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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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Contents

Page

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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).

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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.

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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.

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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*

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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

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— 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.

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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.

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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.

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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)

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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.

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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

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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.

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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.

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5.1.9 Remote access to the control systems

Where a machine is equipped with functions for remote diagnostics or control (remote access) the manufacturer shall provide technical means and detailed information to reduce the risk that hazards can be initiated during remote access sessions. This includes – but is not limited to - the following:

a) remote access shall take place via a safe and secure (i.e. encrypted) connection;

b) remote users shall be mandated by the machine manufacturer or shall have equivalent knowledge of the connection and of the machine which is connected;

c) the limits of remote access (e.g. user profile, rights, time limits), shall be included in the risk assessment and shall be described in the instructions for use;

d) activities, which the remote user shall be able to carry out, shall be included in the risk assessment and shall be described in the instructions for use;

e) activities, which the local user is obliged to carry out (e.g. being present at the machine during the remote session), shall be included in the risk assessment and shall be described in the instructions for use;

f) any single machine shall be positively identified by the remote user, e.g. by point-to-point connection by VPN-tunnel, indicator signal exchange;

g) modification of safety-related software and/or parameters shall be authorised - by written or technical consent - by the local user in each case (i.e. per remote access session);

h) prior to modification of safety-related software and/or parameters the hazardous parts of the machine shall be stopped and shall remain stopped during the remote access session;

i) where safety-related software and/or parameters have been modified, a functional test of the modified software and/or parameters shall be carried out by the local user after termination of the remote session;

j) the activities of each remote access session shall be documented by the remote user.

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

5.1.10 Two-hand control devices

Two-hand control devices (see ISO 13851:2019) shall meet the following requirements:

a) the control system of the machine shall be able to interrupt the hazardous movement in time if one actuator of this device is released;

b) they shall comply with type IIIB of ISO 13851:2019;

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

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

e) 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).

5.1.11 Ergonomics

ISO 12100:2010, 6.2.8, shall be considered. Particular attention shall be paid to the following:

a) dedicated lifting aids or anchoring points for common lifting devices shall be provided whenever frequent lifting or heavy tooling of machines is required;

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b) handles, hand-holds or grips shall be fitted with a slip-resistant (e.g. knurled) surface;

c) 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 movements; the work area shall be sufficiently spacious to handle manual loads close to the body;

NOTE Parts, such as electric motors, should be located on top of structural supports and shelves rather that suspended. This removes the need for manually supporting the item whilst securing it in position;

d) manual handling of loads (e.g. flasks, tooling, core setting, removal of cores) shall be considered (see ISO 12100:2010 and EN 1005-2: 2009).

e) slip-resistant surfaces;

f) vibration protection as defined in 5.1.9;

g) heat protection as defined in 5.1.10;

h) operation elements, e.g. control panels shall be located to allow a direct view or via CCTV to the related area, if applicable.

5.1.12 Noise

5.1.12.1 Noise reduction at source by design

When designing a machine, technical measures for reducing noise at source at the design stage shall be considered (see ISO/TR 11688-1:1995). Examples for general measures which should be considered are

— reduce impact energy (e.g. by reducing the height of fall);

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

— reduce noise of gas flow (e.g. low-noise nozzles, sound absorbers);

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

— dampening of structure-borne noise (e.g. by coating or sandwich plate);

— insulation of structure-borne noise (e.g. by installation of masses), vibration isolated mounting (e.g. by spring elements and dampers);

— acoustic short circuit (e.g. perforated plate/lattice boxes).

The criterion for assessing the efficacy of measures to reduce noise at source is the actual noise emission values from the machine in relation to other machines of the same family and not the nature of the measures themselves.

NOTE ISO/TR 11688-2:1998 gives useful information on noise generation mechanisms.

5.1.12.2 Noise reduction by protective measures

The secondary noise control can be achieved e.g. by the increase of noise dampening and insulation, physical separation for noise source and receiver, sound-insulated control rooms, separate rooms/ cellars for hydraulic pumps and water distribution systems. Examples are reductions by using:

— total or partial enclosures;

— shields;

— silencers;

— increased distance between source and operator.

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NOTE The efficacy of such protective measures can be estimated, e.g. by using the ISO 11546 series (for enclosures), ISO 11691:2020 and ISO 11820:1996 (for silencers) and ISO 11821:1997 (for shields).

5.1.12.3 Secondary noise control

If secondary noise control is applicable it shall be specified by the manufacturer and can be supplied by the user, like separate rooms/ cellars as a part of the building.

If noise reduction at source and/or by protective measures is not sufficient, further protection of the operator is necessary, e.g. noise reduction by using PPE. For recommendations to the user, see 7.4.2.1.

5.1.12.4 Noise test code for measurement and declaration

Noise measurement and declaration shall be made according to regional requirements, e.g. for deliveries into the EU and associated countries, see EN 1265:1999.

5.1.13 Vibrations

Vibrations shall be considered at the design stage using the guidance given in EN 1299:1997 as appropriate.

Where the hands or arms of the worker(s) are subjected to a vibration emission having a weighted root mean square acceleration exceeding 2,5 m/s^2 the actual value should be stated. When experience has shown that the magnitude of hand-arm vibration is in general significantly below 2,5 m/s^2, it is sufficient to mention that the acceleration is below this limit.

Where the risk of whole-body vibration is given, appropriate measurement shall be made. Where the body of the worker(s) is subjected to a whole-body vibration emission exceeding 0,5 m/s^2, the single whole-body vibration value (weighted root means square acceleration) should be stated.

5.1.14 Surface temperatures and heat radiation

Permanent workplaces, operating points and main routes shall be protected against heat radiation and unintentional touching of hot surfaces, if applicable:

a) For heat radiation, EN 12198-3:2003 shall be considered;

b) Surfaces which are accessible and can be touched shall have temperatures not exceeding the burn threshold for contact time and material specified in ISO 13732-1:2006. If said limits cannot be kept because of technical reasons, additional technical measures shall be applied, e.g. isolation, distance guard. Complementary measures shall be included in the operating/maintenance instructions, e.g. for maintenance, repair, adjustment, indication of warnings and wearing of PPE.

For all other accessible places, an indication of the risk and necessary actions(e.g. cooling down time, PPE) shall be given in the operating/maintenance instructions.

5.1.15 Safety signs and warning devices

Safety signs and warning devices according to IEC 61310-1:2007 shall be used. They shall be installed so that they are perceptible before accessing/reaching the zone where the danger exists.

An accumulation of safety signs and warning devices should be avoided as this reduces the effectiveness and, thus, the attention paid to each device.

The meaning of safety signs and warning devices shall be described in the information for use (e.g. the hazard it refers to, indication of the affected area).

Graphical symbols shall be in accordance with ISO 3864-1:2011 and/or ISO 7010:2019.

Danger signals shall be in accordance with ISO 7731:2003, ISO 11428:1996 and/or ISO 11429:1996.

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5.1.16 Exhaust systems

Where hazardous dusts and fumes appear, they shall be collected and extracted by an appropriate exhaust system, e.g. filter, scrubber, ducting.

If dust and fumes cause significant hazards, the machine operation shall be interlocked with the exhaust system to avoid operation without active exhaust system.

