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Machine tools — Safety — Sawing machines for cold metal

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Foreword

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

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

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For an explanation on 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 the following URL: www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 39, *Machine tools*, Subcommittee SC 10, *Safety*.

Introduction

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

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 organisations, market surveillance, etc.)

Others can be affected by the level of machinery safety achieved with the means of the document by the abovementioned 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 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.

Machine tools — Safety — Sawing machines for cold metal

1 Scope

This document deals with all significant hazards, hazardous situations and events to sawing machines as defined in Clause 3, whose primary intended use is for sawing cold metal (ferrous and non-ferrous), or material partly of cold metal and under conditions of misuse which are reasonably foreseeable by the manufacturer (see Clause 4).

This document is applicable to (metal) sawing machines which are manufactured after the date of publication of this document.

When additional processing (i.e. milling, boring, marking, finishing operation, etc.) is considered, this document can serve as a basis for safety requirements. For more detailed information, refer to the bibliography.

This document deals with noise hazards but does not provide a full noise test code. It is intended to draft such a code in the next revision of this document.

This document does not include requirements and safety measures for fire and explosion hazards. It is intended to deal with them in the next revision of this document.

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 683-1, *Heat-treatable steels, alloy steels and free-cutting steels — Part 1: Non-alloy steels for quenching and tempering*·

ISO 3744, *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 4413, *Hydraulic fluid power — General rules and safety requirements for systems and their components*

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

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

ISO 9355-1, *Ergonomic requirements for the design of displays and control actuators — Part 1: Human interactions with displays and control actuators*

ISO 9355-2, *Ergonomic requirements for the design of displays and control actuators — Part 2: Displays*

ISO 9355-3, *Ergonomic requirements for the design of displays and control actuators — Part 3: Control actuators*

ISO 9614-1, *Acoustics — Determination of sound power levels of noise sources using sound intensity — Part 1: Measurement at discrete points*

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

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

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

ISO 13855:2010, *Safety of machinery — Positioning of safeguards with respect to the approach speeds of parts of the human body*

ISO 13856-1, *Safety of machinery — Pressure-sensitive protective devices — Part 1: General principles for design and testing of pressure-sensitive mats and pressure-sensitive floors*

ISO 13857:2008, *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, *Safety of machinery — Permanent means of access to machinery — Part 2: Working platforms and walkways*

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

ISO/TR 11688-1, *Acoustics — Recommended practice for the design of low-noise machinery and equipment — Part 1: Planning*

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

IEC 61000-6-2, *Electromagnetic compatibility (EMC) — Part 6-2: Generic standards — immunity for industrial environments*

IEC 61000-6-4, *Electromagnetic compatibility (EMC) — Part 6-4: Generic standards — Emission standard for industrial environments*

EN 1037:1995+A1:2008, *Safety of machinery — Prevention of unexpected start-up*

EN 1837:1999+A1:2009, *Safety of machinery — Integral lighting of machines*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 12100, ISO 13849-1 and the following apply.

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

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

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

3.1
sawing machine
machine tool that is used for cutting material and cutting into length using a *sawing tool* (3.9)

3.1.1
band-sawing machine
sawing machine (3.1) that is mainly used for cutting material and cutting into length using a *sawing tool* (3.9) which is designed as an flexible endless saw band

Note 1 to entry: Examples are given in Clause 5 and Figures 1 to 8.

3.1.2
circular sawing machine
sawing machine (3.1) for cutting bar and profile material to length with a *sawing tool* (3.9) which is designed as a circular saw blade

Note 1 to entry: Examples are given in Clause 5, Figures 9 to 16 and Annex C.

3.1.3
hack-sawing machine
sawing machine (3.1) for cutting bar and profile material to length with a *sawing tool* (3.9) which is clamped between the ends of a downwardly open bow

Note 1 to entry: Examples are given in Clause 5 and Figure 17.

3.1.4
automatic sawing machine
sawing machine (3.1) in which the power-operated elements perform continuous or repeat cycles

Note 1 to entry: The first cycle initiated by a control system starts from the operator until either an automatically determined condition is achieved, or a stop signal is given by the operator.

Note 2 to entry: A typical cycle can be feeding of *work material* (3.13), clamping of work material, feeding of *sawing tool* (3.9) through work material, sawing tool retraction, unclamping of *workpiece* (3.14), unloading of workpiece and unclamping of work material. Repeat the above cycle until a stop signal is actuated.

3.2
back jaw feed
power-operated *work material* (3.13) feeding device having a carriage-mounted vice which grips the work material at any point along its length and traverses it to the sawing position

3.3
load/unload position
zone of the machine where provision exists for manual loading onto, or unloading *work material*(s) (3.13) from the machine

Note 1 to entry: Frequent, but not continuous access, is required of operators during normal operation of the machine.

3.4
manual sawing process
operation of the machine under manual control, all process steps in the machining sequence being started or manually controlled by the operator

3.5
metalworking fluid
fluid to cool and lubricate the sawing process

EXAMPLE Oil, oil mist, alcohol, mixture of oil and water.

3.6 Metalworking fluid systems

3.6.1
recirculating system
metalworking fluid system with collection and pumped recirculation of the fluid

3.6.2
minimum quantity system
system where a small volume of the fluid is supplied to the *sawing tool* (3.9)

Note 1 to entry: No circulation of the fluid is required due to the small consumption.

3.7
push feed
power-operated *work material* (3.13) feeding device pushing on the tail end of the work material to advance it to a position or length stop which determines the required *workpiece* (3.14) length

3.8
roller feed
power-operated *work material* (3.13) feeding device in which the work material is fed by rollers

Note 1 to entry: The roller feed can incorporate lateral guide rollers and an additional length measuring system.

3.9
sawing tool
tool for sawing operation, consisting of tough blade or band with a hard toothed edge used with a circular–, band–, and hack–sawing machine

3.10
semi-automatic machine
single-cycle machine
sawing machine (3.1) in which the power-operated elements perform a single cycle initiated by the operator

Note 1 to entry: A typical cycle can be clamp *workpiece* (3.14), feed *sawing tool* (3.9) to workpiece, begin sawing process, retract sawing tool and unclamp workpiece.

3.11 Types of sawing processes

3.11.1
contour cutting
pushing *work material* (3.13) either by hand or under power through the *sawing tool* (3.9), following a path which is not parallel to the plane of the sawing tool

Note 1 to entry: Contour cutting uses a vertical *band-sawing machine* (3.1.1), fixed sawing frame and contour cutting type.

3.11.2
mitre-sawing
process in which *work material* (3.13) is cut out of square to the longitudinal axis

3.12
work zone
<sawing machines> maximum range determined by the *sawing tool* (3.9) and the clamping device

3.13
work material
material which is fed into the machine and intended to be machined by a *sawing tool* (3.9)

3.14
workpiece
object which has been machined by a *sawing tool* (3.9)

4 List of significant hazards

4.1 General

The list of hazards contained in Table 1 is the result of a hazard identification and risk assessment carried out as described by ISO 12100 for sawing machines covered by the scope of this document. The safety requirements and/or protective measures and information for use contained in Clause 5 and Clause 6 are based on the risk assessment and deal with the identified hazards by either eliminating them or reducing the effects of the risks they generate.

4.2 Main hazard zones

The main hazard zones are the following:

a) work zone(s) with moving sawing tools;

b) workpiece clamping device;

c) workpiece loading and unloading devices, including the workpiece feed;

d) frames of sawing machines (for band-sawing machines);

e) chip conveyor area;

f) sawing tool brushes;

g) mitre cut devices.

Table 1 — List of significant hazards and major sources of these hazards

Nr.[a]	Causes of hazards and hazardous situations	Examples of hazardous situations and hazard zones on sawing machines	Possible consequences	Relevant subclause in this document
1	**Mechanical hazards**			
1.1	Approach of a moving component to a stationary component	Power-operated work material clamping during loading/re-orientating/ unloading work material — between clamps and work material	Crushing hazard	5.1.1 5.4.3 5.10
		Power-operated in feed during running of the machine, during sawing process, sawing tool changing, maintenance, repair — between material and workpiece support; between fixed and moving parts of the machine	Crushing hazard	5.1.1 5.4.3
		Power-operated and manual work material feeding during loading, unloading, machine setting, sawing tool fitting — between sawing tool and workpiece support; workpiece and workpiece support	Shearing hazard	5.4.4

Table 1 *(continued)*

Nr.[a]	Causes of hazards and hazardous situations	Examples of hazardous situations and hazard zones on sawing machines	Possible consequences	Relevant subclause in this document
1.2	Moving parts	Moving sawing tool during operation, machine setting, sawing tool changing, maintenance, repair — power-operated and manual sawing tool feed during operation Chip transportation/ejection — at moving machine elements	Impact hazard Crushing hazard Cutting or severing hazard Entanglement hazard Drawing-in or trapping hazard	5.1.1 5.4.4
1.3	Rotating parts	At or near sawing tools or power transmission elements	Cutting or severing hazard Drawing-in or trapping hazard	5.1.1 5.3 5.4
1.4	Sharp/cutting parts	Unintended contact with the idle sawing tool while loading/unloading and/or measuring	Cutting or puncture hazard Abrasion hazard	5.1.1 5.3 5.4
1.5	Falling or ejected objects	Ejection or fall of work material and swarf during running, sawing, machine setting, sawing tool changing, maintenance — falling workpiece — sawing tool break or sawing tool teeth stripping and ejection Ejected broken machine element(s) — at or near machine	Crushing hazard Impact hazard Stabbing or puncture hazard	5.1.1
1.6	Gravity	Falling of moving machine elements during machine setting, sawing tool changing, maintenance — sawing head at column guide	Crushing hazard Impact hazard Shearing hazard cutting hazard	5.1.1
1.7	High pressure	At hydraulic elements — during stay at or near machine	Penetration of pressurized media	5.1.3
1.8	Stability	Unrestrained machine or machine part falls or overturns — during stay at or near machine	Impact hazard Crushing hazard	5.14

Table 1 *(continued)*

Nr.[a]	Causes of hazards and hazardous situations	Examples of hazardous situations and hazard zones on sawing machines	Possible consequences	Relevant subclause in this document
1.9	Rough, slippery surface	Floor and stepping areas on and around machine and work material — ejection or spillage of metalworking fluid, lubricants and hydraulic fluid — swarf and detritus entrained in spilled fluids — inadequate railing (edge protection) or other restraint means particularly where there is a risk of falling from one level to another	Slip, trip and fall hazards	5.15
2	**Electrical hazards**			
2.1	Live parts	Contact with live parts during operation, machine setting, sawing tool changing, and maintenance — control and other electrical equipment	Electric shock	5.5
2.2	Parts which have become live under fault conditions	Contact with parts which are live by fault during operation, machine setting, sawing tool changing, and maintenance — conductive parts of the machine	Electric shock	5.5

Table 1 *(continued)*

Nr.[a]	Causes of hazards and hazardous situations	Examples of hazardous situations and hazard zones on sawing machines	Possible consequences	Relevant subclause in this document
3	**Thermal hazards**			
	Objects or materials with high temperature	Ejection of hot swarf or workpieces during sawing — during stay at and/or near machine	Burn	5.1.1 5.6
4	**Noise hazards**			
	Manufacturing process and moving elements	Aerodynamic noise from sawing tool Vibration of sawing tool and/or work material while processing Work material handling The power generation and transmission elements — during stay at and/or near machine	Permanent hearing loss All further (e.g. mechanical, electrical) problems due to interference with speech communication Disturbance of acoustical signals	5.7
5	**Vibration hazards**			
	Vibrating elements	Work material or handle held by operator during running or sawing, machine or operating element	Discomfort Neurological disorder Damage of bone joints	5.8
6	**Radiation hazard**			
6.1	Laser	Alignment laser	Damage of eyes	5.1.1
7	**Material/Substance hazard**			
7.1	Biological and microbiological (viral or bacterial) hazard	Contact with contaminated coolant — during stay at and/or near machine	Infection	5.9
7.2	Liquid	Skin contact with coolant — during stay at and/or near machine	Skin damage	5.9.1
7.3	Mists	Inhalation and ingestion of substances used or generated during operation (e.g. coolant) — during stay at and/or near machine	Difficulties of breathing Poisoning	5.9
8	**Ergonomic hazards**			
8.1	Design or location of visual display units	Misinterpretation of displayed information — at workplace of operator	All further (e.g. mechanical, electrical) problems due to human errors	5.10.6
8.2	Design, location or identification of control devices	Maloperation of the machine — at workplace of operator		5.10.5
8.3	Excessive effort	Feeding work material by hand into sawing tool during idle running and sawing	Fatigue	5.10.1
8.4	Body posture		Musculoskeletal disorders	5.10.1
8.5	Repetitive activities		Fatigue	5.10.1

Table 1 *(continued)*

Nr.[a]	Causes of hazards and hazardous situations	Examples of hazardous situations and hazard zones on sawing machines	Possible consequences	Relevant subclause in this document
8.6	Visibility, local lighting	Judgement and accuracy of manual actions impaired during handling/positioning of work material and sawing tools — during loading and unloading, during machine setting, sawing tool changing and maintenance — at load/unload and sawing tool mounting positions	Fatigue All further (e.g. mechanical, electrical) problems due to human errors	5.10.3
9	**Hazards related to the operational environment of the machine**			
	Human errors, human behaviour	Reasonably foreseeable misuse Maloperation of the machine Incorrect work material and sawing tool handling and setting	All further (e.g. mechanical, electrical) problems due to human errors	5.10.4
10	**Combination of hazards**			
10.1	Failure of the power supply	Fall or ejection of moving machine elements or clamped workpiece Failure of stopping moving elements	Crushing hazard Shearing hazard Impact hazard Cutting or severing hazard Entanglement hazard Drawing-in or trapping hazard Stabbing or puncture hazard Abrasion hazard	5.11
10.2	Restoration of energy supply after an interruption	Uncontrolled movements (including change of velocity) unintended/unexpected start up		5.11.2
10.3	Failure/disorder of the control system	Fall or ejection of moving machine elements or clamped workpiece Failure of stopping moving elements Uncontrolled movements (including change of velocity) unintended/unexpected start up Other hazardous situations due to failure or inadequate design of the control system		5.11

[a] The selection made in this table for sawing tool–specific hazards and their numbering are based on ISO 12100:2010, Table 1.

