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Plastics and rubber machines - Calenders - Safety requirements

Machines pour les matières plastiques et le caoutchouc - Calandres - Prescriptions de sécurité

Kunststoff- und Gummimaschinen - Kalander - Sicherheitsanforderungen

This draft European Standard is submitted to CEN members for second formal vote. It has been drawn up by the Technical Committee CEN/TC 145.

If this draft becomes a European Standard, CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

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Recipients of this draft are invited to submit, with their comments, notification of any relevant patent rights of which they are aware and to provide supporting documentation.

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EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

CEN-CENELEC Management Centre: Rue de la Science 23, B-1040 Brussels

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European foreword

This document (FprEN 12301:2019) has been prepared by Technical Committee CEN/TC 145 “Plastics and rubber machines”, the secretariat of which is held by UNI.

This document is currently submitted to the second Formal Vote.

This document will supersede EN 12301:2000+A1:2008.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association, and supports essential requirements of EU Directive(s).

For relationship with EU Directive(s), see informative Annex ZA, which is an integral part of this document.

The main changes with respect to the previous edition EN 12301:2000+A1:2008 are as follows:

— the Scope is extended to cover also two-roll calenders forming an integral unit with an extruder (roller head) and two or three-roll polishing, laminating or embossing units installed downstream of extruders in film processing lines;

— the structure is modified;

— the list of significant hazards is moved to an informative annex;

— technical developments in safeguards are taken into account;

— requirements for braking system and roll separation are updated;

— revised type-A and type-B standards are taken into account;

— the performance levels of safety related parts of control systems are specified in accordance with EN ISO 13849-1:2015;

— a full noise test code is provided in a normative annex.

Introduction

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

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

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

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

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

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

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

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

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

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

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

1 Scope

This document specifies safety requirements relating to the design and construction of calenders (see 3.1.1) intended for the calendering, polishing, laminating or embossing of rubber or plastics.

This document concerns the calender alone, including the following integrated components: cutting device, stock guides, feeding device and secondary roller.

Annex C shows examples of various types of calenders and Annex D shows examples of calendaring processes.

This document deals with all significant hazards, hazardous situations or hazardous events relevant to the design and construction of calenders, when the machines are used as intended and under the conditions of misuse which are reasonably foreseeable by the manufacturer during all the phases of the life of the machine as described in EN ISO 12100:2010, 5.4 (see Annex B).

This document does not deal with:

— hazards generated by the processing of explosive materials, or materials which give rise to an explosive atmosphere;

— hazards due to laser or ionizing radiation;

— hazards generated if the calender is installed in an explosive atmosphere.

Two roll mills are covered by EN 1417.

This document is not applicable to calenders manufactured before the date of its publication.

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.

CLC/TS 61496-3:2008, *Safety of machinery - Electro-sensitive protective equipment - Part 3: Particular requirements for Active Opto-electronic Protective Devices responsive to Diffuse Reflection (AOPDDR)*

EN 349:1993+A1:2008, *Safety of machinery - Minimum gaps to avoid crushing of parts of the human body*

EN 574:1996+A1:2008, *Safety of machinery - Two-hand control devices - Functional aspects - Principles for design*

EN 614-1:2006+A1:2009, *Safety of machinery - Ergonomic design principles - Part 1: Terminology and general principles*

EN 619:2002+A1:2010, *Continuous handling equipment and systems — Safety and EMC requirements for equipment for mechanical handling of unit loads*

EN 12198-1:2000+A1:2008, *Safety of machinery - Assessment and reduction of risks arising from radiation emitted by machinery - Part 1: General principles*

EN 60204-1:2006, *Safety of machinery - Electrical equipment of machines - Part 1: General requirements (IEC 60204-1:2005, modified)*

EN 60947-5-8:2006, *Low-voltage switchgear and controlgear - Part 5-8: Control circuit devices and switching elements - Three-position enabling switches (IEC 60947-5-8:2006)*

EN 61000-6-2:2005, *Electromagnetic compatibility (EMC) - Part 6-2: Generic standards - Immunity for industrial environments (IEC 61000-6-2:2005)*

EN 61000-6-4:2007, *Electromagnetic compatibility (EMC) - Part 6-4: Generic standards - Emission standard for industrial environments (IEC 61000-6-4:2006)*

EN 61310-1:2008, *Safety of machinery - Indication, marking and actuation - Part 1: Requirements for visual, acoustic and tactile signals (IEC 61310-1:2007)*

EN 61496-1:2013, *Safety of machinery - Electro-sensitive protective equipment - Part 1: General requirements and tests (IEC 61496-1:2012)*

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

EN 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 3746:2010)*

EN ISO 4413:2010, *Hydraulic fluid power - General rules and safety requirements for systems and their components (ISO 4413:2010)*

EN ISO 4414:2010, *Pneumatic fluid power - General rules and safety requirements for systems and their components (ISO 4414:2010)*

EN ISO 4871:2009, *Acoustics - Declaration and verification of noise emission values of machinery and equipment (ISO 4871:1996)*

EN ISO 7731:2008, *Ergonomics - Danger signals for public and work areas - Auditory danger signals (ISO 7731:2003)*

EN ISO 9614-2:1996, *Acoustics - Determination of sound power levels of noise sources using sound intensity - Part 2: Measurement by scanning (ISO 9614-2:1996)*

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

EN 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 11202:2010)*

EN 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 11204:2010)*

EN ISO 11688-1:2009, *Acoustics - Recommended practice for the design of low-noise machinery and equipment - Part 1: Planning (ISO/TR 11688-1:1995)*

EN ISO 12100:2010, *Safety of machinery - General principles for design - Risk assessment and risk reduction (ISO 12100:2010)*

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

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

EN ISO 13850:2015, *Safety of machinery - Emergency stop function - Principles for design (ISO 13850:2015)*

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

EN ISO 13856-1:2013, *Safety of machinery - Pressure-sensitive protective devices - Part 1: General principles for design and testing of pressure-sensitive mats and pressure-sensitive floors (ISO 13856-1:2013)*

EN ISO 13857:2008, *Safety of machinery - Safety distances to prevent hazard zones being reached by upper and lower limbs (ISO 13857:2008)*

EN ISO 14118:2018, *Safety of machinery - Prevention of unexpected start-up (ISO 14118:2017)*

EN ISO 14119:2013, *Safety of machinery - Interlocking devices associated with guards - Principles for design and selection (ISO 14119:2013)*

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

EN ISO 14122-1:2016, *Safety of machinery - Permanent means of access to machinery - Part 1: Choice of fixed means and general requirements of access (ISO 14122-1:2016)*

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

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

EN ISO 14122-4:2016, *Safety of machinery - Permanent means of access to machinery - Part 4: Fixed ladders (ISO 14122-4:2016)*

ISO 7010:2011, *Graphical symbols - Safety colours and safety signs - Registered safety signs*

3 Terms, definitions and symbols

3.1 Terms and definitions

For the purposes of this document, the terms and the definitions given in EN ISO 12100:2010 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 https://www.iso.org/obp

3.1.1
calender
machine for processing rubber, plastics, solutions or dispersions by continuous drawing between two or more rolls, which are supported at both ends by a frame

Note 1 to entry: The processing operations may be, for example:

— continuous calendering of sheets or profiles of rubber or plastics;

— application of one or more sheet(s) or layer(s) onto a support material;

— laminating of two or more sheets of rubber or plastics under pressure or by using heat or adhesive;

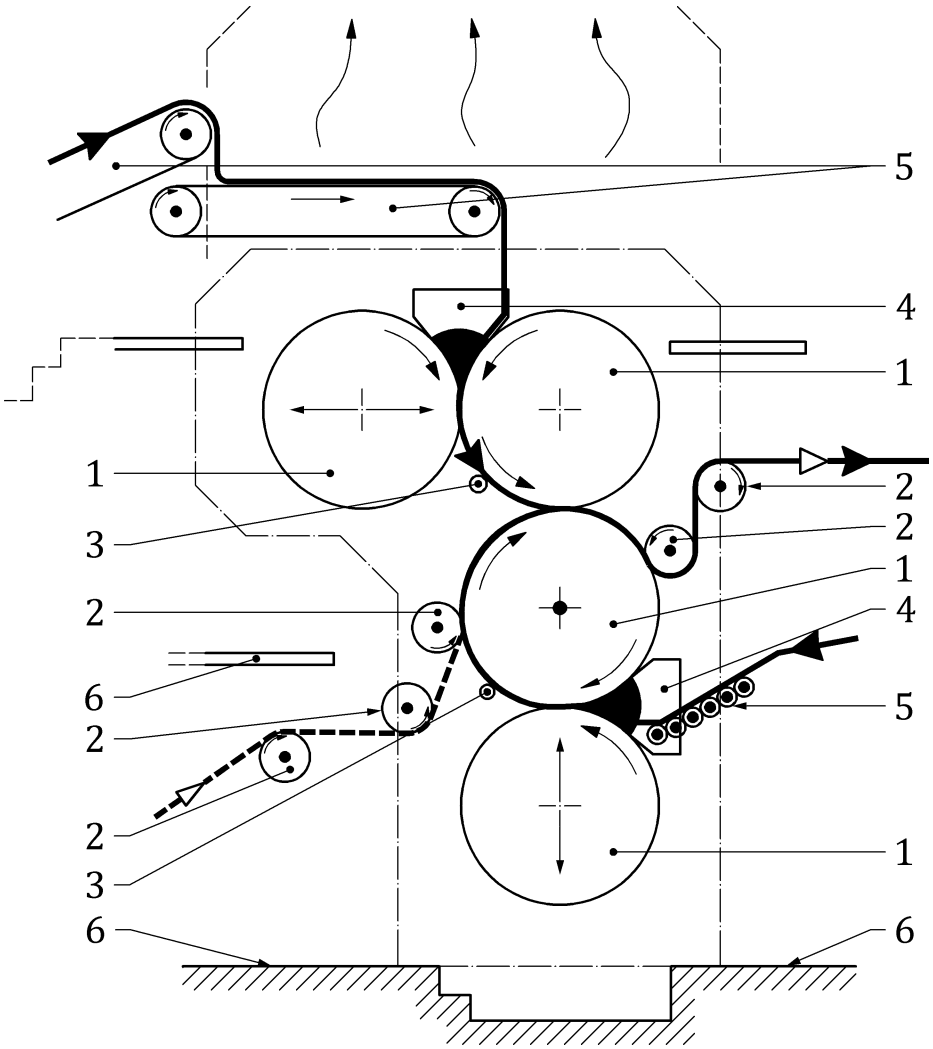
— embossing or polishing of plastics (for example smoothing roll stack).

The calender can be equipped with power operated wheels for the horizontal movement of the complete machine, e.g. for engaging /disengaging it from an extruder head during setting-up operations.

Note 2 to entry: Figure 1 shows a typical calendering sequence and the positions of most of the components and zones defined hereafter. Figure 2 shows a typical 3-roll stack supplied by an extruder.

Note 3 to entry: Annex C shows examples of various types of calenders.

Note 4 to entry: Annex D shows examples of various calendering processes.



Key

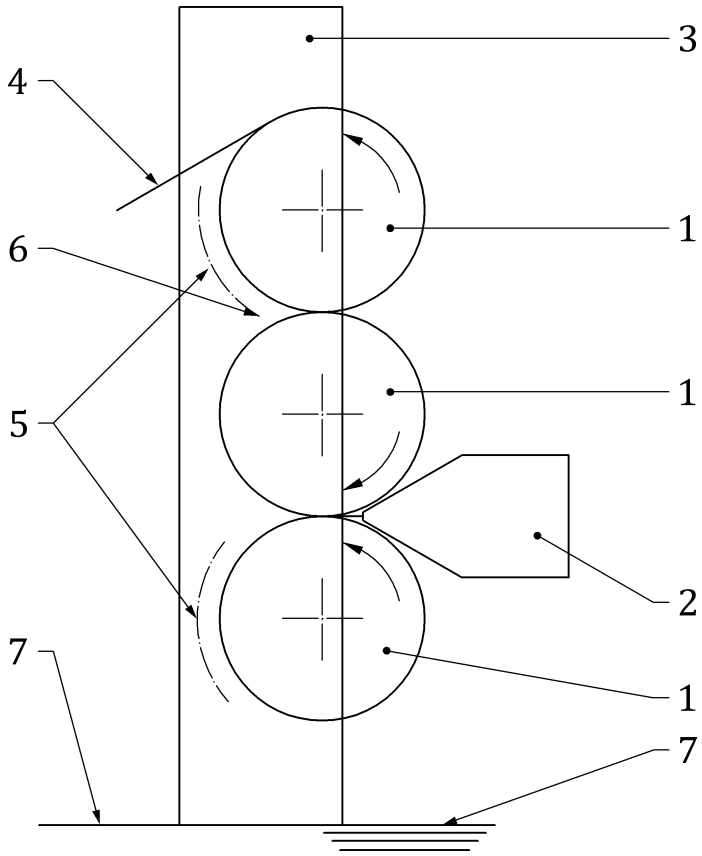
rubber/plastic circuits

cord/fabric circuit

calendered product circuit

1	calender rolls	4	stock guides
2	secondary rollers	5	feeding devices
3	cutting devices	6	working zones

Figure 1 — Example of a 4-roll calender showing the materials circuit for bilateral coating of (textile or metallic) fabric or cords



Key

1	calender roll	5	cleaning zone
2	extruder head	6	crushing zone
3	frame	7	working zone
4	film		

Figure 2 — Example of a 3-roll stack supplied by an extruder

3.1.2
calender roll
roll which is positioned in relation to other calender rolls in order to process the material

Note 1 to entry: The roll can be counterbored or drilled to enable its temperature to be controlled by fluid circulation.

