



BSI Standards Publication

Design of glass structures

Part 4: Glass selection relating to the risk of human injury — Guidance for specification

National foreword

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A list of organizations represented on this committee can be obtained on request to its committee manager.

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Sélection du verre en fonction du risque de blessure -
Document d'orientation pour les spécifications

Bemessung und Konstruktion von Bauteilen aus Glas -
Teil 4: Bestimmung der Glaskonfiguration in
Abhängigkeit des Verletzungsrisikos - Leitfaden zum
Erstellen von Regeln

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EUROPEAN COMMITTEE FOR STANDARDIZATION
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Contents

Page

European foreword	4
0 Introduction.....	5
1 Scope.....	6
2 Normative references.....	7
3 Terms, definitions and symbols	7
3.1 Terms and definitions	7
3.2 Symbols	9
4 Possible content of the Specifications	11
5 Basic notions.....	12
5.1 Type of occupancy and/or type of buildings.....	12
5.2 Mode of breakage of glass.....	12
5.3 Types of safety glass.....	13
5.3.1 General.....	13
5.3.2 Additional considerations for thermally toughened safety glass	13
5.3.3 Laminated safety glass made of thermally treated glass plies	14
5.4 Accessible glass edges	14
6 Vertical glazing	15
6.1 Protection from the risk of injury in the event of a collision with glazed element.....	15
6.1.1 General requirements.....	15
6.1.2 Additional requirements related to the type of glazed element.....	20
6.1.3 Additional considerations related to the mode of fixing.....	21
6.2 Prevention of the risk of person falling through or over a glazed element.....	22
6.2.1 General requirements.....	22
6.2.2 Additional requirements related to the type of glazed element.....	24
6.2.3 Additional considerations related to the mode of fixing.....	27
6.3 Protection against the risk of accidental fall of glass fragments	29
6.3.1 General requirements.....	29
6.3.2 Additional requirements related to the type of glazed element.....	30
6.3.3 Additional considerations related to the mode of fixing.....	30
7 Non-vertical glazing	32
7.1 Protection from the risk of injury in the event of a collision with glazed element.....	32
7.1.1 General requirements.....	32
7.1.2 Additional requirements related to the type of glazed element.....	33
7.1.3 Additional considerations related to the mode of fixing.....	33
7.2 Prevention of the risk of person falling through a glazed element	33
7.2.1 General requirements.....	33
7.2.2 Additional requirements related to the type of glazed element.....	34
7.2.3 Additional considerations related to the mode of fixing.....	34
7.3 Protection against the risk of accidental fall of glass fragments	35
7.3.1 General requirements.....	35
7.3.2 Additional requirements related to the type of glazed element.....	36
7.3.3 Additional considerations related to the mode of fixing.....	36

Annex A (informative) Suggested values for the quantities used in this document.....	38
A.1 Use of this annex	38
A.2 Suggested values for the quantities used in this document	38
A.3 Suggested values for the quantities used in Annex C.....	39
Annex B (informative) Examples of choice of type of glass	40
B.1 Use of this annex	40
B.2 Possible table of glass to be used in several applications.....	40
Annex C (informative) Possible guidance for guarding design	45
C.1 Use of this annex	45
C.2 Space between guarding components.....	45
C.3 Limitations on the guarding protrusion.....	46
C.4 Normal and temporary standing zones	48
C.5 Drop between the normal standing zone and the guarding.....	51
C.6 Differences in the level of the normal standing zone	51
Bibliography	53

European foreword

This document (CEN/TS 19100-4:2024) has been prepared by Technical Committee CEN/TC 250 “Structural Eurocodes”, the secretariat of which is held by BSI. CEN/TC 250 is responsible for all Structural Eurocodes and has been assigned responsibility for structural and geotechnical design matters by CEN.

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This Technical Specification has been drafted to be used in conjunction with relevant execution, material, product and test standards, and to identify requirements for execution, materials, products and testing that are relied upon by this document.