5.1.17 Fire and explosion protection

Where hazardous dusts, fumes or flammable materials appear, this material should be stored in containers made from non-flammable materials.

Storage containers shall be provided with exhaust installations to prevent escape of flammable dusts. Ex- proof containers shall be designed to withstand or depressurize in safe way explosion impulses.

When handling exothermic processes, e.g. mixture of two components with exothermic behaviour, measures shall be taken to prevent fire/explosion, injuries to respiratory tracts or burns.

Prevent ignition, provide fire-detection device, if applicable.

5.1.18 Fluid systems

When designing a machine containing fluid systems, safety requirements according to ISO 4413:2010 and ISO 4414:2010 shall be applied.

Examples of general measures which should be considered are:

— avoid unintended pressures and

— avoid unintended mechanical movements due to stored pressurized fluids

— provide measures to handle gravity loaded parts safely

5.1.19 Mechanical stability

All machine parts shall be designed to take the upcoming loads during normal operation. Additionally, a case related safety factor shall be taken in account. The safety factor shall be at least 1,25. Higher safety factors can be required according to specific risk assessment.

Examples of general measures which should be considered are:

— selection of adequate material;

— consideration of combined stresses and number of intended cycles;

— design according to intended stresses.

5.2 Significant hazards, hazardous situations, safety requirements and/or protective/ risk reduction measures

According to the scope of this document, five tables are developed to allow the designer and manufacturer of the equipment to apply a logical approach for checking the design against a list of significant hazards with respect to the different types of machinery covered by this document. In addition, an individual risk assessment shall be carried out according to 4.2.

Table 1 describes general machine requirements.

Table 2 applies to sand conditioning and reclamation equipment.

Table 3 applies to molding machinery and lines.

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Table 4 applies to coremaking machinery and lines.

Table 5 applies to knock-out equipment.

Tables 1 to 5 are structured as follows:

a) column 1 identifies the significant hazards;

b) column 2 describes the hazardous situations;

c) 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;

d) column 4 refers 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;

e) column 5 identifies the verification methods to be used to demonstrate conformity according to Clause 6.

5.3 Significant hazards, hazardous situations, safety requirements and/or protective/risk reduction measures: General requirements

Table 1 — General requirements

Significant hazard	Hazardous situation	Safety requirements and/or protective/risk reduction measures	Reference in this document	Verification in this document
5.3.1 Handling of machines and heavy component parts				
1 Crushing	Handling and hoisting of large parts Injuries caused by slippage or falling parts	Provide measures for easy and safe handling of machines and their heavy components/parts, e.g. possibility to apply lifting and/or tilting tables and devices.	5.1.11	6.1 6.2
5.3.2 Fire/explosion when coating molds and cores				
1 Fire, explosion	Mold/core coating/drying: Through deliberate ignition of flammable coatings or diluting mediums after coating (e.g. dipping or spraying) to dry molds and cores	Requirements for integrated containers for coatings shall be considered.	5.1.17	6.1 6.2
		Coating cells shall be provided for the coating of molds and cores by alcoholic spraying coatings. They shall be made of non-flammable materials and shall be provided with exhaust installations that prevent the escape of spraying material. Within the coating cell, measures shall be taken to prevent an ignition of the explosive atmosphere.	5.1.7	6.1 6.2
		Provide fire detection device	5.1.17	6.1
		The electrical components in coating cell shall be explosion-proof.	5.1.7	6.2
		Requirements for mold and core coating dryers and ovens	In accordance with appropriate regional standards, e.g. EN 1539	6.1
5.3.3 Maintenance and set-up activities				

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Table 1 *(continued)*

Significant hazard	Hazardous situation	Safety requirements and/or protective/risk reduction measures	Reference in this document	Verification in this document
1 Crushing, shearing	Deliberate or accidental wrong actuation of machine movements Danger to persons working inside the machine/line due to unexpected start-up	Provide multi-pole disconnecting switches for equipment.	5.1.7	6.2 6.3
		Provide mode selection switch.	5.1.6	6.2 6.3
		Location of set-up/maintenance points outside the danger zone, if possible	5.1.11	6.1
		The disabling of safety devices by mode selection shall also simultaneously switch to set-up mode.	5.1.6	6.2 6.3
		When the power actuators for set-up mode are released, hazardous movements shall stop immediately.	5.1.6	6.2 6.3
		The position of the control panel shall be arranged so that a direct view into the danger zone is possible.	5.1.11	6.1
		Provide portable operator panel with emergency-stop.	5.1.6	6.1 6.2
		Provide enabling devices.	5.1.6	6.1 6.2
		In this case, the relief valve and the actuating mechanism for the energy supply shall be labelled as follows: "Attention, prior to repair the pressure accumulator system shall be depressurized".	5.1.15	6.1 6.10
	Unexpected start-up due to failure of components of electronic control systems and uncontrolled orders to control valves or electric drives causes danger to persons working inside hazardous zones	Provide electric/electronic components of safety-related control systems in accordance with at least PLr d.	5.1.6	6.2 6.3
	Unexpected movements/ start-up due to return of the motion energy or the clamping energy after previous drop or failure of energy causes danger to persons working inside hazardous zones.	Hazards from hydraulic and pneumatic equipment shall be prevented.	5.1.6, Annex A	6.1 6.2

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Table 1 *(continued)*

Significant hazard	Hazardous situation	Safety requirements and/or protective/risk reduction measures	Reference in this document	Verification in this document
	Unexpected movements of machine parts due to drop or failure of pressure or unexpected generation of pressure causes danger to personel working on the equipment without optical or acoustical connection to each other	Jacks and/or adequate supporting and/or locking devices when working under raised machine parts or within the danger zone of machines that are depressurized but normally work in a pressurized state. It shall be possible to relieve residual pressure from the supply pipes of machine parts.	5.1.11	6.1
		Machines or parts of the line being moved or held by pressure energy shall be protected against hazardous movements caused by a drop or failure of pressure by: — weighted or spring-loaded locking devices; — non-return valves or control valves that are directly attached to the working cylinder and that take their locking position automatically when there is a pipe failure; or — manually operated locking device.	5.1.6	6.1 6.2
		Operating/maintenance instruction: Advice to the user to instruct operators and maintenance staff accordingly.	7.4.1 7.4.2 7.4.3	6.1
2 Unhealthy postures or excessive effort	Manual handling: Increased fatigue	The machine shall be designed in such a way that there is no hindrance for technical aids for handling, if applicable.	5.1.11	6.1

5.4 Significant hazards, hazardous situations, safety requirements and/or protective/risk reduction measures: Sand conditioning and reclamation equipment

Table 2 — Requirements for sand conditioning and reclamation equipment

Significant hazard	Hazardous situation	Safety requirements and/or protective/risk reduction measures	Reference in this document	Verification in this document
5.4.1 Preventative measures against injuries due to mechanical hazards and noise				
5.4.1.1 Sand mixers, mills, coolers and conveyor systems				
1 Crushing, shearing, drawing-in	Movement of the mixing and milling tools within the mixing or cooling plate or trough: Injury to hands when sampling from above or at the discharge; cleaning of discharge from outside; cleaning of screw of continuous mixers.	Provide fixed guards;	5.1.1	6.2
		Provide interlocking guards with guard locking; and/or	5.1.2 5.1.6	6.2
		Provide devices for isolation and energy dissipation.	5.1.6 5.1.7	6.2

