of the control system, which bring the hazardous moving parts to a stop, should be carried out in at least PLr c. The final disconnection of power after a stop should be carried out in PLr e for normal operation and PLr d for maintenance/cleaning activities.

When there are electronic components within the machine control system, the interlocking of the safety functions (emergency stop, interlocking, electro-sensitive protective devices or two-hand control devices) shall be independent of the electronic control system of the machine or shall be connected to failsafe PLC or safety relays. Limit switches within controls shall be arranged or installed so that no unintended start can be initiated.

The machine shall be designed, that it will stop the operation as soon as possible (according to the risk assessment, see ISO 12100:2010) at any point in its cycle when an emergency stop (see ISO 13850:2015) is activated or a safety function or device (see ISO 14119:2013) has become inoperative.

5.1.6 Electrical equipment

Electrical equipment shall be conforming to IEC 60204-1:2016.

Electrical components to be used in potential explosive atmospheres shall be designed to avoid ignition.

Manufacturer shall identify through an individual risk assessment based on ISO 12100:2010 which electrical hazards are significant. If electrical hazards appear, appropriate measures according to IEC 60204-1:2016 shall be taken into account.

5.1.7 Safety-related control systems

Safety-related control systems and devices shall be in accordance with:

a) IEC 60204-1:2016, 9.4;

b) ISO 13849-1:2015, Clause 5, or IEC 62061:2013, Clause 5; and

c) ISO 4413:2010 for hydraulic and ISO 4414:2010 for pneumatic systems.

5.1.8 Safety-related software and parameters

Safety-related software and parameters shall be protected against unauthorized access and manipulation, e.g. by passwords on different levels. For software safety requirements, see ISO 13849-1:2015, 4.6. In general, passwords are not passed to the user. In case those passwords are passed to the user, information shall be given in the Information for use that modifications of software and/or parameters can lead to additional hazards and thereby have an impact on the safety of the line and can result in losing the presumption of conformity.

Safety-related software and parameters shall be validated according to Clause 6.

Furthermore, ISO 12100:2010, 6.2.11.7.3, shall apply.

NOTE Software modifications can be detected by using a checksum. If the original checksum is different from the current checksum, a modification has been made.