Any feedback and questions on this document should be directed to the users’ national standards body. A complete listing of these bodies can be found on the CEN website.

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0 Introduction

0.1 Introduction to CEN/TS 19100-4

This document is based on several European documents covering the choice of appropriate glazing for the protection against injuries and falling, e.g. national standards, national building codes, professional association recommendations, etc.

The aim of this guidance is to assist experts who want to write new safety Specifications or to revise existing ones, whatever the type of document. It does not pretend to be exhaustive.

The values given are examples only and are based on different practices in Europe. Experts using this guidance are free to choose other values.

In the same spirit, they can also take all or only some of the topics covered in this document and can add requirements for situations not considered here.

0.2 Verbal forms used in the Eurocodes

The verb “shall” expresses a requirement strictly to be followed and from which no deviation is permitted in order to comply with the Eurocodes.

The verb “should” expresses a highly recommended choice or course of action. Subject to national regulation and/or any relevant contractual provisions, alternative approaches could be used/adopted where technically justified.

The verb “may” expresses a course of action permissible within the limits of the Eurocodes.

The verb “can” expresses possibility and capability; it is used for statements of fact and clarification of concepts.

1 Scope

(1) This document provides guidance for the development or improvement of rules deemed to help with the choosing of appropriate glazing for protection against injuries and falling, hereafter called “the Specifications”. The Specifications to be written or revised can be a national regulation, a national standard, recommendations from a professional association, requirements for a particular project, etc.

(2) This document deals with the choice of the mode of breakage (see 5.2) with regard to the safety of people against:

- the risk of injury in the event of a collision with a glazed element, e.g. a partition,
- the risk of falling through or over a glazed element, e.g. a balustrade, and
- the risk of accidental falling of glass fragments on people not having caused the breakage, e.g. an overhead glazing.

(3) These risks can be evaluated in the function of a normal use of the building or construction work. This includes use by the elderly, children and people with disabilities, but excludes deliberate risk taking. It presupposes a rational and responsible behaviour of the users or, in case of children, of those responsible for supervising them.

(4) The information contained in this document can be used to define minimum glass configuration. It does not exempt from the verification according to CEN/TS 19100-1 and CEN/TS 19100-2 and where appropriate CEN/TS 19100-3.

(5) Safety against burglary, vandalism, bullet attack, explosion, exposition to fire and seismic actions are not covered in this document. Preventing these risks needs further appropriate requirements.

(6) This document does not apply to the following glass products:

- glass blocks and paver units;
- channel-shaped glass.

(7) It also does not apply to the following applications:

- escalators and moving walkway;
- lifts;
- accesses to machinery;
- animal enclosures and aquariums;
- greenhouses and agricultural installations;
- temporary scaffolds.

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.

NOTE See the Bibliography for a list of other documents cited that are not normative references, including those referenced as recommendations (i.e. in 'should' clauses), permissions ('may' clauses), possibilities ('can' clauses), and in notes.

CEN/TS 19100-1, *Design of glass structures — Part 1: Basis of design and materials*

CEN/TS 19100-2, *Design of glass structures — Part 2: Design of out-of-plane loaded glass components*

CEN/TS 19100-3, *Design of glass structures — Part 3: Design of in-plane loaded glass components and their mechanical joints*

EN 356, *Glass in building — Security glazing — Testing and classification of resistance against manual attack*

EN 12150-1, *Glass in building — Thermally toughened soda lime silicate safety glass — Part 1: Definition and description*

EN 12488, *Glass in building — Glazing recommendations — Assembly principles for vertical and sloping glazing*

EN 12600, *Glass in building — Pendulum test — Impact test method and classification for flat glass*

EN 14179-1, *Glass in building — Heat soaked thermally toughened soda lime silicate safety glass — Part 1: Definition and description*

EN ISO 12543-1, *Glass in building — Laminated glass and laminated safety glass — Part 1: Vocabulary and description of component parts (ISO 12543-1)*

3 Terms, definitions and symbols

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 12600, EN 356, EN 12150-1, EN 14179-1, EN ISO 12543-1 and the following apply.