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Table 2 *(continued)*

Significant hazard	Hazardous situation	Safety requirements and/or protective/risk reduction measures	Reference in this document	Verification in this document
2 Crushing, shearing	Where there is the possibility of entry/access into the mixer, mill or cooler: Danger to persons working inside (cleaning or maintenance) from unexpected start-up. NOTE During maintenance, personel can be working on the conditioning/reclaiming equipment.	Provide interlocking guard with guard locking;	5.1.1	6.2
		Restart shall be avoided;	5.1.6 5.1.7	6.2
		Provide measures against failure of control, if applicable, in a cumulative way;	5.1.6	6.2 6.3
		Provide devices for isolation and energy dissipation;	5.1.6 5.1.7	6.2 6.3
		Access door shall be secured against unintended closing and locking;	5.1.2 5.1.6	6.1 6.2
		Provide disconnectiong switch for the mixer/mill/cooler/conveyor to lock-off; and	5.1.7	6.2 6.3
		Operating/maintenance instruction: Permanent and clear warning sign "danger zone" and additional sign "before entry, the mixer shall be shut-off and secured against restart by the person(s) who enter(s)".	7.4.1 7.4.2 7.4.3	6.1 6.10
3 Unhealthy postures or excessive effort	Increased fatigue due to manual loading	Design taking into account ergonomic principles	5.1.11	6.1
4 Noise	Hearing loss, stress, loss of awareness and tinnitus. Noise also can lead to accidents because speech communication and acoustic signals are not percievable. Main noise sources are working processes and blow-cleaning devices.	Provide noise reduction measures, e.g. low-noise components, drives as silent as possible, rpm as low as possible; and	5.1.12	6.8
		Operating/maintenance instruction: PPE, e.g. ear phones connected to the main pulpit.	7.4.1 7.4.2 7.4.3	6.1
5.4.1.2 Sand aerators				
1 Crushing, shearing	The discharge point and the entry point especially of the aerating belt or aerating drum to enclosure create a pinch point: Injury to hands or upper/lower limbs	Provide guards.	5.1.1 5.1.2 5.1.6	6.1 6.2

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Table 2 *(continued)*

Significant hazard	Hazardous situation	Safety requirements and/or protective/risk reduction measures	Reference in this document	Verification in this document
2 Noise	Hearing loss, stress, loss of awareness and tinnitus. Noise also can lead to accidents because speech communication and acoustic signals are not percievable. Main noise sources are working processes.	Provide noise reduction measures, e.g. low-noise components, drives as silent as possible, rpm as low as possible, isolation of structure borne noise of aerator casing against the drive, damping of the aerator casing; and	5.1.12	6.8
		Operating/maintenance instruction: PPE.	7.4.1 7.4.2 7.4.3	6.1
5.4.1.3 Sand lump crusher				
1 Crushing, shearing, impact	Openings provided in the machine body for inspection, maintenance of tools, cleaning: Danger from crusher movement if there is unexpected start-up or if the hinged covers are opened before the crusher has stopped. Ejection of lumbs	Provide interlocking guards with guard locking and	5.1.2 5.1.6	6.1 6.2
		Provide devices for isolation and energy dissipation	5.1.6 5.1.7	6.2 6.3
2 Noise	Hearing loss, stress, loss of awareness and tinnitus. Noise also can lead to accidents because speech communication and acoustic signals are not percievable. Main noise sources are working processes.	Provide noise reduction measures, e.g. low-noise components, drives as silent as possible, damping of the crusher casing; and	5.1.12	6.8
		Operating/maintenance instruction: PPE.	7.4.1 7.4.2 7.4.3	6.1
3 Vibration	Stress to human joints, nerves and blood vessels due to whole body vibration. Machinery vibration can have effects on the adjoining work places.	Isolation of vibration at the installation of sand lump crushers producing vibrations	5.1.13	6.9
5.4.1.4 Screening equipment				
1 Drawing-in, trapping, shearing	Injury to the operator during operation, maintenance, cleaning, troubleshooting due to pinch points if the doors are opened during rotation or vibration of the equipment or doors are not closed before the equipment starts	Provide interlocking guards.	5.1.2 5.1.6	6.1 6.2

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Table 2 *(continued)*

Significant hazard	Hazardous situation	Safety requirements and/or protective/risk reduction measures	Reference in this document	Verification in this document
2 Noise	Hearing loss, stress, loss of awareness and tinnitus. Noise also can lead to accidents because speech communication and acoustic signals are not percievable. Main noise sources are working processes.	Provide noise reduction measures, e.g. low-noise components, drives as silent as possible, damping of the screening casing; and	5.1.12	6.8
		Operating/maintenance instruction: PPE.	7.4.1 7.4.2 7.4.3	6.1
3 Vibration	Stress to human joints, nerves and blood vessels due to whole body vibration Machinery vibration can have effects on the adjoining work places.	Isolation of vibration at the installation of screening equipment producing vibrations	5.1.13	6.9
5.4.1.5 Magnetic separators				
1 Stabbing or puncture	Danger to eyes and body due to unprotected discharge of ferromagnetic material from the magnetic separator NOTE The presence of tramp metal in the sand, can cause danger when operating, e.g. a rotation magnetic separator.	Provide metal separation and shielding of separator discharge without creating pinch points; and	5.1.1 5.1.2	6.1
		Provide warning sign (eye protection).	5.1.15	6.10
		Operating/maintenance instruction: PPE.	7.4.1 7.4.2 7.4.3	6.1
2 Crushing, drawing-in	Injuries to arms due to touching of moving parts of the conveyor	Provide fixed guards.	5.1.1	6.1 6.2
3 Electromagnetic fields	Magnetic fields causing interference with, e.g. pacemakers	Provide magnetic shielding, if applicable;	IEC 61000	6.1 6.2
		Provide warning signs; and	5.1.15	6.10
		Operating/maintenance instruction: Danger for "pacemaker holders".	7.4.1 7.4.2 7.4.3	6.1
5.4.2 Preventative measures against hazards caused by substances				
5.4.2.1 Magnetic separators				
1 Inhalation of fumes and dusts	Danger from breathing quartz dust due to feeding and discharging sand	Provide equipment for dust reduction, e.g. enclosed charging and discharging of sand or material accompanied with sand, prevention of spills and leaks, no gravity fed enclosures connected to exhaust systems, possibility for ventilation; and	5.1.16	6.1 6.7
		Operating/maintenance instruction.	7.4.1 7.4.2 7.4.3	6.1

