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Shot blasting machinery — Safety and environmental requirements

Équipements de grenaillage — Exigences de sécurité et d'environnement

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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 document 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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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 and also deals with aspects of environmental impact and energy efficiency.

The design, the construction and the actual operation of shot blasting machinery affects aspects of safety, energy usage and environmental impact. It is essential to minimize energy usage and environmental impact while achieving the safety requirements given in this document.

The machinery concerned and the extent to which hazards, hazardous situations and hazardous events are covered are indicated in the scope of this document. When provisions of this type C standard are different from those which are stated in type A or B standards, the provisions of this type C standard take precedence over the provisions of the other standards, for machines that have been designed and built according to the provisions of this type C standard.

Where for clarity an example of a preventative measure is given in the text, this should not be considered as the only possible solution. Other solutions can be used as far as they fulfil correctly the criteria expressed in the requirement.

This document assumes that the shot blasting machinery is operated and maintained by trained personnel.

Shot blasting machinery — Safety and environmental requirements

1 Scope

This document specifies safety and environmental requirements for shot blasting machinery.

Shot blasting machinery includes:

— wheel blasting machinery;

— air blasting machinery for dry and wet blasting;

— combined wheel and air blasting machinery.

NOTE Annex A illustrates examples of shot blasting machinery.

This document is applicable to:

— all significant hazards, hazardous situations and hazardous events relevant to shot blasting machinery, when used as intended and under the conditions foreseen by the manufacturer, including reasonably foreseeable misuse;

— measures for minimization of environmental impact and energy usage of shot blasting machinery.

Interfaces between shot blasting machinery and other equipment used in shot blasting but not in the scope of this document are:

— mechanical and electrical interface to external workpiece transport system;

— connector to electrical energy supply;

— connector to fresh air supply ducting;

— connector to exhaust air ducting;

— connector to pressurized air supply;

— connector to water supply;

— connector to waste water system;

— interface for safe exchange of control signals;

— connector for fresh air supply for respiratory protection device (in blast rooms).

NOTE Annex C gives an illustration of interfaces between shot blasting machinery and other equipment used in shot blasting but not in the scope of this document.

The specific significant risks related to mobile and movable shot blasting machinery (e.g. shot blasting machines designed for operation at changing locations) are not dealt with in this document.

This document does not apply to:

— high pressure water jet machinery;

— dry-ice blasting machinery.

This document does not apply to shot blasting machines manufactured before the date of its publication as an ISO standard.

NOTE The requirements specified in this document can serve as a guideline for a risk assessment of shot blasting machines manufactured before the date of its publication as an ISO standard.

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 3743-1:2010, *Acoustics — Determination of sound power levels and sound energy levels of noise sources using sound pressure — Engineering methods for small movable sources in reverberant fields — Part 1: Comparison method for a hard-walled test room*

ISO 3744:2010, *Acoustics — Determination of sound power levels and sound energy levels of noise sources using sound pressure — Engineering methods for an essentially free field over a reflecting plane*

ISO 3746:2010, *Acoustics — Determination of sound power levels and sound energy levels of noise sources using sound pressure — Survey method using an enveloping measurement surface over a reflecting plane*

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 4871:1996, *Acoustics — Declaration and verification of noise emission values of machinery and equipment*

ISO 7000:2019, *Graphical symbols for use on equipment — Registered symbols*

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

ISO 10218-2:2011, *Robots and robotic devices — Safety requirements for industrial robots — Part 2: Robot systems and integration*

ISO 11201:2010, *Acoustics — Noise emitted by machinery and equipment — Determination of emission sound pressure levels at a work station and at other specified positions in an essentially free field over a reflecting plane with negligible environmental corrections*

ISO 11202:2010, *Acoustics — Noise emitted by machinery and equipment — Determination of emission sound pressure levels at a work station and at other specified positions applying approximate environmental corrections*

ISO 11204:2010, *Acoustics — Noise emitted by machinery and equipment — Determination of emission sound pressure levels at a work station and at other specified positions applying accurate environmental corrections*

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

ISO 13849-1:2023, *Safety of machinery — Safety-related parts of control systems — Part 1: General principles for design*

ISO 13850:2015, *Safety of machinery — Emergency stop function — Principles for design*

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*

ISO 14122-2:2016, *Safety of machinery — Permanent means of access to machinery — Part 2: Working platforms and walkways*

ISO 14122-3:2016, *Safety of machinery — Permanent means of access to machinery — Part 3: Stairs, stepladders and guard-rails*

ISO 80079-36:2016, *Explosive atmospheres — Part 36: Non-electrical equipment for explosive atmospheres — Basic method and requirements*

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

IEC 60079-0:2017, *Explosive atmospheres — Part 0: Equipment — General requirements*

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
external workpiece transport system
system that transports the workpiece to or from the shot blasting machine

3.2
internal workpiece transport system
system that transports the workpiece within the shot blasting machine

3.3
wheel blaster
device which accelerates the shot blasting media by a rotating wheel with blades

3.4
air blaster
assembly consisting of a nozzle and connected hose(s) or tube(s), which accelerates the shot blasting media by pressurized air

3.5
accessible blasting chamber
blasting chamber which, by designated use, is designed to be entered by personnel

3.6
workspace
workplace for the operator as specified by the manufacturer of the shot blasting machine

3.7
interior workspace
workspace inside of a shot blasting machine

3.8
screw conveyor
device that uses a rotating helical blade to move shot blasting media, horizontally or at a slight incline

3.9
belt conveyor
endless belt between two, or more, pulleys to move shot blasting media or products, horizontally or incline

3.10
vibrating conveyor
device that transports shot blasting media or products by vibration and gravity

3.11
scraper conveyor
device to transport bulk shot blasting media over a plane with the help of scrapers

3.12
hopper
container for storing shot blasting media or for providing or replenishing shot blasting media for the shot blasting process

3.13
bucket elevator
continuous conveyor that uses a series of bucket shaped hoppers uniformly fixed on the endless circular traction component to vertically lift shot blasting media

3.14
hopper discharge conveyor
mechanical device, screw conveyor, belt conveyor or other suitable transport system, to feed shot blasting media from the hopper to the shot blasting machine

3.15
switch valve
electrical, pneumatical or magnetical operated device for closing or opening the shot blasting media flow to the shot blasting process

3.16
magnetic separator
system, mostly operating with partial magnetic drums, where a ferromagnetic- and non-ferromagnetic mixture is separated to obtain reusable shot blasting media for the shot blasting process

3.17
cleaning system
device to separate small particles from shot blasting media, to obtain a required grain size distribution, mostly combined with a sieve for separating large particles

4 Significant hazards, environmental impact and energy usage

4.1 General

The variety of machinery could not be covered in all details in a standard. To deal with this fact, an individual risk assessment of the machinery in question shall be carried out considering the safety requirements of this document.