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

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <https://www.electropedia.org>

3.1.1

safety glass

glass which remains unbroken, or achieves a specified resistance, or fails in a prescribed manner when tested in accordance with a relevant technical standard

3.1.2

impact side

side of the glazing where an impact can occur, necessitating appropriate measures to ensure the safety of the people

Note 1 to entry: This impact can be from a human body, an object, etc.

Note 2 to entry: Depending on the location, both sides can be impacted.

3.1.3

vertical glazing

glazing ranging from a vertical position to $\pm 15^\circ$ from the vertical

Note 1 to entry: Some countries restrict the angle to $\pm 10^\circ$ from the vertical.

3.1.4

non-vertical glazing

glazing not corresponding to definition 3.1.3

Note 1 to entry: Examples of non-vertical glazings are floors, roofs accessible or not, canopies, inwardly and outwardly sloping glazings, ceilings.

Note 2 to entry: When the height of the glazing is such that its projection on the horizontal plane extends over e.g. 50 cm, the glazing can be treated as non-vertical glazing even when the angle is smaller than $\pm 15^\circ$ from the vertical.

3.1.5

guarding

permanent element of building or structure intended to prevent persons from falling and to retain, stop or guide them

3.1.6

sill

bottom member of a window frame

3.1.7

manifestation of glazing

provisions intended to make the glazing visible in order to avoid accidental collisions

3.1.8

normal standing zone

zone mainly horizontal where people can stand without any help

3.1.9

temporary standing zone

zone where people can only completely stand for a limited period of time and usually with the help of at least one hand

3.2 Symbols

For the purposes of this document, the symbols given in Table 1 apply.

Table 1 — Symbols

Symbols	Definitions	Related figures, if any
b_h	minimum guarding height measured from the normal standing zone level	7, 8, 9 (C.6, C.8, C.9)
b_{he}	reduced value of b_h in case of thick guarding	8
d_h	height of the critical zone adjacent to a door and including that door, measured from the finished floor level on the side of possible impact	1, 3, 11
d_s	value of the critical surface of a glazed element in a framed door	11
d_w	width of the critical zone adjacent to a door and including that door, measured from the vertical edge of the doorway on the side of possible impact	1, 3
e_b	thickness of the guarding measured at the height b_h from the floor	8
f_h	critical value of the difference between the finished floor levels on both sides of a glazed element	2, 4, 6
f_s	critical value of the difference between the finished floor level of a landing and the finished floor level at the bottom of the stairs below it	11
l_h	minimum height for landing guarding measured from the normal standing zone level	10
l_L	critical landing length measured from a landing door to the nosing of the first tread ^a	11
m_h	height of the critical zone in case of a glazed element mounted against a rigid backing, measured from the finished floor level	none
m_s	value of the critical surface of a glazed element mounted against a rigid backing	none
p_h	height of the critical zone measured from the finished floor level on the side of possible impact	1, 3, 4, 6, 9
r_h	recommended handrail height	none
s_h	Minimum height of the guarding measured from the nosing of the treads ^a	10
v_L	zone of lower visual manifestation of glazing	5
v_U	zone of upper visual manifestation of glazing	5
Δf	difference between the finished floor levels on both sides of a glazed element in the real situation	4, 6
^a This also applies to ramps.		

NOTE 1 Annex A, Table A.1 gives suggested values for quantities defined by the symbols above.

In case the Specifications cover also the topics given in Annex C, the symbols given in Table 2 also apply.