5 Safety requirements and/or protective measures

5.1 General requirements

Sawing machines shall comply with the safety requirements and/or protective/risk reduction measures of this clause. In addition, the machine shall be designed according to the principles of ISO 12100 for relevant but not significant hazards which are not dealt with by this document.

For guidance on risk reduction by means of design, see ISO 12100:2010, Clause 4; and for safeguarding measures, see ISO 12100:2010, Clause 5.

5.1.1 Guard requirements for all types of sawing machines

5.1.1.1 General

Guards shall be in accordance with ISO 14120. The fixing systems of fixed guards shall remain attached to the guards or to the machinery when the guards are removed.

5.1.1.2 Height and position

Where guards are floor-mounted (e.g. perimeter fencing), they shall be fixed securely and have a minimum height of 1,4 m. The distance from the hazard zone shall be in accordance with ISO 13857:2008, Table 2. Any opening between the bottom of the guard and the floor shall not exceed 200 mm (see ISO 11161:2007, 8.5.2).

5.1.1.3 Guarding of drives

Access to mechanical power transmission drives (e.g. chains and sprockets, gears, lead screws, feed screws and ball screws, etc.) shall be prevented by fixed guards (including telescope type guards), unless they are safe by position. If access to these parts is required during normal operation of the machine, interlocked movable guards shall be provided.

For requirements concerning the safety function interlocking devices associated with movable guards, see 5.3.

5.1.1.4 Interlocking of guards

Movable guards shall be interlocked with or without guard locking in accordance with ISO 14119 in order to prevent access to hazard zones in which hazardous machine movements take place. The selection of interlocking devices shall be in accordance with ISO 14119:2013, Clause 7.

Opening the interlocked guard shall initiate a category 0 or category 1 stop of the machine in accordance with IEC 60204-1:2009, 9.2.2.

Where, due to sawing tool run-down time, it is possible to access the hazardous zones after the interlocked movable guard has been opened, the guard shall be fitted with guard locking (see EN 1088:1995, 7.4), which allows an opening only after the hazardous movement has stopped. The appropriate distance for reaching the hazard zones can be determined from ISO 13855.

5.1.2 Modes of operation

5.1.2.1 Mode selection

When machine movements on automatic and semi-automatic sawing machines are required while the guard is being opened (e. g. measuring or adjustments for subsequent machining process), there shall be a “setting mode” provided in addition to the “automatic mode.”

The selection of a mode of operation shall be either by key switch, selector switch with access code or other equally secure means (e.g. electronic key), and shall only be permitted from outside the hazard zones (see Table 2 for requirements). The selected mode shall be easily visible (e.g. by display or by position of the selector switch). Selection of a mode shall not initiate hazardous movements of machine parts. If a lockable mode selection switch is used, it shall be in accordance with IEC 60204-1:2009, 9.2.3.

5.1.2.2 Mode 1: Automatic mode

All moveable interlocked guards shall be closed and/or the safeguards shall be active to permit automatic or semi-automatic sawing machining.

5.1.2.3 Mode 2: Setting mode

This mode allows adjustment of the machine to be performed under reduced risk conditions. Interlocking of movable guards is suspended in this mode and only those powered machine movements that are essential shall be permitted when initiated and sustained by a hold-to-run control. Examples of movements permitted under hold-to-run conditions are powered motion of the sawing tool, powered movement or clamping of the work material and powered chip removal by conveyors. The additional requirements specified in 5.4 shall remain in effect when setting mode is selected.

Where more than one control panel is provided with hold-to-run controls, only one of them shall be active in setting mode.

5.1.3 Control system requirements

5.1.3.1 Safety-related parts and safety functions

For the purpose of this document, "safety-related parts of the control system" means the chain of components from receipt of initial actuator signal (e.g. control device or position detector) to delivery of the final actuator command (e.g. contactor, solenoid valve). The following functions shall be treated as safety functions and satisfy the requirements of ISO 13849-1, considering the performance level given in Table 2. An example for the determination of a performance level is given in Annex D.

Table 2 — Required performance level for safety functions

No. of SF	Safety function (SF)	Explanation of safety function (SF) effect	Additional information/ requirements	Proposed PLr
1	Start/restart	The unexpected start-up for all power units is prevented.		c
2	Operational stop	The stop-function shall be supplied with each mode of operation. All functions and movements are stopped under safe conditions.	The power drives shall not be switched off.	c
3	Emergency stop	When the emergency stop is activated, all power units shall be switched off.		c
4	Mode selection	The mode of operation and the functions connected with this mode shall be selected in a safe manner.	Only required with automatic or semi-automatic sawing machines while the safeguards are inactive and hazardous movements are necessary (e.g. with special mode, changing the sawing tool).	c
5	Guard interlocking	When the guards are open, all drives which can cause hazardous movements shall be stopped safe. The position of the guards shall be monitored (open/closed).	If access is more than once per hour.	d category 3
			If access is less or equal than once per hour.	c
6	Enabling function		For additional information, see ISO 12100:2010, 3.28.2.	c

Table 2 *(continued)*

No. of SF	Safety function (SF)	Explanation of safety function (SF) effect	Additional information/ requirements	Proposed PLr
7	Hold-to-run control	Prevention of the start from rest position and the safe function of the control device.	Combination with enabling device is not practicable due to the kind of activity of the operator (e.g. change of sawing tool).	c
			If PL = c cannot be achieved, a combination of hold-to-run control and an enabling device complying with PL = d shall be used.	d
8	Control function to prevent the unintended descent of vertical or slant axes	If the drive units are switched off, the unintended descent of vertical axis due to gravitational force shall be prevented.	For machines where access into the danger zone is possible.	c
Control system for workpiece clamping				
9	Power-operated workpiece-clamping device — Limiting of the speed	To avoid crushing and shearing in the area of the workpiece clamping device, the movements of clamping shall be limited to less or equal 10 mm/s.	For machines with access into danger zone. This function shall always be used in combination with an enabling device.	a
10	Power-operated workpiece-clamping device — Interlocking of the control system	The locking of the control system during the sawing process prevents the unintended unclamping of the workpiece.	For automatic and semi-automatic machines, the starting of the drive unit of the sawing device shall only be possible after the full clamping energy has been achieved.	a
11	Power-operated workpiece-clamping device — Loss of clamping energy during sawing operation	In case of loss of the power supply, the clamping energy shall be kept up. In the case of loss of clamping energy, the sawing process shall be switched off.		a
12	Power-operated workpiece-clamping device — Manual controlled opening	Before the manual opening of the clamping device is possible, the power units for the sawing device shall switched off.	For automatic and semi-automatic machines, the power units for the sawing device shall be switched off.	a

Verification: Inspection of circuit diagrams, performance check/test.

5.1.3.2 Start

Start control devices shall be located outside the hazard zone and shall be active only when all safeguards are active. When any interlocked guard is open or protective devices are suspended, all unexpected start-ups and all hazardous movements shall be prevented in accordance with EN 1037:1995+A1:2008, Clause 6. The closure of an interlocked guard shall not result in a machine restart.

Verification: Inspection of circuit diagrams, performance check/test.

5.1.3.3 Normal stop

Each workstation at the machine shall be fitted with a stop control device which, when activated, brings all machine actuators and, if fitted, a demountable power feed safely to a complete stop. After hazardous functions have stopped, the energy supply to the actuators concerned shall be cut off.

NOTE 1 A stop control device can be a push button or a control output of the PLC combined with end of a NC-program or a softkey with reaction in the hardware or auto shut done cycle of the CNC/PLC.

If the machine is fitted with a spring-actuated mechanical brake or no brake is provided for the tool spindle(s), this stop function shall be of a stop category 0 in accordance with the requirements of IEC 60204-1:2009, 9.2.2.

If the machine is fitted with any other type of brake, e.g. an electrical brake for the tool spindle(s), this stop function shall be of stop category 1 in accordance with the requirements of IEC 60204-1:2009, 9.2.2.

NOTE 2 Electrical braking also includes reducing spindle speed by a frequency inverter.

For normal stopping of PDS (SR) (power drive system, safety related), see IEC 61800-5-2:2007, 4.2.2.2 [safe torque off (STO)], 4.2.2.3 [safe stop 1 (SS1)] and 4.2.2.4 [safe stop 2(SS2)].

The safety-related part of the control system for normal stopping (braking function excluded) shall achieve at least PL = c according to ISO 13849-1.

Verification: Inspection of circuit diagrams, performance check/test.

5.1.3.4 Operational stop

An operation stop shall be provided to interrupt the operation of an automatic machine and bring the machine to a controlled, safe stop position.

Verification: Inspection of circuit diagrams, performance check/test.

5.1.3.5 Emergency stop

An emergency stop function shall be provided on all types of machines.

Exception: For sawing machines with hold-to-run controlled sawing tool drive system and manual head feed, stop control device can be provided close to the hold-to-run control instead of an emergency stop.

This emergency stop function shall be in accordance with ISO 13850 and IEC 60204–1:2009, 10.7. The selection of the emergency stop category (i.e. category 1 or category 0) shall be determined according to the technology used (e.g. for a brake).

The emergency stop shall actuate the brake on machines provided with a brake.

Emergency stop controls shall be provided at all control stations of the machine (e.g. the main control panel, the work material load and workpiece unload stations).

An additional emergency stop device shall be provided in any area that is not visible from the operating control position where persons can be at risk.

Verification: Inspection of circuit diagrams, performance check/test.

5.1.3.6 Mode selection devices

Mode selection devices shall ensure that only one mode is active at any given time. Where an access code is employed in a programmable electronic system (PES), measures shall be applied to prevent unauthorised modification of safety critical data or programme control information.

Reselection of automatic mode shall not initiate the machine cycle.

Verification: Inspection of circuit diagrams, performance check/test.

5.2 Machine types described in this document

5.2.1 Band-sawing machines

For machine type–specific safeguarding requirements, see 5.3.1.

5.2.1.1 Horizontal band-sawing machine (horizontal arrangement of the sawing band)

5.2.1.1.1 Pivot type

The sawing head of the machine is pivoted at one end and descends in an arc.

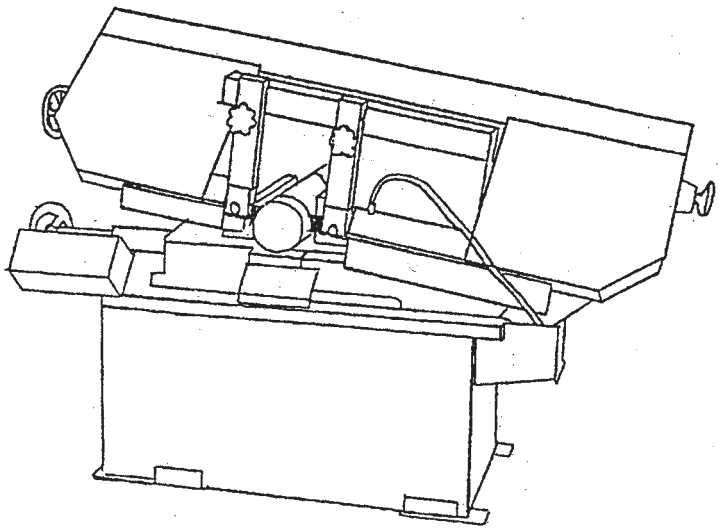


Figure 1 — Horizontal band-sawing machine — Pivot type

5.2.1.1.2 Column type

The sawing head is carried on one or more vertical columns (or pillars) and feeds in a straight vertical downward movement.

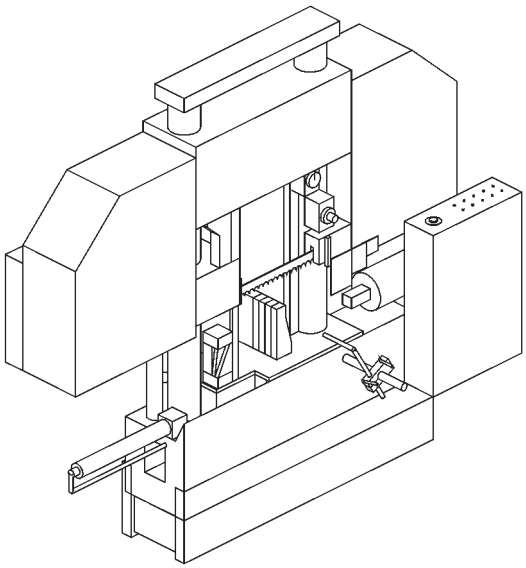


Figure 2 — Horizontal band-sawing machine — Column type

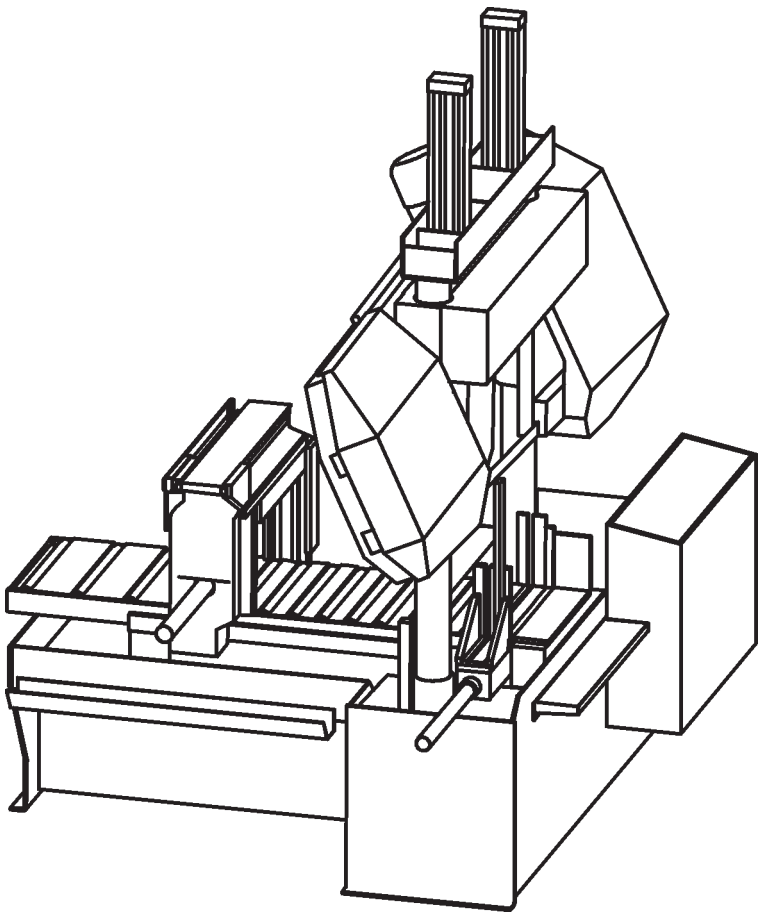


Figure 3 — Automatic horizontal band-sawing machine — Column type

5.2.1.1.3 Band-sawing machine for mitre cut

This type is either column-guided or a pivot-type machine; the sawing frame is pivoted single- or double-sided in relation to the workpiece.