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

Safety requirements described in different clauses of this document shall be considered together if they are referring to the same hazard zone.

4.2 Significant hazards

Clause 5 gives requirements to prevent or minimise all hazards, hazardous situations and events identified by risk assessment as significant for this type of machinery.

See ISO 12100:2010 for measures against hazards that are relevant but not significant for this machine type.

NOTE ISO 12100:2010 contains information for the procedure of risk assessment.

4.3 Environmental impact and energy usage

Clause 6 contains measures for minimization of:

— environmental impact and

— energy usage.

5 Safety requirements, protective measures, risk reduction measures

5.1 General

Shot blasting machinery shall comply with the safety requirements and/or protective measures against the significant hazards given in Clause 5.

Warning devices and safety signs shall be in accordance with ISO 3864-1:2011, ISO 7000:2019 or ISO 7731:2003.

5.2 Guards and doors

All potential accesses to hazardous areas shall be secured by guards in accordance with ISO 13857:2019, ISO 14120:2015 and ISO 14119:2013. If access to a work area is limited by interlocking movable guards (e.g. doors), these shall be secured by the safety-related control system according to the performance level given in Table 1.

5.3 Electrical equipment

Electrical equipment of shot blasting machinery shall comply with IEC 60204-1:2016.

5.4 Emergency stop

Emergency stop devices shall comply with ISO 13850:2015.

5.5 Control systems

Safety related control systems shall be designed according to ISO 13849-1:2023. This applies also for input and processing of safety related parameters (e.g. operating parameters).

Table 1 — Required performance level (PLr) for control systems of shot blasting machinery

Safety function	Clause	PLr
Guard locking of access points of wheel blasters by interlocking movable guards associated with an interlocking device interlocked with the hazardous movement and a guard locking device	5.2 5.6, Table 2, row 1 5.6, Table 3, row 1	d
Guard locking of access points of wheel blasters by fixed guards associated with an interlocking device interlocked with the hazardous movement	5.2 5.6, Table 2, row 1 5.6, Table 3, row 1	c
Guard locking of access to the blasting chamber of wheel blasting machines without additional safety measures	5.2 5.6, Table 2, row 2 5.6, Table 3, row 1	d
Guard locking of access to the blasting chamber of wheel blasting machines with additional safety measures	5.2 5.6, Table 2, row 2 5.6, Table 3, row 1	c
Maximum overrun time of hold-to-run nozzle control device	5.7, Table 4, row 4	d

Table 1 *(continued)*

Safety function	Clause	PLr
Interlocking of means of access with the shot blasting process and hazardous movement of parts, for blasting chambers without interior workspace If access is possible before the shot blasting process has stopped, interlocking with guard locking is required	5.2 5.8, Table 5, row 2, sub-row 1	c
Interlocking of means of access with the shot blasting process and hazardous movement of parts, for blasting chambers with interior workspace	5.2 5.8, Table 5, row 2, sub-row 2	c
Interlocking to prevent start up of the shot blasting process	5.8, Table 5, row 3	c
Interlocking between wheel drive and air blaster	5.8, Table 5, row 3	c
Interlocking with guard locking with hazardous movement of parts	5.8, Table 7, row 1 5.8, Table 7, row 2	c
Access to hazardous moving parts of the shot blasting media transport and recovery system	5.9, Table 9, row 1	c
Avoid uncontrolled movement of machine parts	5.10, Table 10, row 1	c
Avoid uncontrolled movement of machine parts due to loss or reactivation of electric, pneumatic or hydraulic energy supply	5.10, Table 10, row 2	c
Interlocking with external equipment	5.16	Individual risk assessment

5.6 Wheel blaster

See Table 2 for significant hazards or hazardous situations concerning shearing and crushing, cutting and severing, the related safety requirements and/or measures and the requirements for verification of these measures.

Table 2 — Wheel blaster – Shearing and crushing, cutting and severing

Significant hazard	Hazardous situation	Safety requirements	Verification
Shearing Crushing Cutting Severing	Access to shear traps between fixed and internal rotating parts of the wheel blaster.	Access points to internal rotating parts of wheel blasters shall be guarded either by — fixed guards associated with an interlocking device interlocked with the hazardous movement or — interlocking movable guards associated with an interlocking device interlocked with the hazardous movement and a guard locking device. See Table 1 for safety related controls.	Visual inspection Functional test
		The shot blasting media supply opening of wheel blasters shall be guarded by fixed guards.	Visual inspection
	Access from the inside of the blasting chamber to shear traps between fixed and internal rotating parts of a wheel blaster.	Unauthorized access to process openings of wheel blasters shall be prevented by guarding with guard locking of the blasting chamber access (see 5.8, Table 5). Additional safety measures (e.g. key locking the access) can reduce the PLr of the guard locking. See Table 1 for safety related controls.	See 5.8, Table 5

See Table 3 for significant hazards or hazardous situations concerning impact of accelerated shot blasting media and parts, the related safety requirements and/or measures and the requirements for verification of these measures.