3.1.3
secondary roller
roller, which is used to support the calendering process

Note 1 to entry: It can be driven and temperature regulated.

Note 2 to entry: Examples of secondary rollers are: pressure rollers, embossing rollers, filament guide rollers, tension rollers, stripper rollers, crease removing rollers, take-off rollers.

3.1.4
cutting device
equipment for trimming the edges of the sheet to one or more specified widths

EXAMPLE Fixed knives (wires or blades), rotating knives (cutting discs).

3.1.5
stock guides
devices located on either side of the feed zone which determine the width of the sheet to be calendered and retain the stock thus preventing it from extending beyond the normal working area

3.1.6
feeding device
equipment for feeding and distributing the stock in the feed zone

EXAMPLE Table, grid, chute, conveyor, reciprocating feed conveyor.

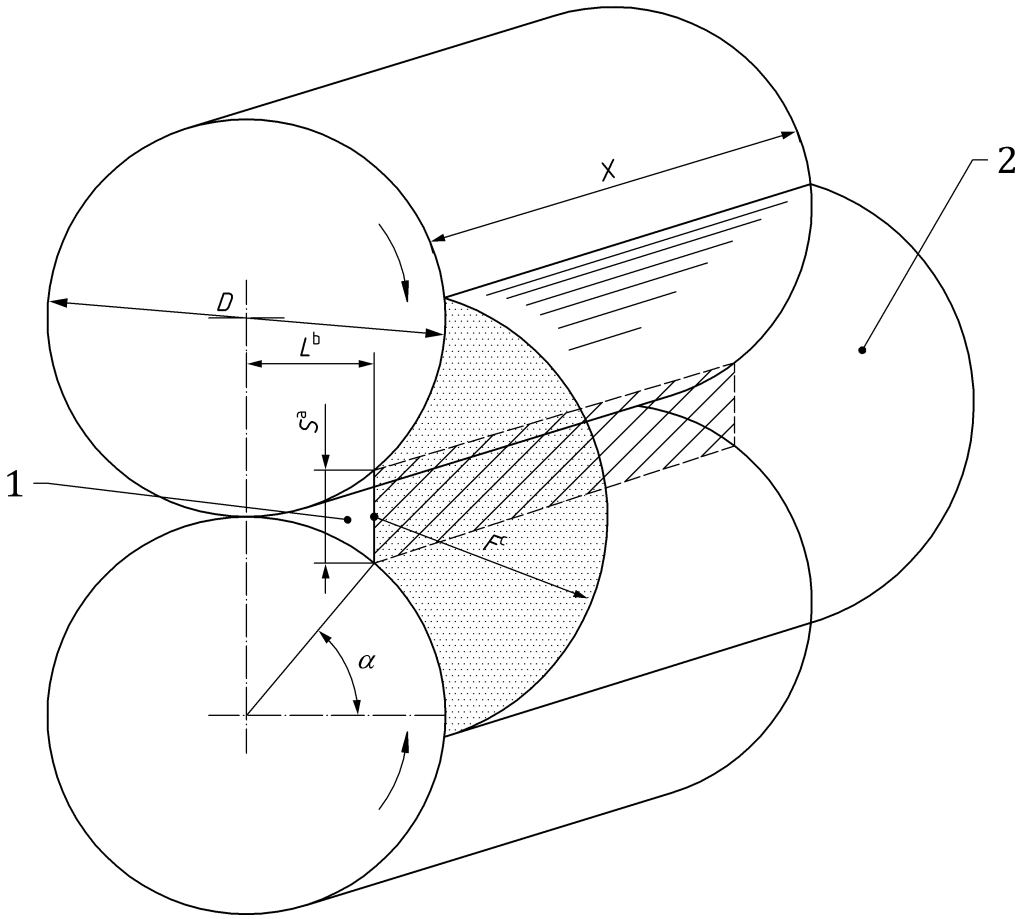
3.1.7
stopping angle
angle through which the calender rolls rotate from the stop signal triggered by a protective device until the calender rolls have come to rest

3.1.8
feed zone
zone in which stock (rubber or plastic etc.) and/or material (cords, web, fabric etc.) is fed into the calender

3.1.9
working zone
area around the calender or standing zone where the operators carry out their normal duties

3.1.10
crushing zone
zone existing between two calender rolls close to each other rotating in opposite directions towards the nip

Note 1 to entry: See Figure 3.



Key

1 crushing zone
2 danger zone
S line dimensioned at the entrance to the crushing zone
X length of calender roll
L depth of the crushing zone, expressed in millimetres
D diameter of the calender rolls, expressed in millimetres
α stopping angle, expressed in radians
F radius equivalent to the length of the arcs of circle on the calender rolls corresponding with the specified stopping angle, expressed in millimetres

[a] *S* needs to be taken as 12 mm when the rolls are theoretically in contact, irrespective of the roll diameter.

[b] $L = \sqrt{6 \times D}$; where the roll diameters are different *D* shall be taken as the larger diameter

[c] $F = \frac{D}{2}\alpha$

NOTE 1 The danger zone is the volume at the inrunning side of the rolls circumscribed by the length X of the rolls and the shaded cross-section. This section is delimitated by:

— the line dimensioned *S* at the entrance to the crushing zone (see 3.1.10);

— the two arcs of circle on the calender rolls corresponding with the specified stopping angle α (see 3.1.7);

— the arc of a circle whose centre is the middle of the line dimensioned *S* and whose radius *F* is equivalent to the length of the arcs of circle on the calender rolls corresponding with the specified stopping angle α.

NOTE 2 An example for the calculation of *L* is given in Annex E; *L* remains constant irrespective of the nip between the rolls.

Figure 3 — Crushing and danger zones at the calender rolls

3.1.11
setting
preparing the machine for production, machine set-up, etc.

3.1.12
cleaning
removal of dust, residual material on the rolls, etc.

3.2 Symbols

α	stopping angle of the calender roll when running with production speed v_p
α_{max}	maximum stopping angle of the calender roll when running with maximum speed v_{max}
α_r	reduced stopping angle of the calender roll when running with reduced speed v_r
v_p	production rotational speed of calender rolls
v_{max}	maximum rotational speed of the calender rolls
v_r	reduced rotational speed of the calender rolls
D	(larger) diameter of the calender rolls
F	length of arc α on the calender roll surface
F_r	length of arc α_r on the calender roll surface
S	height of entrance of the crushing zone
L	depth of crushing zone

4 Safety requirements and/or protective measures

4.1 General

Calenders shall comply with the safety requirements and/or protective measures of this clause. In addition, the machine shall be designed according to the principles of EN ISO 12100:2010 for relevant but not significant hazards, which are not dealt with by this document (e.g. sharp edges).

The hydraulic equipment and its components shall be designed in accordance with EN ISO 4413:2010.

The pneumatic equipment and its components shall be designed in accordance with EN ISO 4414:2010.

4.2 Control systems

4.2.1 General

The safety related parts of the control system shall be designed in accordance with EN ISO 13849-1:2015. The required performance level (PL_r) for each safety function is specified in the relevant subclauses.

In the case where the calender is provided with a mode selector, it shall be in accordance with EN ISO 12100:2010, 6.2.11.10.

4.2.2 Starting

The start of an operation shall be possible only when all safeguards are in place and functional (see EN 60204-1:2006, 9.2.5.2). The machine shall only be started by actuation of the start device provided for that purpose.

4.2.3 Normal stopping

A normal stop device shall be provided to bring the machine to a complete stop.

The normal stop command shall function as a stop category 0 or 1 in accordance with EN 60204-1:2006, 9.2.2, depending on the used technology.

4.2.4 Emergency stop devices

The emergency stop devices shall comply with EN ISO 13850:2015. For electrical braking, stop category 1 of that standard shall apply. For calenders with simple mechanical braking systems which are not dependent on electrical energy, stop category 0 may be selected. An emergency stop device shall be provided on the control panel of the calender. Other emergency stop actuators shall be installed in the vicinity of and on each side of the working zones.

The actuation of any emergency stop device shall

— cause stopping of the calender rolls in accordance with 4.2.6;

— allow the roll separation or cause automatic roll separation on machines equipped with protective device requiring automatic roll separation (see 4.3.1.3, 4.3.1.4, 4.3.1.5 and 4.3.1.6);

— allow the rescue reverse movement in accordance with 4.2.7;

— cause the stopping of all integrated components according to PL_r = c

trigger a visual and/or auditory signal, with manual resetting.

See also EN 60204-1:2006, 10.7.

4.2.5 Failure of energy supply

An interruption or a failure of the power supply shall not result in a loss of safety function and restoration of the energy supply shall not result in the automatic restarting of the machine (see EN ISO 12100:2010, 6.2.11.4 and 6.2.11.5).

Failure of the energy supply which causes opening of a contactor of one of the roll drive motors shall also cause stopping of the rolls as specified in 4.2.6.

The calender shall also be equipped with a device to enable roll separation to be achieved even in the event of energy failure (see 6.2.3 m)).

4.2.6 Braking system

In case where the calender rolls can stop without material from maximum speed within a maximum stopping angle α_{max} of 120° there are no specific requirements for braking system.

In the case where inrunning nips are protected by fixed guards there are no specific requirements for braking system and stopping angle (see 4.3.1.2).

In the case where inrunning nips are protected by an interlocking guard with guard locking function in accordance to PL_r = d, there are no specific requirements for braking system and stopping angle.

If one or more of the inrunning nips are protected by:

— interlocking guard without guard locking or with guard locking function according to PL_r = a, PL_r = b or PL_r = c; or

— trip devices (e.g. trip bar);

the affected calender shall be equipped with a two channel braking system in accordance with PL_r = d, category 3 using:

— either two mechanical brakes, spring operated; or

— one mechanical brake, spring operated and an electronic braking system, operating also without power supply.

Braking shall be started as soon as a protective device is actuated.

The overall system stopping performance (see EN ISO 13855:2010, 3.1.2) shall be calculated taking power failure into account.

For interlocking guards and trip devices, if EN ISO 13855:2010 cannot be respected, interlocking guards with guard locking shall be adopted.

For trip bar, the rolls shall be brought to rest within a maximum stopping angle α_{max} of 120° even in the case of failure of the energy supply. Where the maximum rotating speed of the calender rolls v_{max} is greater than 120 m/min, α_{max} may vary proportionally to v_{max} up to a maximum value of 160°.

EXAMPLE For calender rolls with a maximum rotating speed v_{max} of 140 m/min then:

$$\alpha_{max} = 120 \times \frac{140}{120} = 140$$

with PL_r = d, category 3, where α_{max} is expressed in degrees.

See also 6.2.2 and 6.2.3 a).

The manual release of the brake shall be interlocked with the control circuit in accordance with PLr = d, so that the powered rotation of the calender rolls is prevented as long as the brake is manually released.

4.2.7 Rescue reverse movement

Following stoppage of the calender rolls due to opening of an interlocking guard or voluntary or involuntary actuation of a trip device or actuation of an emergency stop device, it shall be possible to make a reverse movement of the rolls by actuation of a dedicated hold-to-run control device in accordance with EN ISO 12100:2010, 3.28.3 or a manually operated device (e.g. hand wheel) in order to release a person trapped between the rolls or between a roll and the material.

This control device shall function without the need for manual resetting and independently of the position of the mode selector specified in 4.3.1.8.3; it shall be clearly labelled “Rescue Reverse Movement”. The reverse velocity of the rolls shall not exceed 5 m/min. The rescue reverse movement shall stop under action of the brake as soon as the manual control is released. The visual and auditory warning signals specified in 4.3.1.8.3 shall be given (see 6.2.3 p)).

The requirements of 4.3.1.8.3 for safety related parts of the control system (SRP/CS) for the hold to run control and for speed limitation shall be applied.

A rescue reverse movement is not required, if

— an automatic roll separation > 120 mm is possible within 12 s, in accordance with PL_r = d, category 3; or

— the inrunning nip is protected by a fixed guard (see 4.3.1.2); or

— the inrunning nip is protected by an interlocking guard with guard locking (see 4.3.1.3) with a performance level at least PL_r = d for the locking function.

The roll separation shall not create additional hazards, e.g. crushing between roll and fixed part.

See 6.2.3 b).

4.3 Protection against mechanical hazards

4.3.1 Preventing access to the crushing zone

4.3.1.1 General

The access to the crushing zone (see Figure 3) when the rolls are rotating shall be prevented by one or more of the following means:

— fixed guards in accordance with 4.3.1.2; or

— interlocking guards in accordance with 4.3.1.3; or

— trip bar in accordance with 4.3.1.4; or

— pressure sensitive mat or floor in accordance with 4.3.1.5; or

— a non-mechanically actuated trip device in accordance with 4.3.1.6, e.g. light curtain in accordance with EN 61496-1:2013 or scanners in accordance with CLC/TS 61496-3:2008.

The end of an activation of a trip device or closing of an interlocking guard shall not automatically initiate any further movement. A new start command shall be required. A separate device for manual reset shall be installed in a position giving full view of the danger zone and designed in accordance with EN ISO 13849-1:2015, 5.2.2, except for rescue reverse movement see 4.2.7.

If the smallest horizontal gap between the machine frame and

— an interlocking guard is ≥ 100 mm, or

— a non-mechanically actuated trip device is ≥ 150 mm,

an operator can stand between the guard/trip device and machine frame. In this case, restarting of the dangerous movements while an operator remains in that area shall be prevented by additional safety measures (e.g. presence sensing devices), unless for technical reasons this is not possible, e.g. due to a part of the machine being in the way.

The closing movement to engage the calender rolls shall be possible only:

— when the interlocking guards are closed or trip devices are not actuated; or

— by a hold-to-run control device and closing speed limited to 10 mm/s in accordance with PL_r = c; the control station shall be positioned in a place that gives the operator a clear view of the dangerous area.