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Table 2 *(continued)*

Significant hazard	Hazardous situation	Safety requirements and/or protective/risk reduction measures	Reference in this document	Verification in this document
	Damage to health from airborne formaldehyde, phenol, furfurylalcohol both for breathing and for skin contacts due to feeding and discharging during the reclamation of used sand, mixers for resin-bonded mold and core sand	Design to avoid the use of excessive binder, to provide for automatic dosing or enclosed dosing and to avoid skin contact; and	5.1.16	6.1
		Operating/maintenance instruction: local exhaust ventilation.	7.4.1 7.4.2 7.4.3	6.1
2 Exothermic reactions	Supply of resin and hardener which cause an exothermic reaction: — fire and explosion hazard when no sand in machine or hoses wrongly connected; — injury to respiratory tracts from breathing harmful gases; — cauterization because of skin contact	The supply of resin and hardener shall only be possible if probes within the equipment indicate that there is a sufficient quantity of sand.	5.1.17	6.1
		Connecting hoses shall be marked and designed to prevent interchangeability, e.g. with left-hand threads for hardeners and right-hand threads for the other materials (e.g. binders).	5.1.17	6.1 6.10
NOTE Continuous conveyors are not covered by the scope of this document. If continuous conveyors are part of the conditioning and reclamation plant and their operation creates a particular risk of dust and fumes the relevant preventative measures also apply to this equipment				
5.4.2.2 Sand dryers and heaters				
1 Explosion	Gas fired equipment: Ignition procedure, control failure, flow failure	Provide measures according to ISO 13577-2:2014	ISO 13577-2:2014	6.2
2 Trapping	— No possibility of escape from inside of walk-in ovens with doors — Unintended locking of doors when a person is inside the oven — Trapping inside the equipment during maintenance	Provide interlocked guards; and	5.1.2 5.1.6	6.1 6.2
		Provide emergency exit, duplicate opening mechanism actuated also from the inside.	5.1.2	6.1 6.2
5.4.2.3 Equipment for handling of coal dust				
1 Fire, explosion	Burning and injuries by explosion effects due to import or creation of undetected burnings or electrostatic charging in silos and plants for pneumatic conveyance	Provide steep outflow (at least at an angle of 70° against the horizontal) and rounded edges, if necessary aeration installations for the avoidance of deposits, blockages and bridging	5.1.17	6.1

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Table 2 *(continued)*

Significant hazard	Hazardous situation	Safety requirements and/or protective/risk reduction measures	Reference in this document	Verification in this document
	— Explosive mixture of dust or vapours — Removing of material bridging within the silos, e.g. after fire extinguishing	If aerating installations are used, it shall be possible to operate them with inert gas;	5.1.17	6.1 6.5
		Aeration installations shall only be effective during the dust removal and shall avoid the entry of air into the silos at other times;	5.1.6	6.1 6.5
		It shall be possible to provide inert gas atmosphere for coal dust silos. The appropriate provisions of inert gas shall be calculated so that the total volume of the largest silo can be filled with inert gas. Sufficient inertization is ensured if 2 kg CO_2 or 1 m^3 N_2 are brought in for each m^3 silo volume;	5.1.17	6.1 6.2 6.5
		Silos designed to be situated in areas subject to radiant heat shall be protected from such radiant heat; and	5.1.14	6.5
		Provide permanent and legible warning signs. These shall state at least the following: "Danger zone. No smoking. Do not use naked flames near silos or the filling/emptying areas. Flames and/or fires shall only be permitted by the supervision in writing and under strictly controlled procedures which detail any special precautions that need to be taken. Nobody shall go inside to dislodge a bridge";	5.1.15	6.10
		Shock-pressure-resistant design for the silos and the pipework and equipments. The venting of explosion pressure from the silos shall be into safe areas;	5.1.17	6.4 6.5
		Electrostatic earthing of the silos and the pipework, possibility for electrostatic earthing of supply vehicles;	5.1.7	6.2 6.5
		The temperature of the compressed air used for conveying coal dust shall not exceed 80 °C;	5.1.17	6.5
		Permanent temperature or CO measuring devices shall be fitted at the silo outflow and above the maximum charge level in the silo. These shall operate automatic alarms and stop the material supply and outflow when limiting values are exceeded;	5.1.17	6.2 6.5

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Table 2 *(continued)*

Significant hazard	Hazardous situation	Safety requirements and/or protective/risk reduction measures	Reference in this document	Verification in this document
		Operating/maintenance instruction: Reference to limiting values;	7.4.1 7.4.2 7.4.3	6.1
		The electrical components inside the installations mentioned above or in the vicinity of filling and emptying areas, shall be suitable for use in an explosive atmosphere;	5.1.7	6.3 6.5
		Operating/maintenance instruction: Provide instructions on the handling, conveyance and storage of coal dust and coal dust substitutes;	7.4.1 7.4.2 7.4.3	6.1
2 Asphixiation	Oxygen deficiency, toxic gases, suffocation, skin effects during removal of blockages or maintenance inside the silo	Provide warning signs; and	5.1.15	6.10
		Operating/maintenance instruction: PPE and reference to rescue procedures	7.4., 7.4.2 7.4.3	6.1

5.5 Significant hazards, hazardous situations, safety requirements and/or protective/risk reduction measures: Molding machinery and plants

Table 3 — Requirements for molding machinery and plants

Significant hazard	Hazardous situation	Safety requirements and/or protective/risk reduction measures	Reference in this document	Verification in this document
5.5.1 Mechanical hazards and noise				
5.5.1.1 Molding machinery, general				
1 Crushing, drawing-in, trapping, impact	Motion of movable parts, e.g. squeeze head pushing/lifting cylinder, turn table	Provide guards to reduce the possibility of accidental contact by persons or objects; and	5.1.1 5.1.2	6.1 6.2
		Ensure minimum space between movable parts and the immediate surroundings by design; and/or	5.1.11 ISO 13854:2017	6.1 6.2
	Turnover and rollover motion at turnover and rollover machines	Safety devices shall be provided, e.g. two-hand control device. In case of a two-hand control device, a safe distance shall be observed.	5.1.4 5.1.5 5.1.6	6.2
		Provide warning signs (no entry into danger zone, no operating within danger zone).	5.1.15	6.10
		Operating/maintenance instruction	7.4.1 7.4.2 7.4.3	6.1
	Self-acting turnover/rollover at energy failure due to the mass of the molding box	Self-acting turnover/rollover shall be avoided.	Annex A	6.1 6.2