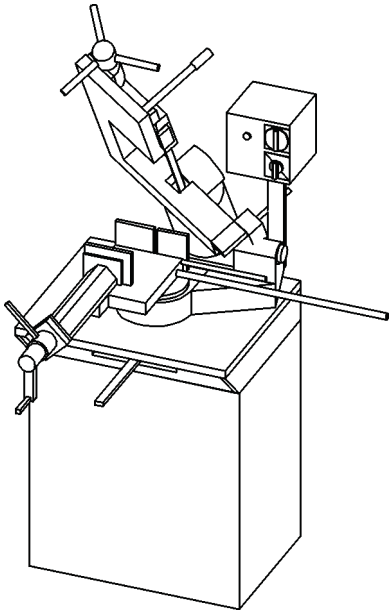


Figure 4 — Band-sawing machine for mitre cut

5.2.1.2 Vertical band-sawing machine

5.2.1.2.1 Band-sawing machine with fixed frame, contour cutting type (also called "vertical contour type")

The frame assembly is fixed and workpiece may be fed by hand or under power into the sawing tool. The sawing path may be straight or contour. Mitre-sawing is achieved by tilting the work table or the frame.

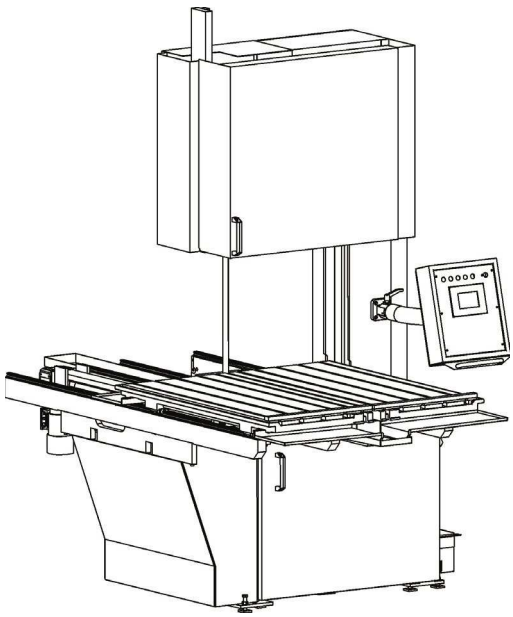


Figure 5 — Vertical band-sawing machine with fixed frame

5.2.1.2.2 Sawing machine — Front cutting type

These machines have a horizontally-moving frame assembly. The work material is clamped to the table and the feed motion of the sawing machine is towards the front of the machine into the back of the work

material. The band-sawing tool is twisted by 90° at the cutting region, to align the sawing tool with the direction of feed motion. On some machines, provision is made to tilt the head on which the sawing tool is mounted for mitre-sawing.

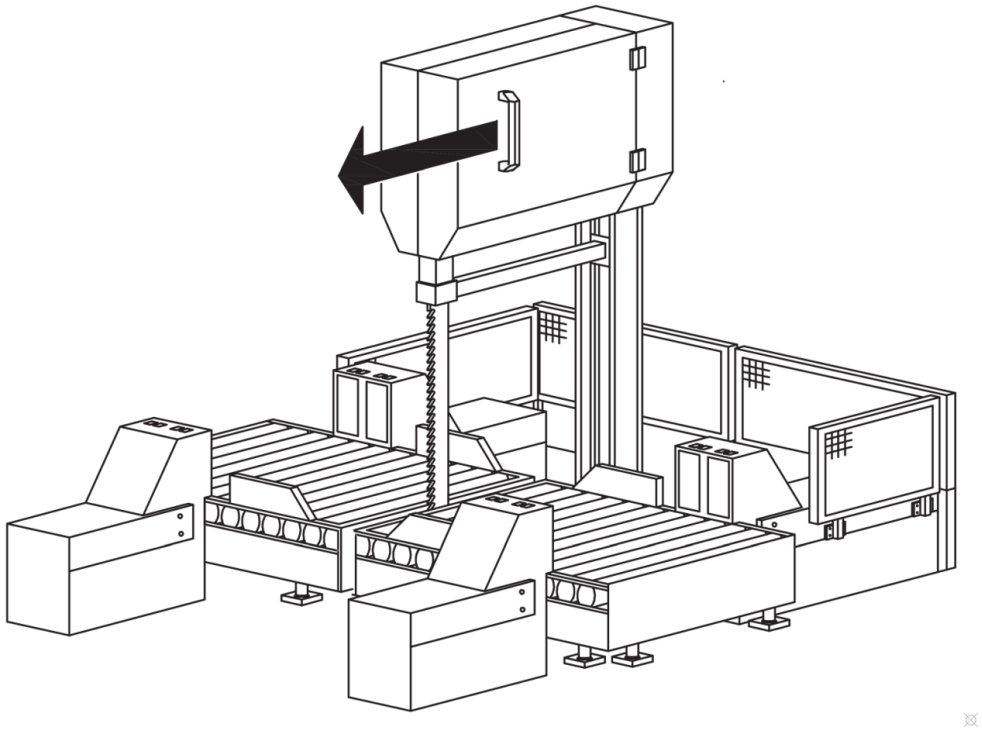
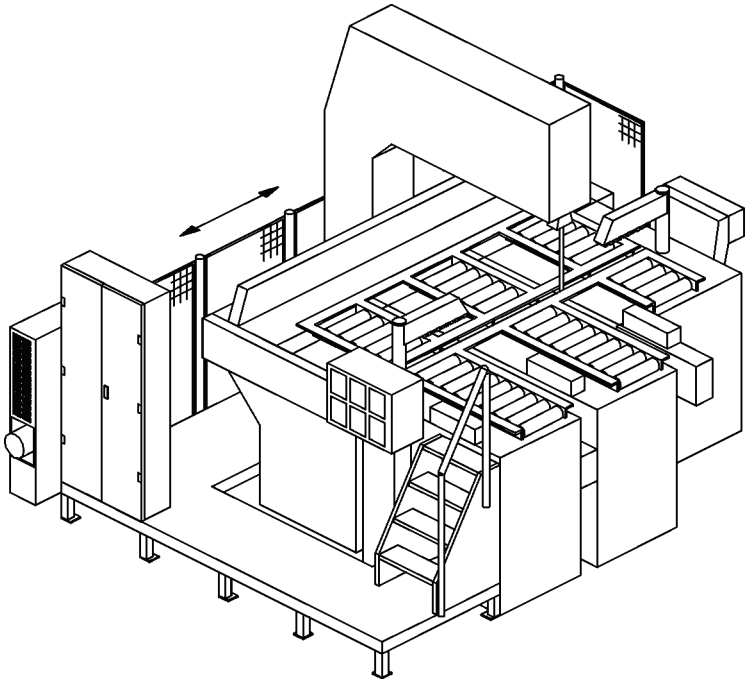


Figure 6 — Sawing machine — Front cutting type

5.2.1.2.3 Sawing machine — Traversing type

The workpiece is clamped (where necessary) to the table which incorporates a slot. The band-sawing blade passes through the slot in the table. Either the table or the frame carrying the band-sawing blade traverses laterally to provide the feed motion. This type is commonly used for plate sawing.



NOTE This figure does not show all the required safety guards.

Figure 7 — Sawing machine with frame feed — Traversing type

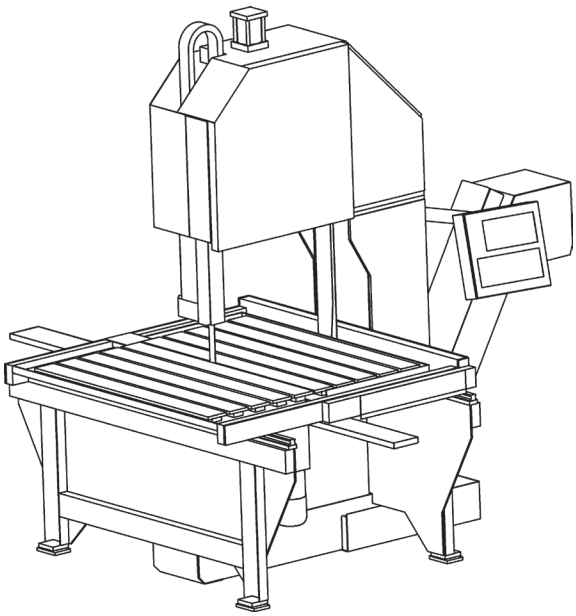


Figure 8 — Sawing machine with table feed — Traversing type

5.2.2 Circular sawing machines

5.2.2.1 Circular sawing machine — Pivoting head type

The spindle and circular sawing tool are mounted on a pivot arm. The plane of the circular sawing blade is aligned with the “front to back” axis of the machine. The sawing blade approaches the work material

in an arc. The head which carries the sawing tool may be fixed or capable of swivelling or tilting. The down feed of the sawing head can be manual or powered.

NOTE This type of machine can be fully automatic or semi-automatic. A fully automatic pivoting head machine normally incorporates power feed of the sawing tool, power in-feed and powered clamping of the work material. A large semi-automatic machine normally incorporates power feed of the sawing tool and power clamping of the workpiece. Provision is often made for swivelling the whole machine to make mitre cuts.

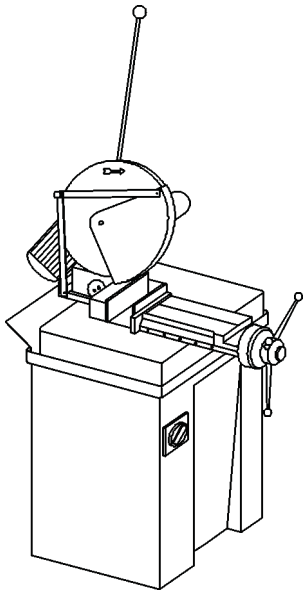


Figure 9 — Circular sawing machine with manual feed — Pivoting head type

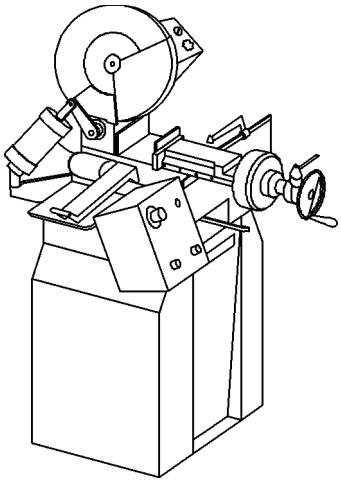
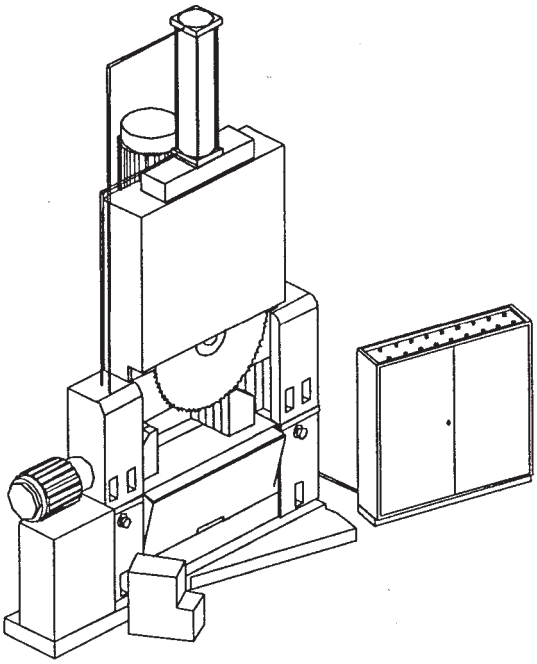


Figure 10 — Circular sawing machine with powered feed — Pivoting head type

5.2.2.2 Vertical/down feeding type

There are two variations of this type of machine, the generally larger and heavier twin pillar type and the single column type. The head carrying the sawing tool slides vertically on the pillars or the column to feed the sawing tool down into the work material.

Provision for mitre-sawing is made on some machines, usually the single column type, by allowing either the head to swivel on the column, or the head and column to swivel on the base. This type of machine can be provided with manual, semi-automatic or fully automatic control.



NOTE This figure shows rotating sawing tool not at its rest position.

Figure 11 — Vertical/down feeding type — Twin pillar

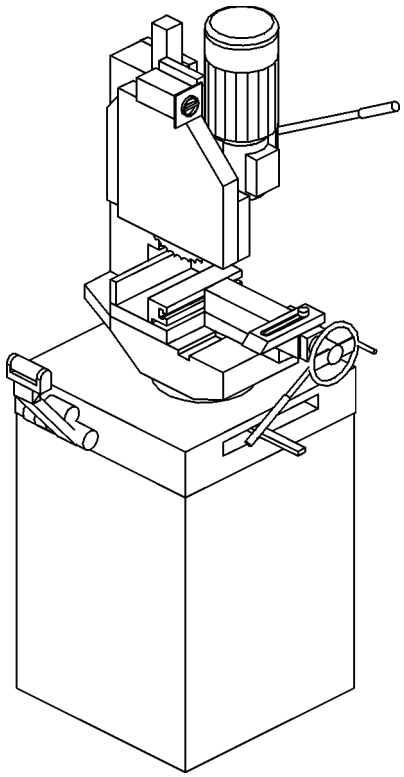


Figure 12 — Vertical/down feeding type — Single column with open front

5.2.2.3 Vertical — Rising/up-stroking type

On this type of machine, the plane of the circular sawing tool is aligned with the "front-to-back" axis of the machine. The circular-sawing tool is mounted on a spindle within the base frame of the machine and rises through a slot in the work table. For mitre-sawing, the whole machine can be mounted on a turntable, or the head which carries the sawing tool can rotate about one or more axes.