4.3.1.2 Fixed guards

Fixed guards as defined in EN ISO 14120:2015, 3.2 shall prevent the access to the danger zone from all sides in combination with the calendar frame.

Safety distances shall be in accordance with EN ISO 13857:2008, Table 2 and Table 3 and Table 4.

If the fixed guard is positioned between the calender rolls:

— it shall extend along the whole length of the rolls; and

— the gap between the guard and the surface of the roll shall be ≤4 mm; and

— the angle between the guard and the tangent to the surface of the roll shall be ≥ 90°.

Examples of layout are given in informative Annex F. Other profiles may be used but circular cross sections are prohibited.

A feeding device alone shall not replace a fixed guard positioned between the calender rolls. However, it may contribute to protecting access to the inrunning nip.

In this case:

— it shall fulfill the above requirements for guards positioned between rolls;

— it shall be associated with fixed guards preventing access to the inrunning nip according to EN ISO 13857:2008, Table 2, Table 3 and Table 4.

Where for operating processes (for cleaning or setting operations, for example) the access into the danger area is necessary a fixed guard shall not be used but an interlocking guard according to 4.3.1.3 shall be installed.

In the case of a fixed guard positioned between the calender rolls, there is no need for automatic roll separation.

4.3.1.3 Interlocking guards

The interlocking function shall be in accordance with PL_r = d.

Interlocking guards without guard locking shall be positioned in accordance with EN ISO 13855:2010, Clause 9.

Safety distances shall be in accordance with EN ISO 13857:2008, Table2 and Table 3 and Table 4.

The type of interlocking device shall be selected in accordance with EN ISO 14119:2013.

The braking system shall be in accordance with 4.2.6.

If interlocking guards with guards locking are used, the unlocking signal of the guard locking shall be in accordance with PL_r = c. The opening of an interlocking guard shall:

— cause automatic roll separation at least in 50 mm within 5 s, in accordance with PL_r = d, category 3. The roll separation shall not create additional hazards e.g. crushing between roll and fixed part; and

— allow rescue reverse movement as specified in 4.2.7.

If the interlocking guard with guard locking has a performance level at least PLr=d for the locking function, the automatic roll separation is not necessary.

A feeding device installed as in 4.3.1.2 shall act as an interlocking guard with guard locking which shall allow the rolls to rotate only when the feeding device is in position and which does not allow to remove

the feeding device from the working position until the rolls have come to rest. The PL_r of the control circuit shall be the same of interlocking guard with guard locking.

4.3.1.4 Trip bar

The trip bar is a mechanically actuated trip device in form of a horizontal rigid bar which when actuated by any part of the body shall:

— cause stopping of the calender rolls as specified in 4.2.6;

— cause automatic roll separation at least in 50 mm within 5 s, in accordance with PL_r = d, category 3. The roll separation shall not create additional hazards e.g. crushing between roll and fixed part;

— allow rescue reverse movement as specified in 4.2.7.

The trip bar shall meet the following requirements:

— it shall be actuated by a displacement not exceeding 10 mm created by a movement of the operator's body toward the rolls;

— actuation of the bar shall not require a force greater than 200 N, on each end and at the middle of the trip bar;

— wherever the pushing action occurs along the length of the bar, the 10 mm displacement of the bar shall trigger at least one position sensor actuated in the positive mode (see EN ISO 14119:2013, 5.4);

— return of the trip bar to its rest position shall not cause restarting. A separate device for manual reset shall be installed in a position giving full view of the danger zone and designed in accordance with EN ISO 13849-1:2015, 5.2.2 (for rescue reverse movement see 4.2.7).

See also 6.2.3 c) and 6.2.3 d).

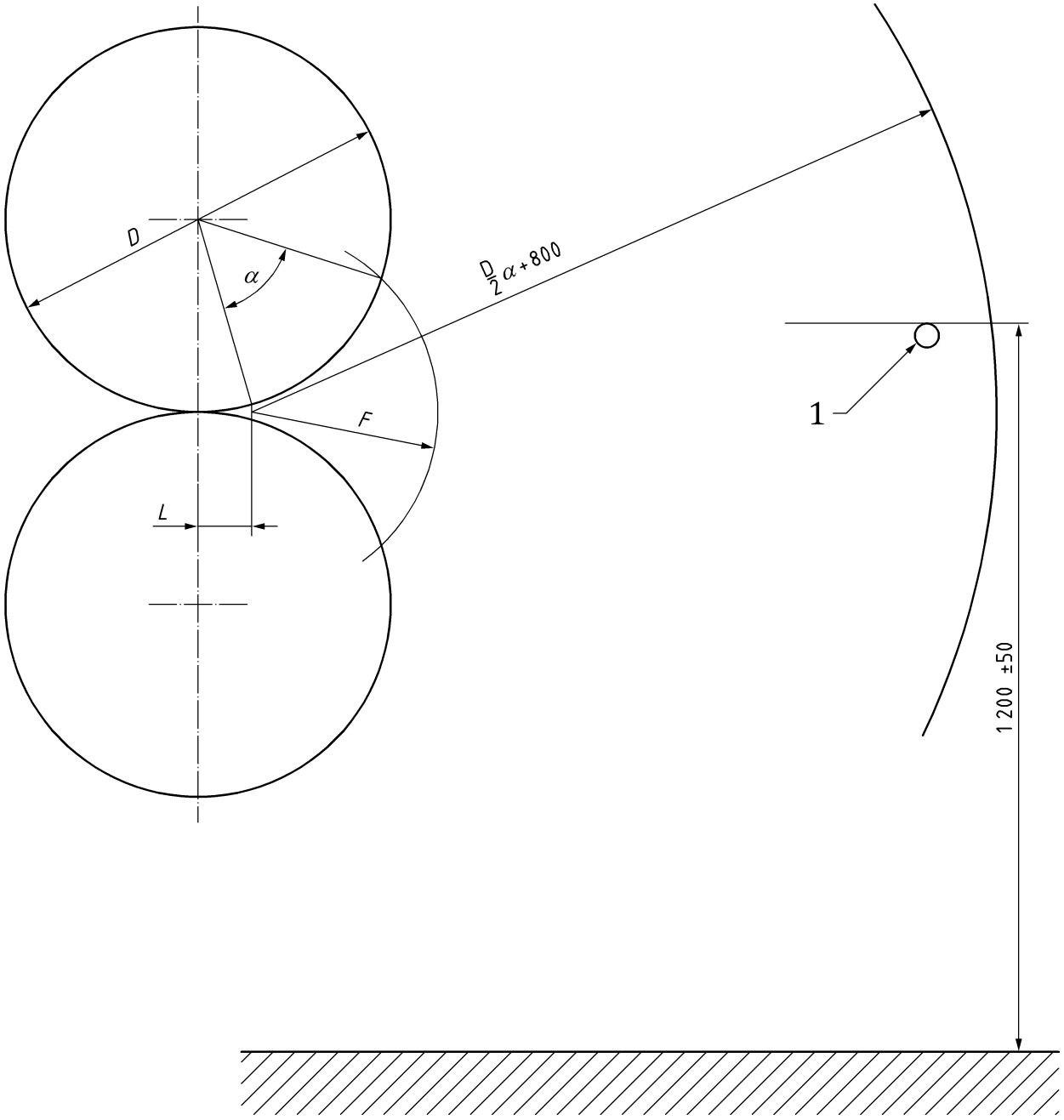
The protection shall be completed with a fixed guard or interlocking guards with guard locking in accordance with 4.3.1.3 preventing access to the crushing zone from below the trip bar. This guard shall be so designed as to prevent foothold. Moreover, if there is access from the sides of the calender to the ends of the rolls on the inrunning side, lateral fixed guards shall be provided taking account of safety distances specified in EN ISO 13857:2008, Table 2, Table 3 and Table 4.

The trip bar shall extend over the full length of the calender rolls.

It shall be fitted at a height 1 200 ± 50 mm (above the level on which the operator stands) and be positioned according to Figure 4.

See also 6.2.3 e).

Linear dimensions in millimetres, α in radians



Key

1 trip bar (in rest position)

L depth of crushing zone (see Figure 3)

F length equivalent to the stopping arc length at $v_{max,}$

D larger diameter of the calender rolls

α stopping angle

Figure 4 — Positioning of the trip bar

4.3.1.5 Pressure sensitive mat or floor

Pressure sensitive mat or floor shall be in accordance with EN ISO 13856-1:2013, positioned in accordance with EN ISO 13855:2010, Clause 7.

Actuation of the trip devices shall:

— cause stopping of the calender rolls as specified in 4.2.6;

— cause automatic roll separation at least in 50 mm within 5 s, in accordance with PL_r = d, category 3. The roll separation shall not create additional hazards e.g. crushing between roll and fixed part;

— allow rescue reverse movement as specified in 4.2.7.

4.3.1.6 Non-mechanically actuated trip devices

Light curtains shall be in accordance with EN 61496-1:2013 type 3 or type 4 positioned in accordance with EN ISO 13855:2010, Clause 6. Scanners shall be in accordance with CLC/TS 61496-3:2008, type 3.

Actuation of a non-mechanically actuated trip device shall:

— cause stopping of the calender rolls as specified in 4.2.6;

— cause automatic roll separation at least in 50 mm within 5 s, in accordance with PL_r = d, category 3. The roll separation shall not create additional hazards, e.g. crushing between roll and fixed part;

— allow rescue reverse movement as specified in 4.2.7.

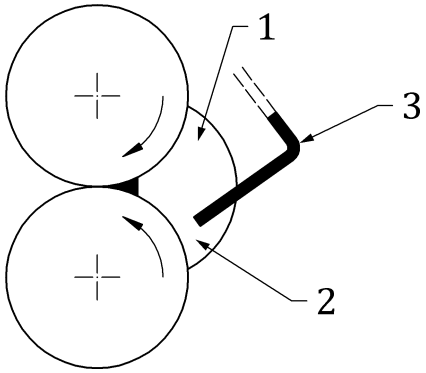
4.3.1.7 Inhibition of interlocked guards or protective devices for setting only

4.3.1.7.1 General

For machine setting it may be necessary to rotate or move the calender rolls with one or more guards or protective devices, preventing access to the inrunning nip, inhibited. In this case, safety of the operator shall be achieved using a specific control mode activated by a mode selector according to 4.2.1 that disables all other control modes. The safety related part of the control system (SRP/CS) shall in accordance with PL_r = d, category 3. Operation of the hazardous elements shall only be possible if:

a) a guard positioned at a distance from the crushing zone according to the dimensions specified in EN ISO 13857:2008, Table 4 and 4.3.1.2 (see Figure 5) is detected in accordance with PL_r = d, category 3 acting as an interlocking guard specified in 4.3.1.3 of this standard; or

b) the requirements in 4.3.1.7.2.4 are fulfilled for the specific movement.



Key

1 danger zone
2 cleaning zone
3 guard positioned in accordance with EN ISO 13857:2008 and 4.3.1.2 of this standard

Figure 5 — Example of a guard specifically designed for cleaning in the danger zone of the rolls

4.3.1.7.2 Requirements for rolls rotation during setting

If one or more guards or protective devices preventing access to the inrunning nip are inhibited and the guard mentioned in 4.3.1.7.1 a) is not used, the rotation of the calender rolls shall only be permitted if all the following requirements are fulfilled:

— the rotation of the calender rolls shall be controlled by continuous actuation of a hold-to-run control device in accordance with PL_r = c. If the hold to run control is fitted on a portable unit, it shall be a three-position enabling switch as defined in EN 60947-5-8:2006, 2.2; and

— the rotation speed shall be limited to a maximum of 3 m/min according to PL_r = d; and

— the gap between both the calender rolls themselves and between the calender rolls and the fixed parts shall be more than or equal to 50 mm; the interlocking circuit between separation and calender rolls rotation shall be in accordance with PL_r = c; and

— the control station shall be positioned in a place that gives the operator a clear view of the dangerous area.

4.3.1.7.3 Requirements for closing movement for setting the gap between the rollers

If one or more guards or protective devices preventing access to the crushing area are inhibited and the guard mentioned in 4.3.1.7.1 a) is not used, the closing movement of the calender rolls for setting the gap shall only be permitted if all the following requirements are fulfilled:

— the closing movement shall be controlled by continuous actuation of a hold-to-run control device in accordance with PL_r = c. If the hold to run control is fitted on a portable unit, it shall be a three-position enabling switch as defined in EN 60947-5-8:2006, 2.2; and

— the closing speed shall be limited to 10 mm/s in accordance with PL_r = d; and

— the control station shall be positioned in a place that gives the operator a clear view of the dangerous area.

If rolls rotation is necessary during the closing movement the same hold-to-run control device can control also rotation according to 4.3.1.7.2.

See 6.2.3 g).

4.3.1.7.4 Requirements for rolls rotation during setting for hot lamination

If one or more guards or protective devices preventing access to the inrunning nip are inhibited and the guard mentioned in 4.3.1.7.1 a) is not used, rotation of the calender rolls for setting for hot lamination shall only be permitted if all the following requirements are fulfilled:

— the calender rolls rotation shall be controlled by continuous actuation of a hold-to-run control device in accordance with PL_r = c. If the hold to run control is fitted on a portable unit, it shall be a three-position enabling switch as defined in EN 60947-5-8:2006, 2.2; and

— the rotation speed shall be limited to a maximum of 15 m/min according to PL_r = d; and

— the control station shall be positioned in a place that gives the operator a clear view of the dangerous area.

4.3.1.8 Start-up

4.3.1.8.1 General

The manufacturer shall provide safe means of access for start-up operation (see 4.11) when it is not possible to do it remaining at ground level. They shall not give access to danger zones of machinery.