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Table 3 *(continued)*

Significant hazard	Hazardous situation	Safety requirements and/or protective/risk reduction measures	Reference in this document	Verification in this document
2 Impact	Loosening or releasing of the box moving system in case of energy failure/failure of control system/ uncontrolled signals to control valves at turnover and rollover machines, box transfer devices	Provide measures against hazards due to failure/malfunction of the control system, if applicable, in a cumulative way;	5.1.6	6.1 6.2
		Provide measures against unexpected restart;	5.1.6	6.2
		Provide measures against hazards from hydraulic and pneumatic equipment; and	Annex A	6.1 6.2
		Provide safe design of the box moving device.	5.1.1 5.1.2	6.1
3 Unhealthy postures or excessive effort	Unhealthy posture or excessive efforts due to manual handling of e.g. molding boxes, cores, patterns	Ergonomical principles shall be considered in the design.	5.1.11	6.1
4 Noise	Hearing loss, stress, loss of awareness and tinnitus. Noise also can lead to accidents because speech communication and acoustic signals are not percievable. Main noise sources are working processes, impact noises, vibration noises, noises from the expansion of compressed air.	Provide low-noise design, e.g. the impact surfaces should be inside the machine, design of the impact elements, in particular, jolt mechanism; and	5.1.12	6.8
		Avoidance of free expansion of compressed air during normal operation.	Annex A	6.1
5.5.1.2 Automatic molding machinery				
1 Crushing, shearing, drawing-in, trapping	Movement of molds, mold parts, mold tools, molding material containers, sand filling slides, molding chambers, molding boxes, pattern changing devices, core setters can lead to injuries to various parts of body, if			
	— there is need for the operator in normal operation to reach in or stand in the equipment to carry out operating tasks;	Provide fixed guards; and/or	5.1.1	6.1 6.2
		Provide movable guards and/or	5.1.2, 5.1.6	6.1 6.2
		Provide ESPD where frequent intervention (i.e. for feeding and/or removing of parts) is required during normal operation and	5.1.3 5.1.6	6.1 6.2
		Provide measures against hazards from hydraulic and pneumatic equipment as well as electrically driven equipment and	Annex A	6.1 6.3
	— there is need for troubleshooting, cleaning, adjustment in normal operation or maintenance	Provide control system and	5.1.6	6.2
		Location of working positions shall be secured by a safely switched-off area and	5.1.6	6.1
		Provide device to switch to manual and set-up control mode and	5.1.6	6.1
		The position of the control panel shall allow a direct view into the danger zone or	5.1.11	6.1
		Provide portable control device with emergency stop to operate the machine with active guards and	5.1.6 5.1.7	6.2
		Provide devices to depressurize pressure pipes and/or reservoirs of machine parts, if necessary and	Annex A	6.1
		Machines or parts of the plant being moved or held by pressure energy shall be protected against hazardous movements caused by loss of energy.	5.1.6 Annex A	6.1 6.2

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Table 3 *(continued)*

Significant hazard	Hazardous situation	Safety requirements and/or protective/risk reduction measures	Reference in this document	Verification in this document
2 Noise	Hearing loss, stress, loss of awareness and tinnitus. Noise also can lead to accidents because speech communication and acoustic signals are not percievable. Main noise sources are working processes, impact and striking of a limit stop, noises from the expansion of compressed air, mechanical blow-off devices.	Provide low-noise design, e.g. impact damping, fixed stop absorption, avoidance of free expansion of compressed air, avoidance of structure-borne noise.	5.1.12	6.8
		Avoidance of free expansion of compressed air during normal operation	Annex A	6.1
5.5.1.3 Shoot-, blow-, fluidization- and squeeze molding machines, impulse molding- and air flow squeeze molding machinery (additional requirements to 5.5.1.1)				
1 Ejection	Injury to eyes and body during normal operation due to ejected sand or media-blast from — shooting (blowing) or impulse head and filling frame; — shooting head and molding chamber (if applicable); — parts of molding chamber (if applicable); — filling frame and molding box; — molding box and pattern plate; — manual blow-off	Provide control system; and	5.1.6	6.1 6.2
		Provide splash protection, e.g. fixed guard or interlocked guard as splash shields; and	5.1.1 5.1.2 5.1.6	6.1 6.2
		Provide interlocking of the ready-to-shoot (impulse/blow) position of the molding box with the shooting (blowing) process; and	5.1.6 Annex A	6.2
		Operating/maintenance instruction: surface must be clean before the shooting (impulse/blow) process; PPE	7.4.1 7.4.2 7.4.3	6.1
2 Impact, crash	Injuries to eyes, face and other parts of the body due to disintegration and flying off of pressurized parts due to inadequacy of mechanical strength	Stress analysis for pressure accumulator and filling frame. Ensure that molding boxes or molding chambers/filling frames can withstand the mechanical and pneumatic forces that will be present in the equipment.	5.1.18	6.6
3 Noise	Hearing loss, stress, loss of awareness and tinnitus. Noise also can lead to accidents because speech communication and acoustic signals are not percievable. Main noise sources are working processes, impact and striking of a limit stop, noises from the expansion of compressed air, mechanical blow-off devices.	Provide low-noise design, e.g. impact damping, fixed stop absorption, avoidance of free expansion of compressed air, avoidance of structure-borne noise.	5.1.12	6.8
		Avoidance of free expansion of compressed air during normal operation	Annex A	6.1
5.5.1.4 Molding line				

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Table 3 *(continued)*

Significant hazard	Hazardous situation	Safety requirements and/or protective/risk reduction measures	Reference in this document	Verification in this document
1 Crushing, shearing, drawing-in, trapping	Injuries to hands or body during operation, troubleshooting, cleaning due to movement of molds, mold parts, mold tools, molding material containers, sand filling slides, molding chambers, molding boxes, pattern changing devices, core setters, vent hole drilling station, down sprue cutting station, punch-out station, closing and separating station, etc.	Provide control system; and	5.1.6	6.1 6.2
		Provide fixed guards; and/or	5.1.1	6.1 6.2
		Provide movable guards; and/or	5.1.2 5.1.6	6.1 6.2
		Provide ESPD where frequent intervention (i.e. for feeding and/or removing of parts) is required during normal operation; and	5.1.3 5.1.6	6.1 6.2
		Provide measures against hazards from hydraulic and pneumatic equipment as well as electrically driven equipment; and	5.1.6 5.1.7 Annex A	
		Unexpected restart shall be avoided; and	5.1.6	
		Provide optical and/or audible warning devices that actuate prior to any restarting of the equipment.	5.1.15	6.10
	Injuries caused by the need for frequent intervention (setting of risers, cores and chills, cleaning, spraying with coating liquids, etc.) due to movement of molds, flasks, etc.	Provide control system; and	5.1.6	6.1 6.2
		Provide interlocking and/or fixed guard to avoid reaching shearing points; and/or	5.1.1 5.1.2 5.1.6	6.1 6.2
		Provide movable guard; or	5.1.2 5.1.6	6.1 6.2
		Provide ESPD, where frequent intervention is required during normal operation; and	5.1.2 5.1.6	6.1 6.2
		Provide measures against hazards from hydraulic and pneumatic equipment as well as electrically driven equipment; and	5.1.6 5.1.7 Annex A	6.1 6.3
		Unexpected restart shall be avoided.	5.1.6	6.2
	Injuries due to intervention in normal operation or maintenance at automatic core-setting devices, movements of turnover facilities, pouring milling devices, molding box assembling devices, transfer devices for weights, molding boxes or pallets, mold punch-out units, molding box separators, molding box cleaning devices, hydraulic, pneumatic or electric transport and damping units, motor driven roller conveyors, lifting tables, etc.	Provide control system; and	5.1.6	6.1 6.2
		Provide fixed guard; and/or	5.1.1	6.1 6.2
		Provide movable guard; and/or	5.1.2 5.1.6	6.1 6.2
		Provide ESPD; and	5.1.3 5.1.6	6.1 6.2
		Unexpected restart shall be avoided; and	5.1.6	6.2
		Provide optical and/or audible warning that actuate prior to any restarting of the equipment; and	5.1.15	6.10
		Provide measures against hazards from hydraulic and pneumatic equipment as well as electrically driven equipment; and	5.1.6 5.1.7 Annex A	6.1 6.3
		Operating/maintenance instruction.	7.4.1 7.4.2 7.4.3	6.1