Some machines have provision for locking the cutting head in the raised position to allow rip-sawing (see 3.11.1).

This type of machine can be provided with semi-automatic or fully automatic control.

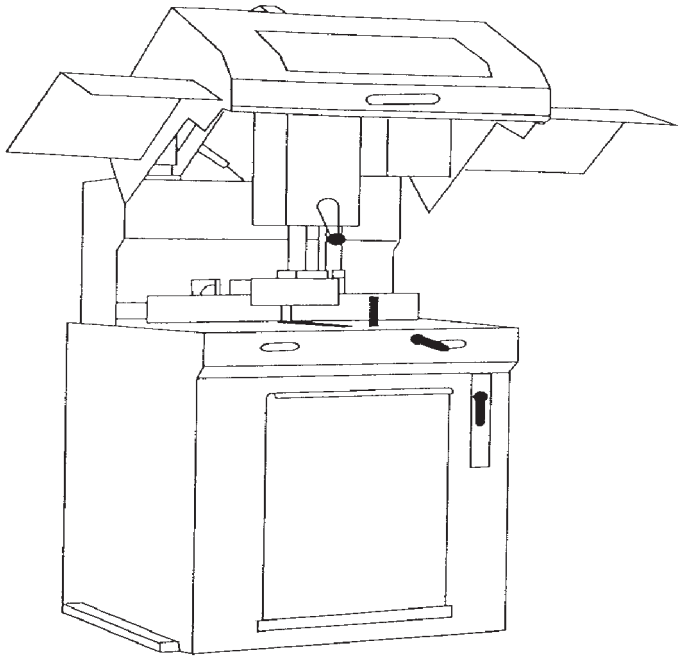


Figure 13 — Vertical — Rising/up-stroking type

5.2.2.4 Sawing machines — Longitudinal traversing — Table type

The spindle and circular-sawing tool are mounted in a carriage which travels below the plane of the table. The plane of the circular-sawing tool is aligned with the "side-to-side" axis of the machine. The sawing tool travels horizontally towards and into the work material. This type of machine can be provided with manual, semi-automatic or fully automatic control.

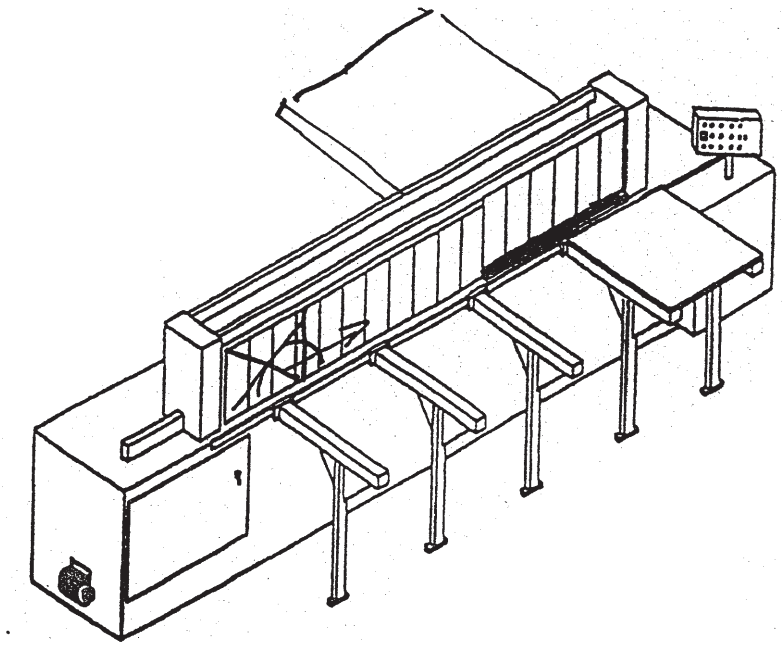


Figure 14 — Sawing machine — Longitudinal traversing — Table type

5.2.2.5 Twin- or multiple-head type

This type of machine is supplied for double-ended sawing and may be provided with two or more heads. In some machines, the sawing tool approaches the workpiece in an arc from the back and the heads may enable the plane of the sawing tool to be tilted from the vertical. In other machines, usually for mitre-sawing, the heads feed the sawing tools vertically into the top of the work material.

This type of machine can be provided with semi-automatic or fully automatic control.

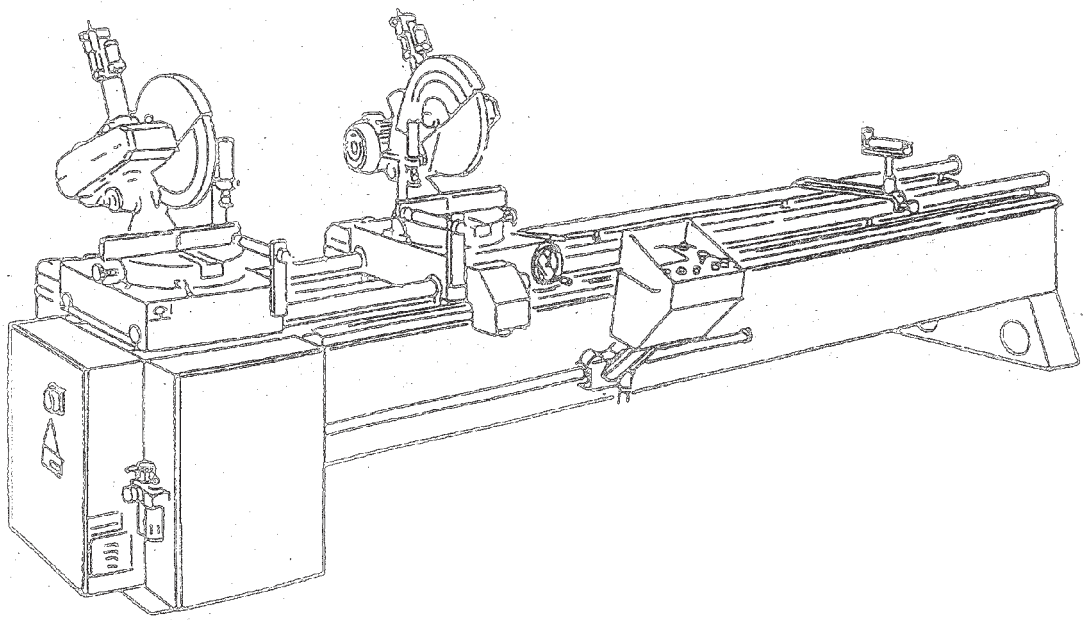


Figure 15 — Twin- or multiple-head type sawing machine

5.2.2.6 Horizontal type (included inclination or slant type)

The spindle and circular sawing blade are mounted in a carriage which travels on slides or rails above the table.

The plane of the circular saw blade is aligned with the “side-to-side” axis of the machine. The sawing blade travels horizontally towards and into the work material. On some machines, the table can tilt. This type of machine can be provided with manual, semi-automatic or fully automatic control.

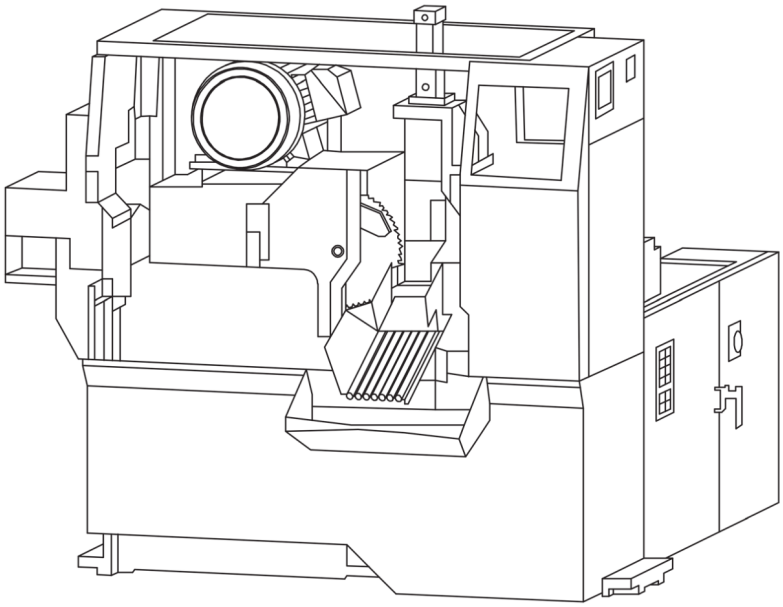


Figure 16 — Horizontal type (or incline type)

5.2.3 Hack-sawing machines — Horizontal-pivot type

The head, which carries the reciprocating frame and sawing tool, is pivoted at one end; feed motion is a downward arc into the top of the workpiece.

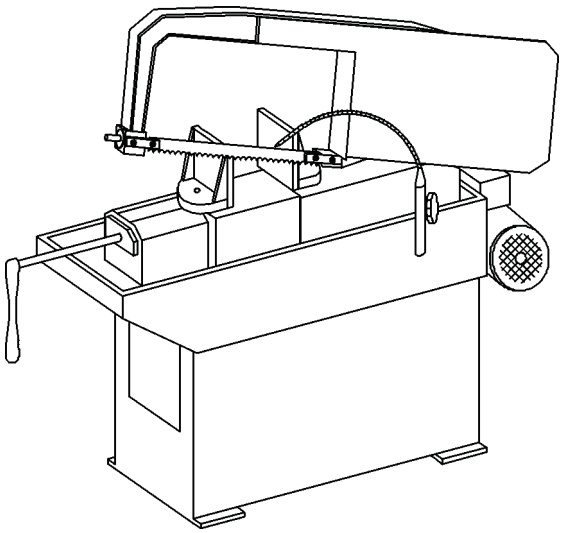


Figure 17 — Hack-sawing machines — Horizontal-pivot type

5.3 Type-specific safeguarding requirements

5.3.1 Band-sawing machines (see Figures 1, 2, 3, 4, 5, 6, 7 and 8)

5.3.1.1 Basic requirements

Fixed or interlocking guards shall be provided to prevent access to the entire length of the band sawing tool. Adjustable guards shall be provided for the range of the sawing tool needed for the sawing process.

NOTE This can be achieved if the band guides are as close as possible to the jaws and do not interfere with the vice plate.

Where sawing tool cleaning brushes or wheels are provided, they shall be safeguarded using one or more fixed, adjustable or interlocked movable guard(s).

Access to moving band wheels shall be prevented by interlocked movable guards which comply at least with the requirements of PL = c (see ISO 13849-1). Guard interlocking shall incorporate, as a minimum, a single detector actuated in the positive mode (see 5.1 and ISO 14119:2013, Annex A).

An adjustable guide shall be provided that moves with the guard to support the sawing tool during sawing, thus reducing the risk of sawing tool breakage during operation.

Verification: Visual inspection, performance check/test, drawings/schematics/calculations.

5.3.1.2 Additional requirements for vertical band-sawing machines with traversing frame feed (see Figure 7) or with longitudinal table feed (see Figure 8)

At machines with power-operated feed (e.g. feed of the work material, feed of the machine frame), with a feed rate,

— less than or equal to 2 m/min: a hold-to-run control shall be provided (see ISO 11161:2007, 8.6.2),

— greater than 2 m/min: access to hazardous movements shall be prevented by fixed and/or interlocking guards.

If the table must be entered by the operator for loading/unloading at vertical band-sawing machines with traversing frame (see Figure 7) appropriate protective measures against fall, slip and trip hazards shall be provided (e.g. handrails or other as listed in 5.15.1).

Verification: Visual inspection, performance check/test, drawings/schematics/calculations, measurement.

5.3.2 Circular sawing machines (see Figures 9, 10, 11, 12, 13, 14, 15 and 16)

5.3.2.1 General

Machines shall be provided with guards and designed so as to

a) prevent access to the teeth of the rotating sawing tool when the sawing head is at its rest position,

b) prevent access for automatic and semi-automatic sawing machines to the sawing tool during the sawing; prevent access for manual sawing machines to the sawing tool during sawing as much as possible depending upon the shape of the workpiece and the sawing process, and

c) prevent access to any sawing tool cleaning device during sawing.

Guards shall be designed to contain ejected fragments (e.g. parts of the sawing tool, work material).

In pivot head machines, the failure of a single component in the counter-balance system shall not cause the sawing head to fall under gravity.

Verification: Visual inspection, performance check/test, drawings/schematics/calculations.

5.3.2.2 Pivoting head type — Manual and power-operated cutting head feed (see Figures 9 and 10)

Access to the sawing tool shall be prevented by a combination of fixed guards and self-closing guards (see Figure C.1). Parts 1 and 2 of Figure C.1 are fixed guards; part 3 is a self-closing guard. The guard shall be completely closed in the rest position. The self-closing guard shall not be brought into its position by gravity or spring. Disconnection of the linkage of the self-closing guard shall require the use of a tool or the opening of a mechanical locking system or a key lock.

Suitable devices shall be provided to prevent fall of the cutting head from the rest or raised position (e.g. retention springs, latches).

If sawing tool guards are removed, (e.g. for sawing tool change, maintenance), then an interlocking device shall ensure that sawing tool rotation is prevented until the sawing tool guarding is fully reinstated.

Verification: Visual inspection, performance check/test, drawings/schematics/calculations.

5.3.2.3 Pivoting head type — Automatic (see Figure C.2) and semi automatic (see Figure C.3)

The work zone and work feed mechanism shall be provided with an interlocking guard.

Verification: Visual inspection, performance check/test, drawings/schematics/calculations, measurement.

5.3.2.4 Vertical/down-feeding type (see Figures 11 and 12)

For automatic machines self-closing guards and for manual machines adjustable guards shall be provided for safeguarding the sawing tool teeth and as much of both sides of the sawing tool as practicable.

If the machine is equipped with automatic feed of work material, access to the work zone and work feed mechanism shall be prevented by fixed and/or interlocked movable guards. Openings in guards at the loading point shall be adjustable in accordance with ISO 13857:2008, Tables 1, 3 and 4.

Guard interlocking shall incorporate, as a minimum, a single detector actuated in the positive mode (see ISO 14119:2013, Annex A).

Verification: Visual inspection, performance check/test, drawings/schematics/calculations.