Table 2 — Additional symbols used in Annex C only

Symbols	Definitions	Related figures (if any)
a	threshold distance between the projection of the most protruding part of the guarding to the standing zone, and the nose of this standing zone	C.5, C.7
b_{ht}	minimum guarding height measured from the temporary standing zone level	C.6
g	maximum distance between the normal standing zone and the bottom of the guarding	C.1, C.3
g_t	threshold height of the possible gap between the bottom of the guarding (excluding its supports) and the standing zone	C.5, C.7
h	maximum vertical distance between elements in the upper part of the guarding	C.1
i	maximum distance between the stringer and the bottom of the stairs' guarding	C.2
j	maximum distance between the nosing of the tread and the bottom of the stair's' guarding	C.2
k	maximum horizontal distance between the guarding and the floor slab	C.3
u	maximum horizontal distance between two consecutive guarding's elements	C.1, C.2,
w	drop width	C.8
x	normal standing zone levels' difference threshold	C.9
y	requested prolongation of the guarding	C.9
z_h	threshold height of the standing zone measured from a normal standing zone	C.5, C.6, C.7
$z_{l,1}$	length of the zone below which it is not possible to stand, even temporarily	C.5, C.7
$z_{l,2}$	length of the zone above which the zone is considered as a normal standing zone, under certain conditions	C.5, C.6, C.7
$z_{w,1}$	width of the zone below which it is not possible to stand, even temporarily	C.5, C.7
$z_{w,2}$	width of the zone above which the zone is considered as a normal standing zone, under certain conditions	C.5, C.6, C.7
$\varnothing d$	maximum diameter of the reference sphere	C.4

NOTE 2 Annex A, Table A.2 gives suggested values for quantities defined by the symbols above.

4 Possible content of the Specifications

(1) In order to give a structure to the possible content of the Specifications, separate sections are made for vertical glazing and non-vertical glazing.

NOTE Floors and roofs are both treated in Clause 7 due to the fact that a glazed floor can be a roof for the space below and a roof can also be accessible for maintenance and repair.

(2) The safety aspects that can be covered are presented following the 3 main types of risks to consider:

- risk of injuries in the event of a collision with a glazed element;
- risk of falling through or over a glazed element;
- risk of injuries in the event of accidental fall of glass fragments.

(3) Both sides of the glazing shall be considered to evaluate the possible existence of a risk.

(4) Different levels of details are possible for the requirements, see Table 3.

(5) The Specifications can deal with all levels of details or be limited to the general requirements. The organization of the chapters of the Specifications should not necessarily follow the one of this guidance.

(6) The scope of the Specifications can select only some of the topics covered by this guidance and it can also cover additional situations.

(7) Exceptions or deviations can be foreseen in case of renovation of cultural heritage.

(8) Impact tests on the complete element or on an element representative of it, including fixations, can be requested by the Specifications, respecting the post fracture limit state verification of CEN/TS 19100-1 CEN/TS 19100-2 and CEN/TS 19100-3.

(9) The Specifications can also give a table with glass configurations allowed without testing, associated with maximal dimensions and installation conditions.

(10) Where general standard or building code dealing with safety are applicable, the Specifications shall not contradict them, unless the aim is to revise or replace them.

Table 3 — Possible levels of details for the requirements

Type of risk	General requirements	Additional requirements related to the type of glazed element	Additional considerations related to the mode of fixing
Vertical glazing			
Collision with a glazed element	6.1.1	6.1.2	6.1.3
Falling through or over a glazed element	6.2.1	6.2.2	6.2.3
Accidental fall of glass fragments	6.3.1	6.3.2	6.3.3
Non-vertical glazing			
Collision with a glazed element	7.1.1	7.1.2	7.1.3
Falling through a glazed element	7.2.1	7.2.2	7.2.3
Accidental fall of glass fragments	7.3.1	7.3.2	7.3.3

(11) For each type of risk and level of requirements, a distinction can be made depending on the type of occupancy, see 5.1.

5 Basic notions

5.1 Type of occupancy and/or type of buildings

(1) Requirements can differ according to the type of occupancy or the type of building. The Specifications shall precise whether several categories are considered or not, and shall clearly define them.