Table 3 — Wheel blaster – Impact of accelerated shot blasting media and parts

Significant hazard	Hazardous situation	Safety requirements	Verification
Friction or abrasion Puncture	Exposure to ejected shot blasting media.	See Table 2	See Table 2
		Information on maintenance and inspection of wheel blasters shall be given in the information for use, see Clause 8.	Documentation
Impact Stabbing or Puncture	Exposure to ejected parts in case of wheel blaster breakdown.	The housing of the wheel blaster shall withstand the impact of accelerated parts that can occur in the event of the collapse of the blast wheel.	Documentation
		Information on maintenance and inspection of wheel blasters shall be given in the information for use, see Clause 8.	Documentation

See Table 14 for noise sources, the related noise reduction measures and the requirements for verification of these measures.

5.7 Air blaster

See Table 4 for significant hazards or hazardous situations concerning impact of accelerated shot blasting media and parts, the related safety requirements and/or measures and the requirements for verification of these measures.

Table 4 — Air blaster – Impact of accelerated shot blasting media and parts

Significant hazard	Hazardous situation	Safety requirements	Verification
Friction or abrasion Puncture Injection	Exposure to ejected shot blasting media, parts and fluids in case of breakdown, wear and malfunction of an air blaster or an air blasting machine.	The construction of the air blaster shall minimize wear by accelerated shot blasting media.	Visual inspection Documentation
		The air blaster shall withstand the pressure generated by the shot blasting process. Its pressurized components (e.g. tubing, hoses, vessel, couplings, valves, nozzle) shall be designed according to ISO 4413:2010 and ISO 4414:2010.	Documentation
		Information on maintenance and inspection of air blasters shall be given in the information for use, see Clause 8.	Documentation
Impact Friction or abrasion Puncture Injection	For manual air blasters: — uncontrolled movement of the nozzle and hose and/or	The air blaster shall be equipped with a hold-to-run nozzle control device which, upon release within 3 seconds, reduces the kinetic energy of the: — the shot blasting media and — the pressurized air	Functional test

Table 4 *(continued)*

Significant hazard	Hazardous situation	Safety requirements	Verification
	— release of shot blasting media.	to assure: — no hazardous movement of the hose; — no hazardous ejection of shot blasting media. This can be achieved by e.g.: — depressurization of the shot blasting media supply system; — a shutter in the supply to the nozzle. For long hoses additional measures (e.g. pressure release valve) may be required. See Table 1 for safety related controls.	

See Table 14 for noise sources, the related noise reduction measures and the requirements for verification of these measures.

5.8 Blasting chamber

See Table 5 for significant hazards or hazardous situations concerning impact of accelerated shot blasting media and parts, the related safety requirements and/or measures and the requirements for verification of these measures.

Table 5 — Blasting chamber – Impact of accelerated shot blasting media and parts

Significant hazard	Hazardous situation	Safety requirements	Verification
Friction or abrasion Puncture Impact	Exposure to accelerated shot blasting media and parts in the workspace outside of the blasting chamber.	The construction of the blasting chamber shall prevent the exposure to hazardous accelerated shot blasting media and parts in the workspace outside of the blasting chamber.	Documentation Functional test
		Information on maintenance and inspection shall be given in the information for use, see Clause 8.	Documentation
Friction or abrasion Puncture Impact	Exposure to accelerated shot blasting media and moving parts in blasting chambers without interior workspace.	Access to blasting chambers without interior workspace shall be prevented by design.	Visual inspection Documentation
		Means of access shall be interlocked with the shot blasting process and hazardous movement of parts. Opening of means of access shall stop the shot blasting process and hazardous movement of parts. If access is possible before the shot blasting process has stopped, interlocking with guard locking is required. It shall not be possible to initiate the shot blasting process and hazardous movement of parts, until the means of access are closed. The shot blasting process shall not re-start automatically upon closure of the means of access. The interlocking device shall comply with ISO 14119:2013. Robots shall be integrated according to ISO 10218-2:2011. See Table 1 for safety related controls.	Functional test

Table 5 *(continued)*

Significant hazard	Hazardous situation	Safety requirements	Verification
		Workpiece inlet and outlet openings shall be secured against unauthorized access by measures to prevent easy access of persons through workpiece inlet and outlet openings.	Visual inspection Measurement
		Information that operator access is not allowed through workpiece inlet and outlet openings, shall be given in the information for use.	Documentation
		Information on measures to be taken against unintended re-start during maintenance and repair shall be given in the information for use, see 8.2.3.	Documentation
		Warning signs "Do not enter" shall be mounted at all access points.	Visual inspection
Friction or abrasion Puncture Impact	Exposure to accelerated shot blasting media and moving parts in blasting chambers with interior workspace.	Means of access shall be interlocked with the shot blasting process and hazardous movement of parts. Opening of means of access shall stop the shot blasting process and hazardous movement of parts. Warning lamps that light up when the blasting process is active shall be installed at all access points or at locations which are visible from any access point and/or operating point. It shall not be possible to initiate the shot blasting process and hazardous movement of parts, until the means of access are closed. The shot blasting process shall not re-start automatically upon closure of the means of access. The interlocking device shall comply with ISO 14119:2013. Robots shall be integrated according to ISO 10218-2:2011. See Table 1 for safety related controls.	Functional test
		Workpiece inlet and outlet openings shall be secured against unauthorized access by measures to prevent easy access of persons through workpiece inlet and outlet openings.	Visual inspection Measurement
		Information that operator access is not allowed through workpiece inlet and outlet openings, shall be given in the information for use.	Documentation
		Information on measures to be taken against unintended re-start during maintenance and repair shall be given in the information for use, see 8.2.3.	Documentation
		Warning signs "Do not enter" shall be mounted at all access points.	Visual inspection
Friction or abrasion Puncture Impact	Exposure to accelerated shot blasting media and parts inside and outside of the blasting chamber due to start-up of shot blasting process e.g.	Devices which prevent start-up (e.g. during maintenance and inspection) shall be fitted, e.g. removable handles, electronic locks, lockable main switch.	Visual inspection Functional test Documentation