5.3.2.5 Rising/up-stroking type (see Figure 13)

5.3.2.5.1 Machines with manual cutting head feed

Interlocking movable guards shall be provided to enclose the sawing tool above the machine table as much as possible.

Where contact with the sawing tool is possible during sawing, rotation shall occur only under a hold-to-run control (i.e. the hold-to-run control may be integrated with the handle).

Verification: Visual inspection, performance check/test, drawings/schematics/calculations.

5.3.2.5.2 Machines with powered cutting head feed

Fixed and/or interlocked movable guards with guard locking shall be provided to prevent access to the moving sawing tool when above the work table.

Guard locking is not required if on opening the guard, either

— a brake is actuated to stop the sawing tool before access to it is possible, or

— the sawing tool retracts to a safe position beneath the work table before access to the sawing tool is possible.

The time for stopping or retracting shall be calculated according to ISO 13855:2010, Clause 5.

Guard interlocking shall incorporate, as a minimum, a single detector actuated in the positive mode (see 5.1 and ISO 14119:2013, Annex A).

Verification: Visual inspection, performance check/test, drawings/schematics/calculations, measurement.

5.3.2.6 Longitudinal traversing — Table type (see Figure 14)

Access to the moving sawing tool and clamps from the load/unload position shall be prevented by a combination of fixed guards (see ISO 14120:2015, 3.2) and sensitive protective equipment or SPE (see ISO 12100:2010, 3.28.5), e.g. active optoelectronic protective devices or AOPDs (see IEC 61496–2) or pressure sensitive mats (see ISO 13856-1 and ISO 13855 for positioning).

Access from the rear of the machine to the moving sawing tool, to clamping devices and any powered gauging or feed devices shall be prevented by fixed guards (see ISO 14120) together with either interlocked movable guards or sensitive protective equipment.

Verification: Visual inspection, performance check/test, drawings/schematics/calculations, measurement.

Access to the moving sawing tool and other hazardous parts below the machine table shall be prevented by fixed guards. Where access to the sawing tool and drive mechanism, including any spindle speed changing facility is required, interlocked movable guards shall be provided. Where necessary, guard locking shall be provided (see ISO 12100:2010, 3.27.5 and ISO 14119:2013, 4.3).

Fixed guards shall also be provided at all sides of the machine, e.g. self-closing guards, to contain chips and metal working fluids and minimize risks from the ejection of process materials.

The interlocking arrangements shall incorporate, as a minimum, a single detector activated in the positive mode (see ISO 14119). Actuation of the interlocks and/or sensitive protective equipment shall cause either a category 0 or a category 1 stop (see IEC 60204–1).

Provision shall be made, where necessary, for the safe integration of ancillary swarf/chip handling equipment (e.g. swarf/chip conveyors).

Verification: Visual inspection, performance check/test, drawings/schematics/calculations.

5.3.2.7 Horizontal type

Self-closing, adjustable or interlocked movable guards shall prevent access to the moving sawing tool (see also Figure 16).

Verification: Visual inspection, performance check/test, drawings/schematics/calculations.

5.3.2.8 Radial arm, pendulum and front-cutting types

Fixed guards, adjustable or interlocked movable guards shall prevent access to the moving sawing tool. Means shall be provided to return the sawing tool to the rest position after use automatically.

Verification: Visual inspection, performance check/test, drawings/schematics/calculations.

5.3.2.9 Twin sawing mitre-cutting type — Vertical feed — Single-head type

Fixed guards and adjustable guards shall be provided to prevent access to the moving sawing tools.

Verification: Visual inspection, performance check/test, drawings/schematics/calculations, measurement.

Where the work material positioning guide-fence is behind the longitudinal axis of the work material, means shall be provided for the clamping of the work material.

Either supplementary fixtures shall be provided to align the work material during sawing, or protection by a work material tunnel shall be provided.

Verification: Visual inspection, performance check/test, drawings/schematics/calculations, measurement.

5.3.2.10 Twin sawing mitre-cutting type — Vertical feed — Twin-head and multiple-head type (see Figure 15)

Access to the hazard zone shall be prevented by fixed and/or interlocked movable guards. Openings in guards at the loading station shall be in accordance with ISO 13857:2008, Tables 3, 4 and 5. The interlocking of the guard shall incorporate, as a minimum, a single detector actuated in the positive mode (see ISO 14119:2013, Annex A).

Verification: Visual inspection, performance check/test, drawings/schematics/calculations, measurement.

For manual or semi-automatic machines, self-closing or adjustable guards shall be provided to prevent access to the sawing tool. Additional adjustable guards, or the work material clamping equipment, shall prevent access to the sawing tool at the load/unload positions.

Verification: Visual inspection, performance check/test, drawings/schematics/calculations.

For automatic machines, access to the sawing tool shall be prevented using interlocked movable guards. The interlocking shall incorporate, as a minimum, a single detector actuated in the positive mode (see ISO 14119:2013, Annex A). Actuation of the interlock shall either cause the sawing tool to retract to a safe position or to stop before access is possible (see ISO 13855 and ISO 13857).

Verification: Visual inspection, performance check/test, drawings/schematics/calculations.

Where power-operated traversing is provided, access to locations where a potential crushing hazard exists shall be prevented. This shall be achieved by providing either

a) trip devices if the workpiece manipulation envelope is not known (see ISO 13855), or

b) fixed guards together with trip devices at the load/unload position if the workpiece manipulation requirements are known, and the minimum gaps given in ISO 13854 are satisfied.

Examples of trip devices are electro–sensitive protective equipment (ESPE) in accordance with IEC 61496–1 and IEC 61496–2, or pressure sensitive safeguards (PSPDs) in accordance with ISO 13856-1.

Verification: Visual inspection, performance check/test, drawings/schematics/calculations, measurement.

Individual cutting heads on multi–head machines shall satisfy the requirements listed in 5.3.2.1.

Verification: Visual inspection, performance check/test, drawings/schematics/calculations.

5.3.3 Hack-sawing machines (see Figure 17)

Access shall be prevented to the crushing/trapping hazards of the reciprocating drive mechanism and moving frame by fixed and/or interlocking guards.

Verification: Visual inspection, drawings/schematics/calculations.

5.4 Other mechanical hazards

5.4.1 Mechanical power transmission elements

Access to motors and drive transmission elements shall be prevented by fixed guards or interlocking movable guards (e.g. telescopic covers) unless inherently safe by virtue of their position. Movable

guards shall be used if normal operation requires frequent access (i.e. more than once per work shift). Guard interlocking shall incorporate, as a minimum, a single detector actuated in the positive mode (see ISO 14119:2013, Annex A).

Verification: Visual inspection, performance check/test, drawings/schematics/calculations.

5.4.2 Work material holding devices

All sawing machines shall be provided with clamping devices which keep the work material secure in position to prevent unintentional movement of the work material during the sawing process.

Verification: Visual inspection, performance check/test, drawings/schematics/calculations.

5.4.3 Power-operated work material clamping devices

5.4.3.1 Crushing hazard

The risk of exposure to crushing hazards between power-operated work material holding devices (clamps) and the work material shall be reduced by one or more of the following measures:

a) limiting the clamp stroke to 6 mm or less (opening and closing);

b) restricting the speed of the clamping device to 10 mm per second or less under hold-to-run control;

c) providing distance guards to ensure that the hazard zone cannot be reached the length of the distance guard (tunnel guard, see ISO 14120:2015, 3.2.2) shall be at least 550 mm (forearm length according to ISO 13857:2008, Table 3) (see ISO 13857 as appropriate for the type of safeguarding);

d) providing a means to prevent the operator from reaching the hazard zone while power-operated work material holding devices are closing, e.g. two-hand control device, closing the device by a function key in combination with an enabling device or locating the control away from hazard zone;

e) providing means to detect access to hazard zone, e.g. active optoelectronic protective device (AOPD);

f) providing fixed guards.

Verification: Visual inspection, performance check/test, drawings/schematics/calculations, measurement.

5.4.3.2 Interlocking of control system

Interlocking of the control system shall prevent unclamping of the work material during the sawing cycle.

On semi-automatic and automatic machines, the control system of the machine shall be interlocked to prevent sawing until work material is clamped.

Verification: Visual inspection, performance check/test, drawings/schematics/calculations.

5.4.3.3 Clamping loss during sawing

Power-operated work material holding devices shall remain clamped or hazardous motion shall be interrupted in the event of a failure or interruption in the work material holding device power supply.

Verification: Visual inspection, performance check/test, drawings/schematics/calculations.

5.4.3.4 Manual release of the clamping system

On semi-automatic and automatic machines, manual release of the clamping shall be permitted only after the sawing tool has been retracted and hazardous motion of the machine has ceased.

Verification: Visual inspection, performance check/test, drawings/schematics/calculations.

5.4.4 Power-operated work material loading/unloading and feeding devices

5.4.4.1 Roller feed (see 3.8)

The power transmission to the powered rollers shall be totally enclosed. The in-running nip points between the powered rollers and work material shall be safeguarded by means of fixed and/or interlocked movable guards except where the intake position (i.e. where the work material enters the machine) satisfies the requirements of ISO 13857.

Verification: Visual inspection, performance check/test, drawings/schematics/calculations, measurement.

5.4.4.2 Back jaw feed (see 3.2)

Access shall be prevented to hazard zones at back jaw feed devices [e.g. fixed guards, movable interlocking guards, active optical protection devices (AOPDs); see IEC 61496–2].

Verification: Visual inspection, performance check/test, drawings/schematics/calculations, measurement.

5.4.4.3 Push feed (see 3.7)

Safeguards shall be provided to prevent access to the path of the pushing device and work material on its forward stroke, the device on its reverse stroke and to prevent crushing hazards between the end of the work material and the feed device (see ISO 13857).

Verification: Visual inspection, performance check/test, drawings/schematics/calculations, measurement.

5.4.5 Swarf/chip collection and removal systems

5.4.5.1 Within the machine

To avoid entanglement or crushing hazard, access to the swarf/chip collection and removal system shall be prevented by fixed and/or interlocking movable guards.

Opening an interlocking, movable guard shall cause the movement of the system to cease and remain inhibited. If movement of the system with an interlocking guard open is essential (e.g. for cleaning purposes), the movement shall be permitted only under a hold-to-run control.

5.4.5.2 Swarf/chip discharge area

To avoid entanglement or crushing hazard, access to the swarf/chip discharge area shall be prevented, e.g. by fencing and/or use of a container or tilting bucket. If the container or tilting bucket is located beneath the ejection point, access to the swarf/chip discharge area shall not be possible. When movable guards are used, they shall be interlocked with the drive of the swarf/chip conveyer.

When due to the type of construction, access to the swarf/chip collection and removal system and accordingly to the swarf/chip discharge area cannot be prevented entirely, this shall be indicated by a warning sign.

Verification: Visual inspection, drawings/schematics/calculations.

5.4.6 Preventive maintenance

Access to hazard zones shall be limited by locating maintenance, fluid addition (e.g. lubrication) and setting/machine adjustment points outside hazard zones (see ISO 12100).

Verification: Visual inspection, drawings/schematics/calculations.

5.5 Electrical hazards

To minimize electrical hazards, all electrical equipment shall be designed and applied in accordance with IEC 60204-1.

Verify compliance with the requirements in IEC 60204-1.

5.6 Thermal hazards

Where a swarf removal system is provided, it shall protect persons from contact with hot swarf material (e.g. by fixed guards).

Verification: Visual inspection, performance check/test, drawings/schematics/calculations.

5.7 Hazards generated by noise

5.7.1 Reduction of noise at source

When designing sawing machines, the information and technical measures to control noise at source given in ISO/TR 11688-1 shall be followed.

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

The design shall take into account noise from each source. Appropriate technical measures for reducing noise at the main sound sources of the sawing machines are listed in Table 3.

Table 3 — Noise reduction measures

Sources and types of acoustical noise	Possible means of reducing noise levels
a) Transmission noise	Damping of motor, belts, gearbox noise
b) Pneumatic exhaust	Silencers
c) Material discharge	Lining of sound reflecting inside surfaces with sound absorbing material
d) Cutting noise	Sawing tooling adapted to the dimensions of the workpiece and material Sawing tool sharpness and geometry; acoustic panels (partial or total), proper work material clamping, optimized feed and speed conditions
e) Aerodynamic noise	Guard characteristics, sawing tool design (for aluminium)
f) Sawing tool vibration during running	Slotted/laminated sawing tools (for aluminium), sawing tool geometry, close tolerance sawing tools
g) Insufficient metalworking fluid during cutting	Increase flow
h) Hydraulic system	Acoustic enclosure, selection of low noise equipment

The above list is not exhaustive. Alternative technical measures for noise reduction with identical or greater efficiency may be used. Design of guarding can contribute to noise reduction by isolation or absorption.

The criteria for assessing efficiency of noise reduction measures are actual emission values from machines of the same family (type) determined in accordance with 6.3.

5.7.2 Reduction of noise on transmission paths

Where noise levels have to be reduced beyond those achievable by design, the machine shall be provided with protective measures (e.g. noise enclosures, screens fitted to the machinery, silencers). See ISO 11546-1, ISO 11546-2, ISO 11691, ISO 11820 and ISO 11821.

Verification: Visual inspection, performance check/test, drawings/schematics/calculations, measurement,.

5.8 Hazards generated by vibration

On sawing machines with manually guided component feed or handle operation, where operators can be subject to vibrations of more than 2,5 m/s^2, measures for preventing or reducing vibrations as far as practicable shall be taken by construction and design, damping, and/or insulation. For measurement of vibration, see EN 1299 and ISO 20643.

Verification: Visual inspection, performance check/test, drawings/schematics/calculations, measurement.

5.9 Hazards generated by materials or substances processed

5.9.1 Hazards from contact with or inhalation of harmful fluids, gases, mists, fumes and dusts

Measures to minimize hazards arising from harmful metalworking fluids shall include the following.

— The system design shall prevent splash, leakage and overflow of the metalworking fluid.

— Fluid reservoirs and other system components (e.g. pipes and hoses) shall be made of materials that are resistant to attack by metalworking fluid. Information on metalworking fluids to be used shall be given [see 6.2.2 g)].

— The metalworking fluid distribution system and delivery nozzles shall be designed to minimize unwanted spray.

— Where harmful concentrations of fine mists, vapour or smoke is foreseen in the work zone, means shall be provided to prevent their escape and provision made for connection of integral or external extraction equipment (see EN 626-1).