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Table 3 *(continued)*

Significant hazard	Hazardous situation	Safety requirements and/or protective/risk reduction measures	Reference in this document	Verification in this document
2 Ejection	Injury to eyes and body during normal operation or media-blast from — shooting (blowing) or impulse head and filling frame; — shooting head and molding chamber (if applicable); — parts of molding chamber (if applicable); — filling frame and molding box; — molding box and pattern plate; — manual blow-off	Provide control system; and	5.1.6	6.1 6.2
		Provide splash protection, e.g. fixed guard or interlocked guard as splash shields; and	5.1.1 5.1.2 5.1.6	6.1 6.2
		Provide interlocking of the ready-to-shoot (impulse/blow) position of the molding box with the shooting (blowing) process; and	5.1.6	6.2
		Operating/maintenance instruction: surface must be cleaned before the shooting (impulse/blow) process; PPE.	7.4.1 7.4.2 7.4.3	6.1
3 Impact, crash	Injuries to eyes, face and other parts of the body due to disintegration and flying off of pressurized parts due to inadequacy of mechanical strength	Stress analysis for pressure accumulator and filling frame. Ensure that molding boxes or molding chambers/filling frames are capable of withstanding the mechanical and pneumatic forces that will be present in the equipment.	5.1.18	6.6
4 Noise	Hearing loss, stress, loss of awareness and tinnitus. Noise also can lead to accidents because speech communication and acoustic signals are not percievable. Main noise sources are working processes, impact and striking of a limit stop, noises from the expansion of compressed air, mechanical blow-off devices.	Provide low-noise design, e.g. impact damping, fixed stop absorption, avoidance of free expansion of compressed air, avoidance of structure-borne noise.	5.1.12	6.8
		Avoidance of free expansion of compressed air during normal operation	Annex A	6.1
5.5.1.5 Sand slingers				
1 Impact	Movement of the wheel	Provide interlocking guard with guard locking.	5.1.2 5.1.6	6.1 6.2
2 Crushing	Movement of the slinger arms	Provide fixed guard.	5.1.1	6.1 6.2
	In case of movable slingers, movement of travel carriage	Provide measures against hazards from hydraulic and pneumatic equipment as well as electrically driven equipment.	5.1.6 5.1.7 Annex A	6.1 6.3
3 Ejection	Injuries to eyes and body due to thrown-out sand by the rotating brush	Provide control system; and	5.1.6	6.1 6.2
		Provide fixed guard in combination with splash shield, if necessary; and/or	5.1.1	6.1 6.2
		Provide movable guard in combination with splash shield, if necessary; and/or	5.1.2 5.1.6	6.1 6.2
		Provide ESPD; and	5.1.3 5.1.6	6.1 6.2
		Operating/maintenance instruction: PPE.	7.4.1, 7.4.2, 7.4.3	6.1
5.5.1.6 Molding box cams for hoisting, transport and turnover				

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Table 3 *(continued)*

Significant hazard	Hazardous situation	Safety requirements and/or protective/risk reduction measures	Reference in this document	Verification in this document
1 Combination of hazards	— Injuries caused by a fall of moulding box off the lifting device (e.g. rope, chain) caused by insufficient or cracked connection of cam with moulding box (e.g. exceeding of stress to connection due to insufficient area of connection point, corrosion of connection point, for welded cams faulty welding of connection point) or loosening of load suspending device — Unintended loosening of cams that are not fixed to the moulding box	Provide safe design, taking into account design codes, data about material properties, etc.; and	5.1.19	6.1
		Provide brackets for cam connection to reduce bending stress; and	5.1.19	6.1
		Stress analysis of welded cams.	5.1.19	6.6
5.5.2 Measures against hazards caused by substances				
5.5.2.1 Hazards to health				
1 Asphyxiation, inhalation, ingestion of and contamination by harmful dusts and fumes	Danger in breathing in CO and decomposing products of molding material binders (main components, see Annex B) during pouring, cooling, knock-out and casting/sand separation of sand molds, increased by thermal upcurrent	Normal operation: Provide enclosure and local exhaust system; and NOTE Currently it is not possible to give common achievable values for concentrations of airborne toxic substances. Regional regulations can apply.	5.1.16	6.1 6.10
		Maintenance and repair: Operating/maintenance instruction: PPE (e.g. CO warning device, gas mask).	7.4.1 7.4.2 7.4.3	6.1
5.5.2.2 Hazards caused by unexpected discharge of liquid metal and contact with liquid metal/fire or explosion				
1 Burns	Operation of ladles and pouring equipment	In accordance with regional requirements, e.g. EN 1247:2010, 5.2 (ladles) and 5.3 (pouring equipment) shall be considered; and	5.1.14	6.1
		Operating/maintenance instruction: PPE.	7.4.1 7.4.2 7.4.3	6.1
	Eruption/discharge of liquid metal during pouring due to faulty assembly of moulds and/or cores	Provide measures to protect the operator from liquid metal by splash and run-through, e.g. sand bed and/or splash shield; and	5.1.1 5.1.2 5.1.6	6.1 6.2
		Operating/maintenance instruction: e.g. PPE.	7.4.1, 7.4.2, 7.4.3	6.1
	Ignition of hydraulic fluid in case of break of hydraulic pipe work or hoses and contact of hydraulic fluids with liquid metal due to hydraulic drives of pouring line/cooling line/displace pallet conveyors	Provide protection of hydraulic pipe work and hoses against mechanical, chemical and thermal influences; and/or	5.1.14	6.1
		Hardly inflammable or flame-resistant fluids shall be used.	Annex A	6.1

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5.6 Significant hazards, hazardous situations, safety requirements and/or protective/risk reduction measures: Coremaking machinery and coremaking lines

Table 4 — Requirements for coremaking machinery and coremaking lines

Significant hazard	Hazardous situation	Safety requirements and/or protective/risk reduction measures	Reference in this document	Verification in this document
5.6.1 Preventative measures against injuries due to mechanical hazards and high temperature hazards				
1 Crushing, shearing	Injury to hand during cleaning activities and troubleshooting due to closing and opening of the filling device (sand gate)	Provide control system;	5.1.6	6.2
		Provide fixed guard;	5.1.1	6.1
		Provide movable guard;	5.1.2 5.1.6	6.1 6.2
		Provide measures against hazards from hydraulic and pneumatic equipment as well as electrically driven equipment; and	5.1.6 5.1.7 Annex A	6.1 6.3
	Operator intervention during operation: Movement of core box parts, shoot head movements, movement of the lifting table, gassing plate/hood, core discharge and transfer devices, etc.	Provide control system: — For zones accessible during core unloading operation the required performance level shall be PLr e; — For zones accessible during maintenance the required performance level shall be PLr d; and	5.1.6	6.2
		Provide fixed guard; and/or	5.1.1	6.1
		Provide movable guard; and/or	5.1.2 5.1.6	6.1 6.2
		Provide ESPD; and	5.1.3 5.1.6	6.1 6.2
		Provide measures against hazards from hydraulic and pneumatic equipment as well as electrically driven equipment; and	5.1.6 5.1.7 Annex A	6.1 6.3
		Unexpected restart shall be avoided.	5.1.6	6.2
	Injuries in the zone of closing edges due to movement of powerdriven guards	Provide measures against hazards due to closing edges, e.g. bumper, ESPD.	5.1.2 5.1.3 5.1.6	6.2
2 Crushing, shearing, impact	Falling of the (hydraulic/pneumatic/electromechanical clamped) shoot head, shoot plate, gassing plate, corebox parts due to incorrect clamping/control during setting or troubleshooting	Provide safety against hazards due to failure of the control or malfunction if applicable in a cumulative way;	5.1.6	6.2
		Provide measures against hazards from hydraulic and pneumatic equipment as well as electrically driven equipment;	5.1.6 5.1.7 Annex A	6.1 6.3