See also 6.2.3 f).

4.3.1.8.2 Normal start-up

Start-up of the production shall only be possible after an auditory warning signal in accordance with EN ISO 7731:2008 and EN 61310-1:2008 has been sounded. The signal shall continue until the rolls start to rotate and have a minimum duration of 5 s.

4.3.1.8.3 Specific control mode for start-up if it is necessary to inhibit guards or protective devices

If it is necessary to remove or inhibit certain guards or protective devices for start-up, safety of the operator shall be achieved using a specific control mode activated by a mode selector according to 4.2.1 that:

— disables all other control modes. The safety related part of the control system (SRP/CS) shall in accordance with PL_r = d, category 3; and

— permits operation of the hazardous elements only by continuous actuation of a hold-to-run control device. The safety related part of the control system (SRP/CS) shall in accordance with PL_r = c; and

— permits operation of the hazardous elements only in reduced speed, 5 m/min. The safety related part of the control system (SRP/CS) shall in accordance with PL_r = d, or PL_r = c if the gap between the rolls is more than 50 mm; if the gap can be adjusted this gap shall be monitored and shall stop the rotation according to PL_r = c; and

— prevents any operation of hazardous functions by voluntary or involuntary action on the machine's sensors.

It is important that the operator shall have a clear view of the danger zones. Depending on the size and layout of the calender, provision of some visual aids may be necessary, e.g. mirrors, closed circuit television (CCTV).

Movement shall stop under action of the brake as soon as the manual control is released.

4.3.1.8.4 Reverse motion selection

If it is necessary to reverse motion for start-up, safety of the operator shall be achieved by the following measures:

— using a specific control mode activated by a mode selector according to 4.2.1 that disables all other control modes. The safety related part of the control system (SRP/CS) shall in accordance with PLr = d, category 3; and

— selection of reverse motion on the mode selector shall initiate a flashing warning light close to the new crushing zones generated by reverse movement (see 6.2.3 p). The signal shall continue as long as the mode selector is in that mode.

If the new crushing zones generated by reverse movement are protected by guards, these shall be in accordance with the dimensions specified in EN ISO 13857:2008, Table 4 and 4.3.1.2 of this standard. If the guards are movable operation of the hazardous elements shall only be possible if the presence is detected in accordance with PL_r = d, category 3.

If the new crushing zones generated by reverse movement are not protected by guards, operation of the hazardous elements shall only be permitted if all the following requirements are fulfilled:

— the movements shall be controlled by continuous actuation of a hold-to-run control device. The safety related part of the control system (SRP/CS) shall in accordance with PL_r = c; and

— the speed shall be limited to 5 m/min. The safety related part of the control system (SRP/CS) shall in accordance with PL_r = d, or PL_r = c if the gap between the rolls is more than 50 mm; if the gap can be adjusted this gap shall be monitored and shall stop the rotation according to PL_r = c; and

— any operation of hazardous functions by voluntary or involuntary action on the machine's sensors shall be prevented.

It is important that the operator shall have a clear view of the danger zones. Depending on the size and layout of the calender, provision of some visual aids may be necessary, e.g. mirrors, closed circuit television (CCTV).

Movement shall stop under action of the brake as soon as the manual control is released.

4.3.1.9 Combination of two protective devices

When it is necessary to allow the operator to go closer to the calendar rolls, the danger zone shall be reduced by limiting the rotational speed of the rolls from v_{max} or v_p to v_r. The stopping angle α then becomes α_r; the resulting danger zone of reduced dimensions is shown in Figure 6 b).

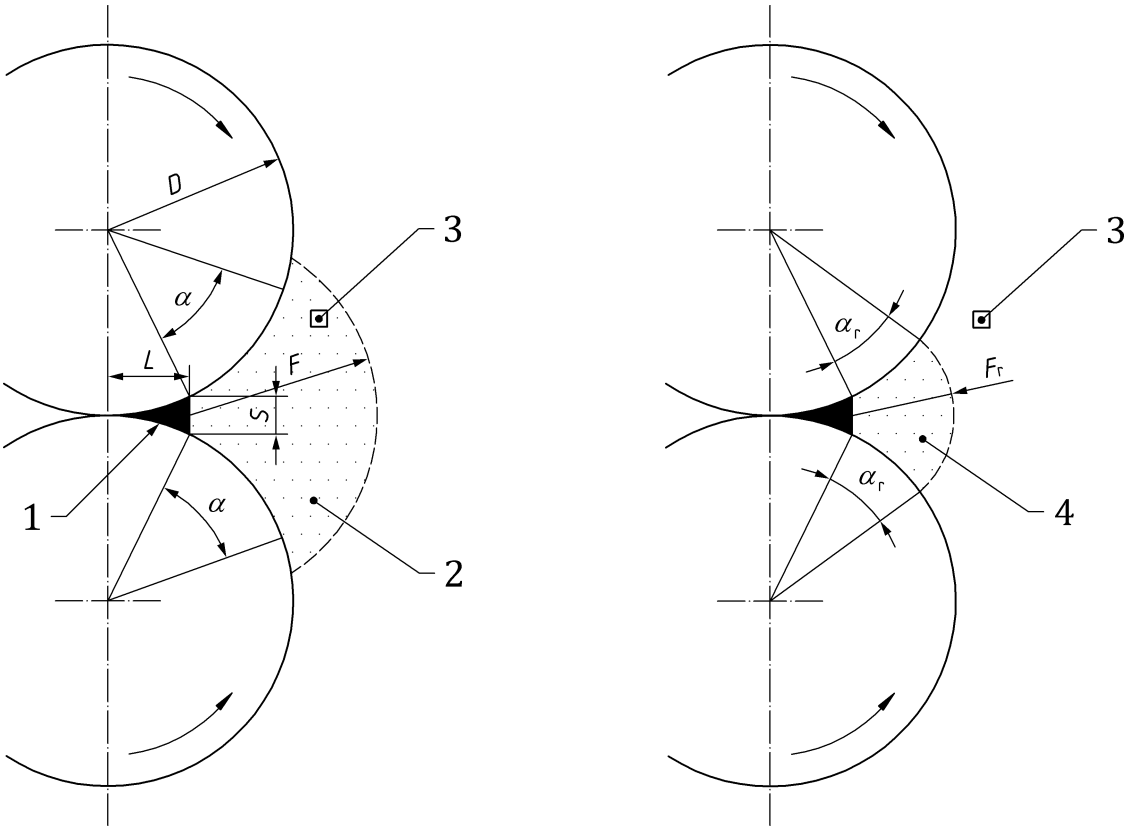
F = length of arc α $\qquad$ F_r = length of arc α_r

$F = \frac{\pi}{360} \times D\alpha$ (with α in degrees) $\qquad$ $F_r = \frac{\pi}{360} \times D\alpha_r$ (with α_r in degrees)

$F = \frac{D}{2}\alpha$ (with α in radians) $\qquad$ $F_r = \frac{D}{2}\alpha_r$ (with α_r in radians)

where

F, F_r and D are expressed in millimetres.



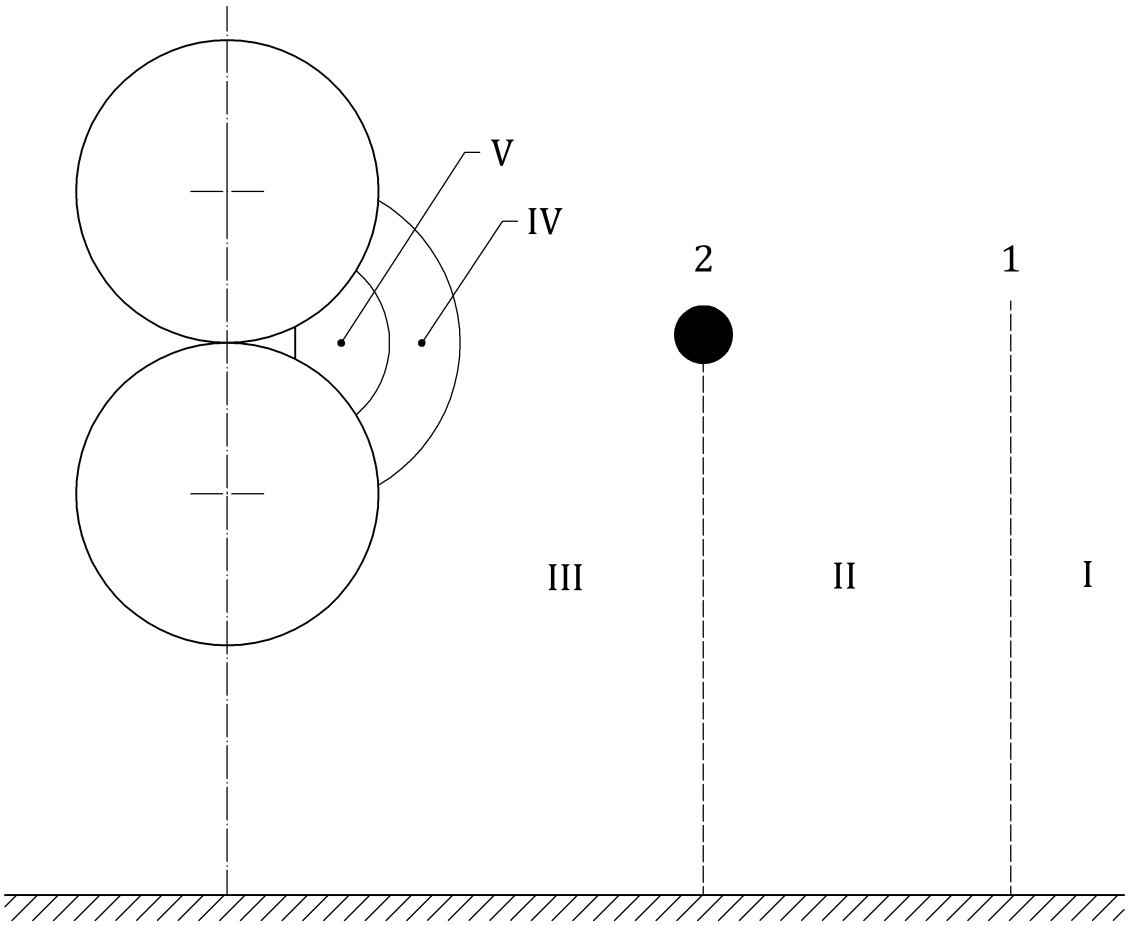
a) Dimensions of the danger zone **b) Dimensions of the smaller danger zone**

Key

1 crushing zone
2 danger zone
3 required approach point
4 danger zone of reduced dimensions

Figure 6 — Danger zone and reduction of the danger zone

Access to the smaller danger zone shall be prevented by a combination of two protective devices as shown in Figure 7.



Key

1	protective device 1: Device further from the danger zone
2	protective device 2: Device closer to the danger zone
Zone I	free access zone, from where zone IV cannot be reached by the upper limbs
Zone II	zone into which bodily access is allowed when the rolls rotate at reduced speed v_r
Zone III	zone into which upper limb access is allowed when the rolls rotate at a speed greater than v_r
Zone IV	danger zone at the calender rolls into which upper limb access is allowed when the rolls rotate at reduced speed v_r
Zone V	danger zone of reduced dimensions in which access is prohibited in all cases

Figure 7 — Combination of two protective devices

Protective device 1 shall be in accordance with 4.3.1.1 except for fixed guard and trip bar.

Protective device 2 shall be in accordance with 4.3.1.1 except for fixed guard.

The combined protective devices shall perform as follows:

— In order to enter zone II, the operator has to request a speed reduction from v_p to v_r by a voluntary action on a control device that shall be located in zone I. The reaching of the reduced speed shall be visually indicated;

— A movement of the operator from zone I to zone II shall cause stopping of the calender rolls in accordance with 4.2.6 by actuation of the protective device 1 when the rolls are running at a speed greater than v_r. A movement of the operator from zone I to zone II when the rolls are running at v_r shall not generate a stop command. The speed monitoring shall have a performance level PL_r = c;

— Reaching zone *V* with the upper limbs shall cause stopping of the calender rolls by involuntary actuation of the protective device 2. If this device is a trip bar as specified in 4.3.1.4, it shall be positioned as in Figure 4 but with α replaced by α_r;

— Increasing the speed of the calender rolls from v_r to v_p shall be possible only via a manual control and after the operator has returned from zone II to zone I. Return of the operator from zone II to zone I shall be signalled by actuation of an acknowledgement switch located in zone I in such a position that it cannot be operated from zone II. The acknowledgement signal shall be given from a position affording a clear view of zone II, if necessary by means of aids to vision.

See also 6.2.3 c) and 6.2.3 f).

4.3.2 Additional requirements for cleaning

The machine shall be so designed to allow cleaning without the operator entering the danger zone at the calender rolls shown in Figure 3, e.g. automatic cleaning device, cleaning tools.

If crushing zones are accessible from the cleaning workstations they shall be safeguarded as specified in 4.3.1.1. If for cleaning, one or more guards or protective devices preventing access to the dangerous area are inhibited, the rotation of the calender rolls shall only be possible if the requirements described in 4.3.1.7, for setting are fulfilled.

The manufacturer shall provide safe means of access for cleaning operations (see 4.11), when it is not possible to do it remaining at ground level. They shall not give access to danger zones of machinery.

Ergonomic principles shall be applied (see EN 614-1:2006+A1:2009).

Comprehensive information on safe cleaning procedures shall be given in the instruction handbook (see 6.2.3 h)).

4.3.3 Hazards due to transmission system

Hazards due to transmission shall be prevented by one or more of the following:

— fixed guards in accordance with EN ISO 14120:2015;

— interlocking guards with a performance level $PL_r = c$ and positioned according to EN ISO 13855:2010, Clause 9.