(2) Examples of categories are:

- categories of use of areas as defined in EN 1991-1-1;
- distinction between private and public indoor spaces (accessible to undefined public or not);
- distinction between private and public outdoor spaces (accessible to undefined public or not);
- distinction between low or high rise buildings;
- nationally defined occupancy categories (dwellings, offices, schools, sport hall, swimming pools, etc...).

(3) Differentiations can also be made by location in the building (ground floor, floors above a certain level...).

5.2 Mode of breakage of glass

(1) Three modes of glass breakage are described in EN 12600 and can be related to specific types of glazing provided that they fulfil the requirements of their corresponding product standard:

- Type A – mode of breakage typical of annealed glass, heat strengthened glass, or chemically strengthened glass;
- Type B – mode of breakage typical of laminated glass, but also achieved by some wired glass or by applying appropriate adhesive safety films on appropriate type of glass;
- Type C – mode of breakage typical of thermally toughened glass and heat soaked thermally toughened glass.

(2) The classification of the glass shall be established by testing according to EN 12600. The list above is given for the ease of the user and does not prejudice the results.

(3) When a requirement is expressed in terms of a class according to EN 12600, the first glass thickness meeting the requirements of the prescribed class is the minimum thickness.

(4) Resistance and robustness evaluation shall be performed according to CEN/TS 19100 parts 1 to 3.

(5) Depending on the application or on the type of glazed element, there may be a need for redundancy.

Annex B gives examples of choice of glass in function of their mode of breakage for several types of applications.

5.3 Types of safety glass

5.3.1 General

(1) The different types of safety glass products that can be considered are as follow:

- Laminated safety glass according to EN ISO 12543-1 and EN ISO 12543-2. Compliance with EN ISO 12543-2 requests the laminated glass being classified according to EN 12600;
- Thermally toughened glass, with or without enamel:
 - Thermally toughened soda lime silicate safety glass according to EN 12150-1;
 - Thermally toughened borosilicate safety glass according to EN 13024-1;
 - Thermally toughened alkaline earth silicate safety glass according to EN 14321-1;
- Heat soaked thermally toughened glass, with or without enamel:
 - Heat soaked thermally toughened soda lime silicate safety glass according to EN 14179-1;
 - Heat soaked thermally toughened alkaline earth silicate safety glass according to EN 15682-1;
- Insulating glass units according to EN 1279-1 made of one or more of the above-mentioned glass products, provided that the safety glass pane(s) is (are) correctly orientated with regards to the risk;
- Adhesive backed polymeric safety film according to EN 15752-1, when correctly applied on the whole surface of an appropriate glass product and when successfully tested according to EN 12600, can ensure or increase the safety of the glass on which it is applied.
- Safety backed mirror and safety backed painted glass (EN standard in preparation), when correctly applied on the whole surface of the mirror or painted glass and when successfully tested according to EN 12600, may be considered as safety glasses for use in certain applications.

(2) The colour of the glass, the possible coatings or an acid etched surface have no influence on the safety performance. Sandblasting a safety glass can lead to the need of reassessing the safety characteristics.

(3) Annealed glass of any chemical composition, chemically treated soda lime silicate glass (see EN 12337-1) and heat strengthened soda lime silicate glass (see EN 1863-1), when used as monolithic glass, are not considered as safety glasses.

NOTE In some countries and under specific conditions, annealed float glass of defined minimum thickness can be used in applications subjected to safety requirements.

(4) Appropriate bonding of an annealed glass (e.g. a mirror or a painted glass) against a rigid support (e.g. a wall, a partition...) can ensure safety in case of impact by holding the fragments in place, see 6.1.3.5.

(5) The user of this document can decide to restrict the use or to exclude some glass types listed above from the Specifications under elaboration.

5.3.2 Additional considerations for thermally toughened safety glass

(1) Nickel sulphide inclusion is a rare, but naturally occurring impurity potentially present in all glass that can, in certain circumstances, lead to spontaneous breakage of thermally toughened glass.

(2) To reduce the risk of toughened glass spontaneously breaking due to the presence of critical nickel sulphide (NiS) inclusions in the glass, it is advisable to perform an additional heat treatment known as the heat-soak process (see EN 14179-1).