Table 5 *(continued)*

Significant hazard	Hazardous situation	Safety requirements	Verification
	— when the blasting chamber is not closed; — during maintenance.		
Friction or abrasion Puncture Impact	Exposure to accelerated shot blasting media and parts in combined wheel and air blasting machinery.	For combined wheel and air blasting machinery, which integrates both blasting types in one chamber, an operation mode selector, lockable in each position, shall be installed. The wheel blaster and the air blaster shall be interlocked to prevent operation of the wheel blasters during manual air blasting.	Functional test
Friction or abrasion Puncture Impact	Exposure to accelerated shot blasting media and parts in the blasting chamber when persons are trapped inside the blasting chamber.	Devices shall be fitted which allow escape of persons from inside of accessible blasting chambers (e.g. doors openable from the inside).	Visual inspection Functional test Documentation
		Devices which allow to stop the shot blasting process from the inside of accessible blasting chambers shall be fitted.	Visual inspection Functional test Documentation
		Means of observation (e.g. viewing window) of the blasting chamber interior shall be provided for blasting chambers with interior workspace. A communication tool may be provided as additional measure, but is not sufficient as sole measure.	Visual inspection Documentation

See Table 6 for significant hazards or hazardous situations concerning height from ground, the related safety requirements and/or measures and the requirements for verification of these measures.

Table 6 — Blasting chamber – Height from ground

Significant hazard	Hazardous situation	Safety requirements	Verification
Falling	Working areas at different height levels	Guard rails shall be installed between working areas at different levels (e.g. working platforms) according to ISO 14122-3:2016.	Visual inspection
		Pits shall be equipped with a fall protection device for operators (e.g. removable gratings which secure a pit not in use, folding railings). Where fixed guards interfere with the shot blasting process or movement of the workpieces, means of fixing personal protection equipment against falling shall be installed and information on personal protection equipment against falling from height shall be given in the information for use.	Visual inspection
		Working platforms and walkways shall be designed according to ISO 14122-2:2016.	Documentation
		If access at a height is required (e.g. for maintenance or servicing) guards or measures for safe access shall be installed.	Visual inspection

See Table 7 for significant hazards or hazardous situations concerning crushing, shearing and cutting, the related safety requirements and/or measures and the requirements for verification of these measures.

Table 7 — Blasting chamber – crushing, shearing and cutting

Significant hazard	Hazardous situation	Safety requirements	Verification
Crushing Shearing Cutting	Exposure to hazardous moving parts inside of the blasting chamber.	See 5.11	See 5.11
		If hazardous moving parts are reachable in the blasting chamber, the blasting chamber openings shall be interlocked with guard locking with the hazardous movement. See Table 1 for safety related controls.	Functional test Documentation
	Exposure to hazardous moving parts of the blasting chamber.	Access to reachable hazardous moving parts of the blasting chamber shall be prevented by — design according to ISO 13857:2019; — fixed guards; — interlocking moveable guards interlocked with the hazardous movement.	Functional test Documentation

See Table 8 for significant hazards or hazardous situations concerning slipping and tripping, the related safety requirements and/or measures and the requirements for verification of these measures.

Table 8 — Blasting chamber – Slipping and tripping

Significant hazard	Hazardous situation	Safety requirements	Verification
Slipping	Slippery floor due to shot blasting media.	Floors of working areas of shot blasting machinery, shall be designed to minimize slippery floor due to shot blasting media, e.g. by gratings.	Visual inspection
		Information on measures against slippery floor due to shot blasting media (e.g. for concrete floors) shall be given in the information for use, see Clause 8.	Documentation
Tripping	Tripping due to uneven floor.	Floors of working areas shall be designed without tripping hazards.	Visual inspection
	Tripping due to insufficient visibility in blasting chambers with internal workspace.	A technical ventilation shall be provided to ensure clear visibility of the workspace and escape routes. The hourly air flow volume of the technical ventilation shall be at least 60-times of the volume of the internal workspace.	Visual inspection Functional test Measurement

See Table 14 for noise sources, the related noise reduction measures and the requirements for verification of these measures.

5.9 Shot blasting media transport and recovery system

See Table 9 for significant hazards or hazardous situations concerning crushing, shearing and cutting, the related safety requirements and/or measures and the requirements for verification of these measures.

Table 9 — Shot blasting media transport and recovery system – Crushing, shearing and cutting

Significant hazard	Hazardous situation	Safety requirements	Verification
Crushing Shearing Cutting	Exposure to hazardous moving parts of the shot blasting media transport and recovery system, e.g.: — conveyor (e.g. screw, belt, vibrating, scraper), — hopper, — bucket elevator, — hopper discharge conveyor, — switch valve, — magnetic separator, — cleaning system.	Access to reachable hazardous moving parts of shot blasting media transport and recovery systems, shall be prevented by: — design, e.g. by maintaining distances according to ISO 13857:2019 or — fixed guards or — interlocking movable guards interlocked with the hazardous movement. Where it is possible for an operator to reach the hazard zone before the risk due to the hazardous machinery functions has ceased, movable guards shall be associated with a guard locking device in addition to the interlocking device. NOTE ISO 11161:2007 + ISO 11161:2007/Amd 1:2010, 8.6.2 gives examples for safe reduced speeds of moving parts.	Visual inspection Measurement
		Elevators shall be equipped with a backstop or a mechanical brake.	Functional test

5.10 Power and driving devices

See Table 10 for significant hazards or hazardous situations concerning crushing, shearing and cutting, the related safety requirements and/or measures and the requirements for verification of these measures.

Table 10 — Power and driving devices – Crushing, shearing and cutting

Significant hazard	Hazardous situation	Safety requirements	Verification
Crushing Shearing Cutting	Uncontrolled movement of machine parts (e.g. workpiece conveying system, shot blasting media transport, wheel blaster).	Uncontrolled movement of machine parts shall be avoided (e.g. brake system which prevents hazardous movement, piloted check valve to avoid hazardous movement in case of pressure-loss). See Table 1 for requirements for safety related controls.	Functional test Documentation
	Uncontrolled movement of machine parts due to loss or reactivation of electric, pneumatic or hydraulic energy supply.	Uncontrolled movement of machine parts shall be avoided (e.g. brake system which prevents hazardous movement at energy loss). Movement of machine parts shall not start automatically upon reactivation of energy supply. See Table 1 for requirements for safety related controls	Functional test Documentation

5.11 Loading and unloading systems for workpieces

See Table 11 for significant hazards or hazardous situations concerning crushing, shearing and cutting, the related safety requirements and/or measures and the requirements for verification of these measures.