— The metalworking fluid capacity shall match the correct function of the machine and be sufficient to avoid excessive heating and subsequent evaporation of the fluid or alternatively coolers shall be provided.

— The metalworking fluid system shall be capable of delivering suitable amounts of fluids to minimize the emission of hazardous vapours at the cutting site.

— Where it is intended that operators will place their hands into the work zone (e.g. during load/unload operations, setting), metalworking fluid shall be stopped or diverted by opening of the movable guard.

— The metalworking fluid system design shall allow for flow and direction adjustments outside the hazard zone or with the machine stopped.

— Metalworking fluid reservoirs shall be fitted with visual level indication and a filling point which is easily accessible.

— All system components shall be designed to reduce exposure of personnel to metalworking fluids during maintenance.

— Means such as filters shall be provided to prevent the accumulation of chips and other materials from sawing operations within the machine and the metalworking fluid tank in order to minimize the dissolving of hard metals into the fluids.

Verification: Visual inspection, performance check/test, drawings/schematics/calculations.

5.9.2 Minimizing biological and microbiological hazards in metalworking fluids

Measures to minimize the hazards of biological and microbiological growth in re-circulating metalworking fluids shall include the following.

— The total content of the metalworking fluid system shall be circulated in normal use so that no stationary volume within the tank exists except where settlement is required by design.

— To avoid stagnant areas remaining within the machine, the metalworking fluid shall drain from the machine under gravity.

— Discharge pipe work shall have sufficient diameter and slope to minimize sludge settlement.

— The metalworking fluid system shall be provided with filtration for the removal of sediment.

— When sediment build–up occurs, cleaning shall be made easy by design (e.g. rounded corners in containers). Cleaning shall not require drainage of the whole system.

— The inside of tanks shall not contribute to the growth of bacteria (e.g. smooth unpainted surfaces).

— Provision shall be made to empty metalworking fluid containers completely.

— Metalworking fluid containers shall have covers designed to prevent the ingress of foreign matter.

— Contamination of the metalworking fluid by oil or grease from external sources such as lost machine lubrication shall be avoided or means shall be provided for their systematic removal.

— Means shall be provided to enable

  — fluid samples to be taken,

  — sumps and pipe work to be cleaned, and

  — filters to be changed

  so as to minimize the exposure of an operator to the fluid.

Verification: Visual inspection, performance check/test, drawings/schematics/calculations, measurement.

5.9.3 Swarf and cleanability

The machine shall be designed to minimize the build-up of swarf in the work zone and facilitate its removal with minimum removal of safeguards.

Verification: Visual inspection, performance check/test, drawings/schematics/calculations.

5.10 Hazards generated by neglect of ergonomic principles in machinery design

5.10.1 Avoidance of unhealthy posture, excessive effort, fatigue and repetitive strain

The machine and its controls shall be designed in accordance with ISO 12100.

Machines shall be designed in accordance with ergonomic principles so as to avoid excessive effort, unhealthy posture, fatigue or repetitive strain during use.

Movable guards shall be power operated where the use of them will lead to repeated excessive effort (see also ISO 12100:2010, 4.8).

NOTE Further guidance is given in IEC 60204–1, EN 614–1, ISO 9355-2, ISO 9355-3 and ISO 14738.

Verification: Measurement, posture requirements not excessive and in accordance with the referenced standards.

5.10.2 Inadequate consideration of hand-arm or foot-leg anatomy

The positioning, labelling and illumination of control devices and points for observation or service such as those for filling and draining of tanks shall be chosen to satisfy ergonomic principles (see EN 614-1, EN 614-2; ISO 9355-1, ISO 9355-2, ISO 9355-3; EN 1005-1, EN 1005-2, EN 1005-3; ISO 7250).

Verification: Measurement, check that distances involved in normal operation are in accordance with the referenced standards.

5.10.3 Inadequate local lighting

Integral lighting on the machine for the illumination of the work zone shall be provided when the design of the machine and/or its guards render the ambient lighting inadequate for the safe and efficient operation of the machine.

Verification: Visual inspection, performance check/test, drawings/schematics/calculations, measurement.

Exception: At vertical band-sawing machines with manual feed (see Figure 5), the luminescence of the integral lighting shall be at least 500 lx in accordance with EN 1837.

Fluorescent-type lighting may be provided, subject to the provision that the stroboscopic effects shall not conceal a hazard.

Verification: Visual inspection, measurement.

5.10.4 Human error, human behaviour

Equipment and accessories for adjusting and maintaining the machine, indicated in the Instruction handbook and not readily available, shall be provided.

Verification: Performance check/test.

5.10.5 Inadequate design, location or identification of manual controls

Input devices (e.g. keyboards, key pads, push buttons) shall be in accordance with ISO 9355-1, ISO 9355-2 and ISO 9355-3.

Verification: Visual inspection.

5.10.6 Inadequate design or location of visual display units

Screen-displayed information shall be clear and unambiguous. Reflections and glare shall be minimized.

Verification: Check legibility and visibility from operating position(s).

5.11 Unexpected start up, unexpected overrun/over-speed

5.11.1 Failure/disorder of the control system

Control systems shall be designed in accordance with ISO 13849-1, IEC 60204-1, ISO 4413 and ISO 4414; and ISO 12100:2010, 6.2.11 shall apply.

The use of a programmable electronic system shall not reduce the level of safety specified in this document. Where safety-related functions are implemented within the programmable electronic system, they shall satisfy the requirements of 5.1.3.1.

Unexpected machine movements (e.g. sawing tool movement, work material clamping, work material feed) shall be prevented (see ISO 14118).

Verification: Visual inspection, performance check/test, drawings/schematics/calculations.

5.11.2 Restoration of energy supply after an interruption

Control system design shall ensure that automatic restart is prevented and re-actuation of the start control is always required to initiate powered movement following for example any change of mode, selection of optional function, system reset, guard interlock interruption, restoration of adequate pressure or voltage, or correction of a system failure (see IEC 60204-1:2009, 5.4 and 7.5).

Verification: performance check/test, drawings/schematics/calculations.

5.11.3 External influences on the electrical equipment

Machines employing electronic parts and programmable electronic systems (PES) shall demonstrate electromagnetic compatibility as follows.

a) **Immunity:** Electronic control systems shall be designed and installed so as to be protected from electromagnetic interference and stable when exposed to electrical system operation or failure in accordance with IEC 61000-6–2.

b) **Emission:** Electrical/electronic design shall apply technical information and physical measures to limit electromagnetic emissions in accordance with IEC 61000-6–4.

NOTE Machines employing only CE-marked electrical parts, wired and connected in accordance with the manufacturer's instructions can be considered to have adequate electromagnetic immunity protection.

Verification: Use the verification methods described in IEC 61000-6–2 *and* IEC 61000-6–4*.*

5.12 Errors of fitting

The design of machine parts shall prevent errors of fitting (e.g. use of male/female connections, asymmetrical location features) and/or the machine parts shall be marked with instructions for fitting if any hazard could result from incorrect fitting.

Verification: Drawings/schematics/calculations.

The direction of cut of the sawing tool shall be indicated by a durable arrow symbol. This can be displayed on the outside or the inside of the enclosing guards or the power transmission parts (e.g. pulleys for band-sawing blades, spindle for circular sawing tools, frame for hacksaw blades).

Verification: Visual inspection.

5.13 Falling or ejected objects or fluids

5.13.1 Containment of work material, chips and fluids

Guards shall be provided to retain or contain the foreseeable ejection of work material, chips and fluids. Such guards shall be designed in accordance with ISO 14120:2015, 5.1.

Verification: Drawings/schematics/calculations.

5.13.2 Ejection of parts — Guard strength

Guards shall be provided to contain the energies of, or protect persons from, the machine parts and/or components which can reasonably foreseeable be ejected, in particular the sawing tool (see ISO 14120:2015, 5.1).

Verification: Visual inspection, performance check/test, drawings/schematics/calculations.

5.14 Loss of stability/overturning of machinery

Machines shall be designed and constructed so that they are stable under foreseeable operating conditions, and without risks of overturning, falling or unexpected movement. When the use of foundation bolting is one of the measures used to help prevent overturning, manufacturers shall specify the bolts and foundation requirements necessary (see also Clause 6).

Verification: Visual inspection, measurement where necessary during normal operation.

5.15 Slip, trip and fall of persons

5.15.1 General requirements

Places of work and means of access on machines (such as integral stairs, platforms, walkways, in accordance with ISO 14122-2 and ISO 14122-3) shall be designed to minimize the likelihood of slips, trips and falls by the provision of hand holds, foot holds, and, where necessary, slip-resistant surfaces.

Verification: Visual inspection.

5.15.2 Contamination of floors

Where a fluid application system is provided, it shall be designed to prevent splash, spray and mist outside the machine enclosure [see 6.2.2 g)]. Where this is not possible, other means shall be provided, e.g. drip tray or grate flooring. For measures against further hazards arising from metalworking fluids, see 5.9.1.

Verification: Visual inspection, performance check/test involving the use of a fluid.

5.15.3 High parts of the machine which shall be accessible for maintenance or trouble shooting

Where frequent access is required (i.e. more than once per shift), permanent means of access shall be provided (see Example A).

If only occasional access is required, one or both of the examples in Example B shall be provided.

Example A

— Permanent means of access (e.g. stairways, ladders, see ISO 14122-2).

— Fixed working platforms with fixed railings and toe boards against falling hazards (see ISO 14122-3).

Example B

— Supports for safety belt.

— Means to attach movable ladders.

Verification: Visual inspection.

5.16 Verification of safety requirements and/or measures

Safety requirements and/or measures specified in Clause 5 shall be verified using the procedures listed at the end of each measure or group of measures.

Visual inspection shall be used to verify the features necessary for the requirement by visual examination of the components supplied.

A performance check/test shall verify that the features provided perform their function in such a way that the requirements are met.

Measurement shall verify by the use of instruments that requirements are met to the specified limits.

Drawings/calculations shall verify that the design characteristics of the components provided meet the requirements.

6 Information for use

6.1 Markings

The machine shall be marked in a distinct and durable manner with the following:

a) business name and full address of the manufacturer and, where applicable, his/her authorized representative;

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

c) mandatory marking, to indicate its compliance with mandatory requirements;

NOTE The mandatory marking for Europe is the CE marking.

d) designation of machinery and the designation of series or type;

e) serial number (where applicable);

f) mass of the machine, without sawing tools or ancillary devices;

g) direction of cut of the sawing tool, indicated by an arrow symbol.

6.2 Instruction handbook

6.2.1 The general requirements laid down in ISO 12100:2010, 6.4 shall be followed.

6.2.2 The instruction handbook shall include the following information:

a) repeat of marked information (see 6.1);

b) details of lifting points for transportation and instructions for the installation of the machine and its safeguarding equipment (e.g. floor conditions, bolting down details, services, anti-vibration mountings);

c) details about supply data for electrical, hydraulic and pneumatic systems (where applicable);

d) details of control systems, including circuit diagrams for electrical, hydraulic, pneumatic systems; the circuit diagrams shall show the interfaces between these and any hard-wired parts if a programmable electronic or pneumatic control system (PES, PPS) is incorporated;

e) information about work material capacity range and of usable sawing tool sizes of the machine;

f) information about sawing tool and feed speed ranges (where applicable);

g) specification for any lubricants, hydraulic or metalworking fluids and instructions for their application (should draw attention to the importance of preventing fluid spillage onto the surrounding area and thus creating a slipping hazard);

h) noise emission declaration in accordance with 6.3, Annexes A and B and ISO 12100:2010, 6.4.5.1;

i) instructions for testing of the machine and its safety equipment prior to being taken into service;

j) instructions for the operation, setting, sawing tool changing, cleaning, use of clamping and feed devices of the machine;

k) recommendations on the need for personal protective equipment for operators (e.g. hearing protection, eye protection);

l) instructions for the adjustment of guards and sawing tool guides together with specifications for suitable sawing tool types;

m) instructions for the inspection of guards or other protective devices after sawing tool changing or adjustment;

n) instructions for the safe handling of work material in profile or contour cutting operations;

o) information concerning hazards due to vibration during sustained high force level manual feeding;

p) requirements for periodic maintenance of the machine, its guards and protective devices;

q) information about the reasonable foreseeable misuse;

r) information about the specification of the spare parts to be used when these can affect the health and safety of operators.

It is recommended that checklists be prepared for relevant operations covered by items h), i), j) and k). In particular, for the safety examinations, there shall be a specific checklist which can be signed by the examiner.

6.3 Noise declaration

A declaration concerning the noise emission of the machine shall be made using noise emission values determined according to Annexes A and B.

The following declaration shall be made concerning the airborne noise emission:

— A-weighted sound emission pressure level at workstations (should it exceed 70 dB(A); if it does not, this fact shall be stated);

— peak value of the instantaneous C-weighted sound pressure level at workstations, if exceeding 63 Pa (130 dB(C) in relation to 20 µPa);

— A-weighted sound power level emitted by the machine when the A-weighted emission sound pressure level at any workstation exceeds 80 dB(A);

— declaration of noise emission values in accordance with ISO 4871, using the dual-number form of declaration; the declaration shall be accompanied by a statement of the measuring method used and the conditions applied during the test and values for the uncertainty K (see ISO 4871) as follows:

  — 2 dB when using ISO 3744 or ISO 11202 (grade 2);

  — 4 dB when using ISO 3746 or ISO 11202 (grade 3) or ISO 11204 (grade 3).

EXAMPLE For a sound power level L_{WA} = 93 dB (measured value), uncertainty K = 4 dB for measurements made in accordance with ISO 3746.

If the accuracy of the declared emission values is to be verified, measurements shall be made using the same method and the same operating conditions as those employed for the declaration.

The noise declaration shall be accompanied by the following statement:

> "The figures quoted are emission levels and are not necessarily safe working levels. While there is a correlation between the emission and exposure levels, this cannot be used reliably to determine whether or not further precautions are required. Factors that influence the actual level of exposure of the workforce include characteristics of the work room, the other sources of noise, etc., i.e. the number of machines and other adjacent processes. Also, the permissible exposure level can vary from country to country. This information, however, will enable the user of the machine to make a better evaluation of the hazard and risk."

Information on noise emission shall also be given in the sales literature providing performance data.