(3) This is a destructive process which eliminates the majority of the thermally toughened glass that is at risk. While the technique cannot eliminate totally the glass that contains nickel sulphide inclusions, the risk of breakage is considerably reduced.

(4) This treatment is recommended for all situations where the stability of the structure and the safety of users can be jeopardized in case of glass breakage. The risk of broken fragments remaining stuck together and forming a larger and heavier element may also be considered. Heat soak treatment is also recommended when the replacement of broken thermally toughened glass is difficult or costly due to its location.

5.3.3 Laminated safety glass made of thermally treated glass plies

(1) Thermally toughened safety glass can be necessary to increase mechanical resistance or to prevent the risk of thermal breakage. When all plies of the laminated glass are thermally toughened, attention should be paid to the risk of collapse in case of accidental breakage of all glass plies (wet towel effect). The risk shall be evaluated in function of the boundary conditions (framed/unframed edges, cantilever, punctual fixing, size of the laminated glass, expected temperatures in service...).

(2) Possible laminated safety glass configurations to mitigate that risk are:

- the use of stiff interlayers (e.g. ionomer, stiff PVB or stiff EVA interlayers) to bond the thermally treated plies;
- the use of at least one heat strengthened glass in the laminated glass configuration;
- redundancy, e.g. the use at least 3 plies among which any 2 shall be sufficient to carry the loads.

(3) Fixing system might need to be adapted.

5.4 Accessible glass edges

(1) Unframed glass edges, when accessible, shall at least have their edges arrissed. Types of edge working of thermally treated glass are given in the appropriate product standard, e.g. EN 12150-1, EN 14179-1, EN 1863-1, etc. For laminated glass, it is given in EN ISO 12543-5. In case of insulating glass unit, the requirements related to the glass edge is applicable to each accessible pane that constitute the glazing.

(2) Alternatively, accessible edges can be permanently covered by e.g. a metal or plastic strip to protect them against damage or breakage and to prevent the risk of injuries by cutting.

(3) Accessible corners should be made blunt or protected to mitigate the risk of injury.

(4) Glass elements with protruding corners should be avoided.

(5) Care should be taken to reduce the risk of finger entrapment in the space between two consecutive glass panes with free edges. This space can be filled with a seal, or can be such that a probe of diameter 8 mm (simulating children finger) or of diameter 12 mm or 18 mm, do not enter or can be removed with a force lower than 50 N.