Table 11 — Loading and unloading systems for workpieces – Crushing, shearing and cutting

Significant hazard	Hazardous situation	Safety requirements	Verification
Crushing Shearing Cutting	Crushing, shearing cutting due to hazardous moving parts (e.g. power operated doors, conveyor, moving workpieces, robots).	Safety distances to hazardous moving parts shall be ensured according to ISO 13857:2019.	Measurement
		Robots shall be integrated according to ISO 10218-2:2011.	Documentation
	Workpieces falling off internal conveying systems.	Internal conveying systems and interfaces between internal and external conveying systems shall be designed to ensure safe transport of workpieces within the scope of the intended use. Typical criteria are: — Mechanical strength of fixtures, — Wear of fixtures by the shot blasting process.	Visual inspection Documentation
		Information on: — wear of fixtures; — intervals for periodic inspection shall be given in the information for use.	Documentation

See Table 14 for noise sources, the related noise reduction measures and the requirements for verification of these measures.

5.12 Wear related hazards

See Table 12 for significant hazards or hazardous situations concerning wear, the related safety requirements and/or measures and the requirements for verification of these measures.

Table 12 — Wear

Significant hazard	Hazardous situation	Safety requirements	Verification
Friction or abrasion Puncture Injection Crushing Cutting	All shot blasting machine parts subjected to shot blasting media are underlying excessive abrasive wear. Failure of shot blasting machine parts due to wear can result in hazards like — impact of accelerated shot blasting media; — crushing by loss of structural stability; — crushing by falling elements; — contact with sharp edges.	Wear shall be kept under control by regular inspection and maintenance. The intervals for inspection and maintenance depend on — the design of the shot blasting machine and — the shot blasting process (e.g. operating duration, change of load, number of blasting units). The wear related lifetime of shot blasting machine parts can be influenced by thickness and wear resistance of the materials of the machine parts as well as wear protection mats or lining to reduce impact energy of accelerated shot blasting media.	Documentation
		Information on inspection and maintenance shall be given in the information for use (e.g. maintenance cycles).	Documentation
		A warning notice, that lifting accessories can underlie strong wear, shall be given in the information for use.	Documentation

5.13 Static electricity

See Table 13 for significant hazards or hazardous situations concerning static electricity, the related safety requirements and/or measures and the requirements for verification of these measures.

Table 13 — Static electricity

Significant hazard	Hazardous situation	Safety requirements	Verification
Shock	Electric shock from contact with electro-statically charged parts of the shot blasting machine.	Machine parts, which can be electrostatically charged (e.g. hoses, nozzles, holding devices for workpieces, dust collection hoppers, ducting) shall be conductive and earthed at ground potential with a maximum resistance to ground of 10^6 Ω. See IEC/TS 60079-32-1:2013 + Amd 1:2017.	Visual inspection Documentation Measurement

		Information on the:
		— intended use of shot blasting machinery (e.g. type of workpiece material, shot blasting media);
		— requirements:
		  — to earth equipment attached to the shot blasting machine (e.g. ducting);
		  — for protection against electrostatic charging of equipment to be used in shot blasting machinery (e.g. vacuum-cleaners);
		shall be given in the information for use.
			Documentation

5.14 Noise

5.14.1 Measures for reducing noise at source at the design stage

See Table 14 for significant hazards, noise sources, the related noise reduction measures and the requirements for verification of these measures.

Table 14 — Noise reduction measures

Significant hazard	Noise sources	Noise reduction measures	Verification
Hearing loss Stress Loss of awareness Tinnitus Risk of accidents due to interference with speech communication and acoustic signals	General	Technical measures for noise reduction at source shall be applied. ISO/TR 11688-1:1995 provides information for the design of low-noise machinery.	
	Noise of: — wheel blasters and their drives; — loading and unloading system; — hydraulic systems and hydraulic drives; — blow-off nozzles and their ventilators; — the expansion of compressed air.	Particular considerations shall be given to: — acoustic enclosures and screens to shield noise radiation of components and at openings required for operation (e.g. material transport); — sound insulation of the blasting chamber; — low noise ventilators; — placing noise producing components away from the operator position whenever reasonable; — sound decoupling of machine parts; — measures to avoid resonating surfaces (e.g. stiffening of large surfaces); — silencers for pneumatic machinery parts (e.g. valves at handling devices).	Visual inspection Measurement
	Noise of blasting nozzles	Particular considerations shall be given to: — installation of low noise blasting nozzles; — sound insulation of the blasting chamber.	Visual inspection
		Information on recommended hearing protection for people working inside an air blasting chamber and/or for free jet working people shall be given in the information for use, see Clause 8.	Documentation
	Noise and vibration due to out of balance blast wheels and their drives.	Information on maintaining wheel blasters in balance shall be given in the information for use, see 8.2.3.	Documentation

The success of the applied noise reduction measures is assessed on the basis of the actual noise emission values in relation to other machines of the same family.

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

5.14.2 Noise emission measurement and declaration

Noise emission measurement on shot blasting machines and declaration of noise emissions shall be carried out according to the noise test code specified in Annex B.

NOTE Regional/national regulations or standards related to noise measurement and declaration can exist, e.g. EN 1265:1999 in the European Union or GB/T 25371:2010 and GB/T 34388:2017 in China.

5.15 Substances

See Table 15 for significant hazards or hazardous situations concerning health, the related safety requirements and/or measures and the requirements for verification of these measures.