Annex A
(normative)

Noise emission measurement

Operating conditions for noise measurement shall be those of Annex B. If noise measurement according to Annex A is not possible for technical reasons, it is allowed to deviate. The reasons shall be justified. In this case, the noise declaration shall describe which test conditions were used.

Mounting and operating conditions of the machine shall conform to the manufacturer's instructions and be identical for the determination of emission sound pressure level at the workstation and the sound power levels.

Emission sound pressure level at the workstation shall be measured in accordance with ISO 11202 with the following modifications:

— the environmental correction, K_{2A}, or the local environmental correction, K_{3A}, shall be equal to or less than 4 dB;

— the difference between sound pressure levels measured at the workstation with the machine under test in operation and turned off, respectively shall be equal to or greater than 6 dB;

— the correction of the local environmental correction, K_{3A}, shall be calculated in accordance with ISO 11204:2010, A.2, with the reference restricted to ISO 3746 instead of the method given in ISO 11202:2010, Annex A.

  When determining K_{3A} in accordance with ISO 11204:2010, A.2, the environmental correction K_{2A} required for this procedure may be determined either according to ISO 3746 (preferred) or according to ISO 3744, whichever standard has been used for the determination.

Sound power levels shall be measured in accordance with the enveloping surface measuring method shown in ISO 3746 with the following modifications.

— The environmental correction, K_{2A}, shall be equal to or less than 4 dB.

— The sound pressure levels due to background noise averaged over the microphone positions on the measurement surface shall be at least 6 dB below the mean sound pressure level due to the machine under test in operation when measured in the presence of this background noise.

  NOTE 2 The correction formula for this difference (see ISO 3746:2010, 8.3.3) applies up to a difference of 10 dB.

— Only the parallel piped measurement surface shall be used at 1,0 m from the reference surface.

— Where the distance from the machine to an auxiliary unit is less than 2,0 m, the auxiliary unit shall be included in the reference surface.

— The measuring time required in ISO 3746:2010, 8.3.1, referring to 10 s shall be excluded.

— The accuracy of the test shall be greater than 3 dB.

— The number of microphone positions shall conform to ISO 3746.

Alternatively, where the facilities exist and the measuring method applies to the machine type, sound power levels may also be measured according to a method with higher precision (i.e. ISO 3744) without the preceding modifications.

For determination of sound power levels by the sound intensity method, use ISO 9614-1 (subject to agreement between the supplier and the purchaser).

Annex B
(normative)

Test conditions for measurement of noise level at sawing machines and work material specifications

B.1 Test conditions for measurement of noise level at sawing machines

Work material clamping device(s) as supplied with the machine shall be used for the test.

All ancillary units (e.g. chip conveyor, metalworking fluid, hydraulics and lubrications systems) shall be in operation during both loaded and idling tests.

All protective devices and acoustic guards normally supplied with the machine shall be fitted and in operation during the tests.

A new or re-sharpened sawing tool shall be used for each set of measurements and they shall be run according to the recommendations of the sawing tool manufacturer.

For noise tests, the installation shall be representative of the typical use of the machine, and where variable sawing tool speed is provided, the speed shall be set in the upper quartile of the range.

The location of the machine under test shall be indicated by means of a sketch giving the position and details of any reflecting surfaces likely to influence the noise emission values obtained. The sketch shall also include the measurement positions indicating those at which sound pressure/power levels have been recorded and the normal position of the operator(s).

If test conditions according to this subclause are not practicable for technical reasons, it is allowed to deviate. The reasons shall be justified. In this case, the noise declaration shall describe which test conditions were used.

B.2 Work material specifications

B.2.1 General

Measurements shall be done using the material(s) defined hereafter depending on the intended use of the machine (steel or aluminium or both). Noise emission results shall be given in the noise declaration.

B.2.2 Material of test workpieces

B.2.2.1 Steel

The workpiece material shall be a low-alloy carbon steel in accordance with ISO 683-1 with the following chemical components:

C = 0,35 % up to 0,5 %;

Si = 0,15 % up to 0,4 %;

Mn = 0,5 % up to 0,8 %;

P = max. 0,35 %;

S = max. 0,35 %.

The material shall be in the normalized condition and the ranges of mechanical properties shall be in the following range:

Yield stress	335 MNm^{-2} to 480 MNm^{-2}
UTS	600 MNm^{-2} to 840 MNm^{-2}
Hardness	170 Brinell to 215 Brinell

B.2.2.2 Aluminium

The workpiece material shall be a commercial grade of an aluminium alloy like AlMgSi1 (no pure aluminium), with the following chemical components:

Si = 0,75 % up to 1,3 %;

Mg = 0,6 % up to 1,2 %;

Mn = 0,4 % up to 1,0 %.

B.2.3 Dimensions of test workpieces

In order to provide a representative noise generation process, Table B.1 specifies the test piece geometries (transverse section) for various types and sizes of sawing machines.

Table B.1 — Specifications of test pieces

Machine		Work material steel Material composition see B.2.1		Work material aluminium Material composition see B.2.2	
Ref. Clause 5	Description	Size	Section	Size	Section
5.2.1.1	Horizontal band-sawing machine — Pivot and column types Capacity ≤ 250 mm	100 mm diameter	Solid	100 mm	Solid
	Horizontal band-sawing machine — Pivot and column types Capacity > 250mm ≤ 400 mm	150 mm diameter	Solid	150 mm	Solid
	Horizontal band-sawing machine — Pivot and column types Capacity > 400mm ≤ 800 mm	250 mm diameter	Solid	250 mm	Solid
	Horizontal band-sawing machine — Pivot and column types Capacity > 800 mm				
	Horizontal band-sawing machine — Swing head type	100 mm diameter	Solid	100 mm	Solid
5.2.1.2	Vertical band-sawing machine — Fixed sawing frame type	10 mm thickness	Plate	10 mm thickness	Plate
	Vertical band-sawing machine — Front cutting type	100 mm diameter	Solid	100 mm × 100 mm × 6 mm	Square tube
	Vertical band-sawing machine — Table and sawing frame feed Capacity ≤ 500 mm	100 mm thickness	Plate	100 mm thickness	Plate
	Vertical band-sawing machine — Table and sawing frame feed Capacity > 500 mm	300 mm thickness	Plate	300 mm thickness	Plate

Table B.1 *(continued)*

Machine		Work material steel Material composition see B.2.1		Work material aluminium Material composition see B.2.2	
Ref. Clause 5	Description	Size	Section	Size	Section
5.2.2.1	Circular sawing machine — Pivoting head type — Manual and power cutting head feed	50 mm diameter	Solid	50 mm × 50 mm × 5 mm	Square tube
	Circular sawing machine — Pivoting head type — Automatic	50 mm diameter	Solid	50 mm × 50 mm × 5 mm	Square tube
	Circular sawing machine — Large pivoting head type — Semi-automatic	300 mm × 200 mm	Rect. hollow sect.	Specific application	
5.2.2.2	Circular sawing machine — Vertical/Down-feeding type	At least 50 % of maximum diameter capacity	Solid	50 mm × 50 mm × 5 mm	Square tube
5.2.2.3	Circular sawing machine — Rising/Up-stroking type Sawing diameter ≤ 425 mm	At least 50 % of maximum diameter capacity	Solid	50 mm × 50 mm × 5 mm	Square tube
	Circular sawing machine — Rising/Up stroking type Sawing diameter > 425 mm	125 mm diameter	Solid	100 mm × 100 mm × 6 mm	Square tube
5.2.2.4	Circular sawing machine horizontal — Longitudinal traversing type or Overhead type	50 mm thickness	Plate	50 mm thickness	Plate
5.3.2.8	Circular sawing machine — Radial arm type	15 mm thickness	Plate	50 mm × 50 mm × 5 mm	Square tube
5.3.2.8	Circular sawing machine — Pendulum type	15 mm thickness	Plate	15 mm thickness	Plate
	Circular sawing machine — Front cutting type Max. sawing diameter ≤ 300 mm	At least 50 % of diameter capacity	Solid	50 mm × 50 mm × 5 mm	Square tube
	Circular sawing machine — Front cutting type 300 mm < Max. sawing diameter < 500 mm	At least 50 % of diameter capacity	Solid	100 mm × 100 mm × 6 mm	Square tube
	Circular sawing machine — Front cutting type Max. sawing diameter > 500 mm				

Table B.1 *(continued)*

Machine		Work material steel Material composition see B.2.1		Work material aluminium Material composition see B.2.2	
Ref. Clause 5	Description	Size	Section	Size	Section
5.2.2.6/ 5.3.2.10	Multiple sawing type Circular sawing machines — Twin sawing/mitre-cutting type Twin-/Multiple-head type	At suppliers discretion commen-surate with typical application		At suppliers discretion commensurate with typical application	
5.2.3	Hack-sawing machine — Horizontal-column and -pivot types Capacity ≤ 250 mm diameter	100 mm diameter	Solid	100 mm diam-eter	Solid
	Hack-sawing machine — Horizontal-column and -pivot types Capacity > 250 mm diameter	150 mm diameter	Solid	150 mm diam-eter	Solid

For sawing machines at which the above is not suitable, the following alternative conditions shall be used:

Large pivoting head type — Steel: Material that has at least half the nominal machine width capacity and at least half the nominal machine height capacity shall be used.

Plate sawing machines — Steel: A “flat” plate in general engineering steel of at least half the nominal machine width capacity and of at least half the nominal machine height capacity shall be used.

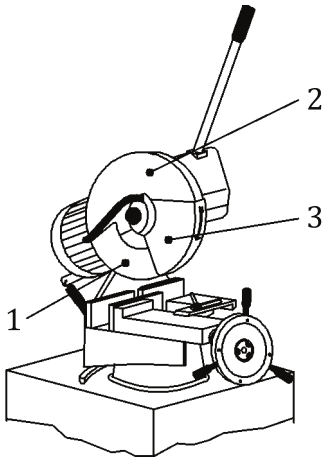
Plate sawing machines — Aluminium: A “plate” in a general commercial-grade aluminium of at least half the nominal machine width capacity and of at least half the nominal machine height capacity shall be used.

Circular sawing machines specifically for aluminium: A workpiece corresponding to Table B.1 shall be used. The length of the profile (square tube) shall be in the range 2 000 mm to 6 000 mm, the size of the plate shall have a length of at least 1 000 mm and a width of at least 500 mm.

Where the intended use of the machine is for a specific application (e.g. tube cutting), the manufacturer should use a test material and geometry appropriate to the application.

Annex C
(informative)

Examples of guards for circular sawing machines

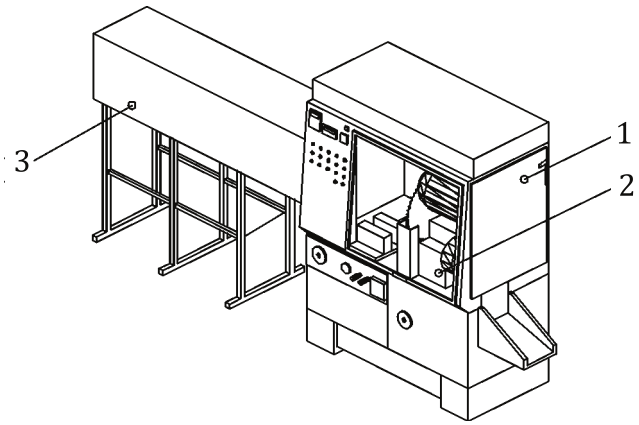


Key

1 and 2 fixed guard (removable for sawing tool changing)

3 linkage operated, self-closing guard which pivots on a spigot (concentric with the spindle) on guard 2 and is operated by the link attached to a pin on the base

Figure C.1 — Example for guard on a circular sawing machine — Pivoting head type — Manual and power-operated cutting head feed



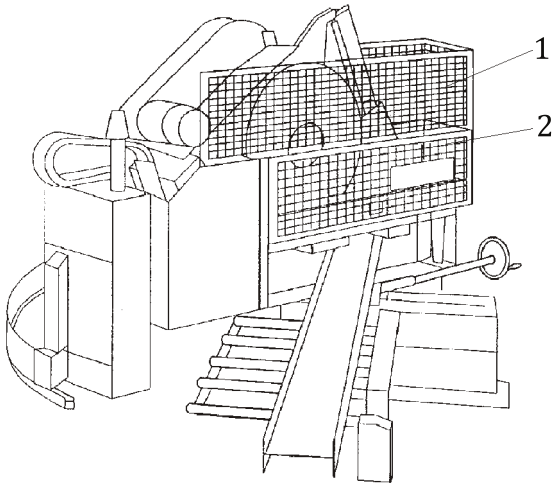
Key

1 automatic hinged movable interlocking guard with impact resistant viewing window

2 fixed guards providing enclosure of the sawing tool and work zone

3 interlocking and fixed guards enclosing the auxiliary workpiece loading and feeding mechanism

Figure C.2 — Example for safeguards on circular sawing machines

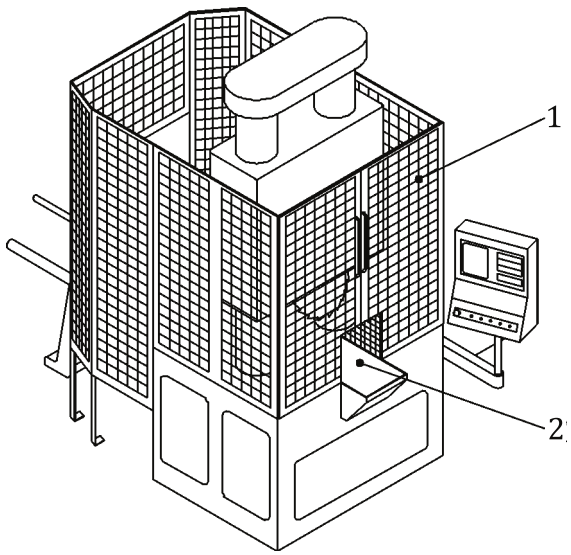


Key

1 automatic hinged movable interlocking guard with impact resistant viewing window

2 fixed guards providing enclosure of the sawing tool and work zone

Figure C.3 — Example for safeguards on circular sawing machine — Large pivoting head type — Semi-automatic

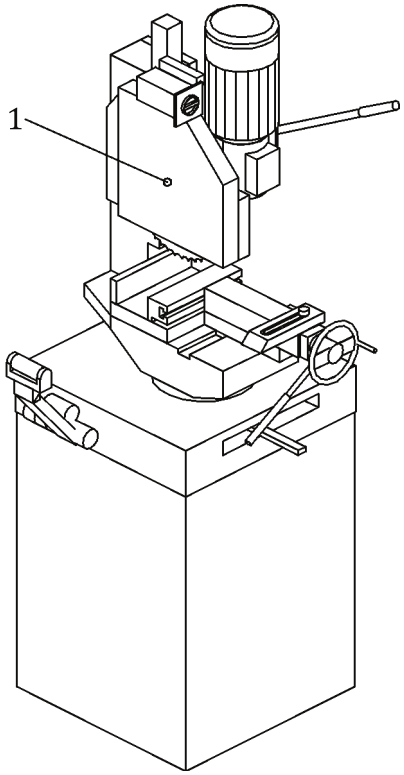


Key

1 fixed and interlocking hinged guards

2 adjustable distance guard at workpiece unload station

Figure C.4 — Example for Safeguarding of circular sawing machine — Large vertical type — Semi-automatic



Key

1 self-closing guard — as sawing machine head descends guard contacts top of workpiece

Figure C.5 — Example for safeguarding of circular sawing machine — Small vertical type — Manual feed

Annex D
(informative)

Examples for the determination of the performance level

D.1 General

Annex D shows a calculation example of the determination of performance level (PL). Examples shown in this annex have not validated effectiveness for machines and have not been recommended.