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Table 4 *(continued)*

Significant hazard	Hazardous situation	Safety requirements and/or protective/risk reduction measures	Reference in this document	Verification in this document
	Parts of core boxes blown-off by air pressure due to inadequacy of mechanical strength during operation	Provide fixed guard;	5.1.1	6.1
		Provide movable guard; and	5.1.2 5.1.6	6.1 6.2
		Operating/maintenance instruction: Core boxes shall be capable of withstanding both mechanical and pneumatic forces.	7.4.1 7.4.2 7.4.3	6.1
3 Burns	Contact with parts of hot corebox due to assembling and separation of hot core boxes during operation	Provide fixed guard; or	5.1.1	6.1
		Provide movable guard; and/or	5.1.2 5.1.6	6.1 6.2
		Provide ESPD; and	5.1.3 5.1.6	6.1 6.2
		Operating/maintenance instruction: PPE.	7.4.1 7.4.2 7.4.3	6.1
	Gas heated coreboxes: Contact with heating flame in case of unexpected automatic ignition during manual core discharging, control activities or trouble-shooting	Any burner of fuel handling systems shall meet the requirements of ISO 13577-2:2014;	ISO 13577-2:2014	6.1 6.2
		Hardly inflammable or flame-resistant fluids shall be used; and	Annex A	6.1
		During manual core discharging, control activities and troubleshooting, no automatic ignition of open burner shall take place.	5.1.6	6.2
	Thermo-oil heated coreboxes: Contact with leaking hot oil	Provide protection of thermo-oil pipe work and hoses against mechanical, chemical and thermal influences ;	5.1.14	6.1
		Provide leakage-tight couplings and shut-off elements; and	5.1.14	6.1
		Operating/maintenance instruction: PPE.	7.4.1, 7.4.2, 7.4.3	6.1
4 Electrical shock, touching live parts	Electrically heated coreboxes: Electrical shock due to damaged isolation	Provide protection of cables, terminal boxes and plugs against mechanical, chemical and thermal influences; and	5.1.14	6.1
		Provide failure current switches.	5.1.7	6.3
5 Ejection	Ejection of cold or hot sand at separating lines between shooting- or blowhead and the core box and the parting lines of the core box during operation, corebox air-cleaning and spraying	Provide fixed guard, e.g. protective shielding; and/or	5.1.1	6.1
		Provide movable guard. Interlocking of the ready to shoot (blow) position of the core box with the shooting (blowing) process; and	5.1.2 5.1.6	6.1 6.2
		Provide sealing areas between joint surfaces.	5.1.1 5.1.2	6.1

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Table 4 *(continued)*

Significant hazard	Hazardous situation	Safety requirements and/or protective/risk reduction measures	Reference in this document	Verification in this document
		Provide sufficient exhaust devices to collect spray fumes; and	5.1.16	6.1 6.7
		Operating/maintenance instruction: PPE.	7.4.1, 7.4.2, 7.4.3	6.1
6 Unhealthy postures or excessive effort'	Unhealthy posture or excessive efforts due to removal of parts	Ergonomical principles shall be considered in the design, e.g. no hindrance to use technical aids and possibility for good working postures.	5.1.11	6.1
7 Noise	Hearing loss, stress, loss of awareness and tinnitus. Noise also can lead to accidents because speech communication and acoustic signals are not percievable. Main noise sources are working processes, impacts at limit stops, expansion of compressed air, mechanical blow-off devices.	Provide low-noise design, e.g. impact damping, sound absorption, isolation of structure borne noise, sound-absorbing design and arrangement of blowing nozzles, machinery enclosure, deadening of sand hopper; and	5.1.12	6.8
		Operating/maintenance instruction: PPE.	7.4.1, 7.4.2, 7.4.3	6.1
5.6.2 Measures against hazards caused by substances (Hazards to health, fire/explosion hazards)				
1 Asphyxiation, inhalation, ingestion of and contamination by harmful dusts and fumes	Inhalation of formaldehyde, phenol (shell core, hotbox method), amines of all types (cold box), SO_2 (SO_2-method), methylformate, furfurylalcohol/phenol (cold-setting), other alcohols for core coating (main components see Annex B) due to opening of core boxes, core removal (thermal upcurrent of hot gases and vapours) spraying core boxes, gassing procedure, core handling and core washing/coating	Provide measure to reduce emissions with extensive shielding and local exhaust as close as possible to the source of the gases and vapours;	5.1.16	6.1 6.7
		Operating/maintenance instruction: Information to the user about the required rate of exhaust air from the equipment;	7.4.1, 7.4.2, 7.4.3	6.1
	Inhalation of alcoholic vapours during core coating	Provide an integrated container for coatings; and	5.1.16	6.1
		Provide an ex-proof exhaust system.	5.1.7 5.1.16	6.3 6.7
7 Fire, explosion	— Working with cold-box catalysts, organic peroxides, methylformate storage, fuel gases for core box heating. — Ignition sources, in case of storage of peroxides/ gassing equipment	The components in the relevant areas for organic peroxides and in the gassing equipment shall be suitable for use in an explosive atmosphere.	5.1.7	6.3 6.7

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Table 4 *(continued)*

Significant hazard	Hazardous situation	Safety requirements and/or protective/risk reduction measures	Reference in this document	Verification in this document
	Unintended ignition of alcoholbased coatings or dilutings due to core coating	Integrated containers for coatings (dip tanks, reclaiming tanks) shall be made of nonflammable material and shall be stable. The containers shall be equipped with covers that overlap the outside edge;	5.1.17	6.1
		Provide an ex-proof exhaust system; and	5.1.7 5.1.16	6.1 6.7
		Operating/maintenance instruction: Information to the user about the need for fire extinguishing facilities	7.4.1, 7.4.2, 7.4.3	6.1

5.7 Significant hazards, hazardous situations, safety requirements and/or protective/risk reduction measures: Knock-out equipment