Safety distance shall be in accordance with EN ISO 13857:2008, Table2, Table 3 and Table 4.

4.3.4 Hazards at secondary rollers

Access to secondary rollers shall be prevented by one or more of the following:

— positioning of the secondary rollers at a height equal or more than 2 700 mm over the standing level;

— positioning of the secondary rollers in relation to the calender rolls, the other rollers or fixed parts so that the distances given in EN 349:1993+A1:2008, Table 1 for arm are complied with;

— fixed guards in accordance with EN ISO 14120:2015 or fixed part of the machine acting as fixed guards and positioned according to EN ISO 13857:2008, Table 2, Table 3 and Table 4 or to 4.3.1.2;

— interlocking guards in accordance with EN ISO 14119:2015 or interlocking guards with guard locking in accordance with EN ISO 14119:2015. Safety distance shall be in accordance with EN ISO 13857:2008, Table 2, Table 3 and Table 4. The type of interlocking shall be selected in accordance with EN ISO 14119:2013;

— trip devices in accordance with 4.3.1.4.

Opening of an interlocking guard or voluntary or involuntary actuation of a trip device shall bring the rollers to rest or cause roller separation so that the distances given in EN 349:1993+A1:2008 according to Table 1 for arm are complied with.

Interlocking guards or trip devices

— shall stop or cause automatic rolls separation according to PL_r = d;

— shall be positioned according to EN ISO 13855:2010.

The unlocking signal of the guard locking shall be in accordance with PL_r = c.

The stop and the separation of the secondary rollers shall not create additional hazards due to the incoming material.

After separation, the rollers that could drop by gravity shall be secured in the opened position, e.g. using a check valve, and unintentional closing shall be prevented. Release shall only be possible by manual action. A separate manual reset shall be installed in a position giving full view of the danger zone. The actuation of the manual reset shall not result in any movement of the secondary rollers.

4.3.5 Hazards due to ancillary equipment

4.3.5.1 Cutting hazards due to involuntary contact with the cutting edges of strip cutting devices

Unless the cutting edges are inherently safe due to their location, they shall be protected against involuntary contact; see also 6.2.3 i).

Only the part necessary to cut during operation shall be uncovered.

4.3.5.2 Cutting, shearing and crushing hazards caused by movements of the strip cutting devices (with cutting or non-cutting edges) and their actuating mechanisms

Movement of the strip cutting devices from the rest position to the working position shall only be effected:

— manually, provided that both hands are required in order to achieve the movement, e.g. two mechanical devices activated simultaneously; or

— by a hold-to-run control device according to PL_r = c situated at least 2 m from the strip cutting device in the rest position; or

— by a two-hand control device in accordance with EN 574:1996+A1:2008, Type I positioned in accordance with EN ISO 13855:2010, Clause 8.

Cutting, shearing or crushing hazards due to the contact of strip cutting devices against the calendar roll or secondary rollers shall be prevented by positioning of the strip cutting device at a height equal or more than 2 700 mm over the standing level or by guards positioned in accordance with EN ISO 13857:2008, Table 2.

Where guards are used, they shall be interlocking guards with guard locking or fixed guards. The interlocking shall be designed so that:

— it is not possible to open the guard before the strip cutting device is in its rest position or the calender rolls or secondary rollers have come to rest; and

— the machine cannot be started until the strip cutting device is in its rest position or the guard is closed and locked.

The SRP/CS shall be in accordance with PL_r = c.

The setting of the strip cutting devices shall be performed:

— with the guard closed, or;

— with the guard open if all of the following conditions are fulfilled:

  — the calender rolls or secondary rollers have come to rest;

  — a specific operational mode is activated by a mode selector in accordance with 4.2.1 and EN ISO 12100:2010, 6.2.11.9 in accordance with PL_r = c;

  — movements are controlled by a hold-to-run control device according to PL_r = c situated at least 2 m from the strip cutting device in the rest position with a good visibility.

See also 6.2.3 i).

4.3.5.3 Stock guides

When the calendar is equipped with stock guides, the gap between the calender rolls and the stock guides shall not exceed 4 mm during normal operation and the working position of the stock guides shall be detected. Operation of the calender shall be possible only if the stock guides are in the working position. This safety function shall be in accordance with PL_r = c.

Where gravity fall hazard exists, this hazard shall be prevented by a restrain device (e.g. a check valve). Where control circuit is involved it shall be in accordance with PL_r = c.

4.3.5.4 Feed conveyor

The feed conveyor shall be in accordance with EN 619:2002+A1:2010 to prevent hazards created by in running nips.

To prevent hazards related to the movement of the reciprocating feed conveyor, one or more of the following shall be provided (see Figure 8):

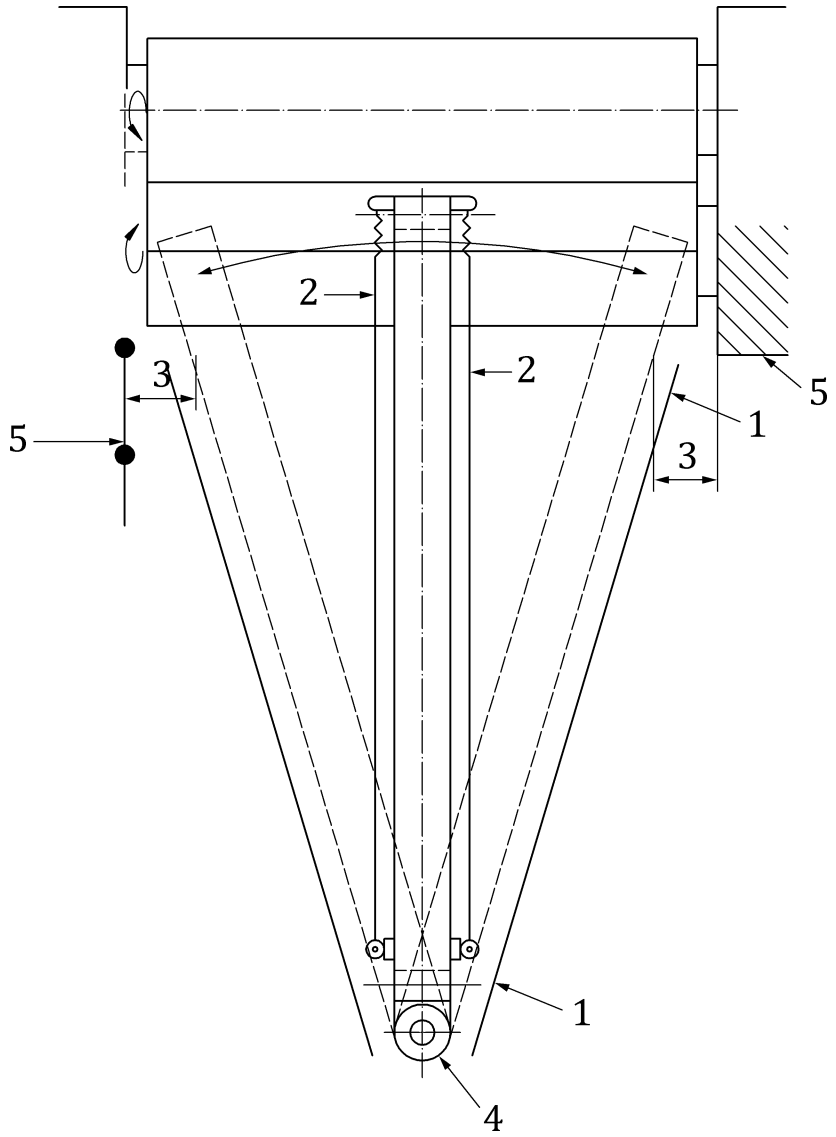
— fixed guards in accordance with EN ISO 14120:2015, positioned in accordance with EN ISO 13857:2008, Table 2, Table 3 and Table 4;

— pressure sensitive mat or floor or trip devices in accordance with, 4.3.1.5 or 4.3.1.6 that cause the stopping of the conveyor;

— minimum gaps between the conveyor and fixed parts in accordance with EN 349:1993+A1:2008, Table 1 for arm;

— limitation of the force actuating the reciprocating movement of the conveyor to 150 N.

Control circuit related to pressure sensitive mat or floor or trip devices or if involved in force limitation shall stop the conveyor according to PL_r = c.



Key

1 fixed guard
2 trip devices
3 application of EN 349:1993+A1:2008
4 limitation of force
5 fixed parts

Figure 8 — Reciprocating feed conveyor, examples of methods of protection

4.3.5.5 Powered moveable infrared unit

When the calendar is equipped with powered moveable infrared heating unit, the dangerous movement shall be prevented by one of the following:

— a hold to run control device giving good visibility and in accordance with PL_r = c, 2 m away;

— a two-hand control device in accordance with EN 574:1996+A1:2008, Type I positioned in accordance with EN ISO 13855:2010, Clause 8;

— interlocking guards with a performance level PL_r = c, in accordance with EN ISO 14119:2013 and positioned in accordance with EN ISO 13855:2010, Clause 9;

— fixed guards in accordance with EN ISO 14120:2015.

Safety distances for guards shall be in accordance with EN ISO 13857:2008, Table 2 and Table 3 and Table 4.

4.3.6 Powered movement for engaging/disengaging the calender

To prevent impact and crushing hazards related to the powered movement of the complete calender one or more of the following shall be adopted:

— interlocking guards in accordance with EN ISO 14119:2013 and positioned in accordance with EN ISO 13855:2010, Clause 9;

— fixed guards in accordance with EN ISO 14120:2015;

— pressure sensitive mat or floor in accordance with EN ISO 13856-1:2013, positioned in accordance with EN ISO 13855:2010, Clause 7;

— light curtains in accordance with EN 61496-1:2013 type 3 or type 4 positioned in accordance with EN ISO 13855:2010, Clause 6 and/or scanners in accordance with CLC/TS 61496-3:2008, type 3.

Safety distances for guards shall be in accordance with EN ISO 13857:2008, Table 2, Table 3, Table 4 and Table 7.

Control circuit shall stop the movement of the complete calender according to PL_r = c.

If the interlocking function of guards and protective devices is inhibited using a mode selector for mode selection in accordance with 4.2.1 with a control mode in accordance with EN ISO 12100:2010, 6.2.11.9 according to PL_r = c:

— a hold-to-run control device shall be provided allowing only movement of the machine at a maximum speed of 100 mm/s in accordance with PL_r = c, and

— an automatically operated acoustic and/or optical signalling device shall be provided giving warning of imminent movement of the machine (see 6.2.3 p)).

Unexpected movement of the calender shall be prevented securing the transport wheels on the floor, e. g. by providing a brake or clamping elements.

4.4 Stability

4.4.1 Hazards due to gravity fall following roll separation

Where rolls gravity fall hazard exists, a device (e.g. a check valve) shall be installed to prevent falling under gravity. Where control circuit is involved it shall be in accordance with PL_r = c.

4.4.2 Stability of the calender

The designer of a calender shall ensure stability including dynamic loads either by design or by provision of fixing points to allow connection to the floor or foundation (see 6.2.3 q)).

4.5 Electrical hazards

4.5.1 Electrical shock or burns caused by direct or indirect contact with live parts

Electrical equipment shall comply with EN 60204-1:2006, and in particular the requirements given in EN 60204-1:2006, 6.2 for protection against direct contact and EN 60204-1:2006, 6.3 for protection against indirect contact.

4.5.2 Electrical shock, or fire due to electrostatic discharge

Machinery shall be so designed and constructed to prevent or limit the built-up of potentially dangerous electrostatic charges and/or be fitted with a discharging system.

Generation of electrostatic charges shall be prevented by appropriate measures such as creating or using conductive surfaces which are inter-connected and earthed or by using ionization equipment.

See also 6.2.3 j).

4.6 Thermal hazards

4.6.1 Burns from contact with hot parts of the calender or hot materials

To prevent burns through involuntary contact with hot parts of the calender, fixed guards, thermal shields or insulation shall be provided so that the burn thresholds as specified in EN ISO 13732-1:2008 are not exceeded. Where access to hot parts is not prevented due to technical reasons, those parts shall be identified by warning signs.

If hot materials are accessible outside the means of protection provided for the hot parts of the calender, warning signs shall be fixed near to the access points. In addition, instructions shall be given in the instruction handbook (see 6.2.3 k). See also 6.3.

4.6.2 Scalds from ejection of heat transfer fluid

To protect the operators against scalding from heat transfer fluid in the event of hose rupture, solid enclosing guards or solid screens shall be placed to protect zones where persons are working or passing.

The ends of hoses conveying fluids with a pressure higher than 5 MPa shall be fitted with additional restraining devices in accordance with EN ISO 12100:2010, 6.2.12.2.

4.6.3 Burns from infrared radiation

Hazards due to burn from infrared radiation shall be eliminated by installing a shield or by distance.

Radiation emissions shall be established at the lowest level according to EN 12198-1.

4.7 Protection against fire

When infrared radiation unit is present, machine shall be designed that no flammable material shall have contact with hot parts that can generate fire.

4.8 Hazards due to noise

4.8.1 Main noise sources

The main sources of noise are:

— motor drives;

— power transmission systems;

— pneumatic systems;

— pressure relieving valves/exhaust systems;

— ventilation systems;

— hydraulic unit;

— control valves;

— pipelines.

In addition, noise can be generated by ancillaries and by the process itself.

4.8.2 Noise reduction at source by design

Calenders shall be designed and constructed so that risks resulting from the emission of airborne noise are reduced to the lowest level, taking account of technical progress and the availability of means of reducing noise, in particular at source; see EN ISO 11688-1:2009.

NOTE EN ISO 11688-2 provides useful information on noise generation mechanisms.