This annex demonstrates the use of the methods of ISO 13849-1 to identify safety functions and determine the performance level (PL). The stepwise procedure consists of the following steps:

— identification of the safety functions to be performed by safety-related parts of the control system (SRP/CS). For each safety function, perform the following steps:

  — specification of the required characteristics;

  — determination of the required performance level, PLr;

— design and technical realization of the safety function; identification of the safety-related parts which carry out the safety function;

— evaluation of the performance level, PL, considering

  — quantifiable aspects: category, reliability of components ($MTTF_d$), diagnostic coverage of tests (DC), measures to avoid common cause failures (CCF);

  — non-quantifiable, qualitative aspects which affect the behaviour of the SRP/CS of the safety function under fault conditions, safety-related software, systematic failure and environmental conditions;

  — verification of the PL for the safety function (Is PL greater or equal to PLr?);

  — validation (Have all the requirements been met?).

The evaluation of the PL, considering non-quantifiable aspects and the validation, is not given in this annex.

D.2 Safety function(SF) and required performance level

The chosen example of a safety-related control circuit (see Figures D.1 and D.3) performs the safety function for workpiece clamping, which may be chosen as follows.

SF1: The hazardous movement will be stopped in case of pressure decrease.

SF2: The unintended release of the clamping jaws in case of pressure decrease will be avoided.

For the application of the risk graph method and the definition of risk parameters, see ISO 13849-1:2006, Annex A.

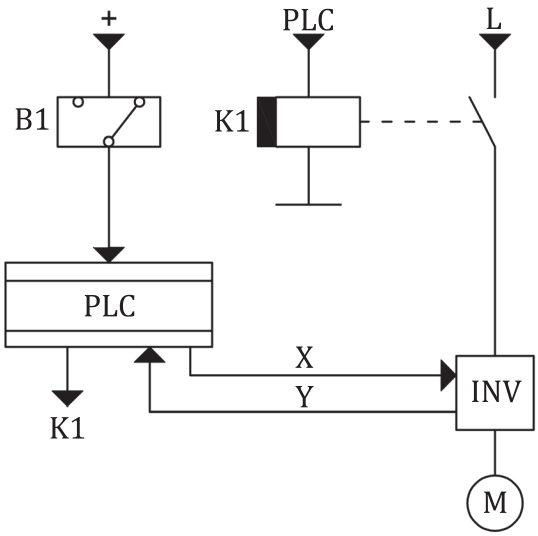
The required performance levels, PLr, for sawing machines are determined and described in Table 2. According to Table 2 11), for both safety functions, the required performance level shall meet PLr = a.

In this annex, two examples, Example A and Example B, are prepared.

D.3 Example A — Stop the hazardous movement by the decrease of the hydraulic pressure (SF1)

D.3.1 Identification of safety-related parts

All components contributing to the safety function that stop the blade driving by the decrease of hydraulic pressure during sawing are represented in Figure D.1.



Key

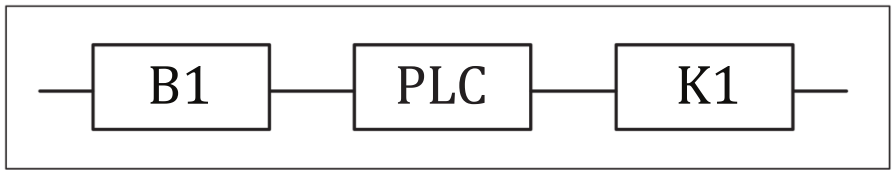
B1	pressure sensor
PLC	programmable logic controller
K1	contactor
INV	blade drive inverter
M	blade drive motor
X	start signal
Y	alarm signal

Figure D.1 — Control circuit A for performing safety function

In this example, pressure sensor B1 is connected with programmable logic controller (PLC).

PLC is connected to contactor K1, able to close the power of the blade drive motor M.

The safety-related parts and their division into channels can be illustrated in a safety-related block diagram as shown in Figure D.2.



Key

B1 pressure sensor
PLC programmable logic controller
K1 contactor

Figure D.2 — Block diagram for identifying safety-related parts of example A

D.3.2 Evaluation of the performance level

D.3.2.1 General

The values for mean time to dangerous failure, $MTTF_d$, for each channel, average diagnostic coverage, DC_{avg}, and common cause factor are assumed to be evaluated in accordance with ISO 13849-1:2006, Annexes C, D, E, and F, or to be given by the manufacturer. The categories are estimated in accordance with 6.2 and ISO 13849-1:2006, Annex B.

D.3.2.2 Quantification of $MTTF_d$ for each channel, DC_{avg}, common cause failure, category, PL

— $MTTF_d$

Contactor (K1), programmable logic controller (PLC) and pressure sensor (B1) contribute to the $MTTF_d$ of the concerned channel.

The $MTTF_d$ of PLC of 10 years is assumed to be given by the manufacturer.

The $MTTF_d$ of contactor, K1, is calculated using B_{10d} = 2 000 000, given by the manufacturer and Formula (D.1).

*T*cycle: 20 min/cycle = 1 200 s/cycle

h_{op}: 16 h/day

d_{op}: 365 day/year

n_{op} = 16 × 365 × 3 600 / 1 200 = 17 520 cycles/year

$$MTTF_{dk1} = \frac{B_{10d}}{0,1 \times n_{OP}} = \frac{2\,000\,000}{0,1 \times 17\,520} = 1\,141 \text{ years} \quad \text{(D.1)}$$

The $MTTF_d$ of pressure sensor B1 is calculated by B_{10d} = 1 000 000, given by the manufacturer and Formula (D.2).

*T*cycle: 120 s/cycle

h_{op}: 16 h/day

d_{op}: 365 day/year

n_{op} = 16 × 365 × 3 600 / 120 = 175 200 cycles/year

$$\mathrm{MTTF_{dB1}} = \frac{B_{10d}}{0,\ 1 \times n_{op}} = \frac{1\ 000\ 000}{0,1 \times 175\ 200} = 57\ \text{years} \tag{D.2}$$

These above data lead to the $\mathrm{MTTF_{dc}}$ of the channel.

$$\frac{1}{\mathrm{MTTF_{dc}}} = \frac{1}{\mathrm{MTTF_{dB1}}} + \frac{1}{\mathrm{MTTF_{dPLC}}} + \frac{1}{\mathrm{MTTF_{dK1}}} = \frac{1}{57} + \frac{1}{10} + \frac{1}{1\,141} = \frac{1}{8,4} \tag{D.3}$$

$$\mathrm{MTTF_{dc}} = 8,4\ \text{years} \tag{D.4}$$

— DC

Because no testing is done in control circuit A, the DC = 0 or “none” according to ISO 13849-1:2006, Table 6.

— Category

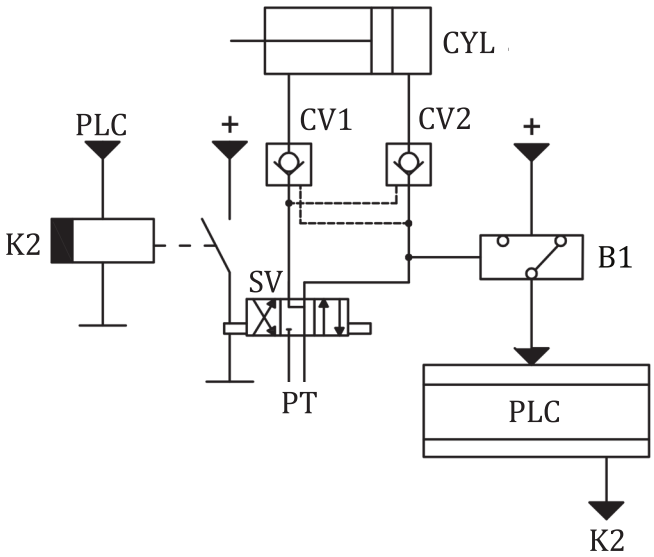
The preferred category for this circuit is category B, 1, the resulting $\mathrm{MTTF_d}$ of the channel is “Low (8,4 years).” This is an argument that only category B is reached by this design.

This can be interpreted as performance level “a” category B for SF1.

D.4 Example B — Prevention of opening of clamping jaws due to the decrease of hydraulic pressure (SF2)

D.4.1 Identification of safety-related parts

It turns off the solenoid valve during sawing when pressure sensor detects hydraulic pressure reducing. All components contributing to the safety function that it holds the clamping pressure by closing check valve and solenoid valve neutral condition are represented in Figure D.3.



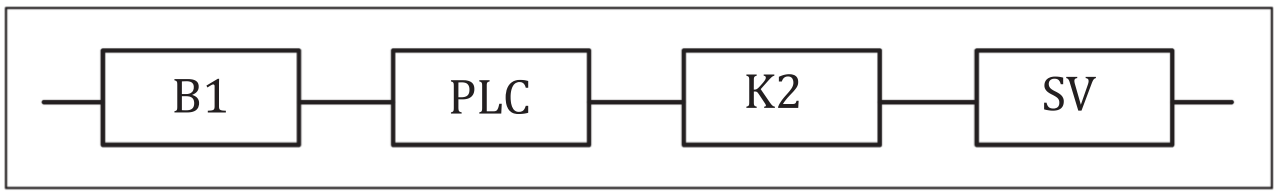
Key

B1	pressure sensor
PLC	programmable logic controller
K2	relay
SV	solenoid valve for clamping
CV1/CV2	check valve
CYL	clamp cylinder

Figure D.3 — Control circuit B for performing safety function

In this example, pressure sensor, B1, is connected with programmable logic controller (PLC). PLC is connected to relay, K2, able to close the power of the solenoid valve, SV.

The safety-related parts and their division into channel can be illustrated in a safety-related block diagram as shown in Figure D.4.



Key

B1	pressure sensor
PLC	programmable logic controller
K2	relay
SV	solenoid valve

Figure D.4 — Block diagram for identifying safety-related parts of Example B

D.4.2 Evaluation of the performance level

The values for mean time to dangerous failure, $MTTF_d$, for each channel, average diagnostic coverage, DC_{avg}, and common cause factor are assumed to be evaluated in accordance with ISO 13849-1:2006, Annexes C, D, E, and F, or to be given by the manufacturer. The categories are estimated in accordance with 6.2 and ISO 13849-1:2006, Annex B.

— $MTTF_d$

Solenoid valve (SV), relay (K2), programmable logic controller (PLC) and pressure sensor (B1) contribute to the $MTTF_d$ of the concerned channel.

The $MTTF_{dplc}$ of PLC of 10 years is assumed to be given by the manufacturer.

The $MTTF_d$ of solenoid valve, SV, is estimated at 150 years by ISO 13849-1:2006, Annex C.

The $MTTF_d$ of relay, K2, is calculated by B_{10d} = 100 000, given by the manufacturer and Formula (D.5).

*T*cycle: 120 s/cycle

h_{op}: 16 h/day

d_{op}: 365 day/year

n_{op} = 16 × 365 × 3 600 / 120 = 175 200 cycles/year

$$MTTF_{dk2} = \frac{B_{10d}}{0,1 \times n_{op}} = \frac{100\,000}{0,1 \times 175\,200} = 5,7 \text{ years} \quad \text{(D.5)}$$

The $MTTF_d$ of pressure sensor, B1, is calculated by B_{10d} = 1 000 000, given by the manufacturer and Formula (D.6).

*T*cycle: 120 s/cycle

h_{op}: 16 h/day

d_{op}: 365 day/year

n_{op} = 16 × 365 × 3 600 / 120 = 175 200 cycles/year

$$MTTF_{dB1} = \frac{B_{10d}}{0,1 \times n_{op}} = \frac{1\,000\,000}{0,1 \times 175\,200} = 57 \text{ years} \quad \text{(D.6)}$$

The above data lead to the $MTTF_{dc}$ of the channel.

$$\frac{1}{MTTF_{dc}} = \frac{1}{MTTF_{dB1}} + \frac{1}{MTTF_{dPLC}} + \frac{1}{MTTF_{dK2}} + \frac{1}{MTTF_{dSV}} = \frac{1}{57} + \frac{1}{10} + \frac{1}{5,7} + \frac{1}{150} = \frac{1}{3,3} \quad \text{(D.7)}$$

$MTTF_{dc}$ = 3,3 years (D.8)

— DC

Because no testing is done in control circuit B, the DC = 0 or “none” according to ISO 13849-1:2006, Table 6.

— Category

The preferred category for this circuit is category B, 1, the resulting $MTTF_d$ of the channel is “Low (3,3 years).” This is an argument that only category B is reached by this design.

This can be interpreted as performance level “a” category B for SF2.

D.5 Verification

This result matches the required performance level “a” of D.2; therefore, these control circuits meet the requirements for risk reduction of the application example of D.2.

NOTE For a further example of the determination of performance level, see ISO 23125:2015, Annex F.

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