Table 15 — Substances - Health

Significant hazard	Hazardous situation	Safety requirements	Verification
Breathing difficulties	Inhalation or contact with health hazardous dust, generated in the shot blasting process (e.g. workpiece material, shot blasting media, wear of machine parts).	Dust escaping from shot blasting machinery shall not lead to a health hazardous atmosphere in the surrounding workspace. This can be achieved by operating the blasting chamber at lower pressure than the pressure of the surrounding workplace.	Visual inspection Measurement
		Information on requirements for installation (e.g. technical ventilation, filter system) of shot blasting machinery, shall be given in the information for use, see 8.2.1.	Documentation
		Information on the specification of the filter system required for exhaust air treatment shall be given in the information for use. NOTE 1 Exposure limit values are subject to national regulation. NOTE 2 Limit values for dust emissions into the environment are subject to national regulation. NOTE 3 Limit values for dust emissions into the workplace are subject to national regulation. NOTE 4 ISO 29042-1:2008, ISO 29042-2:2009, ISO 29042-3:2009, ISO 29042-4:2009, ISO 29042-5:2010, ISO 29042-6:2010, ISO 29042-7:2010, ISO 29042-8:2011, ISO 29042-9:2011 give information on the evaluation of the emission of airborne hazardous substances.	Documentation
		Information on the use of personal protection equipment for operation in shot-blasting machines with interior workspace and maintenance shall be given in the information for use.	Documentation
		Information on the intended use of shot blasting machinery (e.g. type of workpiece material, shot blasting media) shall be given in the information for use.	Documentation

See Table 16 for significant hazards or hazardous situations concerning fire and explosion, the related safety requirements and/or measures and the requirements for verification of these measures.

Table 16 — Substances – Fire and explosion

Significant hazard	Hazardous situation	Safety requirements	Verification
Fire Explosion	Ignition of dust atmosphere in shot blasting machinery.	Ignitable dust atmosphere in the blasting chamber shall be avoided. NOTE VDMA 24388:2019 describes a procedure to assess the potential explosibility of dust generated in shot blasting processes.	
		If ignitable dust is generated in shot blasting processes allowed by the intended use of the shot blasting machine, the formation of an ignitable dust atmosphere shall be avoided by a fresh air flow designed considering the amount and ignitability of the dust generated in the shot blasting process. This dust is composed of the shot blasting media, the abraded material of the processed workpieces and the material adhering to the workpiece surface. The combustion- and explosion behaviour of the shot blasting dust depends on these three components, the particle size and the shot blasting process parameters.	Documentation
		If ignitable dust atmosphere cannot be avoided in parts of the shot blasting machine (e.g. bucket elevator), ignition sources shall be avoided in the respective part of the shot blasting machine. An ignition hazard assessment in accordance with ISO 80079-36:2016 shall be carried out. Electrical and non-electrical equipment installed in machine parts with potentially explosive atmospheres shall be designed and constructed according to good engineering practice. Non-electrical equipment shall comply with the requirements of ISO 80079-36:2016. Electrical equipment shall comply with the requirements of IEC 60079-0:2017.	Visual inspection Documentation
		Information on risks of treating workpiece materials or using shot blasting media not covered by the intended use of the shot blasting machine shall be given in the information for use.	Documentation
		Information on requirements for fire and explosion protection of the filter system required for exhaust air treatment shall be given in the information for use.	Documentation
	Ignition of dust deposits in shot blasting machinery.	Dust deposits shall be minimized by design of the shot blasting machine (e.g. smooth surfaces, sufficient air flow).	Visual inspection

5.16 Integration with external equipment

Integration of external equipment with shot blasting machinery can be required for safe operation. If this integration is necessary, the shot blast machine shall be equipped with interfaces allowing the exchange of safety related signals, so that stop controls, including emergency stop devices, can stop not only the shot blasting machine itself but also all related equipment (e. g. filter system, conveying systems, handling systems for workpieces), if its continued operation may cause hazardous situations. See Table 1 for safety related controls.

6 Energy-efficiency and reduction of environmental impact

6.1 General

The comprehensive assessment of the planned shot blasting process is essential to obtain the best result for energy efficiency and environmental impact and shall be done prior to optimizing energy efficiency and minimizing environmental impact of a single process step or machine.

Clause 6 deals with the fundamental environmental impact over the life cycle of a shot blasting machine.

NOTE National or local regulation can apply.

6.2 Acquisition

Construction material shall be selected with regard to process conditions to:

— optimize durability and lifetime of the shot blasting machine;

— minimize hazardous waste.

6.3 Production

No significant environmental impact.

6.4 Use

6.4.1 Input

6.4.1.1 Shot blasting media

Information on operation shall include working procedures to minimize the usage of shot blasting media.

NOTE 1 Minimization of shot blasting media usage corresponds to reduction of blasting dust emission and waste.

NOTE 2 Minimization of shot blasting media usage corresponds to reduction of energy usage.

Information on maintenance intervals for optimization of the shot blasting machine shall be given.

6.4.1.2 Water

Water usage should be reduced by design and construction (e.g. reusage of water).

6.4.1.3 Energy

Idle operation of the shot blasting machine (e.g. forced ventilation, wheel blaster) should be avoided. This can be achieved by an adequate layout of the control system.

Energy consumption of the shot blasting machine should be reduced by measures of construction and design e.g. by:

— installation of energy efficient components (motors, fans etc.);

— installation of high efficiency wheel blasters or blast nozzles;

— avoid leakage in pneumatic systems;

— layout of forced ventilation;

— layout of shot blasting media recovery system;

— recirculation of air in shot blasting machinery.

NOTE 1 The energy consumption of the operating site can be reduced by air recirculation of the shot blasting machine.

Energy usage can be monitored.

NOTE 2 Monitoring of energy usage allows the implementation of operational energy efficiency concepts.

6.4.2 Output

6.4.2.1 Emissions to air

Information on the specification of the filter system required for exhaust air treatment shall be given in the information for use (see 8.2.2).

NOTE Dust emission limit values are subject to national regulation.

6.4.2.2 Waste

The materials introduced (e.g. shot blasting media, sand from foundry process) into the shot blasting process should be separated to allow reusage of materials.

Note Waste material disposal can be subject to national regulation.

6.4.2.3 Noise

Noise emissions to the environment can be reduced by measures for noise reduction at the design stage (see 5.14.1) and e.g. installation of a sound absorber at the exhaust duct.

6.5 End of life

There are no significant impacts on the environment.