For the drive and transmission unit(s) noise reduction shall be achieved by selecting low noise components. Low noise cooling systems should be used to reduce the noise levels.

4.8.3 Noise reduction by devices

The pneumatic systems shall be fitted with noise reduction devices (e.g. silencers on the air inlets/outlets, vent silencers on the pneumatic systems, in particular on the exhaust).

See 6.2.4.

4.8.4 Information connected with noise hazards

See also 6.2.4 and Annex A.

4.9 Hazards generated by neglecting ergonomic principles

The calender and its control actuators shall be designed to provide a good, not fatiguing work posture.

As the embossing roll or rollers have to be changed frequently, a mechanical handling device shall be provided to assist in changing it. See also 6.2.3 l).

See also EN ISO 12100:2010, 6.2.8.

See 6.2.3 n) for calendar where a pit is necessary for start-up operation.

4.10 Hazards due to unexpected start-up

Prevention of unexpected start-up shall be achieved in accordance with EN ISO 14118:2018 and EN 60204-1:2006, 5.4.

4.11 Slip, trip and fall hazards

Designated elevated working positions on the calenders shall be provided with safe means of access (see Figure G.1).

See also EN ISO 12100:2010, 6.3.5.6.

Means of access shall be in accordance with EN ISO 14122-1:2016, EN ISO 14122-2:2016, EN ISO 14122-3:2016, EN ISO 14122-4:2016.

4.12 Hazards generated by the materials being processed

The machine shall be so designed that a local exhaust ventilation system can be positioned without modification to the machine, for the extraction of harmful substances when emitted.

See 6.2.3 o).

4.13 Hazards due to electromagnetic interference

Electronic control systems shall be designed and installed so as to be protected from electromagnetic interference and stable when exposed to operation or a failure of the electrical system in accordance with EN 61000-6-2:2005.

During installation of electrical and electronic components, the machine manufacturer shall follow the information for use provided by the manufacturer of those components.

5 Verification of the safety requirements and/or measures

5.1 Verification of compliance with the safety requirements and/or measures shall be undertaken as shown in Table 1.

5.2 In Table 1 functional testing includes the verification of the function and efficiency of the guards and protective devices on the basis of:

— descriptions given in the information for use;

— safety related design documents;

— the requirements given in Clause 4 and in the other quoted standards.

Table 1 — Verification methods

Subclause	Safety measure	Verification method			
		Visual inspection	Functional testing	Measurement	Calculation
4.1	Hydraulic and pneumatic equipment	X	X	X	X
4.2.1	Control mode	X	X		
4.2.2	Start device	X	X		
4.2.3	Stop device	X	X		
4.2.4	Emergency stop equipment	X	X	X	X
4.2.5	Stopping of the rolls		X	X	
	Ability to separate the rolls		X		
4.2.6	Stopping of calender rolls	X	X	X	X
4.2.7	Rescue reverse movement	X	X	X	X

Subclause	Safety measure	Verification method			
		Visual inspection	Functional testing	Measurement	Calculation
4.3.1.1	Restart and manual reset	X	X		
	Additional safety measures	X	X	X	
	Interlocking guards closed or trip devices not actuated		X		
	Hold-to-run device and speed limited	X	X	X	X
4.3.1.2	Fixed guard	X		X	
	Feeding device	X	X	X	
4.3.1.3	Interlocking guard	X	X	X	X
	Feeding device acting as interlocking guards with guard locking	X	X		
4.3.1.4	Trip bar	X	X	X	X
	Additional fixed guards below the trip bar	X		X	
	Additional interlocking guards with guard below the trip bar	X	X	X	X
4.3.1.5	Other mechanically actuated trip devices	X	X	X	X
4.3.1.6	Non-mechanically actuated trip device, e.g. light curtains or scanners	X	X	X	X
4.3.1.7.1	Specific control mode	X	X	X	X
4.3.1.7.2	Specific control mode	X	X	X	X
4.3.1.7.3	Specific control mode	X	X	X	X
4.3.1.7.4	Specific control mode	X	X	X	X

Subclause	Safety measure	Verification method			
		Visual inspection	Functional testing	Measurement	Calculation
4.3.1.8	Auditory warning signal		X	X	
	Mode selector	X	X		X
	Hold-to-run control forward mode	X	X	X	X
	Reduced speed		X	X	X
	Rolls gap		X	X	
	Flashing warning light	X	X		
	Hold-to-run control reverse mode	X	X	X	X
	Reduced speed		X	X	X
4.3.1.9	Combination of two protective devices	X	X	X	X
4.3.2	Cleaning without operator entering the danger zone	X			
	Crushing zones not accessible or safeguarded	X	X	X	
	Special control mode	X	X	X	
	Safe means of access	X		X	X
	Ergonomic	X		X	
4.3.3	Fixed guard	X		X	
	Interlocking guards	X	X	X	X
4.3.4	Distance			X	
	Positioning			X	
	Fixed guard	X		X	
	Interlocking guard	X	X	X	X
	Trip device	X	X	X	X
	Gravity	X	X		X
4.3.5.1	Involuntary contact	X		X	

Subclause	Safety measure	Verification method			
		Visual inspection	Functional testing	Measurement	Calculation
4.3.5.2	Necessity for two hands to make the movement of the strip cutting device	X	X		
	Hold-to-run control device	X	X	X	X
	Two-hand control device	X	X		X
	Safety distance	X		X	
	Fixed distance guards	X		X	
	interlocking guards with guard locking	X	X	X	X
4.3.5.3	Stock guides			X	X
4.3.5.4	Fixed guards	X			
	Trip devices	X	X	X	X
	Minimum gaps			X	
	Limitation of force			X	X
4.3.5.5	Hold-to-run control device	X	X	X	X
	Two-hand control device	X	X		X
	Interlocking guards	X	X	X	X
	Fixed guards	X			
4.3.6	Safety fence	X			
	Interlocking guards	X	X	X	X
	Hold-to-run control device	X	X	X	X
	Acoustic and/or optical signalling device	X	X		
	Braking system	X	X		X
4.4	Device preventing a gravity fall	X	X	X	X
4.5	Electrical hazards	X	X	X	
4.6.1	Fixed guard, thermal shield, insulation	X		X	
	Warning signs	X			

Subclause	Safety measure	Verification method			
		Visual inspection	Functional testing	Measurement	Calculation
4.6.2	Solid enclosing guards or screens	X			
	Restraining devices	X			
4.6.3	Shield or distance	X			
	Radiation			X	
4.7	Fire	X			
4.8	Noise	X		X	
4.9	Neglecting ergonomic principles	X		X	
4.10	Prevention of unexpected start-up		X		
4.11	Safe means of access	X		X	X
4.12	Possibility for an exhaust ventilation system	X			
4.13	Electromagnetic interference	X	X		X

6 Information for use

6.1 General

Information for use shall be provided in accordance with EN ISO 12100:2010, 6.4.

6.2 Instruction handbook

6.2.1 General

Each calender shall be accompanied by a handbook giving general instructions for use in accordance with EN ISO 12100:2010, 6.4.5 and the following information and instructions:

6.2.2 Information on the design of the machine:

— The values of reduced speed v_r, maximum speed v_{max};

— the values of stopping angles α, α_{max} ;

— a list of the protective devices the position of which shall not be modified by the user.

6.2.3 Instructions:

a) Instructions about procedures for measuring the stopping angles and about the method and frequency of brake testing.

These instructions shall specify the measures to be taken for the readjustment of the braking system to ensure that:

1) the measured stopping angle never exceeds the specified stopping angle α;

2) the measured stopping angle in the event of failure of the energy supply never exceeds α_{max} (see 4.2.6).

If the braking system consists of a mechanical brake and a power operated brake the instructions shall cover both the testing of the complete braking system and the testing of the mechanical brake alone;

b) instructions about rescue reverse movement (see 4.2.7);

c) instructions about the method and frequency of functional testing of the trip bar (see 4.3.1.4) or the combination of two protective devices (see 4.3.1.9);

d) instructions about the correct use of the trip bar, specifying that this bar shall not be used to achieve normal stopping during production;

e) instructions about the limits of the danger zones and the warning notice mentioned in 6.3, stressing that after installation of the calender nothing shall be used to allow the operator to stand above the floor or working platform;

f) instructions for safe procedures for machine start-up, setting, process changeover, fault finding and maintenance operations (see 4.3.1.8 and 4.3.1.9);

g) instructions for safe setting-up gap between the rollers (see 4.3.1.7.3);

h) instructions for safe cleaning procedures on the rolls (see 4.3.2);

i) instructions for safe procedures for knife setting and changing (see 4.3.5.1 and 4.3.5.2);

j) instructions about additional earthing connections required because of the hazards due to electrostatic discharge (see 4.5.2);

k) if applicable, instructions about the provision of personal protective equipment where eye and/or skin contact with harmful materials or substances is possible e.g. protective gloves, against burns due to contact with hot machine parts or hot materials;

l) instructions for safe procedures for roll or roller changing;

m) instructions for use of the roll separation device independent of normal energy sources mentioned in 4.2.5;

n) instructions for the dimension of the pit, if needed;

o) instructions about the fitting or positioning of a local exhaust ventilation system should be given to the user, indicating that the local exhaust ventilation system should be positioned under the responsibility of the user if harmful emissions can be expected due to certain materials being processed. The installation of a local exhaust ventilation system should take into account the assembly and dismantling of the calender rolls.

p) instructions for safe procedures when a warning device is activated;

q) instructions for safe transportation and installation (floor conditions, foundations, fixing points, services, anti-vibration mountings, lighting, etc.).

6.2.4 Noise emission

The instruction handbook, the technical documentation and the sales literature describing the calenders shall:

— give the declared noise emission values of the calenders in accordance with the noise test code specified in Annex A;

— refer to the noise test code specified in Annex A upon which the determination of the noise emission values of the calenders is based and state which basic noise measurement standards have been used;

— contain information on possible methods of installation to minimize noise emission, in particular the installation of acoustic screens;

— recommend the wearing of personal hearing protection because calenders usually operate in a line with other noisy machines.

6.3 Marking

Each calender shall be marked at least with:

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

— designation of the machinery;

— mandatory marking[1)];

— designation of series or type;

— serial number if any, or machine number;

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

— warning signs indicating hot surfaces (see 4.6.1).

For hot parts a warning plate shall alert about the hot temperature according to warning sign W017 of ISO 7010:2011.

Additionally, on calenders equipped with trip bars according to 4.3.1.4:

— the limits of the danger zones shall be clearly and permanently marked on the machine frame at both ends of the calender rolls by lines (arcs of circle) not less than 10 mm wide and extending unto the level of the roll surfaces;

— the machine shall bear the following notice close to the trip bars: “This calender is not safe for persons who can reach beyond the limits marked on the machine frame without actuating the trip bar”.

1) For machines and their related products intended to be put on the market in the EEA, CE marking as defined in the applicable European directive(s), e.g. Machinery, Lifts, Outdoor Noise, Explosive Atmospheres ATEX, Pressure Equipment.

Annex A
(normative)

Noise test code

A.1 Introduction

This noise test code specifies all the information necessary to carry out efficiently and under standardized conditions the determination, declaration and verification of the airborne noise emission values of calenders.

The determination of these quantities is necessary for:

— manufacturers to declare the noise emitted;

— comparing the noise emitted by machines in the family concerned;

— purposes of noise control at source at the design stage.

It specifies the noise measurement methods and operating and mounting conditions for the test.

The use of this noise test code ensures the reproducibility of the measurements and the comparability of the airborne noise emission values within specified limits determined by the grade of accuracy of the basic measurement method used. Noise measurement methods allowed by this noise test code are accuracy grade 2 (engineering grade) methods. If this is technically not possible accuracy grade 3 (survey grade) methods may be used stating the justification for the use of such a method.

A.2 Determination of the A-weighted emission sound pressure level at workstation(s)

A.2.1 Basic standards and measurement procedure

The determination of the A-weighted emission sound pressure level shall be carried out using one of the standards EN ISO 11201:2010 with grade 2 of accuracy, EN ISO 11202:2010 with grade 2 of accuracy or EN ISO 11204:2010 with grade 2 of accuracy.

NOTE Useful information about the various methods for measuring the A-weighted emission sound pressure level at workstations can be found in EN ISO 11200:2014.

For calenders where there are no defined workstations, microphone positions shall be located at 1m from the contour of the machine and at a height of 1,6 m. The highest value measured and the location where it is observed shall be recorded, reported and declared.

For calenders which are manually loaded and unloaded by an operator the determination of the A-weighted emission sound pressure level shall be carried out at all designated operators' positions defined by the manufacturer in the instruction handbook. The measurement duration shall be as follows:

— if the noise emission is steady, the duration interval shall be at least 10 s;

— if the calender runs in a continuous mode but with impulsive sound emissions, the duration shall be at least 1 min.

If it is not possible to use an engineering method (grade 2 of accuracy), a survey method (e.g. EN ISO 11202:2010 with grade 3 of accuracy) may be used stating the justification for the use of such a method.

A.2.2 Measurement uncertainty

If a grade 2 (engineering) method is used, the standard-deviation of reproducibility for A-weighted levels is:

σ_{RA} = 1,5 dB, resulting in a measurement uncertainty of 3 dB if the operating conditions of the machine are stable, which is normally the case for calenders.

The measurement uncertainty can be much higher if a grade 3 (survey) method is used and/or the operating conditions of the machine are not stable.

NOTE Detailed information about uncertainty is given in EN ISO 11201:2010, Clause 11, EN ISO 11202:2010, Clause 12 and EN ISO 11204:2010, Clause 11. See also EN ISO 4871:2009.

A.3 Determination of the A-weighted sound power level

A.3.1 Basic standards and measurement procedure

For calenders that emit an A-weighted sound pressure level at workstation(s) higher than 80 dB, the sound power level shall also be measured.