6 Vertical glazing

6.1 Protection from the risk of injury in the event of a collision with glazed element

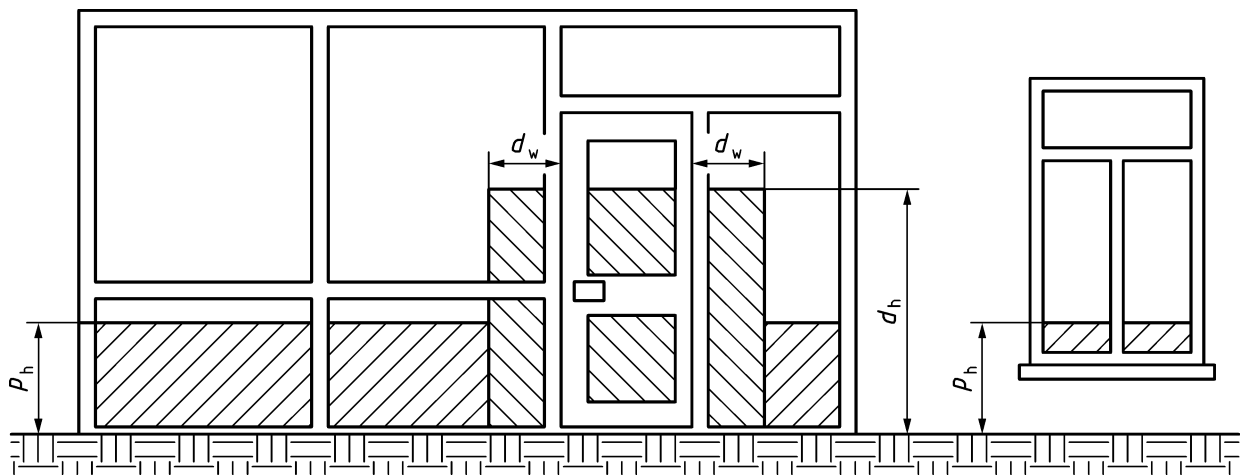
6.1.1 General requirements

6.1.1.1 Quantities relevant to express safety requirements

(1) The Specifications shall define basic quantities used to express the safety requirements.

(2) Due to the risk of accidental impact and the possible consequences in case of glass breakage, a critical zone is generally defined by its height measured from the finish floor level, p_h , see Figure 1. In that zone, the risk of impact shall be evaluated and the use of safety glass is generally requested.

(3) Around a door, a critical zone may be defined by a different height, d_h , and by the width of that zone d_w , see Figure 1. In the absence of definition of a zone around a door, the requirements of the general critical zone apply.

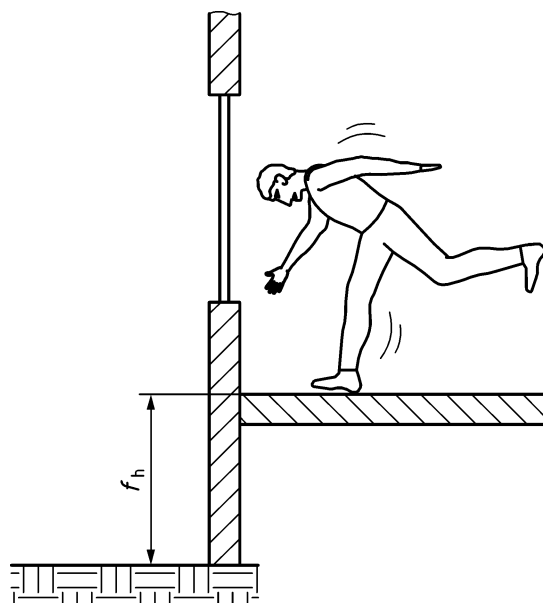


Key

- p_h height of the critical zone measured from the finished floor level on the side of possible impact
- d_h height of the critical zone adjacent to a door and including that door, measured from the finished floor level on the side of possible impact
- d_w width of the critical zone adjacent to a door and including that door, measured from the vertical edge of the doorway on the side of possible impact

Figure 1 — Example of critical zones

(4) In addition, the floor level difference on both sides of the glazed element shall also be considered. Indeed, it will determine whether or not the risk of falling through or over the glass element shall be assessed according to 6.2. The critical value of the difference between the finished floor levels on both sides of a glazed element is defined as f_h , see Figure 2.

**Key**

f_h critical value of the difference between the finished floor levels on both sides of a glazed element

Figure 2 — Example of critical floor levels difference expression

NOTE In some countries, f_h is expressed as the difference between the sill of the glazing and the finished floor level of the fall side. In this document, for sake of simplification, only the first definition is considered as it is the most often used in Europe.

(5) In some project situations, the risk shall be evaluated in the opposite direction or in both of them.

NOTE The direction to which the risk has to be assessed is not necessarily from the inside to the outside of a room.

(6) The quantities p_h , d_h , d_w and f_h can keep the same value whatever the situation or they can depend on:

- The type of occupancy, see 5.1;
- The value of another quantity, for instance p_h being greater when f_h is above a certain threshold value;
- The type of glazed elements.

(7) Table A.1 gives the usual ranges within which the values of the quantities can be chosen.

6.1.1.2 Glazing not installed in a critical zone

(1) In case the sill height is equal to or greater than p_h , see Figure 3, it is usually considered that the risk of accidental glass breakage is low. In that case, the difference between floor levels f_h is not considered.