Machines should be disposable and applicable local regulations can apply. Relevant information shall be given by the manufacturer in the information for use.

7 Verification of the safety requirements and/or measures

Column 4 of the tables, except Table 1, given in Clause 5 specifies the method of verification for the corresponding requirement.

Methods of verification are:

— visual inspection,

— functional test,

— measurement,

— documentation (check of documentation).

Verification may involve more than one method.

8 Information for use

8.1 General

The information for use shall comply with ISO 12100:2010, 6.4, especially ISO 12100:2010, 6.4.5 for the instruction handbook and ISO 12100:2010, 6.4.4 for the marking.

The information for use shall give information concerning installation, commissioning and use, together with references to the general maintenance and the intended use specified by the manufacturer.

8.2 Instruction handbook

8.2.1 Information related to installation

Additional to the requirements given in ISO 12100:2010, the information related to installation shall contain:

a) requirements for replacement air (e.g. flow rate);

b) requirements for exhaust ducting (e.g. minimum flow rate to avoid dust deposits);

c) requirements of the filter system, which is necessary for safe operation of the shot blasting machine;

d) requirement for earthing the shot blasting machine and the attached equipment (e.g. ducting) at equal potential.

8.2.2 Information related to operation

Additional to the requirements given in ISO 12100:2010, the information related to operation shall contain:

a) warning against risk of excessive concentration of ignitable dust due to e.g.:

   1) modification of shot blasting media;

   2) modification of workpiece material;

b) position of workpiece;

c) maximum dimension of workpiece;

d) minimum dimension of workpiece;

e) maximum weight of workpiece;

f) minimum weight of workpiece;

g) measures for the fixation of workpieces, if required;

h) information dealing with noise:

   1) a noise emission declaration, see Annex B.8;

   2) a recommendation to use hearing protection.

8.2.3 Information related to maintenance

Additional to the requirements given in ISO 12100:2010, the information related to maintenance shall contain:

a) measures to be taken against unintended re-start during maintenance and repair;

b) specification of maintenance, inspection intervals and procedures of the e.g.:

1) interior of the shot blasting machine and ducting (e.g. removal of shot blasting dust deposits);
2) balancing of wheel blasters and their drives;
3) forced ventilation (measurement of the air flow rate and air flow velocity);
4) shot blasting media transport systems;
5) earthing;
6) floor gratings.

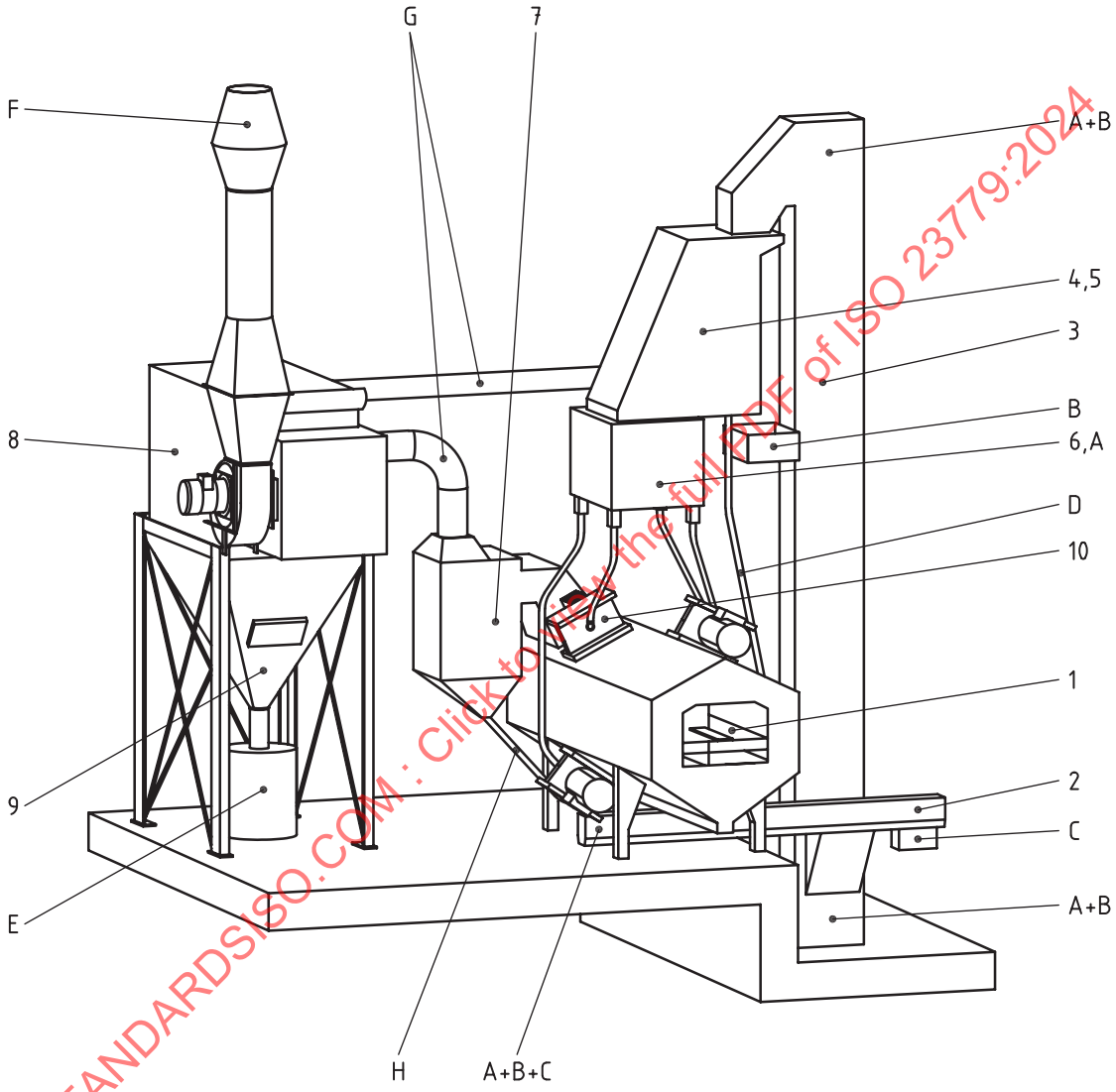
8.3 Marking

The shot blasting machine shall be marked according to ISO 12100:2010, 6.4.4.