The determination of the A-weighted sound power level shall be carried out using one of the standards EN ISO 3744:2010 or EN ISO 9614-2:1996 with grade 2 of accuracy.

If it is not possible to use an engineering method (grade 2 of accuracy), a survey method (e.g. EN ISO 3746:2010 with grade 3 of accuracy) may be used stating the justification for the use of such a method.

When EN ISO 3744:2010 or EN ISO 3746:2010 is used the measurement surface shall be a parallelepiped and the measurement distance shall be 1 m.

The measurement duration shall be as follows:

— if the noise emission is steady, the measurement duration shall be at least 10 s;

— if the calender runs in a continuous mode but with impulsive sound emissions, the duration shall be at least 1 min.

A.3.2 Measurement uncertainty

If a grade 2 (engineering) method is used, the standard-deviation of reproducibility for A-weighted levels is:

σ_{RA} = 1,5 dB, resulting in a measurement uncertainty of 3 dB if the operating conditions of the machine are stable, which is normally the case for calenders.

The measurement uncertainty can be much higher if a grade 3 (survey) method is used and/or the operating conditions of the machine are not stable.

NOTE EN ISO 4871:2009 provides a method for deriving the total measurement uncertainty from the value of the standard deviation of reproducibility.

A.4 Mounting and operating conditions

During the noise test the machine shall be mounted and operated as specified/recommended by the manufacturer in the instruction handbook.

For the noise test the machine shall be operated unloaded but in a working condition (e.g. ready to process material) and at maximum rotation speed.

Noise emission measurement shall be made by the manufacturer in collaboration with the user. Under different operating conditions the noise level can differ and can be higher.

Noise emission of calenders without material may not be representative of real use of the machine because the noise added by the processing material may increase noise emission significantly.

This is why manufacturers shall also provide to the user information on noise emission with load resulting from measurements at user's premises and/or at their test centre. This information shall consist of noise emission values or estimated increases of noise emission compared to no load conditions.

NOTE Noise due to the process depends on the design of the machine and material/product characteristics, e.g. temperature, torque.

From no load and under load noise emission data, manufacturers will be able:

— to assess the effectiveness of the noise control measures they implement at the design stage;

— to inform a user about noise emission values that can be expected in conditions of use that are of interest to the user and, consequently, will help him to compare noise emissions of calenders on the market and to make his risk assessment for noise.

A.5 Information to be recorded and reported

A.5.1 General

The information to be recorded and reported shall include all the data required by the basic measurement standards used i.e. precise identification of the machine under test, acoustic environment, instrumentation, presence and position(s) of the operator(s) if any. If there is any deviation to this test code this shall be recorded, reported and declared.

The operating conditions of the machine during measurement and the methods that have been used for the measurement shall be indicated.

At least the data specified in A.5.2 to A.5.5 shall be recorded and reported.

A.5.2 General data

— Type, serial number if any, year of manufacture of the machine;

— date of test, location, person in charge;

— ambient temperature.

A.5.3 Mounting and operating conditions

Mounting and operating conditions during noise measurement:

— parameters of the drive system;

— rotation speed of the rolls;

— list of ancillary equipment in operation during measurement (local exhaust ventilation system, hydraulic power unit, etc.).

A.5.4 Standards

The measurement standard(s) that have been used.

A.5.5 Noise data

— Location of measurement positions;

— determined noise emission values and associated uncertainty.

A.6 Declaration and verification of noise emission values

The noise declaration shall be a dual-number declaration as defined in EN ISO 4871:2009, i.e. the measured value and the measurement uncertainty shall be indicated separately. It shall include the following:

— the A-weighted emission sound pressure level at workstations and the value of the associated measurement uncertainty, where this exceeds 70 dB(A); where this level does not exceed 70 dB(A), this fact shall be indicated; and

— the A-weighted sound power level emitted by the machinery and the value of the associated measurement uncertainty, where the A-weighted emission sound pressure level at workstations exceeds 80 dB(A).

The noise declaration shall mention explicitly that noise emission values have been obtained according to this noise test code. It shall indicate which basic measurement standards have been used and give details of the mounting and operating conditions of the machine during the determination of its noise emission. The noise declaration shall clearly indicate deviation(s) from this noise test code and/or from the basic measurement standards used if any.

The technical sales literature providing performance data of the machine shall give the same information on noise as that declared in the instructions.

If undertaken, the verification of declared values of noise emission shall be carried out according to EN ISO 4871:2009, 6.2 by using the same mounting and operating conditions as those used for the initial determination of noise emission values.

Table A.1 gives an example of noise emission declaration for a calender that fulfils the requirements of this annex.

Table A.1 — Example of noise emission declaration for a calender in accordance with this annex

Machine model number and other identifying information: Type XXX, Model XXX, 50 Hz, 230 V	
DECLARED DUAL-NUMBER NOISE EMISSION VALUES in accordance with EN ISO 4871 **No load condition*** — type and power of the main motor(s): …… — maximum rotational speed of the calender rolls, v_{max}: …… — number of rolls: ……	
Measured A-weighted sound power level, L_{WA} (ref. 1 pW), in decibels	XXX
Uncertainty, K_{WA}, in decibels	XXX
Measured A-weighted emission sound pressure level, L_{pA} (ref. 20 µPa) at the operator's position in decibels	XXX
Uncertainty, K_{pA}, in decibels	XXX
* Values determined according to the noise test code given in Annex A of FprEN 12301:2018, using the basic standards EN ISO 11202:2010 (Grade 2) and EN ISO 3744:2010.	

Machine similar to the one above with similar operating conditions **loaded with the following products**: Product 1: *detailed description of product and operating conditions of the machine* Product 2: *detailed description of product and operating conditions of the machine*		
	Product 1 Measured values	Product 2 Increase of level in decibels compared to no load conditions (estimated by manufacturer from his experience)
A-weighted emission sound pressure level, L_{pA} (ref. 20 µPa) at the operator's position, in decibels	XXX	XXX

In this example, the manufacturer provides the user with noise emission data under load for two different products that are of interest to the user.

Annex B
(informative)

List of significant hazards

This annex contains all the significant hazards, hazardous situations and events identified by risk assessment as significant for this type of machinery and which require action to eliminate or reduce the risk.

Table B.1 — List of significant hazards

Significant hazards	Applicable subclauses
Mechanical hazards	
Hazard of drawing-in and/or crushing between the calender rolls between a calender roll and the material or between a calender roll and a fixed part of the machine	
Such hazards exist: — during start-up; — in forward movement during production operations, including during feeding operations of rubber bands and cords or textile; — during reverse operation; — during cleaning or polishing operations; — during machine setting, process changeover fault finding, and gap setting.	4.2.2 4.2.3 4.2.4 4.2.6 4.2.7 4.3.1 4.3.2 4.3.3 4.3.4
Hazard of drawing-in and/or crushing due to rolls closing movement	4.3.1.1 4.3.1.7.3
Hazards at the calender rolls for manual feeding of the calender rolls during hot lamination	4.3.1.7.4
Hazards due to transmission system	
Hazards of entanglement due to the rotation of the transmission system, e.g. gears, belts …	4.3.3
Hazard of drawing-in and/or crushing at secondary rollers	4.3.4
Hazards due to ancillary equipment	
Cutting hazards due to involuntary contact with the cutting edges of cutting devices	4.3.5.1
Cutting, shearing and crushing hazards caused by movements of the strip cutting devices (with cutting or non-cutting edges) and their actuating mechanisms	4.3.5.2
Drawing-in and/or crushing between calender rolls and the stock guides	4.3.5.3
Impact and/or crushing caused by movement of the reciprocating feed conveyor	4.3.5.4
Impact and/or crushing caused by movement of infrared heating unit	4.3.5.5

Significant hazards	Applicable subclauses
Impact and/or crushing hazards due to the powered movement of the calender unit	4.3.6
Hazard of crushing to the gravity fall of a roll when separated	4.4
Electrical hazards	
Electrical shock or burns caused by direct or indirect contact with live conductive parts	4.5.1
Electrical shock, or fire due to electrostatic discharge	4.5.2
Thermal hazards	
Burns from contact with the hot parts of the calender or hot materials	4.6.1
Scalds from ejection of heat transfer fluid as a result of rupture of hoses and/or hose assemblies	4.6.2
Burns from infrared radiation emitted from the infrared heating unit, if integral part of the calender	4.6.3
Fire hazards due to infrared unit	
Fire due to flammable material on the infrared heating unit.	4.7
Hazards generated by noise	
Hazards from high noise levels resulting for example in hearing impairment, tinnitus, tiredness, stress, loss of balance or awareness, interference with speech communications or with the perception of acoustic signals.	4.8
Hazards generated by neglecting ergonomic principles	
Mismatch of machinery with human characteristics and abilities generating hazards, for example, by unhealthy postures or excessive efforts, especially when changing the embossing roll or roller or during start-up operation.	4.9
Hazards due to failure of energy supply	
Hazard of drawing-in and/or crushing due to malfunctioning of protective devices following failure of the energy supply.	4.2.5 4.10
Hazards due to failure of safety related parts of the control systems	
Such hazards can result for example, from: — unexpected start-up; — failure of the control modes for setting, start-up, process changeover, cleaning, fault finding, maintenance, reverse operation; — unexpected speed change; — failure of one or more protective devices.	4.2.1
Slip, trip and fall hazards	
Injury caused by slipping, tripping and falling on or from working positions or the means of access thereto.	4.11
Hazards generated by the materials being processed	
Contact with and/or inhalation of harmful gases, vapour, fumes or dust which may be released from the materials processed.	4.12
Hazards due to electromagnetic interference	
Malfunction of the control circuits due to electromagnetic interference with the electrical equipment.	4.13

Annex C
(informative)

Examples of different types of calenders

For Figures C.1 to C.5 the rolls may be of different diameters.

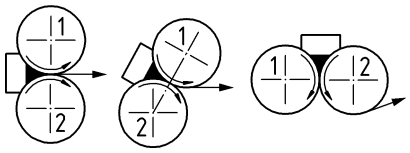


Figure C.1 — 2-roll calenders

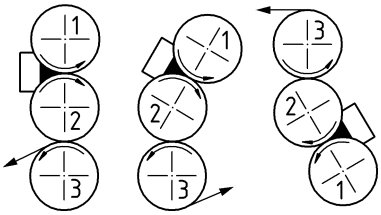


Figure C.2 — 3-roll calenders

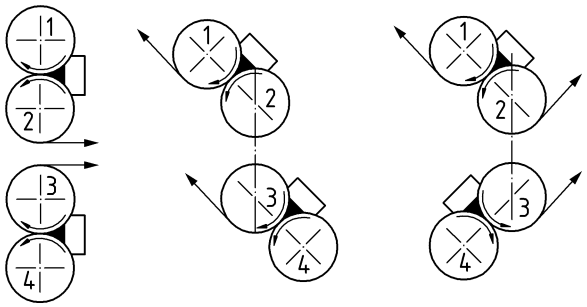


Figure C.3 — Calenders with 2 + 2 rolls

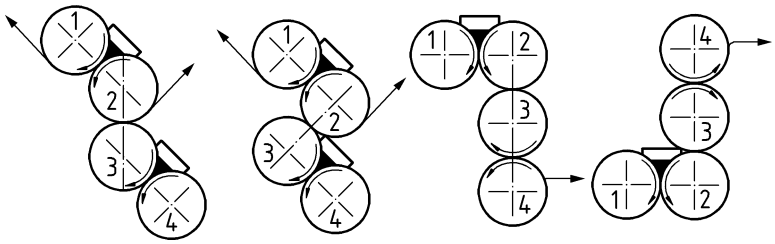


Figure C.4 — 4-roll calenders

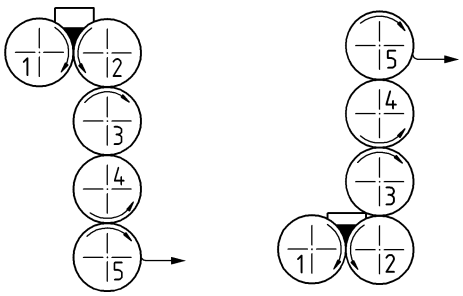


Figure C.5 — 5-roll calender

Annex D
(informative)