Table 5 — Requirements for knock-out equipment

Significant hazard	Hazardous situation	Safety requirements and/or protective/risk reduction measures	Reference in this document	Verification in this document
1 Crushing, shearing	Between fixed and oscillating/reciprocating parts and springs	Provide control system; and	5.1.6	6.1 6.2
		Safety by design: Assure minimum distance; or	ISO 13854:2017	6.1
		Provide fixed guards; and/or	5.1.1	6.1
		Provide movable guards.	5.1.2 5.1.6	6.1 6.2
2 Entanglement	Rotating shafts, drive mechanisms	Provide control system; and	5.1.6	6.1 6.2
		Provide fixed guard; and/or	5.1.1	6.1
		Provide movable guards.	5.1.2 5.1.6	6.1 6.2
3 Drawing-in	Rotary drums, drives	Provide control system; and	5.1.6	6.1 6.2
		Provide fixed guard; and/or	5.1.1	6.1
		Provide movable guards.	5.1.2 5.1.6	6.1 6.2
4 Impact, burns	Ejection/falling of hot parts (hot sand/metal) out of the knock-out device	Provide control system; and	5.1.6	6.1 6.2
		Provide spillage chute.	5.1.1	6.1
		Provide fixed guard; and/or	5.1.1	6.1
		Provide movable guards.	5.1.2 5.1.6	6.1 6.2
5 Burns	Ignition of hydraulic fluid in case of break of hydraulic pipe work or hoses and contact of hydraulic fluids with hot surfaces	Provide protection of hydraulic pipe work and hoses against mechanical, chemical and thermal influences; and	5.1.14	6.1
		Hardly inflammable or flame-resistant fluids shall be used.	Annex A	6.1

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Table 5 *(continued)*

Significant hazard	Hazardous situation	Safety requirements and/or protective/risk reduction measures	Reference in this document	Verification in this document
6 Asphyxiation, inhalation, ingestion of and contamination by harmful dusts and fumes	Danger of breathing in quartz dust, CO and decomposing products of molding material binders (main components see Annex B) during knock-out	Normal operation: Provide enclosure and local exhaust system; and NOTE Currently it is not possible to give common achievable values for concentrations of airborne toxic substances. Regional regulations can apply.	5.1.16	6.1 6.7
		Maintenance and repair: Operating/maintenance instruction: PPE (e.g. CO warning device, gas mask).	7.4.1, 7.4.2, 7.4.3	6.1
7 Noise	Hearing loss, stress, loss of awareness and tinnitus. Noise also can lead to accidents because speech communication and acoustic signals are not percievable. Main noise sources are working processes and impact of moulding boxes and castings on the grid surface.	Provide sound insulated enclosure; and	5.1.12	6.8
		Operating/maintenance instruction: PPE.	7.4.1, 7.4.2, 7.4.3	6.1
8 Vibration	Stress to human joints due to whole body vibration	Safe design: Isolation of the vibration source	5.1.13	6.9
	Low frequency oscillations (1 Hz to 100 Hz), resulting in disturbance of well-being	Safe design: — isolation of the vibration source; — minimization of amplitudes; avoidance of resonance between the exciting frequency and the natural frequency.	5.1.13	6.9

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6 Verification of the safety requirements and/or preventative measures

6.1 General

Verification can be achieved by a variety of methods, e.g. by inspection of the machine, of the associated equipment and the associated documents, appropriate testing and analysis and shall be in accordance with the verification column of Tables 1 to 5.

Where verification is more complex than simple inspection, the following should be considered. For verification, it can be helpful to provide a guideline, preferably in the form of a list or a table, that indicates danger zones, reaching distances, the presence and the functioning of interlocking guards with and without guard locking, hold-to-run control devices, two-hand controls, trip devices, limited movement control devices, safety circuits, interlockings, main switches, emergency-stopping devices, if necessary sound protection measures, seals and joint surfaces and capture devices for inhalable harmful substances generated during operation, as applicable.

Verification includes the criteria given at 6.2 to 6.10.

6.2 Safety systems

Interlocks (ISO 12100:2010, ISO 14119:2013), safety systems (ISO 12100:2010, ISO 13851:2019, IEC 61496-1:2020, ISO 13577-2:2014), guarding (ISO 14120:2015), emergency-stop (ISO 13850:2015), isolation and energy dissipation, dosing of substances, electrical apparatus for potentially explosive atmospheres shall be verified according to:

— design and physical assembly, provision and function for the intended use;

— its location (in situ).

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6.3 Electrical safety

Conduct tests in accordance with IEC 60204-1:2016, Clause 18.

Make provision for earthing.

Provide electromagnetic shielding, if required.

6.4 Pressure release of dust and gas explosions

Check design and physical assembly, provision and function for the intended use.

Ensure venting into a safe area.

6.5 Explosiveness of dust or gaseous substances

Determine explosion indices of combustible dusts in air according to ISO 6184-1:1985.

Determine combustible gases.

Ensure the absence of ignition sources, e.g. radiant heat, naked flames, electric sparks, electrostatic discharge in the area surrounding.

6.6 Stress analysis

Stress analyses for parts designed to withstand stress caused by pressure, dynamic and static loads have been carried out, if applicable.

6.7 Airborne substances generated during operation

Verification in accordance with appropriate regional standards.

For deliveries into the EU and associated countries, verification shall be in accordance with EN 1093-1:2009.

6.8 Noise

Verification in accordance with appropriate regional standards, e.g. for deliveries into the EU and associated countries, see EN 1265:1999.

6.9 Verification in accordance with Vibration

Check design and physical assembly for provision of vibration isolation and its efficiency, if applicable.

6.10 Safety marking

Check information for use about residual risks and the need for corresponding warning signs (e.g. symbols and text) and its provision on the equipment.

7 Information for use

7.1 General

ISO 12100:2010, 6.4, defines the contents and requirements of the information for use.

The information for use shall be addressed to the qualification level of the trained personnel.

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7.2 Warning devices and safety signs

The manufacturer shall provide safety signals and/or signs according to 5.1.15 to give a warning for residual risk arising from the use of the machine.

7.3 Minimum marking

According to ISO 12100:2010, 6.4.4, the following information shall be attached clearly and durably to the machine at a point visible after installation:

— name and address of the manufacturer and where applicable the name and address of the authorized representative;

— mandatory marking[1)];

— serial number/machine number, if any;

— year of construction, that is the year in which the manufacturing process is completed;

— designation of the machinery and series or type;

— rating information (mandatory for electro-technical products, e.g. voltage, frequency, power, etc., and for machinery intended for use in a potentially explosive atmosphere).

The electrical equipment on all types of machines shall have affixed durable plates containing their characteristic data, according to IEC 60204-1:2016 including casing protection grade.

7.4 Accompanying documents

7.4.1 Instruction handbook

An instruction handbook in accordance with ISO 12100:2010 shall be provided by the manufacturer for each machine. In this handbook, the characteristics of the machine and the measures relevant to it shall be given. It shall provide information concerning the avoidance of hazards, emissions such as hazardous noise, vibration, radiation, gas and dust. If information on the reduction of the emission of gases and dusts is not available, the manufacturer shall inform the user that an assessment under the conditions of use is required. Furthermore, the part operation manual in the instruction handbook shall provide information concerning safety devices and the specification of spare parts and wear parts affecting the health and safety of the operator (see also 7.4.2) and safety measures regarding intended use, transport, assembling and disassembling e.g. protection against falling elevated parts, hazards due to non-relieved excessive pressures, hazards due to malfunction of programmable electronic systems, hazards due to temperature, fire or explosive atmospheres.

7.4.2 Operation manual

7.4.2.1 Operating instructions in general

For each machine, including all auxiliary systems, the manufacturer shall supply a manual of operating instructions. These instructions, accompanied by diagrams, drawings and leaflets (when applicable), shall contain at least the following details:

— rating details;

— description of the type of machine;

— requirements for installation and transport;

1) 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.

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