Annex A
(informative)

Figures of shot blasting machinery

Figure A.1 illustrates an example of a wheel blasting machine.



Key

Components

1 shot blasting chamber
2 cross conveyor
3 bucket elevator
4 main magnetic drum
5 cleaning unit
6 hopper
7 expansion chamber

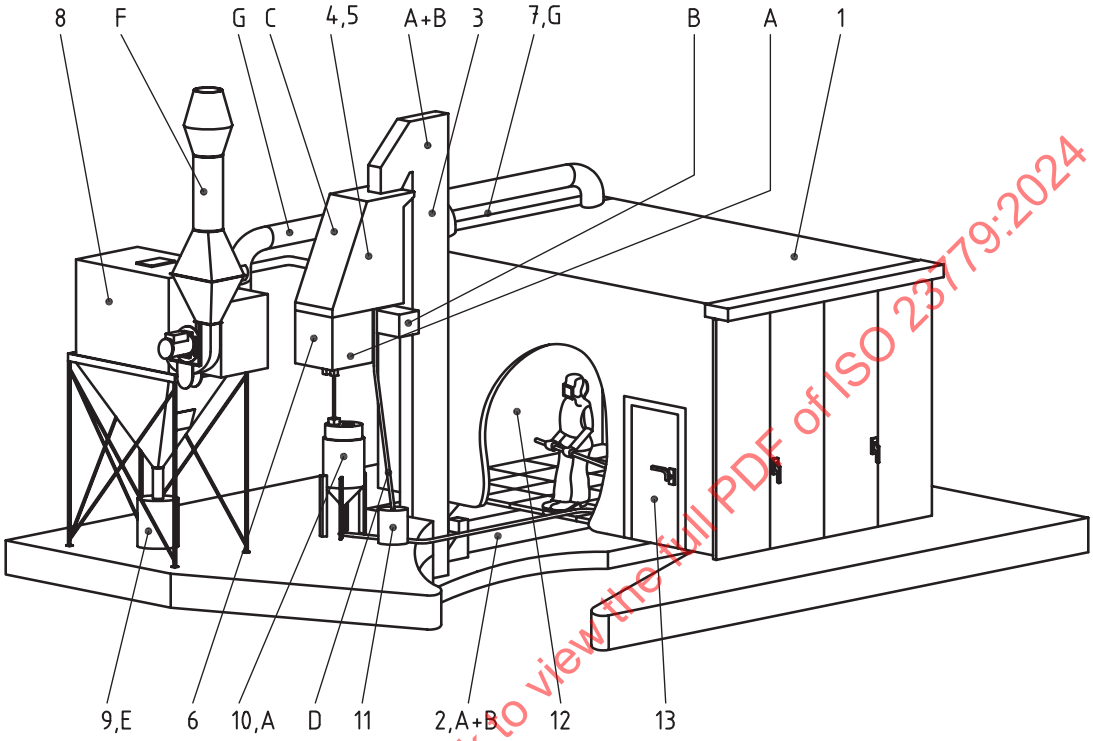
Media

A shot blasting media
B debris
C large particles
D coarse dust
E fine dust
F cleaned Air
G air with fine particles

8 filter unit (not in scope of this document)
9 dust collector (not in scope of this document)
10 wheelblaster
H reusable shot blasting media

Figure A.1 — Wheel blasting machine

Figure A.2 illustrates an example of an air blasting machine.



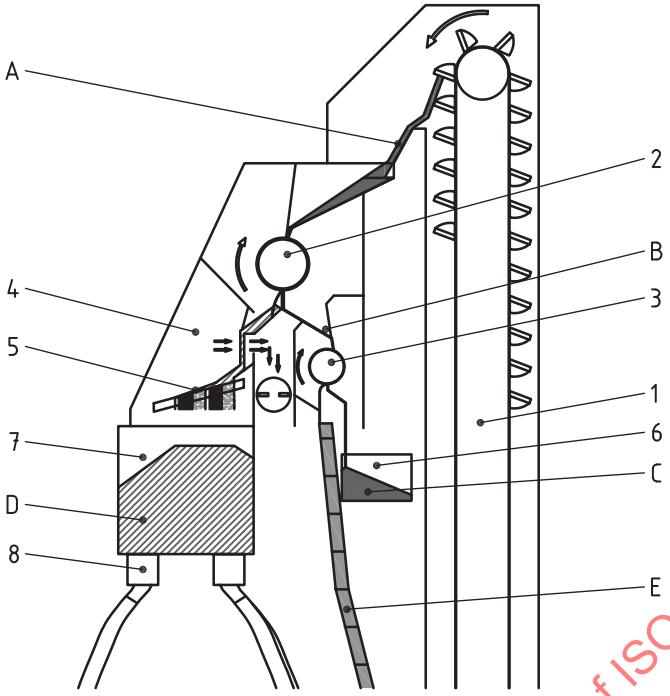
Key

Components
1 shot blasting chamber
2 recovery shot blasting media
3 bucket elevator
4 main magnetic drum
5 cleaning unit
6 hopper
7 ducting
8 filter unit (not in scope of this document)
9 dust collector (not in scope of this document)
10 pressure vessel
11 safety valve for depressurization
12 blasting nozzle with safety valve
13 door

Media
A shot blasting media
B debris
C large particles
D coarse dust
E fine dust
F cleaned Air
G air with fine particles

Figure A.2 — Air blasting machine

Figure A.3 illustrates an example of a preparation of shot blasting.



Key

Components

1 bucket elevator
2 main magnetic drum
3 secondary magnetic drum
4 cleaning unit
5 sieve
6 sand collector
7 hopper
8 shut-off valves

Media

A shot blasting media + non-magnetic debris
B left over shot blasting media + non-magnetic debris
C non-magnetic debris
D shot blasting media
E reusable shot blasting media

Figure A.3 — Preparation of shot blasting media