Examples of calendering processes

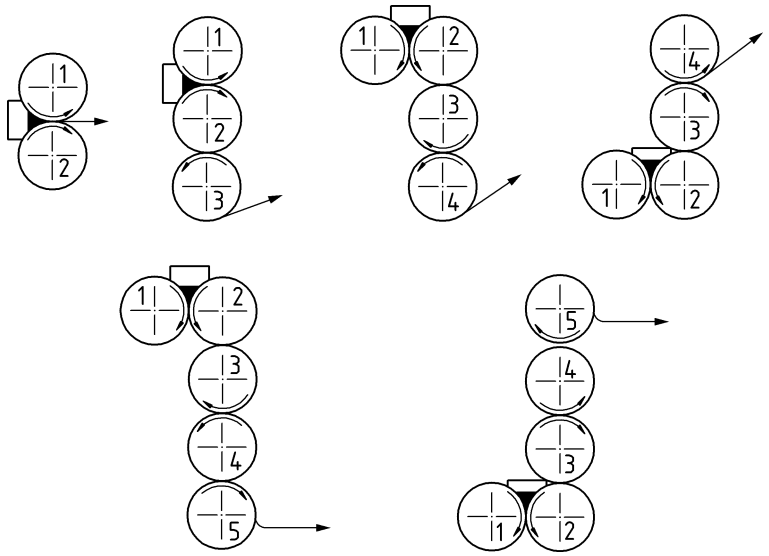


Figure D.1 — Sheet drawing

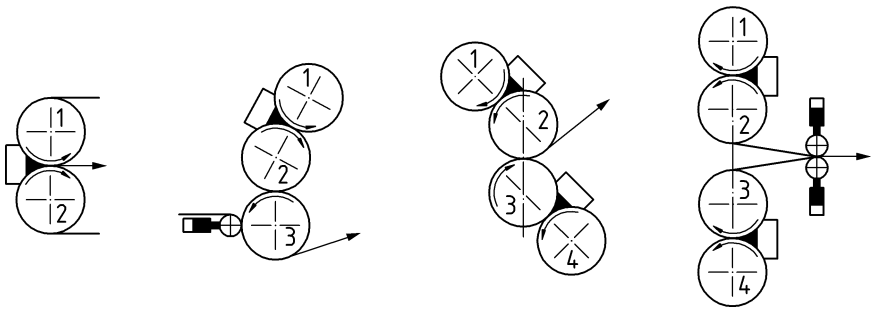


Figure D.2 — Sheet doubling

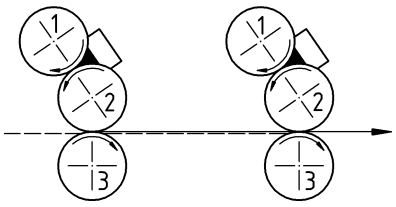


Figure D.3 — Coating one side and doubling

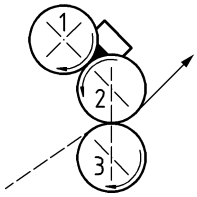


Figure D.4 — Coating one side

Figure D.5 — Coating both sides

Annex E
(informative)

Calculation of dimension L of the crushing zone (for rolls of equal diameters)

O,O' : roll axes

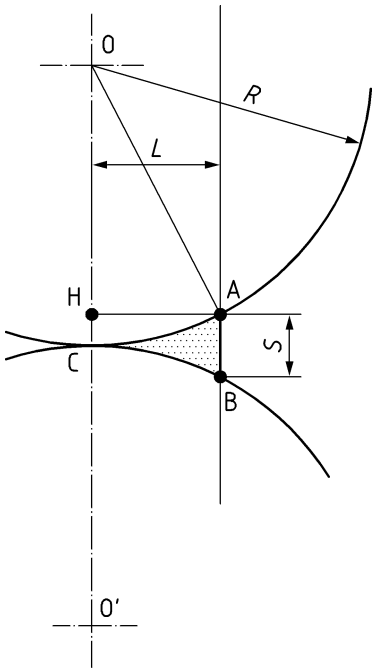
C : theoretical roll contact point

OA : roll radius (OA = *R*)

AB : crushing zone entry (AB = *S* = 12 mm)

H : projection of A on axis OO'

AH : depth of the crushing zone (AH = *L*)



$OA^2 = OH^2 + AH^2$

$AH^2 = OA^2 - OH^2$

where

OA = R and

OH = R – S/2 and

AH = L

$$L = \sqrt{\left(2R - \frac{S}{2}\right)\frac{S}{2}}$$

where

$S = 12$

$$L = \sqrt{12 \times R - \frac{144}{4}}$$

$L = \sqrt{12 \times (R - 3)}$ which may be simplified as

$L \approx \sqrt{6 \times D}$

Example:

If $R = 300$ (roll diameter = 600 mm)

$L = 60$

D, *L*, *S* and *R* are expressed in millimetres

Figure E.1 — Dimensions used for calculation

Annex F
(informative)

Fixed guards at the crushing zone

Linear dimensions in millimetres

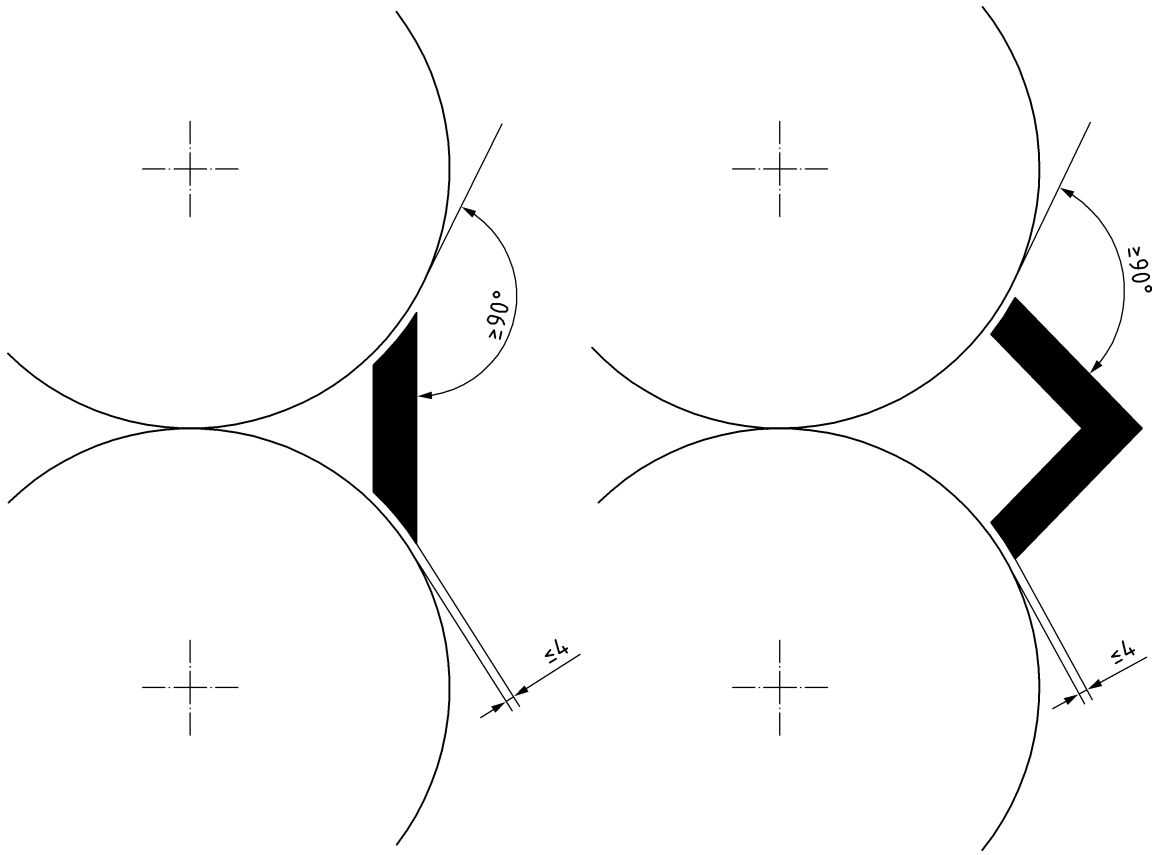
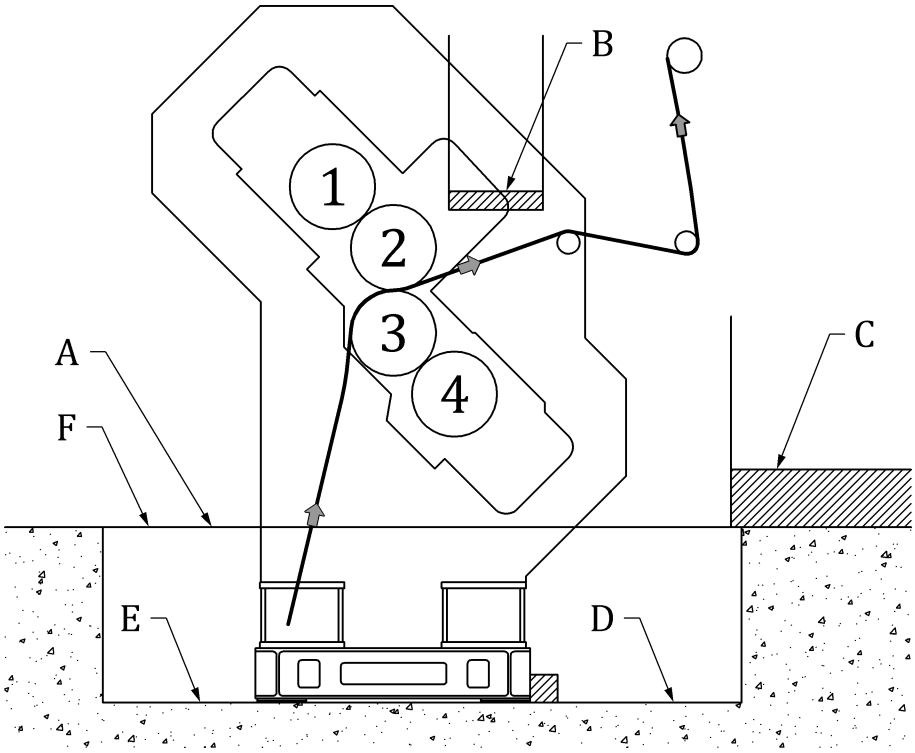


Figure F.1 — Examples of fixed guards at the crushing zones

Annex G
(informative)

Means of access



Key

Position A:	working position at calender inlet – floor level
Position B:	access inside calender frames granted by service platform, for maintenance operations only, between rolls 1 and 2
Position C:	working position at calender outlet platform (or floor level)
Position D:	calender pit, for maintenance and start-up operations on roll 4
E	pit level
F	floor level

Figure G.1 — Example of safe means of access for a big size calenders

Annex ZA
(informative)

Relationship between this European Standard and the Essential Requirements of Directive 2006/42/EC aimed to be covered

This European Standard has been prepared under a Commission's standardization request "M/396 Mandate to CEN and CENELEC for Standardization in the field of machinery" to provide one voluntary means of conforming to essential requirements of Directive 2006/42/EC of the European Parliament and of the Council of 17 May 2006 on machinery, and amending Directive 95/16/EC (recast).

Once this standard is cited in the Official Journal of the European Union under that Directive, compliance with the normative clauses of this standard given in Table ZA.1 confers, within the limits of the scope of this standard, a presumption of conformity with the corresponding essential requirements of that Directive and associated EFTA regulations.

Table ZA.1 — Correspondence between this European Standard and Annex I of Directive 2006/42/EC

Essential Requirements of Directive 2006/42/EC	Clause(s)/sub-clause(s) of this EN	Remarks/Notes
1.1.2	4.1, 5, 6	
1.1.3	4.6.1, 4.6.2, 4.7, 4.12, 5, 6.2.3	
1.1.5	4.9, 5	
1.1.6	4.9, 5, 6.2.3	
1.1.7	4.12, 5	
1.2.1	4.2, 4.3, 4.13, 5	
1.2.2	4.2, 4.3, 4.13, 5	
1.2.3	4.2.2, 4.3.1.8, 5, 6.2.3	
1.2.4.1	4.2.3, 5	
1.2.4.3	4.2.4, 5	
1.2.5	4.2.1, 4.3, 5	
1.2.6	4.2.5, 5	
1.3.1	4.4.2, 5	
1.3.2	4.1, 5	
1.3.3	4.4.1, 5	
1.3.4	4.1, 5	
1.3.6	4.2.1, 4.3, 5	
1.3.7	4.3, 4.4.1, 5	
1.3.8	4.3, 5	

Essential Requirements of Directive 2006/42/EC	Clause(s)/sub-clause(s) of this EN	Remarks/Notes
1.3.8.1	4.3.3, 5	
1.3.8.2	4.3, 4.4.1, 5, 6.2.2, 6.2.3	
1.3.9	4.3.6	
1.4.1	4.3, 5	
1.4.2.1	4.3, 4.3.1.2, 5	
1.4.2.2	4.3, 4.3.1.3, 5	
1.4.3	4.2.6, 4.2.7, 4.3, 4.3.1.1, 4.3.1.3, 4.3.1.4, 4.3.1.5, 4.3.1.6, 4.3.1.9, 4.3.4, 4.3.5.5, 5, 6.2.3	
1.5.1	4.5.1, 5	
1.5.2	4.5.2, 5, 6.2.3	
1.5.3	4.1, 5	
1.5.4	4.1, 4.5, 5	
1.5.5	4.6, 5, 6.2.3	
1.5.6	4.7, 5	
1.5.8	4.8, 5, 6.2.4, Annex A	
1.5.10	4.6.3, 5	
1.5.11	4.13, 5	
1.5.13	4.12, 5, 6.2.3	
1.5.14	4.3, 5, 6.2.3	
1.5.15	4.11, 5	
1.6.1	4.3.1.7, 4.3.5.2, 4.3.6, 5, 6.2.3	
1.6.2	4.11, 5	
1.6.3	4.1, 4.10, 5	
1.6.4	4.3, 4.6, 5	
1.7.1.1	6	
1.7.1.2	4.2.4, 4.2.7, 4.3.1.8, 4.3.6, 5	
1.7.2	4.6.1, 5, 6.3	
1.7.3	6.3	
1.7.4	6.2	
1.7.4.1	6.2.1	
1.7.4.2	6.2.1, 6.2.2, 6.2.3, 6.2.4, Annex A	
1.7.4.3	6.2.4	

WARNING 1 — Presumption of conformity stays valid only as long as a reference to this European Standard is maintained in the list published in the Official Journal of the European Union. Users of this standard should consult frequently the latest list published in the Official Journal of the European Union.

WARNING 2 — Other Union legislation may be applicable to the product(s) falling within the scope of this standard.

Bibliography

[1] EN ISO 11688-2, *Acoustics - Recommended practice for the design of low-noise machinery and equipment - Part 2: Introduction to the physics of low-noise design (ISO/TR 11688-2)*

[2] EN ISO 11200:2014, *Acoustics - Noise emitted by machinery and equipment - Guidelines for the use of basic standards for the determination of emission sound pressure levels at a work station and at other specified positions (ISO 11200:2014)*